The Queensland community's propensity to invest in the resilience of their community and the electrical distribution network

Kate Austin, Graduate Diploma in Energy and the Environment

Master of Renewable Energy Dissertation

May 2019

Declaration

I declare that this dissertation is my own account of my research and contains, as its main content, work which has not previously been submitted for a degree at any tertiary education institution.

Where I have included others research to support this work I have ensured that their research has been appropriately acknowledged.

Signature:

Name: Sara Katrina (Kate) Austin

Abstract

Electricity supply is vital for community response and recovery in the aftermath of a disaster. Everything from disaster response coordination, communication, public lighting and safety, as well as the provision of health services, basic household operations and the economic recovery of the community, relies on electricity to function. This dependency, coupled with the vulnerability of our electricity networks, highlights the need to establish resilient distribution networks.

The notion that small-scale solar PV (SSPV) and battery energy storage systems (BESS) might contribute to network resilience, has become a popular avenue of investigation, with the growing uptake of these technologies. Beyond the technical challenges of establishing a smart grid network and reaching the required uptake of the technology to have sufficient storage capacity, a third factor relating to householders' willingness to share stored energy with their community, remains largely unexplored.

In a marked departure from the existing literature, this thesis investigates the use of SSPV and BESS for distribution network resilience and the community's attitudes towards sharing energy resources. The research focusses, not on the technical and regulatory aspects of network resilience which are favoured by researchers', but the behavioural component founded in social sciences. A model for network resilience utilising SSPV and BESS is presented, which argues that a key component of resilience in the aftermath of a disaster event, hinges on the community's commitment to conservation of energy resources and their willingness to share their stored reserves for the common good.

This research investigates the community's perspectives on this resilience approach, by exploring attitudinal and behavioural aspects associated with helping the community, to determine the viability of pursuing SSPV and BESS as a practical network resilience option.

Table of contents

List of Figures

List of Tables

Acknowledgements

Firstly, I would like to thank my thesis supervisor, Dr Farhad Shahnia, for providing support and guidance on the direction of this research and for taking the time to review my work and in so doing, expand my thinking.

I would like to acknowledge and thank my employer, Energy Queensland (EQL) and the two Distribution Network Service Providers, Ergon Energy and Energex, for supporting this research and providing a range of platforms from which to launch my survey questionnaire. Thanks too for the financial and in-kind contributions towards prize incentives for respondents who completed the research survey.

Thank you too, to my industry supervisor, Ms Sara Collins (Manager Community Strategy). Your enthusiasm for the topic and advocacy of my research was both pivotal in refining my research topic and inspirational in igniting my energy and passion for the project. I've no doubt that this research is just the beginning of our investigations into these topics and many more!

I would like to further acknowledge my wonderful family, friends and colleagues for their support and encouragement throughout this dissertation and all my prior studies. Many a word of encouragement has been offered, re-igniting the fire and the energy needed to push through tough times and deliver great results.

Finally, I would like to offer a special thank you to my partner Pete. Your numerous sacrifices throughout my many years of study, as well as your eternal support for everything I pursue, your encouragement and abundance of patience, cannot be underestimated, nor understated. Success was inevitable with my very own 'coach' beside me, each day reminding me that it would take 'just one more day of effort' to achieve this milestone. Finally, that day has arrived. You truly are one of a kind!

I could not have achieved this significant milestone, without the numerous contributions and unconditional love and support of everyone in my life throughout the many years of my postgraduate studies, and for that support, patience and encouragement, I sincerely thank you all.

1. Introduction

1.1. Research background

The severity and frequency of severe storms and natural disasters are increasing and are reported to continue to escalate because of climate change (Wu et al., 2017). These natural disasters can inflict significant damage to critical infrastructure, like distribution electricity networks, which are vulnerable to the effects of strong winds, driving rain, flooding and bushfires.

Electricity is fundamental to all aspects of our daily lives and the safe and effective functioning of our communities. Electricity outages can lead to a broad range of impacts on individuals and communities from small inconveniences, to community-wide economic hardship and devastating loss of life.

Traditionally there has been a focus on network hardening practices for resilience, yet more recently, researchers and practitioners have emphasised that integrated small-scale solar PV (SSPV) and battery energy storage systems (BESS) could provide a level of electricity network resilience in the aftermath of a disaster. Whilst these systems are relatively new, and are yet to reach a critical mass, they may contribute to future solutions (Zhou et al., 2018; Chen et al., 2016; Wang et al., 2016), helping to support the electricity networks and other critical community infrastructure we have become so reliant upon.

This research investigates the community's perspectives on this resilience approach, by exploring attitudinal and behavioural aspects associated with helping the community, to determine the viability of pursuing SSPV and BESS as a practical network resilience option.

1.2. The need for the research

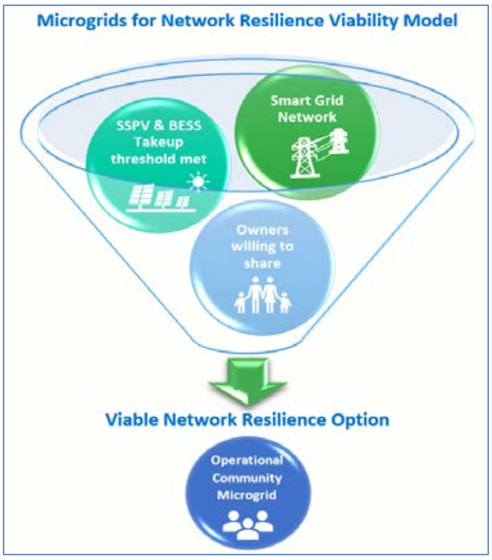
Distributed energy resources such as SSPV and BESS have been investigated as an option for network resilience (Zhou et al., 2018; Gao et al., 2016; Gholami et al., 2016). These investigations continue to focus strongly on the technical and regulatory aspects of the electricity network (Yazaine et al., 2018; Palizban et al., 2014) aiming to trigger the evolution of networks to become 'smart grids'. Some research also seeks to investigate the take-up rates of these technologies (Agnew & Dargusch, 2015) with a view to determining the ‘threshold’ at which enough installed capacity is reached to feasibly support network resilience. Although the author is an exponent of this transition, I postulate that a gap remains in the research; a third characteristic that has largely been ignored, that warrants investigation to support the contention that SSPV and BESS microgrids could provide practical network resilience.

Whilst many tout microgrids as a solution to electricity network resilience, three elements must be met before microgrids can be considered a practical viable solution – see Figure 1. Firstly, several technical requirements would need to be resolved and network utilities would need to invest considerable capital towards creating smart grids to control these microgrid systems.

Additionally, to reach a self-sustaining capacity in the network, the uptake of these systems would need to reach critical mass. Although Queensland boasts one of the highest penetration rates of rooftop solar per capita in the world (Bailey, 2017b), the uptake of premise-based energy storage systems in Queensland is still in its infancy with less than 3,000 systems registered (Colmar Brunton, 2019), leaving a significant gap in the critical mass needed to provide a practical level of resilience.

This dissertation research is built on the premise that there is a third, and equally important element, that must be realised before SSPV and BESS can be considered a viable solution. For privately owned SSPV and BESS to form part of the solution to network resilience, the owners of integrated solar-energy storage systems, must be willing to share their energy resources in times of need.

Figure 1 – Microgrids for Network Resilience Viability Model



A significant body of research has already been conducted and continues to solve the technical aspects of using microgrids for network resilience. Reaching critical mass in the uptake of battery systems is, only a matter of time and market forces, as it has been for the successful take-up of SSPV across Australia. Both variables are somewhat mechanical in their resolution, in that, it is only a matter of time before the technical challenges are answered and a 'smart grid' is established and battery storage critical mass is achieved.

There is, however, a significant void in current research and in the understanding of consumer behaviour relating to sharing energy resources. Kinn and Abbott (2014) highlight such a gap where the disciplines of social sciences and humanities, which focus on the human impact and behaviour in the aftermath of disasters, are rarely discussed in the same realm as topics such as electricity which is traditionally grounded in engineering research. This can lead to the creation of policy and strategies founded in the technical realm, which may prove unsuccessful in the social environment, particularly if the intended policy outcomes are at odds with human behaviour.

The author posits that regardless of how quickly a smart electricity network can be created and the requisite capacity of SSPV and BESS is established, the use of these technologies will not present a viable solution for network resilience, if the community is unwilling or unable to share these resources at the network's time of need. Understanding how society might respond to these challenges is crucial to creating a viable resilience solution.

1.3. Problem statement and research questions

Framed within this context, this research seeks to investigate the views of Queenslander's regarding their social responsibility following natural disaster events, to 'share' their energy resources for the 'greater good' of their communities, and to identify factors that might influence their willingness to contribute to the electricity distribution network's resilience.

Soliciting these views aims to serve the ultimate goal, of determining if the use of SSPV and BESS could indeed provide a level of network resilience for Distribution Service Network providers (DNSP's), beyond the theoretical ideal currently being pursued.

To achieve this aim, the objectives of this research was to:

- Determine Queenslander's propensity to 'share' their energy resources with others in their communities following natural disaster events;
- Identify if respondent intensions to share energy resources and their self-described behaviours align, or if an intension-behaviour gap might exist;
- Inform Queensland's Distribution Network Service Providers (DNSPs) business decisions and policy design to support resilience of the distribution network using household SSPV and BESS and to promote future research in this area; and
- Encourage a broader industry-wide discussion around customers' understanding of their electricity usage and their willingness to share their electricity resources during times of natural disaster.

As a means of transitioning beyond an aspirational predication of network resilience using SSPV and BESS and to emerge into the practical realm, the central focus of this research is to understand influencing behavioural variables and to determine if any intention-behaviour discrepancies exist, by answering the following questions:

- RQ1 - Do Queenslander's feel a social obligation towards supporting the resilience of their community and the electricity distribution network in the aftermath of a disaster?
- RQ2 - Are Queenslander's willing to share their household electricity resources following a natural disaster or major event to support the restoration of the electricity network in their community?
- RQ3 - If they are willing to share, are there any potential barriers or conditions that may need to be met and/or do they expect some form of incentive or compensation in return?

These questions will assist in uncovering Queenslanders' belief spectrum relating to their positioning as an exponent of an 'every man for himself' attitude, or an advocate 'for the greater good'. This will ultimately determine their propensity for sharing their household energy resources with their community to support the resilience of the electricity network in times of need. It is important to validate this notion because, without the willingness of the owners to share their energy resources when they are most needed, it is futile to pursue privately-owned SSPV and BESS as a mechanism for network resilience.

Understanding the consumer's beliefs and behaviour will determine if, once the technical challenges are solved and the physical assets are in place, the concept of privately owned SSPV and BESS can be taken beyond the realm of aspirational resilience and be employed to support the practical resilience of the electricity network.

1.4. Research scope

This research focusses on the Queensland community's willingness to share their SSPV and BESS resources to support network resilience following disaster events.

Although the report will touch on the technical focus of current research to establish a network capable of supporting this resilience option, this research does not aim to investigate or comment on the practicality of, or progress towards, the DNSP's developing smart grid capability. Nor does this research aim to investigate or report on the practicality of SSPV and BESS as a resilience option in comparison to other solutions, although the adoption rates of these technologies will be considered.

This research is based on the premise that the first two requirements to establish resilience, have or will be met; that the network is technically capable and there is enough installed SSPV and BESS capacity to theoretically provide network resilience.

Based on this premise, this research seeks to understand if SSPV and BESS could present a practical option for network resilience. This determination will be based on the third requirement for resilience, that being, the available stored capacity in BESS being readily released into the network at the time of need. Meeting this requirement would be a function of the communities' willingness to share their stored energy resources, rather than an arbitrary theoretical estimate of available capacity based purely on installed capacity.

This research is supported by Energy Queensland's (EQL) network distributors, Ergon Energy and Energex however, the findings and views expressed in this paper do not represent the views of EQL nor its DNSP's.

1.5. Overview of chapters

This report begins with a literature review to explore the concepts of disaster resilience, responsibilities for creating resilience, and the contributions communities can make towards investing in, and building resilience.

Following this initial review, Chapter 3 further establishes the research context, by reviewing aspects of the geographical area of the research, the State of Queensland. This section describes its electricity network, disaster vulnerabilities and the current and future methods for providing network resilience to the Queensland distribution network.

Chapter 4 outlines the methods used to conduct the research including the survey design, survey promotion, data collection methods, data analysis approach and reporting design.

The findings of the research are then explored in Chapter 5. This section firstly establishes the survey's response validity and the basic demographic characteristics of respondents. The survey results are then organised and explored across five (5) central areas including, the benefits of electricity in the aftermath of disasters, the penetration of energy resilience measures, attitudes towards the sharing of energy resources, energy conservation and willingness to share conditions and incentives.

The final chapters of the paper complete the report, with conclusions drawn and the implications of the research findings considered in Chapter 6, and finally, Chapter 7 describes research limitations and highlights potential future research and investigation opportunities.

2. Disaster Resilience and Responsibilities

2.1. Disaster resilience

Extreme weather events can result in damage to critical infrastructure and even loss of life. Considerable focus has therefore been applied to the notion of 'resilience', with a variety of scholars and practitioners attempting to define the concept. In the realm of physical sciences, resilience has been described as *'the* *capacity of a material or system to return to equilibrium after a displacement'*, (Norris et al., 2008, p. 127). Resilience is therefore not only about recovery from a disaster, but the ability to grow stronger through the adversity. Resilience could be considered a perpetual evolution of capability, rather than an end-state, thereby requiring ongoing effort to develop capability and build community capacity (Abron et al., 2016).

Applying this definition to the resilience of the electricity network, it represents the ability of the network to quickly recover from a failure or disaster and to be stronger as a result. Electricity is fundamental to community resilience and to our standard of living. Our growing dependence upon electricity exacerbates the economic and social impacts when supply is unavailable, particularly for prolonged outages, often associated with disaster events (Kinn & Abbott, 2014).

The increasing frequency and severity of these events, combined with our dependence on the electricity the network provides, is driving an urgent need to improve the resilience of our electricity networks (Panteli et al., 2017; Chen et al., 2016). This complexity, coupled with the interdependencies of critical infrastructure, makes them more vulnerable to disasters, and increases the difficulty in building resilience (Egli, 2013). The notion that that communities can simply 'return to normal' following the initial response and restoration effort is unfounded. Indeed, the magnitude of extreme weather events, experienced over a broad continuum of spatial and temporal variation, can result in delays in response and restoration efforts and subsequently in significant economic and social loss (Linnenluecke & Griffiths, 2010).

Sage et al., (2014) contemplates these complexities and questions how resilience can effectively be developed to counter events characterised by significant variable spatial and temporal scales and across numerous interconnected and critical systems. Resilience clearly cannot be achieved by a single agency or entity operating in such a complex environment. Linnenluecke and Griffiths (2010) concur, suggesting that the efforts required to build resilience, to meet the increasing frequency and severity of events, is beyond the scope and capability of any individual organisation, suggesting shared responsibility for building resilience capability.

2.2. Who's responsible for resilience

2.2.1. *Shared responsibility for resilience*

Historically, there has been an entrenched community dependence upon government and emergency services in the aftermath of disaster events (Linnenluecke & McKnight, 2017; Singh-Peterson et al., 2015), fuelling the community's expectations that critical infrastructure be rapidly re-established in the aftermath of a disaster. A commodity that is taken for granted, coupled with a community feeling of entitlement towards electricity, this dependence is exacerbated (Ghanem, et al., 2016). Whilst Egli (2013) found that many viewed resilience as a public good, significant research has been conducted to understand disaster resilience in the context of the communities' responsibility (Kulig et al., 2013; Norris et al., 2008). Contrary to opinions expressed in research, that governments are responsible for emergency actions, recovery and resilience (Burger & Gochfeld, 2014 Egli, 2013), Egli maintains the view that '*all disasters are personal, and the first priority in preparedness planning is an individual responsibility'* (2013, p.36). Individual responsibility has been identified as a key attribute in building community resilience (Singh-Peterson et al., 2015; Colten et al., 2008) and an important factor in building psychological preparedness (Soetanto et al., 2017).

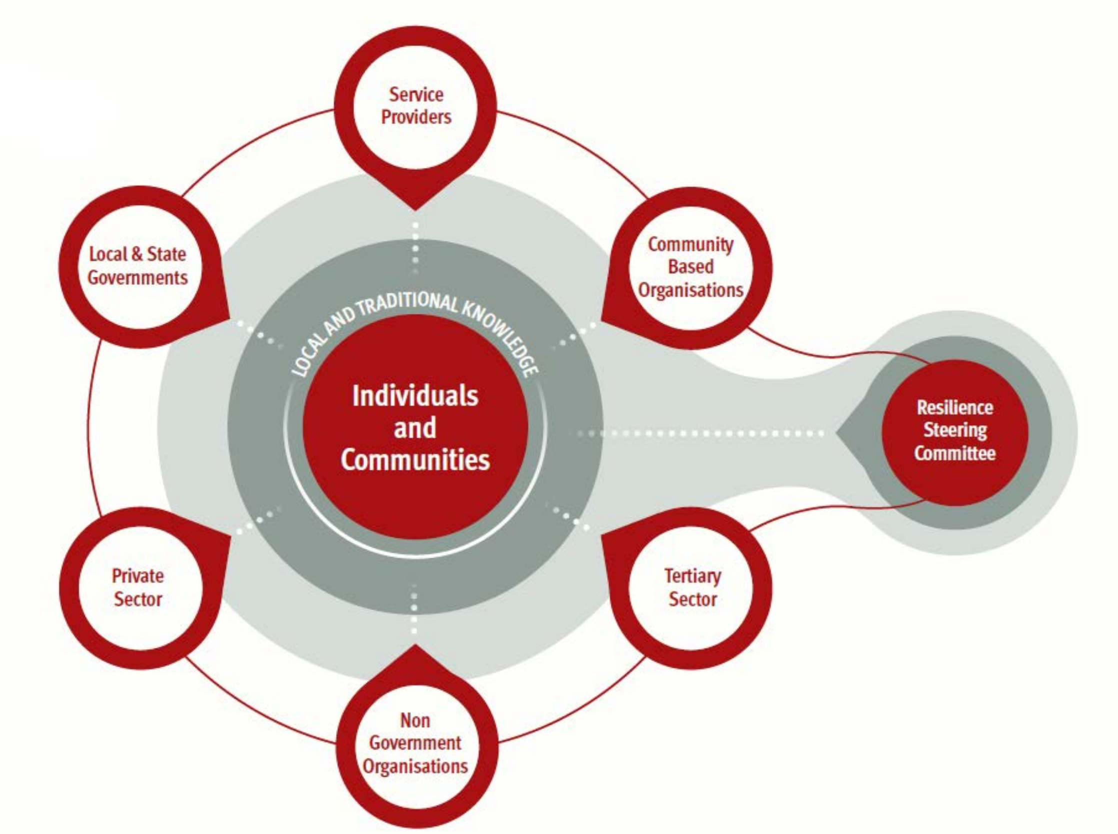
Yet across the community, there are firm beliefs that resilience and response is someone else's responsibility, often that of government and volunteer agencies. To some degree this paradox is a result of the legacy successes of response agencies. Swift responses from government agencies and emergency responders in previous disaster events has reinforced this notion, and as a result, the community's subsequent abdication of responsibility to others.

Egli asserts that '*resilience is a public good enabled by collective action*' (2013, p. 32) and about more than just critical infrastructure protection, heralding the call for individuals to be proactive and act to be self-sufficient and collectively improve their community's resilience. Proponents agree, urging the public to take responsibility for creating personal resilience and bolstering community resilience (Tarhan et al., 2016; McLennan & Handmer, 2014).

Recognising that critical infrastructure is not isolated from the complexities of social and economic dimensions, Opdyke et al. (2017), emphasise the importance that these factors play in establishing resilience. More broadly, resilience literature identifies environmental, infrastructure, economic, governance and social dimensions as fundamental components (Cutter et al., 2010). This extensive range of dimensions contributes to the complexity in creating resilience and drives the need for establishing capability at the community level.

The Queensland government's resilience model is based on a concept of shared responsibility, established through strong, connected networks with individuals and their communities at the heart of the model - see Figure 2. This shared responsibility model recognises that all actors are encouraged to build networks, understand their risk exposure and undertake planning and preparation activities (Qld Govt., 2017). Essentially a collective effort is required to build and maintain resilience.

Figure 2 - Queensland Government's Resilience Shared Responsibility Model



Source: Queensland Government. 2017. Queensland Strategy for Disaster Resilience 2017. p. 22.

Fahey (2003) sees a requirement to re-think the role of citizens in disasters. Calling on individuals to actively assist the needy, she also challenges the needy to take responsibility for their preparation and resilience, stating that citizens '*now no longer have only rights, but an obligation to be active and productive citizens'* (Fahey, 2003, p. 13), reinforcing the notion of shared responsibility.

2.2.2. Community resilience

The concept of community resilience, derived from numerous theoretical and applied research disciplines, has resulted in a plethora of definitions. In the context of disaster management, community resilience is understood to be '*a reflection of people's shared and unique capacities to manage and adaptively respond to the extraordinary demands on resources and the losses associated with disasters*' (Cox & Perry, 2011, p. 395). Emphasising the importance of community connection in building resilience, it has also been described as a continuous process of engagement, that prior to an event, builds disaster preparedness and facilitates a speedy recovery in the aftermath of an event (Abron, 2014). This complex construct is a function of individuals aggregating resources and assets to build social capital for the common good of the community.

The rising interest in community resilience research has suggested societal benefits will be derived from better understanding the concept (Miles, 2015). Community resilience is invariably positively viewed, with a range of benefits acknowledged, including increased wellbeing, identity, services and capital (Miles, 2015), and a corresponding reduction in adverse effects such as risk exposure, miscommunication and the physical and mental traumas often associated with disaster events (Ludin et al., 2017).

To achieve this, community resilience requires members of the community to 'invest' in resilience enhancing measures and sharing common pool resources (CPRs).

2.3. Investing in community resilience

Grootaert (1998) identified a range of different types of capital which underpin economic development and growth, these being natural capital, physical capital, human capital and social capital. These forms of capital are invested to create the reward of financial capital, in the form of wealth, which is then reinvested to further prosper. Capital investment is required to facilitate community recovery and ultimately prosperity.

2.3.1. Individual capital investment

The ability to access a variety of forms of capital determines how a household or community copes with disasters (Ghanem et al., 2016). Capital investment at the individual or community level has typically taken the form of financial investment. The purchase of items like generators, gas cookers and BBQs are typical, designed to increase self-sufficiency and reduce the impact of a disaster. More recently, investment has expanded to include purchases of emerging technology such as SSPV and BESS, which increases individual resilience, but have also been touted as an option for broader community-wide network resilience (Chen et al., 2016; Wang et al., 2016).

The notion of financial investment in resilience is well understood, however establishing resilience requires not only financial capital investment, but also social capital investment. Social capital has been defined as *'the set of norms, networks, and organisations through which people gain access to power and resources'* (Grootaert, 1998, p. 2). Social capital has also been described as '*the norms of reciprocity for each other's wellbeing'* (Masud-All-Kamal & Monirul Hassan, 2018, p. 1549) and has been attributed to explain why some communities flourish, yet others deteriorate (Murphy, 2017; Aldrich & Meyer, 2015).

Community exists in the collective actions of its members (Brennan et al., 2007), where the whole is greater than the sum of its individual parts. Putnam's work on social capital argues the benefits of harnessing and nurturing the internal capacity of community networks for the greater good (Putnum, 1995). Social capital draws on this notion of pooling the community's individual internal capability for the benefit of the entire community. Therefore, social capital is an individual and community level attribute that can be called upon in a disaster and is an integral factor in establishing community resilience (Murphy, 2007). It is created through the promotion of collective action towards prevention and preparation activities and cooperation for recovery in the aftermath of an event (Witvorapong et al., 2015; Chamlee-Wright & Storr, 2011).

Whilst social capital has been linked to positive outcomes, Murphy warns of the exclusivity which can emerge, with the creation of social capital among some groups, to the detriment of others (2007). Where access is stifled, or relationships are weak - particularly among minority groups such as the elderly, the poor, uneducated or ethnic groups - social capital may be low and difficult to develop, exacerbating their isolation and undermining the ability to increase their social capital. This can create an imbalance and exacerbate the divide between the 'haves and have-nots'.

Community resilience can only be realised when trust and goodwill, the fundamental components of social capital, are entrenched across all of society (Wolsilk, 2012). Fukuyama agrees, suggesting that solid community networks will increase the likelihood that individuals will band together in times of adversity under a *'norm of reciprocity'* (Fukuyama cited in Friel, 2005, p. 82) and that social capital will increase with use (Fukuyama, 2000). Witvorapong et al. (2015) asserts that social capital should be deemed a public resource that can be invested in, exchanged and inherited, ultimately enhancing the overall well-being of the community. Miles, advocating for the collective good over the individual gain, states that '*ultimately, the well-being of a community is dependent on that community's collective capital*' (2015, p. 103). These views overwhelmingly support the notion of social capital as a common pool resource (CPR) which should be shared and that this capital needs to be developed over time to be truly effective.

2.4. Pooling and sharing resources

2.4.1. Sharing resources to build resilience

A CPR is described by Ostrom as "*a natural or man-made resource in which it is difficult to exclude or limit users once a resource is provided, and one person's consumption of the resource units makes those units unavailable to others*", (1999, p. 497). In the face of preparing for, and recovering from the aftermath of a disaster, self-reliance is encouraged if external resources are unavailable. To pursue the collective goal of community resilience, individuals should '*forgo their self-interests and act in the interests of the collective'* (Rivera & Nickels, 2014, p. 185). Qi et. al, agrees, promoting the ideal, '*where people collaboratively share access to goods and services*' (2017, p. 455). George (2013) also supports the need to look beyond our individual needs and consider the welfare of the community at large when disaster strikes, bolstering community resilience by uniting individual resources through active networks (Arbon et al., 2016). Skopik (2014) investigated this through the application of coalitional game theory where the benefits for individuals grow with active collaboration across many.

This may be easier said than done, with a lack of established governance mechanisms for the management of energy as a CPR (Wolsink, 2012). Further, with an absence of operational microgrids in Queensland, it is little wonder that a void exists in published research examining SSPV and BESS sharing behaviours across the community.

In a general sense, most research supports sharing for the broader good, rather than hoarding for individual benefit. This premise is justified with studies finding resilient communities were those who could successfully mobilise community resources in response to disaster events (Linnenluecke & McKnight, 2017; Singh-Peterson et al., 2015), reducing the need for outside assistance, which improves recovery time, decreases economic impacts, in turn develops further capability and resilience. This establishes the benefits of investment in, and the mobilisation of, community resources to create resilience in the local electricity network.

These benefits are predicated in community solidarity and burden-sharing, often reported in the aftermath of disasters, however demonstrations of entitlement, resentment and community fracture have also been observed (George, 2013). There are many reasons for these observations, however Aijazi (2015) suggests a contributing factor could be the inequity amongst the community as possible trigger. Perception of inequity can hamper sharing behaviours and drive a greater wedge between a fragile community. Sage et al., (2014) warn that the increased independence of some, through investment in decentralised infrastructure, could in fact disadvantage others when energy is not readily shared, thus exacerbating the divide between the 'haves and have nots'.

With the energy industry fostering a sharing economy that allows the exploitation of excess capacity generated and stored in residential SSPV and BESS, Su et al. (2018) is calling for research into householders' wiliness to share their resources. This is based on the premise that a *'collection of resilient individuals does not guarantee a resilient community'* (Norris et al., 2008, p. 128) and that individual participation is fundamental to community resilience. Yet it remains unclear if individuals would participate in the creation of community resilience.

Indeed, concerns have been raised that incentive regimes designed to facilitate the uptake of DERs and future pricing regimes can aggravate social inequity (Bell & Foster, 2017), which may promote an 'every man for himself' mentality, ultimately stifling sharing behaviours during times of need.

2.4.2. Hoarding resources in the aftermath of disasters

In a disaster, the notion of sharing resources so that everyone benefits seems only logical, particularly for CPRs. However, examples abound where in the lead up to and the aftermath of natural disasters, demonstrations of self-interest override sharing behaviours. Fuelled by media coverage of empty shelves, emotional responses to scarcity, can result in hoarding and stockpiling behaviours where consumers respond with excessive buy-ups of essential goods (Sterman & Dogan, 2015; Abe et al., 2014; Stiff et al., 1975). This emotion-fuelled hoarding behaviour creates stockpiles of resources beyond that which is needed to survive the event and often leads to widespread shortages. Created by those who were either, fast enough or had the financial means to undertake panic-buying, these shortages are often at the expense of those who were too slow or without financial means. Rarely is this sort of purchasing behaviour founded in basic need.

A similar paradox could arise with energy where individuals, encouraged to bolster their personal resilience and that have the means to invest in SSPV and BESS, may fail to connect these resources to the community network, preventing overall community resilience gains (Su et al., 2018). In the aftermath of a disaster, it is not unusual to find 'energy hoarders' secluded in their air-conditioned homes going about their daily lives, oblivious of their neighbours needs who are going without basic requirements such as refrigeration and lights.

However, if asked, rarely would people believe that *they* are hoarders. Sterman and Dogan, (2015) cite a cartoon from World War II depicting a customer about to purchase dozens of cans of food despite rationing, with the caption reading, *'I'm not hoarding, I'm just stocking up before the hoarders get here'*. These observations imply a fundamental discrepancy, where individuals fail to associate their own actions with hoarding behaviour and fail to acknowledge the ramifications of stockpiling to excess at the detriment of others. These observations could provide insight into determining individual sharing behaviour in times of scarcity and have implications for the success of SSPV and BESS as a resilience measure.

2.5. Intention-Behaviour Discrepancy

Traditional behavioural models, based on Ajzen and Fishbein's (1980) Theory of Reasoned Action, are founded on the premise that intentions will determine behaviour. Used extensively in academic and commercial research, stated intentions are easy-to-collect indicators of human behaviour (Sheeran & Webb, 2016). Whilst historically intentions have provided invaluable insight for researchers, more recently, inconsistencies have been identified between stated intensions and actual behaviour, drawing criticism towards these traditional models as oversimplifications of complex decision-making processes (Grimmer & Miles, 2016; Davies et al., 2002). Frank (2018) highlights that stated intentions are often based on ethical and altruistic motivations, yet despite these intentions, actions often fail to correspond (Carrington et al., 2014; Azjen et al., 2003). Residential energy use is one domain where this disconnection has been observed (Frederiks et al., 2015).

The intention-behaviour gap is thought to be created in the difference between, the altruistic intentions formed in the hypothetical world of the proposed scenario and the reality of where the habitual behaviour, triggered by experience and environmental factors occurs (Papies, 2017; Azjen et al., 2003). Understanding intention-behaviour gap is integral to identifying if the community would share their resources during a time of need, and if not, why their behaviour deviates from their stated intentions.

Beyond the technical challenges, the success of this model fundamentally relies upon the concepts of CPR. This requires a deep understanding of the sharing and conservation behaviours of the community. This understanding of basic behavioural responses, in the aftermath of disasters, is critical because the model is "*dependent on social co-operation and on the outcome of behaviour within the new configuration*" (Wolsink, 2012, p. 228).

3. Queensland Electricity Distribution Network Resilience

3.1. Queensland and its electricity distribution networks

Queensland is home to a population of almost five million residents, representing over 20% of the nation's population (Qld Treasury, 2019). The state economy, which exceeds $300 billion (Dept Premier & Cabinet, 2017), is vulnerable to the increasing effects of climate change and natural disasters.

Queensland's residences and business are powered by two state-owned DNSP's, Energex in south east Queensland, and Ergon Energy in regional Queensland. These two distribution networks supply some 2.3 million network customers across a geographical area greater than 1.7 million square kilometres (EQL, 2018). The distribution area reaches from Tweed Heads to the Torres Strait with some 60% of the state's population sprawled along a coastline that spans close to 7,000km (Australia's Guide, 2016).

Covering 97% of the state, Queensland's distribution networks comprise of over 1.7 million poles and 220,000km of powerlines, delivering 34,482GWh of electricity annually (EQL 2018). One of the largest in the world, around 40% of Ergon's distribution network is single wire earth return (SWER), measuring more than 64,000km (EE, 2018). This vast SWER network, supplying rural and remote regional Queensland, is characterised by sparse customer numbers dispersed across long distances of aging assets. Queensland's extensive distribution networks continue to age (Ergon & Energex, 2019), and operating in Queensland's harsh environments, presents a range of technical challenges for the network operators. Maintaining operational reliability and withstanding the forces of increasingly frequent and severe weather events, is a significant challenge in an atmosphere where network customers' reliability expectations continue to rise.

3.2. Electricity network in modern life – criticality and vulnerability

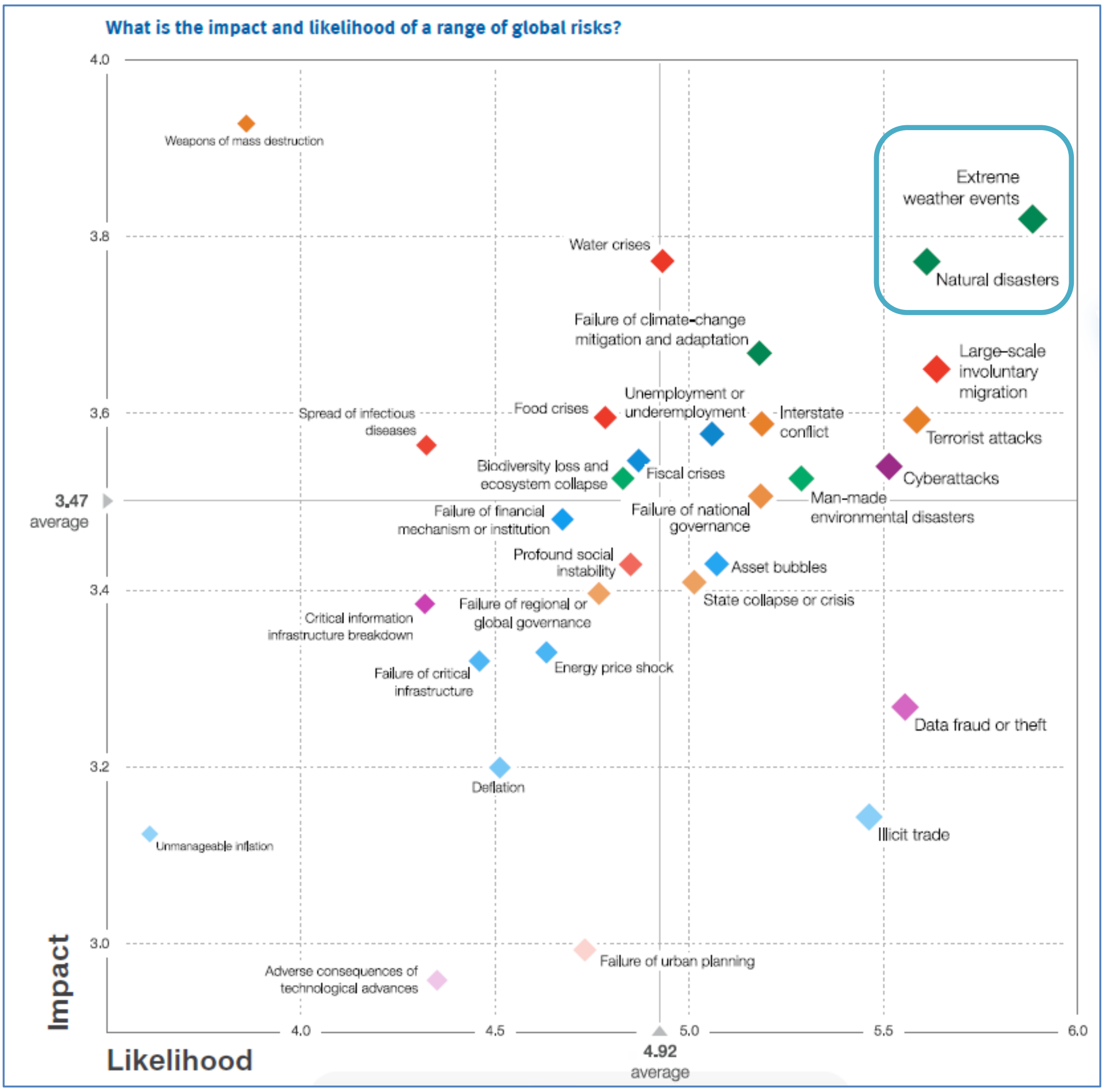
3.2.1. Electricity network as critical infrastructure

Electricity, considered by many as the lifeblood of our modern society, enables all aspects of our daily lives - at home, at work and recreationally at play. The infrastructure that enables this capability and energises the developed world's fundamental way of life, represents a significant investment, now and into our future.

The electricity network not only represents an important financial investment for Queensland taxpayers, it also holds significant societal value, supporting all our communities' essential services (Opkdyke et al., 2017). Queensland's distribution network supplies residential and business customers, as well as community groups and importantly, the operation of critical loads such as hospitals, public transport, petrol stations and sewerage and water pumping stations that allow these communities to function. Disruptions to electricity services can result in an inability to maintain our lifestyles and can result in significant economic loss, and as such, the electricity network is deemed critical infrastructure (Qld Govt, 2019a). Yet even with the community's significant dependence upon this critical commodity, electricity is largely taken for granted (Ghanem et al., 2016).

Further, the interconnected nature of electricity networks can leave this critical infrastructure vulnerable to '*multiple instantaneous component failures, affect a large number of customers, and require relatively complex restoration strategies*' (Bie et al., 2017, p. 1254), amplifying the subsequent social and economic consequences of natural disasters. QFES report that the risks with the highest probability and impact globally, are extreme weather events and natural disasters (QFES, 2017), both of which are prevalent in Queensland and to which the electricity network is highly susceptible – see Figure 3.

Figure 3 – The Global Risks Landscape 2017



Source: QFES. 2017. Queensland State Natural Hazard Risk Assessment 2017, p. 11.

The electricity network not only plays a critical role in a functioning society, its importance is amplified during times of natural disaster. The fundamental requirement for electricity supply to support response efforts during a disaster event further emphasises the criticality of a robust and resilient electricity network and the need to expedite timely supply restoration (Chen et al., 2016).

Our growing dependence upon electricity exacerbates the economic and social impacts when supply is unavailable, particularly for prolonged outages associated with disaster events (Kinn & Abbott, 2014). The priority for network operators in major events is therefore to restore supply to critical loads and minimise inconvenience and economic loss for communities (Wang et al., 2016). Our expanding populations and the community's increased reliance on electricity, results in the evolution of societal systems becoming increasingly interconnected, therefore rendering them more vulnerable to impacts such as natural disasters (Ahmadi et al., 2014).

3.2.2. Queensland's electricity network vulnerability

Colloquially dubbed 'The Sunshine State', Queensland regularly faces a barrage of extreme weather events, including tropical cyclones (TCs), severe storms, flooding and bushfires. QFES (2017) reported that to 2017, some 146 TCs (since 1967), and more than 3,500 severe weather events (since 1917), have wreaked havoc across Queensland. Each of these natural hazards caused significant damage and disruption to infrastructure, property, services and ultimately, the State's economy. Considered a relatively mild storm season, 2017/18 saw the formation of three TCs and several severe storms in Queensland. These systems impacted more than 500,000 customers for a total outage duration of 34 days, requiring the deployment of around 3,000 employees to support the electricity restoration efforts (EQL, 2018).

In 2017, severe TC Debbie is estimated to have resulted in an economic loss of production of around a $2 billion (QFES, 2017). TC Debbie's disaster zone spanned some 1,400km, resulting in the destruction of thousands of homes and businesses and sadly, the loss of two lives due to associated flooding in the south (Robertson, 2017). More than 1,000 field and support staff worked tirelessly for two weeks following TC Debbie to restore power supply to 270,000 affected customers across Queensland (Bailey, 2017a). The infrastructure damage bill was forecast to peak at $1 billion (IGEM, 2017).

More recently, North Queensland experienced a significant monsoon event causing record-breaking rain and flooding, which led to loss of property, livestock and loss of life. The cost of this event is yet to be calculated, but it is estimated that the Queensland state budget will take a $1.5 billion hit after the recent bushfires and flooding (Siganto, 2019) and have long-term social and economic impacts to the North Queensland region. Getting power back on after these events is critical to the long-term community recovery (EE, 2018 – DAPR).

As the end of April 2019 nears, Queensland has already been battered by five tropical cyclones and numerous topical lows, and severe thunder and dust storms, since the start of the 2018-19 storm season. Because of these types of events, the Queensland Government has activated a range of government assistance programs across several Local Government Authorities (LGAs) to help communities recover from the worst of these natural disasters – see Table 1.

Table 1 - Queensland Government Assistance Activation for LGAs 2018-2019

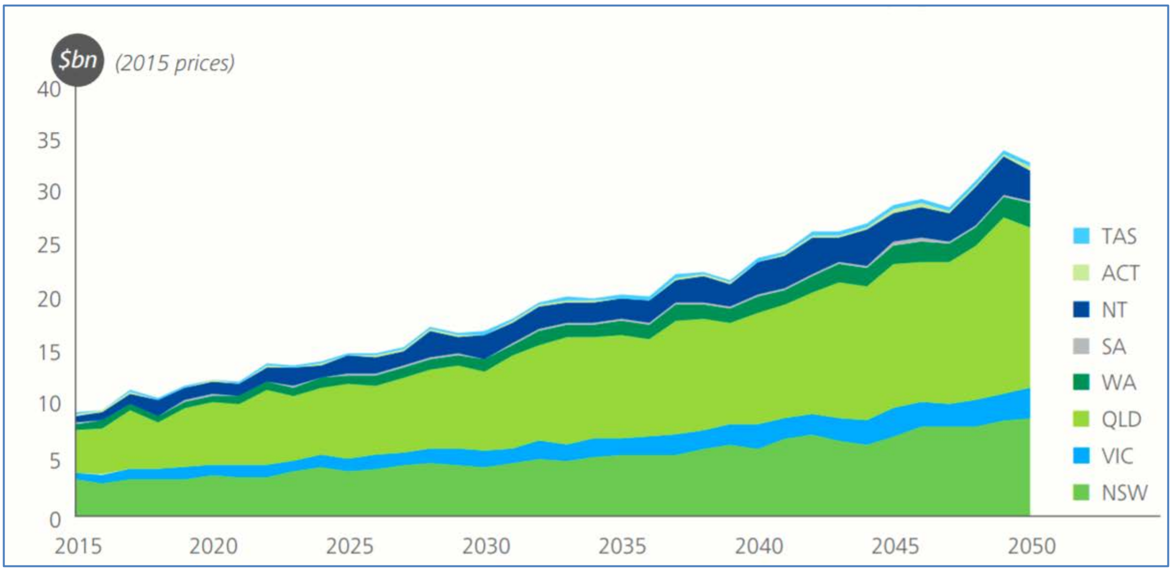
Queensland Government Assistance Activation for LGAs 2018-2019			
Event Name	Time	LGA's	Type of Assistance
Severe Tropical Cyclone Nora	March 2018	• Mareeba Shire • Ethridge	• Structural Assistance Grant • Essential Services Safety and Reconnection Scheme
Far North Queensland Flooding	March 2018	• Cassowary Coast Regional Council	• Structural Assistance Grant • Essential Services Safety and Reconnection Scheme
North Queensland Flooding	March 2018	• Hinchinbrook Regional Council	• Structural Assistance Grant • Essential Services Safety and Reconnection Scheme
Central Queensland Bushfires	December 2018	• Bundaberg Regional Council • Gladstone Regional Council • Isaac Regional Council • Livingstone Shire Council • Mackay Regional Council • Rockhampton Regional Council	• Essential Household Contents Grant • Structural Assistance Grant, and • Essential Services Safety and Reconnection Grant.
Monsoonal Trough	January-February 2019	• Burdekin Shire Council, North Queensland • Burke Shire Council, North West Queensland • Carpentaria Shire Council, North West Queensland • Charters Towers Regional Council, North Queensland • Cloncurry Shire Council, North West Queensland • Cook Shire Council, Far North Queensland • Douglas Shire Council, Far North Queensland • Flinders Shire Council, North West Queensland • Hinchinbrook Shire Council, North Queensland • McKinlay Shire Council, North West Queensland • Palm Island Aboriginal Shire Council, North Queensland • Richmond Shire Council, North West Queensland • Townsville City Council, North Queensland • Winton Shire Council (including Winton township), North West Queensland • Wujal Wujal Aboriginal Shire Council, Far North Queensland	• Essential Household Contents Grant • Structural Assistance Grant • Essential Services Safety and Reconnection Grant • Essential Services Hardship Assistance Grant.
Tropical Cyclone Trevor	March 2019	• Lockhart River Aboriginal Shire Council, Far North Queensland	• Emergency Hardship Assistance Grant • Essential Household Contents Grant

Source: Adapted from Qld Govt. 2019b. Queensland Disasters.

These recent examples illustrate the vulnerability facing Queensland communities. They serve as a vivid reminder that life and limb, as well as Queensland's $300 billion economy is at risk, and that in extreme cases, some communities simply do not fully recover from disasters (Rivera & Nickels, 2014). It is estimated that the national cost of natural disasters exceeded $9 billion in 2015 (Deloitte, 2016). Despairingly the human and financial costs resulting from these events is forecasted to escalate (QFES,

2017) - see Figure 4 - Forecast of Total Economic Cost of Natural Disasters 2015-2050 - with a combination of increased frequency of events, aging energy infrastructure and the increased impacts of climate change at the heart of this vulnerability (Bie et al., 2017; Linnenluecke & McKnight, 2015).

Figure 4 - Forecast of Total Economic Cost of Natural Disasters 2015-2050



Source: Deloitte cited in QFES. 2017. Queensland State Natural Hazard Risk Assessment 2017, p. 13.

3.3. Electricity distribution network resilience

Bie et al., (2017) and Ahmadi et al. (2014), suggest that around 90% of power outages originate at the distribution network level, with a significant proportion due to natural weather events. The electricity network is considered a critical enabler of basic society functions, economic development and prosperity, and a substantial, essential financial community investment (Opdyke et al., 2017). As a critical infrastructure, network operators, planners, policymakers and scholars call for the establishment of greater resilience in electricity networks.

The community views reliable power as a fundamental right, and a responsibility of the government of the day and the electricity utilities, to ensure supply (Economic Times, 2018; Burger & Gochfeld, 2014). The community has high expectations that following catastrophic natural disaster events, that power supply will be restored quickly, further emphasising the importance of resilience around this infrastructure.

Resilience of critical infrastructure such as electricity distribution networks is a fundamental component of community resilience. Traditional approaches for network resilience have focussed on technological solutions such as network hardening (Eisenberg, Park & Seager, 2017) which are costly and may not provide effective resilience given the scale of the networks in Queensland. In the past, traditional restoration practices have led to unintentional biases, with the prioritisation of restoration given to areas close to priority assets such as critical infrastructure and high volumes of downstream customers (Lievanous & Horne, 2017). Whilst this seems a logical approach to restoration, this method can further exacerbate the impacts on small, remote and disadvantaged communities, with less resources available to support their resilience, further compounding the difficulties they face in their recovery processes.

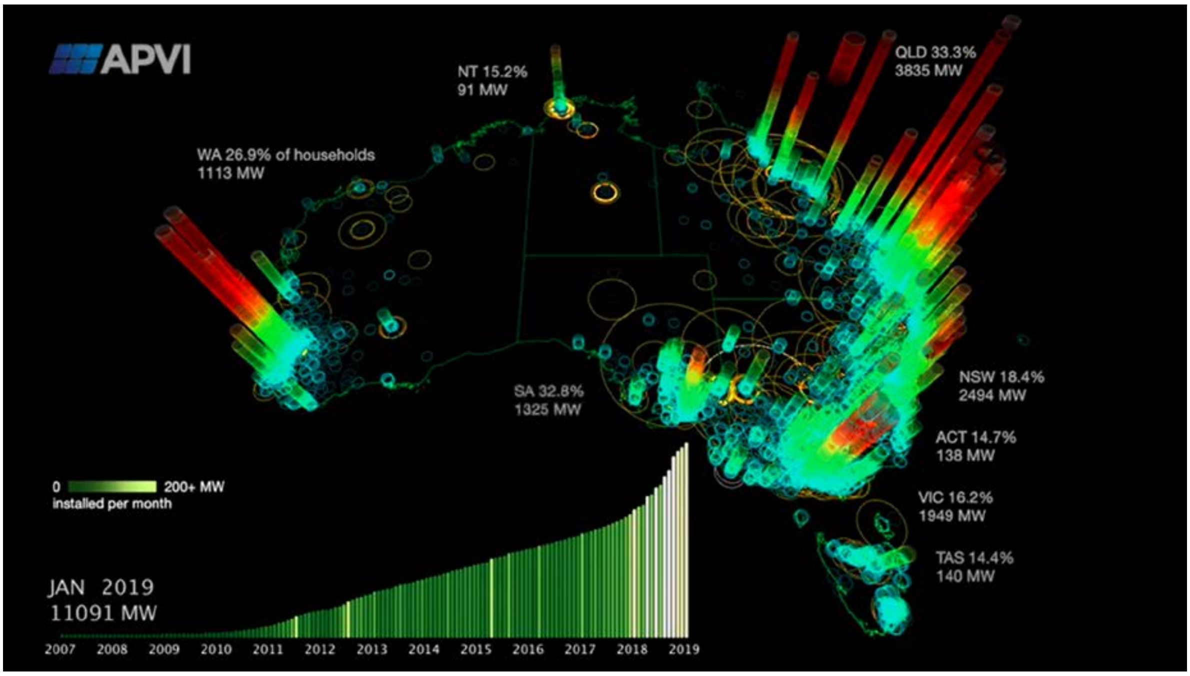
The extensive temporal and spatial scale of natural disasters in Queensland, coupled with the vast scale of the distribution network, are critical components in the community's response and recovery, and can exacerbate the effects the disaster can have, particularly on regional communities (Morley et al., 2018). These spatial and temporal scale effects, coupled with extended durations of outages, has led to investigations into alternate resilience and restoration options. The evolution of energy technology has prompted investigation into SSPV and BESS configured into microgrids as a primary area of research and more recently the conduct of practical trials.

3.4. Community microgrids as a network resilience solution

3.4.1. Emergence of solar and battery technology as a resilience solution

Considered a world leader, Australia's installed capacity of solar PV per inhabitant is the highest in the world (OECD, 2019). The Australian PV Institute (APVI, 2019a) highlight the unprecedented uptake of solar PV nationally, from a level of 28MW in 2007, to a startling 11,091MW in January 2019, with a third of these solar PV resources - 3,835MW - installed in Queensland – see Figure 5 5. Solar capacity in Queensland continues at record rates with more solar being installed in 2018 than the previous 5 years combined (Petkovic, 2018). In recent years, much of the installed capacity was large scale solar, with residential installations peaking in 2012, following the removal of the government's 44-cent feed-in-tariff and small-scale technology certificates (Petkovic, 2018). Although the installation rate at the residential level has dropped, almost one third of Queensland households have installed SSPV, representing one of the highest per-capita rates in the world (Agnew et al., 2018).

Figure 5 - Australian PV Installations 2007-Jan 2019



APVI 2019b. Australian PV Installations 2007-Present. http://pv-map.apvi.org.au/analyses

Whilst system sizes are growing exponentially, historically much of the investment in PV has been at the residential level in response to rising electricity prices and buoyed by attractive government incentives (Qld Govt. 2018). In a powerful demonstration of customer-led technology acceptance, the rapid uptake of SSPV demonstrates a willingness of Australian households to invest in distributed energy resources (DERs). Whilst the willingness of residences to invest is clear, it is also apparent that the driver of this rapid uptake is based in rising electricity prices, rather than in an investment in personal resilience. Agnew and Dargusch (2017) found a similar trend in respondent reasoning for the primary motivation of BESS installation. Savings on electricity bills, reducing dependence on electricity utilities, increasing self-sufficiency and safety were all prominent concerns, yet energy back-up during outages, was surprisingly deemed less important.

Price was a factor Queenslanders' identified in the Queensland Household Energy Survey (QHES), conducted by Colmar Brunton on behalf of Powerlink, Ergon Energy and Energex (2019). The QHES highlights that Queensland's SSPV uptake has been constrained by the high penetration of rental properties where the buying decision is in the landlord's control (Colmar Brunton, 2018). With around 34% of Queensland's household tenure being rentals (ABS, 2016), this represents a significant pool of future market potential, and a significant gap in the feasibility of attaining the critical mass required for a viable network resilience solution. In a bid to entice landlords into installing SSPV on their rental properties, the Queensland Government is conducting a 'Solar for rentals trial' across regional Queensland offering attractive rebates (Qld Govt, 2019c).

Whilst the explosion of SSPV has been unprecedented, the take-up rate of battery storage technology currently falls significantly short of the critical mass required to develop microgrids, let alone have the capacity to provide network resilience. Although penetration has been slow, adoption of batteries appears to be at the cusp of penetrating the mass market (Agnew & Dargusch, 2017), set to follow in the path of SSPV adoption. Many researchers agree, citing the market for small residential BESS is poised to explode, signifying the emergence of prosumers, a turning point in the characteristics of the network and the discussion of the application of microgrids in the network (Shaw-Williams et al., 2018; Walton, 2015). Australia's residential storage market is forecast to triple in 2019 with around 70,000 households expected to install BESS, the uptake driven by government-funded low interest loans and subsides (BNEF, 2019). The latest QHES shows however that the cost of BESS falls somewhat short of widespread uptake (Colmar Brunton, 2018).

Yet, the emergence of these new technologies is driving a fundamental and rapid change which is creating opportunities at an unprecedented rate. The introduction of DERs are proving a valuable alternative to traditional centralised generation (Yamagata et al., 2016), with the flexibility derived from microgrids, increasingly cited by researchers as a viable network resilience option (Agnew et al., 2018; Zhou et al., 2018; Shang, 2017; Jongerden et al., 2016; Okafor, 2010). Whilst much of the research is focussed on grid-scale solutions, residential solar and storage are fast becoming an area of interest.

3.4.2. Joining forces – SSPV and BESS microgrids

Residential SSPV and BESS connected to the network can together provide greater reliability than each separate system alone (Montoya et al., 2013). Panteli et al. (2017), tout microgrids as one of the greatest means of enhancing the resilience of the power supply against a catastrophic event. According to Wang et al., (2016), microgrids can contribute to restoration in three ways, by serving as an extra resource aiding conventional load restoration; operating in grid-connected mode to provide ancillary services; and, operating in islanded-mode to serve critical loads at the community level.

Local generation, storage and control of energy, reduces the reliance on upstream transmission, sub-transmission and distribution assets, which are vulnerable in disasters. SSPV and BESS present higher value when coordinated at community level (Zhou et al., 2018), increasing community energy independence, allowing high priority loads to be bolstered during power outages (Jongerden et al., 2016). Localised distribution of microgrids can enhance network resilience allowing the DNSP to restore damaged network from the bottom-up distribution level, at the same time as the sub-transmission top-down restoration is underway, thus fast-tracking resupply to localised critical infrastructure and therefore speeding up community recovery. The spatial distribution of microgrids could provide localised resilience, with variable damage patterns unlikely to affect all microgrids, if damaged sections of the network are isolated (Wang et al., 2016).

Although microgrids provide many opportunities, they are unlikely to be without their challenges. Acceptance of microgrid technology deployment across the community is doubtful to be different from other infrastructure deployment. Community concerns regarding location, visual amenity, heat rejection, noise and the like, could be divisive issues (Montoya et al., 2013). These concerns can spark a 'not in my backyard' response, or alternatively create competition and a, 'I paid for the system, why should I share it?" response by owners unwilling to share the benefits of their financial outlay.

Without operational microgrids the benefits and challenges are difficult to quantify. Yet we can remain optimistic with findings from a mini-grid trial conducted by AusNet (2018) seeing increased support for DER and an interest in 'sharing power' as a concept. However, trials often focus on deriving benefits for the network and nowadays, customers expect to also benefit. Mutual benefits can be realised (Agnew et al., 2018). Participation in microgrid communities can bring broader paybacks such as a shared experience between neighbours (Matthews, 2016), and a sense of connectedness, suggesting a level of social capital is derived through the participation.

3.4.3. Energy conservation behaviours of SSPV owners

Another factor in the debate of microgrids for network resilience relates to the availability of enough stored energy capacity to share. Beyond cost drivers, it appears that residences are taking little or no action to reduce energy consumption. Worse, a correlation has been observed between high energy consumption and socio-demographic variables such as income (Abrahamse & Steg, 2011). Higher income householders have the means to install SSPV and BESS to offset their energy costs, but also use more appliances and devices, resulting in increased energy use. For a microgrid resilience solution to be viable, residents would not only need to share their energy resources but must also adopt energy conservation behaviours in the aftermath of a disaster.

The likelihood of this conservation behaviour is under question. A range of studies have instead identified a phenomenon described as the 'rebound effect'. The rebound effect identifies circumstances where energy services designed to be more cost effective for consumers, led to greater energy consumption (Chitnis & Sorrell, 2015; Giddings & Park, 2012). These effects are being observed with Sekitou et al. (2018), finding that the installation of a SSPV did not drive household behaviour to conserve energy, but rather identified that some residences increased their energy consumption. Supporting these findings, Deng and Newton (2017), who explored the rebound effect associated with SSPV households, found that households with SSPV had higher levels of electricity consumption relative to those without SSPV. Further evidence of this phenomenon was identified by Havas et al. (2015) citing a 15% rebound effect by adopters of SSPV systems in Central Australia. They highlighted that the adoption of SSPV can actually '*confound consumer behaviour, such as when a rebound effect occurs as households increase electricity usage due to the electricity savings made from adopting renewable energy technologies—which have been promoted to reduce household electricity consumption*' (Deng & Newton, 2017, p.315).

Attitudinal studies in the theory of planned behaviour (TPB) are founded in the assumption that people are typically motivated by self-interest with intentions towards energy conservation depending on an assessment of the perceived costs and benefits, often resulting in higher energy consumption to accommodate comfort and convenience (Abrahamse & Steg, 2011). This begs the question, would individual households indeed be willing to share their energy resources for the collective good, or would they put self-interests above those of the community? For the shared model to work, the community will have to sacrifice some individual benefits for the collective good, both conserving and sharing their stored energy so that the excess can be redirected and diverted to supply basic services for critical loads.

3.5. Network resilience - beyond technical solutions

Network hardening, redundancy, automation and other smart technological solutions remain the primary focus of international efforts to improve network resilience (Panteli & Mancarella, 2015). Panteli et al., (2017) highlight that network hardening and operational enhancement strategies can defend against extreme events, improving resilience. Eisenberg et al. (2017) argues however, that this narrow focus produces an overemphasis on technical solutions and jeopardises critical infrastructure resilience at the expense of decision-making and an appreciation of the social context.

These concerns are shared by Wolsink (2012) who emphasises the highly institutionalised nature of the energy system, and more broadly, the tendency for technical studies to adopt speculative assumptions and totally neglect social factors, suggesting that "*almost no social scientific knowledge is applied in the development of smart grids*" (Wolsink, 2012. p. 224). These foundational social connections across the community are fundamental to securing cohesion and synergy between schemes (Walker et al., 2010). Yet establishing these connections and synergies can be challenging.

Yamagata et al., (2016) asserts to the complexity of designing effective local sharing communities and highlights that the mechanisms to incorporate self-sufficiency, stability and determining sharing price schemes, remains unclear. Exacerbating these design challenges is the uncertainty associated with disasters' magnitude, location and timing, coupled with the heterogeneous behavioural patterns of the community.

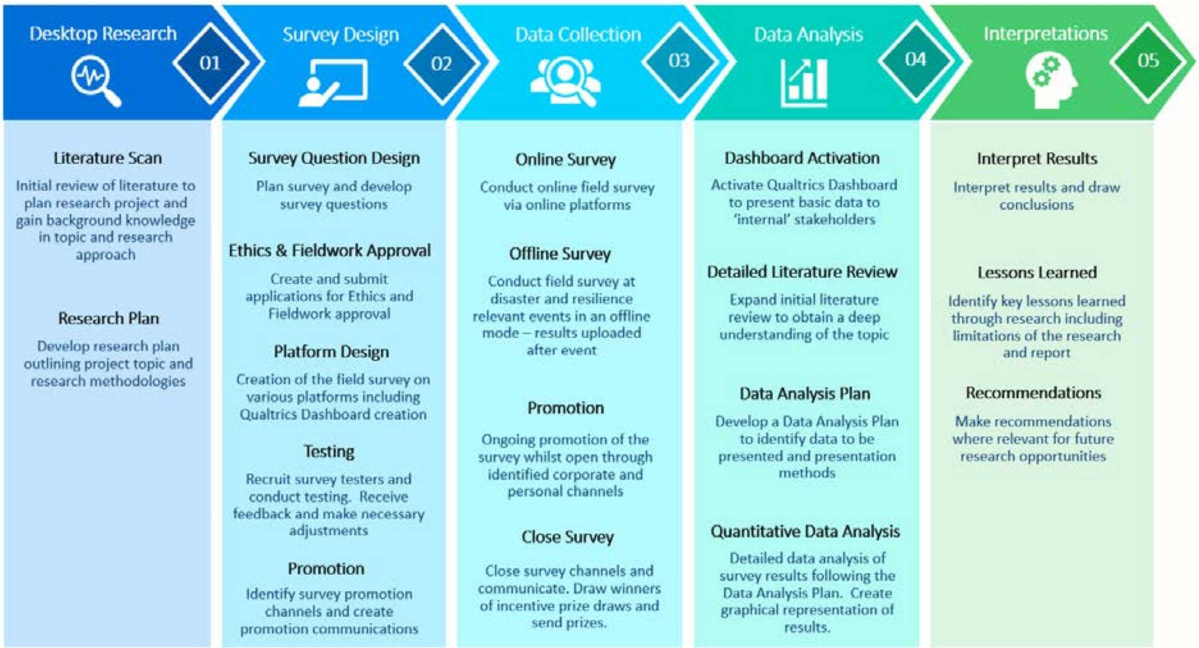
Resiliency and survivability are factors believed to be missing from much of the work undertaken on the network transition to smart grids and the focus is generally on the technical function of the network, rather than end users (Jongerden et al., 2016). Describing the numerous layers of technical hardware and software required to establish a system capable of providing resilience against extended power outages, Jongerden et al. (2016) emphasises the delicate balance required between demand, production, capacity and the state of charge of storage systems to achieve what they call the survivability-probability. Beyond the technical challenges, consumption in the aftermath continues to draw interest. Jongerden et al. (2016) investigate the effects of consumption and posit that outage survivability could be improved by networks utilising control mechanisms, regulating non-critical loads to override excessive consumption during major outages.

There is strong support for the notion that community resources can be leveraged to improve network resilience. Predicated on this idea, this research investigates the community's willingness to contribute to network resilience, to determine the practicality of electricity distributors utilising SSPV and BESS to improve network resilience based on the community's wiliness to share these resources.

4. Research methodology

A semi-structured qualitative research survey was developed to solicit Queenslander's views on network resilience, helping the community and willingness to share stored household energy resources, in the aftermath of a disaster event. The approach taken to design and conduct this research was developed in 5 stages. These stages are outlined in Figure 6 and are covered in more detail in the remainder of this chapter.

Figure 6 – Flowchart of Research Methodology



4.1. Survey design and testing

4.1.1. Survey Questionnaire Design

Empirical quantitative research techniques were employed to determine if SSPV and BESS might practically support network resilience. Quantitative research techniques, in the form of a survey questionnaire, were adopted to facilitate the collection and comparison of large, random samples of data through statistical aggregation (Yilmaz, 2013). Described by the International Institute of Business Analysis as an effective *'means of eliciting information from many people, anonymously, in a relatively short time* (IIBA, 2006, p. 177), surveys facilitate large-scale assessments, efficiently collecting volumes of information across large populations and producing generalisable findings (Sauermann & Roach, 2013; Ryan et al., 2012). Antoun et al. (2017) highlights the ability of surveys to reach a growing number of participants by adopting technologies such as the internet and smartphone devices. Some researchers however raise concerns about online survey response rates and quality (Fan & Yan, 2010; Fricker & Schonlau, 2002; Couper, 2000).

Even so, the time efficiency, simplicity of data collection and cost effectiveness of web-based surveying, can't be overlooked. These characteristics, as well as the time and cost savings associated with printing, postage and subsequent electronic capture of results of traditionally mailed surveys, reinforced the decision to use an online survey questionnaire for this research project. A web-based survey mechanism facilitated the quick, consistent and efficient collection of responses from across Queensland's vast geographically diverse population.

Iarossi (2006) highlights the importance of survey design to both the researcher and respondents, warning that design considerations such as question style and survey length can influence completion rates and impact data accuracy. Literature on web survey design and development abounds, generally highlighting two major factors influencing questionnaire response rate, the content and presentation (Fan & Yan, 2010). With these factors in mind, questionnaire design was based on the design principles outlined by Deutschlander (2009). A key consideration in the survey design was striking a balance between survey completion time and soliciting enough quality information to achieve the research objectives. Therefore, the aim of the survey design approach was to create a survey that would maximise the rate of valid responses. To achieve this balance, a range of question styles was adopted in the design of the survey content, and consideration was given to how the survey was presented and distributed.

Closed-ended questions dominate the survey design as they are considered easy for respondents to answer, simplifies analysis and allows more questions to be asked, whilst balancing the completion time (Deutschlander, 2009). Basic demographic information was sought using single-response open (postcode) and closed (state of residence) questions. As well, a couple of dichotomous closed-ended questions were used to drive respondents towards one of two options. The dichotomous questions were to establish: respondents experience of an extended power outage following a cyclone or storm; and if they supported mandating sharing of stored energy in disaster events.

The universally adopted psychometric Likert scale was used on several questions in the survey to determine respondents' level of agreement or disagreement to the statements presented. Likert scales are easy to understand, are not time consuming and allows respondents to select from a range of extremes (Deutschlander, 2009). An 11-point Likert scale was used to determine respondent values and attitudes. These scales measured values such as the importance respondents placed on helping others, with the extremes anchored in 0 = not at all important, and 10 = extremely important; and for the measurement of likelihood to purchase an integrated solar and battery system with the scale extremes being 0 = not at all likely and 10 = extremely likely. The choice of an 11-point scale was founded in the need to align the scale to EQL's standard surveying format to allow comparison of results with EQL's existing and future research findings.

Most questions used closed-ended question style. This design allowed respondents to select one or more from the predetermined list, making them simple to answer and facilitate simple analysis of results. This design also allowed follow-up questions to be asked of respondents based on the answer provided in the previous question. This facilitated establishing a deeper understanding based on previous responses. The design effectively determined the number of questions presented and time it would take to complete, based on the answers provided by responses, removing unnecessary questions where there were not relevant to the respondent's answers.

Some questions offered respondents a long list of options from which to choose, presenting the potential for 'order effect' response bias. Responses to closed-ended questions can be influenced by 'order effect' where the order in which options are presented, drives a primary (selecting from the top) or recency (selecting the most recent) effect, biasing responses (Lavrakas, 2008). To avoid the tendency of respondents selecting from the top or bottom, longer lists of options were designed to present in a randomised order, thus ensuring the that the order presented did not bias results.

Free-text comment boxes were provided in the survey, allowing supplementary information to be provided by respondents. Although challenging to analyse, free-text comment boxes can assist in establishing response context and unearth issues or concepts not distinguishable through purely quantitative surveys (Rich et al., 2013).

Two final design features were adopted, the first was the introduction of qualifying filter questions, and the second was prompting for incomplete data. Often referred to as 'qualifiers' these questions are built into the design of the survey to identify those who do not fit the specified criteria for survey completion. This research was only interested in respondents based in Queensland, over the age of 18. Therefore, two qualifying questions were included in the design to identify those respondents who did not meet these criteria. The qualifiers were built into the beginning of the survey, to prevent a poor user experience which might be created if a respondent had completed a range of questions to then be disqualified. The next design feature ensured that respondents received prompts if questions were missed or insufficient data was provided before attempting to move onto the next question. The electronic format of the survey facilitated these design features and helped to ensure only complete sets of data within the parameters were returned.

4.1.2. Survey Platform Design

The electronic survey design was adopted to simplify the state-wide distribution of the survey. The electronic platform allowed the survey to be web-based, facilitating both online and offline access to the survey. Utilising an electronic survey platform also assisted respondents being able to share the survey across their own networks, increasing the chances of a higher response rate.

Antoun et al. (2018), raised concerns regarding the inadequacies of single platform designed questionnaires. Fan and Yan ((2010) warn that single browser survey software can have adverse effects on response rates and promote the use of survey software that accommodates a range of browsers. To overcome these concerns and provide users with a range of options, a multi-platform survey design was created using the Qualtrics online survey tool. The Qualtrics online survey tool is favoured by EQL for its centralised collection of data; electronic dashboard to present basic survey results; security based, multi-user access allowing multiple approved users to view the data; and being cloud-based, allows upload of data in both online and offline modes. Because of the human participation of this research, once the survey questions were agreed upon, they were submitted to the Murdoch University Ethics Committee for ethical approval. The survey questions were loaded up into the Qualtrics software.

Qualtrics is compatible with a range of technologies including personal computers (PC's) and a variety of mobile devices including iPhones, android devices and iPads. Multiple platform design options ensured a positive user experience irrespective to the technology being used, which in turn, aimed to improve data accuracy and higher survey completion rates. The feature allowing an offline mode - whereby the survey can be completed offline and later the survey results can be uploaded to the online cloud environment -

made the survey able to be completed offline at events. Several EQL corporate iPads were loaded with the software and used at field day events.

4.1.3. Survey testing

The aim of survey pretesting is to detect and remediate problems that may have manifested in the initial survey design and to facilitate a positive user experience, with the view that it will result in higher return rates and improved data quality. Willis (2016) highlights the importance of usability testing for online surveys, which unlike interviews, focuses strongly on the visual element, simulating the user experience to identify usability issues. This form of user testing allows inadequate elements of the survey to be modified prior to survey deployment, ultimately improving the user experience and quality of data returned.

Testing also assists in the identification and rectification of simple typos as well as more complex technical and design issues. Complex compatibility issues associated with deploying the survey across multiple platforms, the effects of unreliable connections, slow modem speeds and varying degrees of computer literacy (Nair & Adams, 2009) can all be identified and resolved with survey testing.

The questionnaire was tested on the full range of platforms that would host it, including online PC's – using both corporate network and at home internet connections – on various smartphones, as well as online and offline on iPads and tablets. Up to twenty colleges, family and friends tested the survey in different locations on different devices. This broad form of platform testing provided confidence there were no technical issues and solicited feedback reporting a positive user experience regardless of the platform that hosted the survey.

The primary improvement opportunity identified through the survey pretesting was the revelation that where large lists of options were presented, there was a strong propensity for selecting the options at the top of the list. This feedback led to a design change in the presentation of the survey which randomised the list each time the survey was opened, thus removing the potential for order effect.

Testing also confirmed that the survey would take approximately 10 mins to complete if all the questions were presented to a participant.

4.2. Survey promotion

Research has identified that an absence of engagement has been positively associated with low survey response rates (Nair & Adams, 2009). Higher response rates to online surveys were observed where email invitations were sent to online communities (Petrovcic et al., 2016). This prompted the development of a comprehensive promotion plan for the research survey. The promotion plan included the identification of target groups; the identification of the range of channels through which the survey would be promoted and the corresponding design of copy for 'invitations' for each of these channels, as well as the design of a competition to incentivise survey completion. The promotion plan and its associated activities were designed to draw attention to the survey, entice people to access the survey and ultimately submit a completed survey.

4.2.1. Survey promotion – target groups

Several factors can influence survey response rates. Survey communications and promotion targeting potential respondents is a method to counter these influences. One factor influencing response rates is representativeness, where targeting characteristics, such as demographics like age or location, can result in poor responses (Paraschiv, 2013). The aim of the survey design was to obtain a representation of respondents from across the state, from different locations, age groups and socio-economic backgrounds. Whilst some research does warrant targeting sample groups with specific characteristics, the aim of this survey was to obtain a respondent group representative of the entire population of Queensland, so no direct targeting based on characteristics was conducted. Instead, an approach combining targeting existing contacts and a generalised, broad promotion of the campaign was adopted. With this approach determined, the promotion plan was created.

The first step involved identifying existing channels through which the survey could be promoted. EQL had a range of existing online and physical communities identified as logical groups to send the research survey. These groups included followers of Ergon Energy and Energex's Facebook pages, as well as subscribers of EQL's Talking Energy forum. Personal Facebook and LinkedIn profiles were also identified, from which the followers could be targeted and asked to share the survey more broadly across their own online networks.

The Queensland Government created the Queensland Battery Register (register) in 2016 to capture details relating to all BESS installed across Queensland. The DNSPs manage this register on behalf of the Queensland Government. An application was made to the custodian of the register for permission to target registered owners with an invitation to complete the survey. This cohort was important because they have already purchased and installed the technology which is the focus of the research.

The legal and ethical appropriateness of targeting registered owners were considered. EQL's legal department confirmed that targeting registered owners did not breach confidentiality or contractual requirements. The ability to readily access respondents electronically, whilst convenient, can lead to an increased risk that overcontact may result in a decreased desire to participate (Keusch, 2012). So, in addition to confirming contractual arrangements, EQLs customer and marketing departments confirmed that this group were not being saturated with communications and therefore should be responsive to the research request. The register custodian sent an email invitation to registered owners to avoid privacy concerns.

EQL staff were also targeted via internal communications channels. This decision was not taken lightly, with the potential for bias being introduced, discussed at length before including this cohort. Given EQL's regional geographic distribution of staff and that staff are customers of the DNSPs it was agreed that they were an important group to target and no more likely to bias results any more than another group. Staff were also encouraged to share the survey, with their families and across their business and social networks, helping to further promote the survey across a broader section of the community. Staff were excluded from the incentive prize draws.

To expand the geographic and demographic profile of respondents and to encompass a broader spectrum of the community, several Queensland Facebook Communities were targeted – see Appendix 4. This helped to promote the survey across several metropolitan and regional areas that may not have otherwise been accessible. Additionally, opportunities for direct contact with business stakeholders and the community at a range of disaster preparation and resilience events was also adopted, further expanding the reach and target audience.

4.2.2. Survey promotion – incentives

There is historical evidence that monetary incentives may result in improved return rates in online studies (Hall et al., 2019). Incentivising completion of the survey by offering prizes was designed to increase awareness of the research and translate into a positive take-up and completion rate of the survey.

EQL offered a competition to win one of six $50 Visa gift cards as an incentive for respondents to complete the survey. Terms and conditions for the competition were published and made available for all respondents to access, both for online and offline completion – see Appendix 3. EQL staff and direct family members were excluded from all prize draws. Prize winners were drawn at random from the list of completed surveys. A random number generator (Hedges, 2008) was used to select the winners. In addition, three portable battery power packs were available at each of the emergency services field days. This encouraged visitors to the field days to complete the survey for the additional chance of winning a power pack. These incentives aligned the resilience focus of the events and the survey. Winners of the event-based incentives were still eligible for the Visa card draw.

4.2.3. Survey promotion – promotion mechanisms

Internet based surveys are reported to suffer from an 11% lower response rate than other forms of surveying (Manfreda et al., 2008). To overcome this challenge, Paraschiv (2013) recommends the use of personalised invitations, reminders and appropriate timing of survey communications. These factors were incorporated into the design of the survey communication and promotion. The approach required tailoring the plan to achieve a balance between, broadcasting the survey widely to potentially increase the response rate, and not oversaturating any single channel or stakeholder group. To achieve this balance, communication and promotion of the survey utilised both targeted contact with stakeholder groups where a relationship preexisted, and a general broad promotion approach for the wider community.

The plan to tailor communications and promotions included a series of communications from the introduction of the survey, as well as throughout the survey lifetime to reignite interest, and at the closure of the survey to thank participants for their interest and notify of competition winners – see Appendix 4. Invitations to participate were offered using email and social media platforms, allowing respondents to ‘opt in’ to complete the survey. Accompanying the invitation was a covering letter, providing background into the research and thus offering legitimacy to the research - see Appendix 2.

These communications and promotions were distributed via a range of EQL business channels including EQL's Talking Energy network, Ergon Energy and Energex's Facebook sites, the Queensland Battery Register. As well, personal channels were utilised to target personal networks of family, friends, colleagues and business associates. This included direct emailing, personal Facebook posts and LinkedIn posts. Personal and business networks were leveraged to further promote the survey across respondents' own business and personal networks. These networks proved valuable in 'on-sharing' the survey beyond the author's pre-existing networks. Facebook also provided a channel to tap into established community groups. Targeting these groups assisted in raising awareness of the survey by broadening the reach into metropolitan, regional and remote communities where existing relationships may not be established.

A range of resilience related events, attended by the DNSPs, were also targeted as channels to promote the research survey and solicit respondents. These events included various community 'Get Ready' emergency services days, such as Cyclone Sunday in Townsville and the Lockyer Valley Emergency Services Day, as well as Council Safety Days. Respondents who completed the survey at these events were offered an additional incentive. Promotional signage was developed to help draw attention to the survey and the prizes on offer. As well, the survey was promoted at a Sustainability Forum held by Townsville City Council. Attendees at the Sustainability Forum were sent an invitation to complete the survey and share amongst their respective networks - see Appendix 4.

4.3. Data collection methods

The Qualtrics survey software facilitated the efficient collection of data. Data collection was conducted across the seven weeks that the survey remained open. Online responses were automatically collated in the Qualtrics tool upon completion of the survey and the upload of offline responses were manually triggered for collation into Qualtrics.

This gradual collation of data allowed ongoing monitoring of the successful loading of data and offered the opportunity for early identification of any systemic issues, none of which were identified. The data collated by the software can be viewed, both within the Qualtrics software and presented in a dashboard or, exported into Excel for further analysis.

4.4. Data Analysis and Reporting Design

Analysis of data enables conclusions to be drawn from survey data. To facilitate effective analysis and subsequent reporting, a Research Analysis Plan was developed, based on Irwin and Stafford (2016) – see Appendix 5. The Research Analysis Plan assisted the analysis design by mapping the survey questions to the topics of interest and outlining potential analysis techniques and subsequent presentation of results. The Research Analysis Plan helped to inform the best means for communicating the research results to stakeholders. The Research Analysis Plan assisted in the identification of connections between individual data sets and broader concepts or trends that may emerge through the comparison of data.

The Qualtrics software offers a dashboard view of basic summary statistics such as frequencies and means. The Qualtrics dashboard was used to quickly summate the survey results for EQL internal stakeholders who may hold an interest in the research. Some areas of interest, unique to the DNSP's, might include the difference in results across network areas or brands, which might indicate potential trends in metropolitan verses regional areas. The dashboard also facilitated the comparison of results with other research historically undertaken by the organisation.

A complete set of raw survey data was extracted from the Qualtrics survey software into a Microsoft Excel spreadsheet for deeper analysis. The data spreadsheet allowed additional statistical analysis to be conducted based on the analysis plan.

5. Research results and discussion

Beginning with establishing the validity of the survey, this section identifies the benefits that electricity brings in the aftermath of a disaster, in the eyes of respondents. Adoption rates of SSPV and BESS are investigated, along with the barriers Queenslanders' face, in their pursuit to introduce SSPV and BESS into their homes. Respondent views on helping the community, sharing energy resources and conservation behaviours are then analysed, with an understanding of incentives and conditions required to encourage sharing further investigated. These areas are analysed and presented with a Qualtrics dashboard summary of results provided in Appendix 6 and greater detail explored, and insights presented in this section.

5.1. Survey Response Validity and Respondent Demographics

5.1.1. Level of response and validity

The Future of Energy Technology and Community Resilience Survey was open for seven (7) weeks duration, from 22nd October to 9th December 2018. Researchers have hypothesised that high response rates give surveys credibility, suggesting low response rates create biases (Lesley, 1972). A total of 530 surveys were returned following the seven-week survey period, consisting of 483 complete and 47 incomplete questionnaires - see Appendix 6. Incomplete and non-qualifying (<18 an non-Queensland residents) responses were excluded from the data set for analysis. Of the complete surveys, most were taken online, with 404 surveys conducted online and the remaining 79 completed at events in an offline mode.

In 2017, the population of Queensland was approximately 4,111,081 (Queensland Treasury, 2018). Although only 483 completed surveys were returned, representing only 0.01% of Queensland's population, literature has established that '*a representative sample build on less than 1% of the population can generate more accurate results than a sample with a higher coverage of the national population' (Cook et al., 2000, p.821).* To determine if the research sample could be considered representative of the population of Queensland, the confidence interval or margin of error was calculated using the following formula:

$$\text{Margin of error} = z \times \frac{\sigma}{\sqrt{n}}$$

n = sample size   σ = population standard deviation   z = z-score

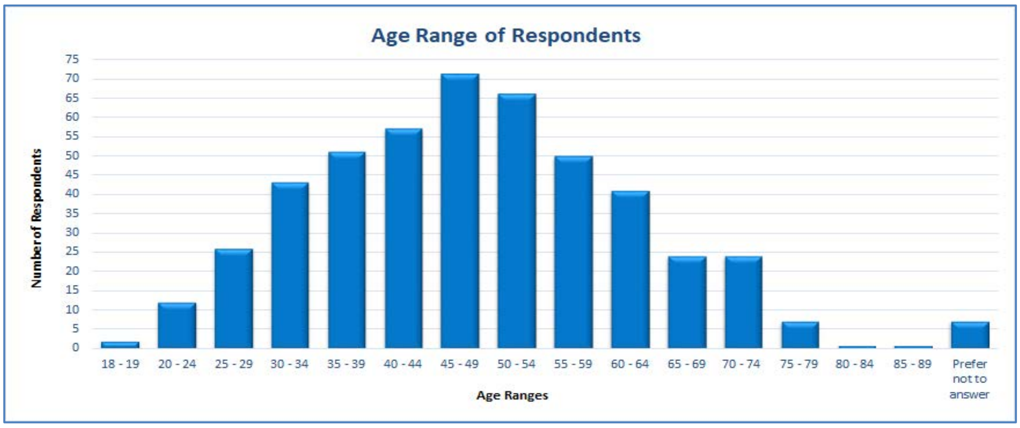
Adopting a 95% confidence level, the margin of error is 4.46% and with a 99% confidence level the margin of error is 5.86%. Although a larger sample size would have been preferable, the returned sample size of 483, is deemed enough to draw generalized conclusions for the purpose of this research.

5.1.2. Respondent demographics

Personal characteristics have a role to play in social sciences as they can have an influence on survey results. Demographics such as age can affect respondent cooperation or the degree in which participants might engage in the survey (Glaser, 2012). This can influence areas such as return rates of surveys, where older participants may be unable to or unwilling to engage in online surveys due to access to a computer or computer literacy. It may also influence respondent attitudes based on their areas of interest in the subject, or their maturity and experience. Understanding the demographics of respondents such as age and geographic distribution can help to establish if the results are likely to represent the views of the broader population and importantly, may help to identify if these characteristics have an influence on responses.

Responses were received for age groups between the ranges of 18-19 years to 85-89 years – see Figure 7 – with seven respondents choosing not to identify an age range. The highest number of responses came from the age group 45-49 with 71 responses. The mean age of respondents was 30 and the median age was 26.

Figure 7 – Age Ranges of The Future of Energy Technology and Community Resilience Survey Respondents

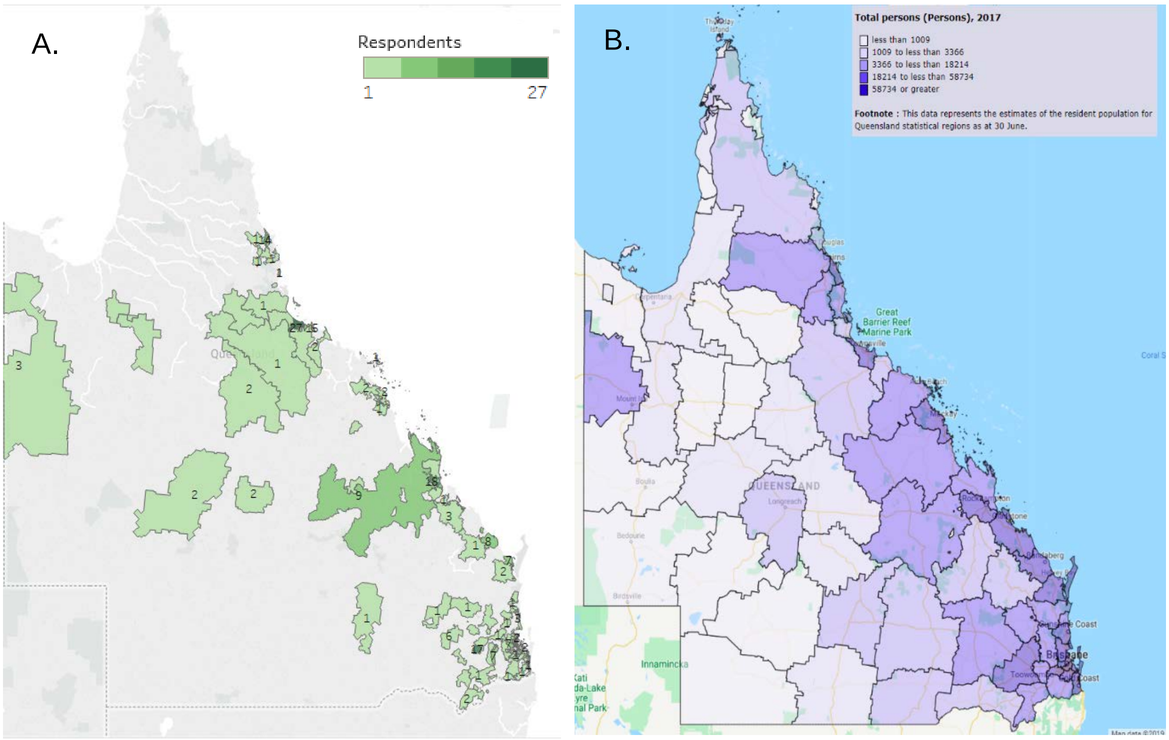


The geographical distribution of survey respondents based on their postcode, is compared to the distribution of the Queensland population by LGA and depicted in Figure 8. Evident from the shading in this figure, the geographical location of respondents covers metropolitan, regional and rural areas and is largely clustered in coastal areas of the state. There is a distinct lack of respondent representation from far-north and south-west Queensland.

Figure 8 – Distribution of Survey Respondents Relative to Queensland Population

Distribution of respondents via postcode

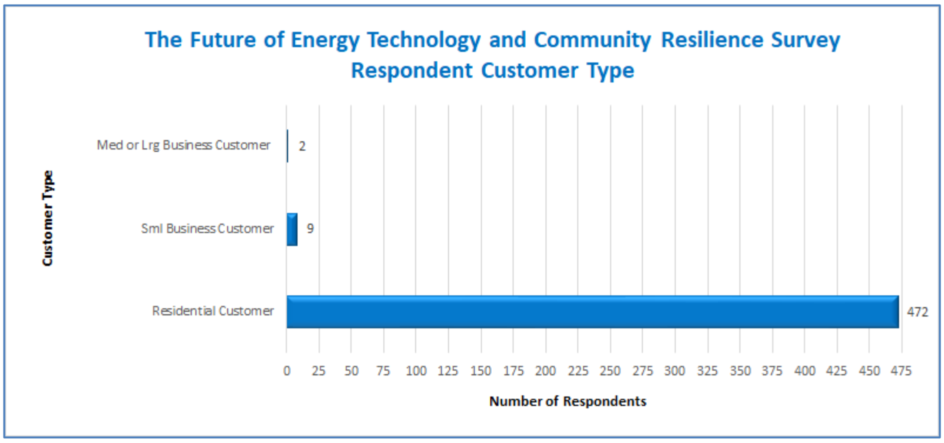
Distribution of Qld population via LGA



Source: A). Original data from research survey. B). The State of Queensland (Queensland Treasury) 2019b.

The survey also sought to differentiate between residential respondents and those who might represent a small to medium business – see Figure 9. The clear majority of respondents, some 472 representing 98% of the respondent population, were residential customers whilst the remaining 2% were small (9 respondents) and medium-to-large (2 respondents) business customers. Given the significant representation of residential respondents, it is possible to draw conclusions based on households, however the lack of business representation prevents extrapolation of results to Queensland businesses.

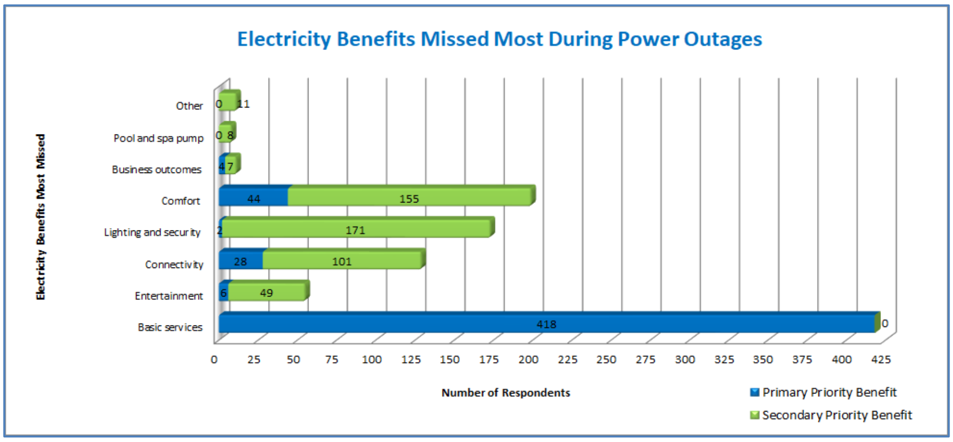
Figure 9 – The Future of Energy Technology and Community Resilience Survey Respondent Customer Type



5.2. Benefits of Electricity

It is vital to understand the significance householders' place on the various household services energised by their electricity supply. Respondents were asked to indicate their top two (2) priority services, from a list of eight (8), with highest priority attributed to their first selection – see Figure 10. The priority services are not only an indicator of those services likely to be missed most during power outages, they are also indicative of the services householders are likely to use during power outages, if they had an alternate energy supply.

Figure 10 – Electricity Benefits Missed Most During Power Outages



Respondents overwhelmingly indicated (82% of responses) the provision of basic household services including refrigeration (refrigerators and freezers), cooking, hot water and water supply, as the most missed service during power outages. Of particular importance was the availability of refrigeration, to prevent food spoilage. Food spoilage from lack of refrigeration was recognised by several respondents as a significant challenge. Accessing fresh food and keeping it cold was problematic for several reasons including leaving the house because of storm damage or flooding, or a lack of available fresh food and ice due to hoarding behaviours coupled with an inability for shops to operate without power. As well, the economic costs associated with throwing out spoiled food, buying takeaway food (R81; R281), queuing and buying ice for eskies or fuel for generators was a burden. A familiar response to power outages across Queensland is having to '*buy ice to keep things cool and cook everything on the BBQ*' (R79).

Although basic services were unanimously given highest priority, there were different reasons for the importance placed on these services. In the metropolitan area, where alternate services are often only a suburb away, concerns were raised about building access by an elderly resident (R18) of a large apartment building who mentioned the inconvenience of walking up and down several flights of stairs with lift access disabled for several days during outages. Alternatively, in regional areas, particularly rural and remote areas, respondents indicated the importance of basic services associated with water pumps as their priority (R207: R273; R289; R477). One respondent indicated significant hardship faced by rural properties that use pumps for drinking and grey water, where following a tornado they '*needed pumps to get water. As powerlines were down we couldn't leave our street and once we used all of our water we had to get water out of the downpipes and boil it to drink*' (R22). Several respondents indicated owning camping equipment which helped to reduce dependence on electricity for cooking (R60; R95; R127; R235; R388; R404), with some respondents almost enjoying the experience of '*camping in your own house*' (R294).

The second highest priority given by respondents (40%) was placed on the benefits of comfort provided by fans, air-conditioning and heating. Queensland's temperate climate in the aftermath of disasters such as cyclones can make power outages particularly uncomfortable. According to one respondent (R59), surviving the power outage was '*a rather uncomfortable experience through the heat'*. Cyclone Yasi was considered '*hot without fans and air con, felt it at night especially*' (R28), where heat can affect sleep. Without cooling, homes can become intolerable. Following a cyclone, household temperatures in one home were *'just under 40 degrees'* forcing one family of *'2 adults and 3 kids to sleep in our car for a few nights with the engine running to keep the car air-con going all night'* (R370). Whist discomfort is felt by some, for others power outages could mean life or death where reliance upon life support systems, communications to emergency services, cooling for medical conditions and refrigeration to keep medical supplies cool is an essential (R408; R431; R462).

Lighting and security were considered valuable by 34% of respondents. Several respondents indicated that lighting was provided by generation (R28; R183; R399), basic camping equipment (R192; R303; R388) or candles (R232; R236). Generally, less of a focus was placed on security. One respondent did however comment on feeling less safe in the absence of streetlighting stating, *'the thing that stood out the most was how dark it was when driving at night'* (R198).

Interestingly, in our era of connection and devices, lesser importance was given to connectivity and entertainment with 26% and 11% respectively. Although connectivity was not attributed the highest value, the importance of staying connected for information on the response was a key concern around connectivity. Concerns relating to charging phones and other devices to access outage restoration information and to stay in touch with family and friends were important (R223; R514). Other impacts including access to cash and internet access to complete university assignments and exams proved challenging (R70). An interesting nostalgia for old-fashioned camping at home and conversations was evident, with *'sitting on the patio, listening to music on the transistor and talking*' (R318), and *'kids learning to read and play charades'* (R488) proving popular, with the reported impact '*limited to no TV and the kids having to talk to mum and dad instead!'* (R60).

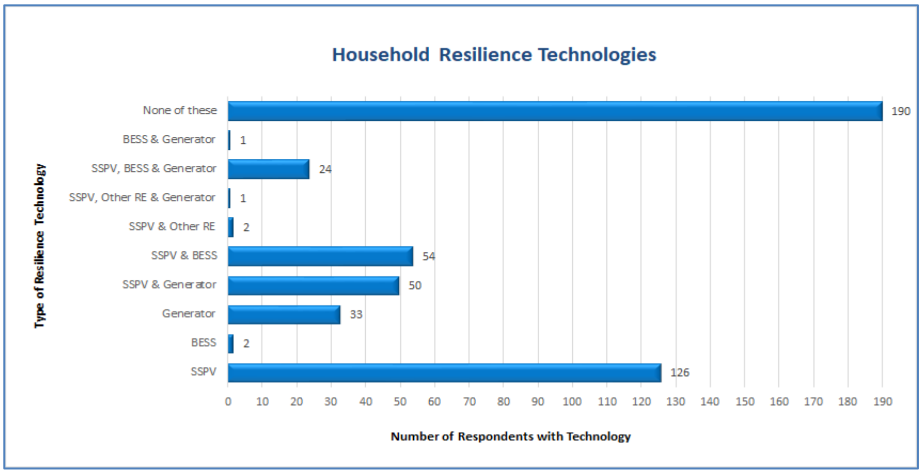
The eleven (11) responses relating to business outcomes indicate the priority given to the importance of electricity on home-run businesses. Where small businesses are run from home, the loss of power can have a compounding effect. Other benefits such as maintaining pool pumps (R281; R294) were considered important. As well, loss of power can hamper clean-up efforts (R50; R194; R355).

5.3. Penetration of electricity resilience measures

5.3.1. Adoption of household energy resilience technologies

Several respondents indicated a level of resilience with the adoption of a range of energy technologies – see Figure 11. Many respondents had no form of energy resilience with 190 respondents, equating to 39%, indicating they had none of the technologies listed to support their energy resilience. The most popular stand-alone form of technology take-up is SSPV with 126 respondents, or 26% of the survey population, indicating they had SSPV. This figure rises to 257 respondents, or 53%, when combined with other technology options and is almost double the percentage of residents across the state with SSPV installed (APVI, 2019). These figures indicate the survey population has a higher level of energy resilience than the general state population.

Figure 11 – Penetration of Electricity Resilience Measures



However only 54 respondents had teamed up their SSPV with BESS, allowing access to stored energy during an outage. Several respondents recognised this limitation of their SSPV (R22; R279). Whist the SSPV, the largest form of energy resilience technology, could not be accessed without storage, this cohort representing 26% of respondents, are well positioned to integrate BESS into their homes in the future. At least one respondent indicated an intention to expand their capabilities stating, 'battery storage connected to my solar array in my new home is now on my next long-term planning list' (R279).

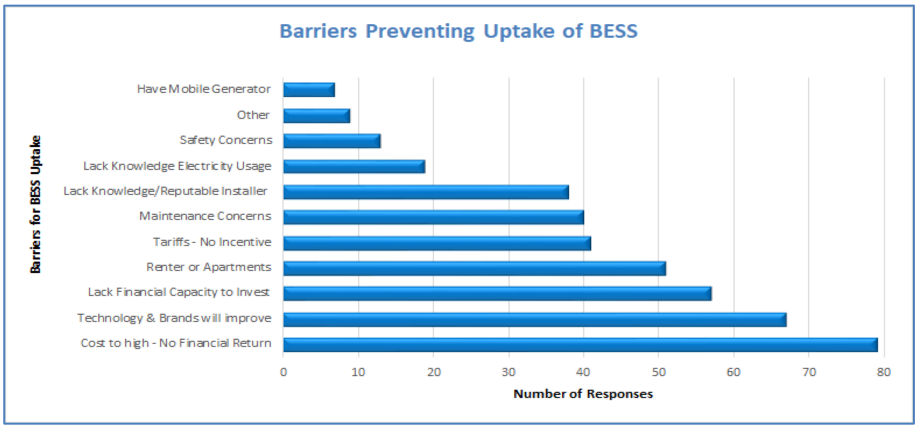
Resilience was available for 33 respondents who have generator alone. A large proportion of others (50), had a generator as well as their SSPV, using the generator during outages. R378 experienced an outage for over a month following a cyclone, relying on the generator for the household energy needs. Although deemed an effective means of energy in the aftermath of disasters by some (R404; R462), others identified drawbacks including difficulties accessing fuel (R218) and the cost to operate the generator (R86) as off-putting. R249 raised concerns about generators being '*noisy and smelly and expensive to run'*, yet R183 reported having a generator through Cyclone Yasi and felt fortunate for the technology, which provided refrigeration and lighting, likening the experience to *'camping in our own house, LOL!'*. Those without adequate resilience measures have described their experiences as 'horrible' (R182; R185).

Integrated SSPV and BESS have proved a successful resilience measure, allowing '*power to be quickly and efficiently replaced'* (R398), following an outage. A significant 11% of survey respondents indicated they have SSPV and BESS compared to the 0.14% installed across the state at the end of 2018 (Colmar Brunton, 2019). There is a growing trend to leverage the benefits of BESS and reduce reliance on generation (R415; R422). R401 has used generation in the past but notes that '*additional batteries have been ordered for this cyclone season to minimise generator usage'*. R422 places a caveat on this transition to BESS noting that use is *'provided the next cyclone doesn't destroy the roof-top solar panels. That's why I will retain the 6kW gen set'*. Although the experiences of these respondents are polarising, there is agreement that having some form of energy resilience in the aftermath of a disaster is better than having none, yet not everyone in the community is able to adopt energy resilience measures.

5.3.2. Barriers preventing adoption of BESS technology

Although there is an increase in the adoption of BESS, several barriers remain, preventing respondents from adopting BESS technology – see Figure 12. The primary reason identified was cost, with respondents not seeing the financial return from investing in BESS and choosing not to purchase. In addition to cost, there is a belief that the technology will improve and the range of brands to choose from will increase, so respondents have indicated they would rather delay their purchase. Several respondents indicated their desire to invest in BESS but a lack of financial capability to purchase was a significant barrier.

Figure 12 – Barriers Preventing the Uptake of BESS

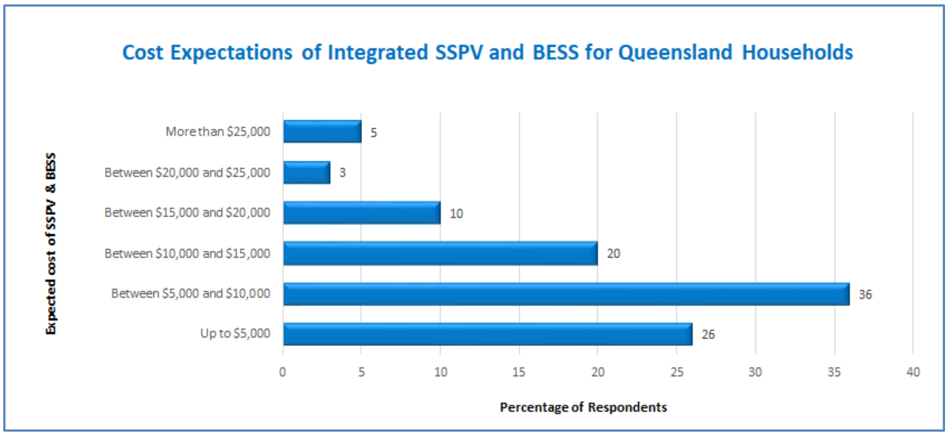


A lack of electricity usage, technology and reputable installer knowledge, were also prominent barriers. This lack of knowledge can prevent technology adoption because people are concerned about making such a large investment without a solid knowledge base upon which to make sound decisions. Other barriers included having a mobile generator, a lack of incentives offered to entice purchase and concerns relating to maintenance and safety were also raised.

Another significant barrier identified was respondents living arrangements, with 51 respondents (around 11% of the survey population) indicating they rent or live in apartments, excluding them from opportunities to build energy resilience. Translating this to the broader population, around one-third of the Queensland population live in rental accommodation (ABS, 2016). R30 shared the challenges associated with being a tenant stating, *'I have moved over 8 times in thirty years (as renter and owner). Would never get a return on investment'*. This presents a challenge regarding entering into discussions with the rental cohort on energy resilience strategies. Renters often report feeling excluded from the conversation, or their views less valid, as they are not the decision makers associated with their premise. This was reflected in R288 comment suggesting that whilst happy to provide views, *'I rent so it's a moot point what I think about it'*. This perception makes bridging the gap between 'those who have and those that have not', even more difficult.

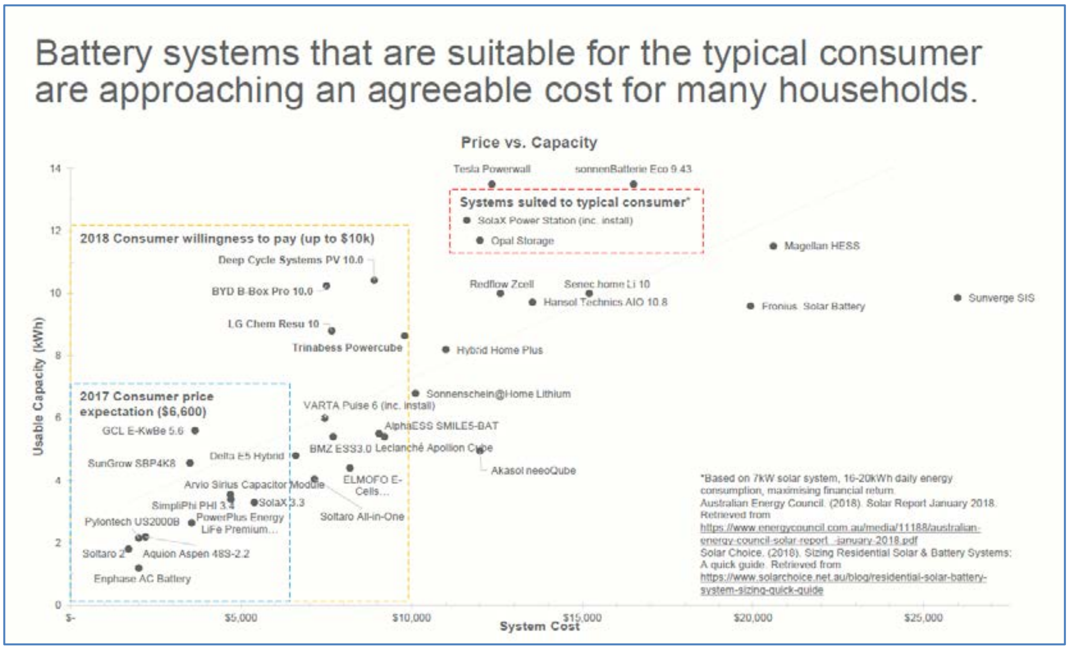
Cost remains the most significant barrier and there is evidence of a lack of understanding of the true costs of installing SSPV and BESS (Colmar Brunton, 2019). Understanding about the cost of BESS does however seem to be growing, with the 2017 customer price expectation reported to be $6,600, rising to a more realistic $10,000 in 2018 (Colmar Brunton, 2019). These figures correlate closely with the Future Energy Technology and Community Resilience Survey findings where 26% of respondents who may purchase BESS in the future expected to pay up to $5,000 and 36% expected to pay between $5,000 and $10,000 – see Figure 13. These findings indicate that education is required to help householders to understand the true costs to install BESS, or there is some way to go before the actual cost to install meet the price customers are willing to pay.

Figure 13 – Cost Expectation of Integrated SSPV and BESS for Queensland Households



Colmar Brunton (2019) reports that the gap is closing, between the actual cost of a suitable BESS for a typical household, and the cost householders suggest they would be willing to pay – see Figure 14.

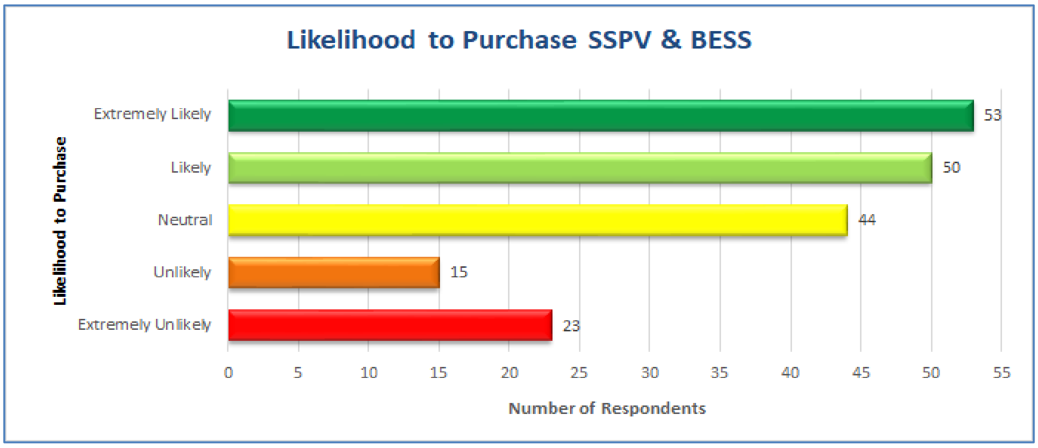
Figure 14 – BESS Approaching Agreeable Cost Threshold for Householders



Source: Colmar Brunton. 2019. Queensland Household Energy Survey 2018. P. 32

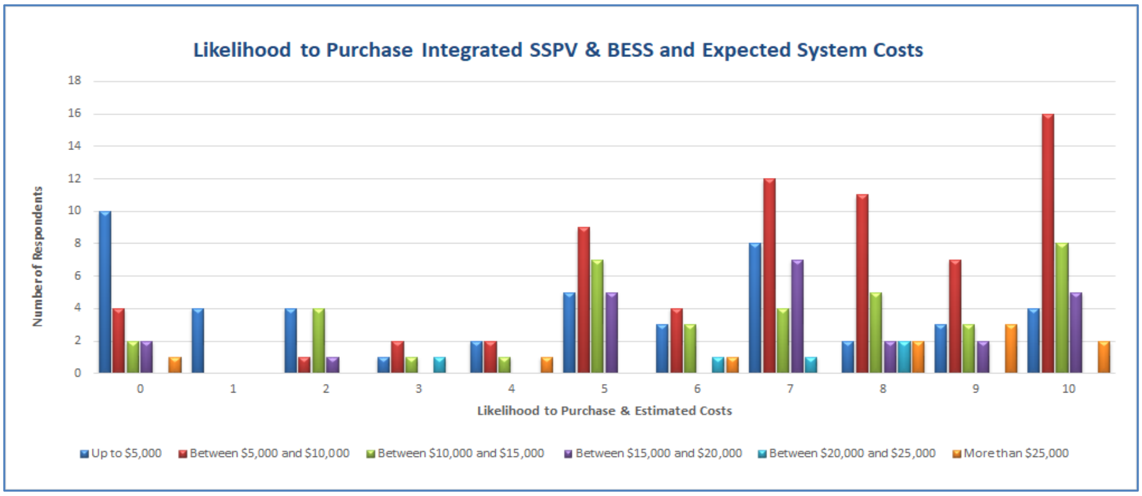
These findings suggest the current cost for a suitable BESS is between around $11,000 and $19,000 for the typical household. 20% of the Future Energy Technology and Community Resilience Survey respondents said they expected to pay between $10,000 and $15,000, with another 10% expecting the price to be between $15,000 and $20,000. Irrespective of these costs and other barriers, 53 respondents indicated they are extremely likely to purchase SSPV and BESS in the future, and another 50 likely to purchase – Figure 15.

Figure 15 – Likelihood to Purchase Integrated SSPV and BESS



Future purchase likelihood may be stifled by an underestimate in the cost of systems. When the likelihood of respondents to purchase SSPV and BESS is compared to respondents' expectations of the cost of these systems, a disconnect is apparent – see Figure 16. Most respondents have indicated they expect to pay between $5,000 and $10,000, somewhat short of the cost estimated for suitable household systems today. This disconnect is most noticeable in the responses from those who indicated they would be most likely to purchase SSPV and BESS in the future.

Figure 16 – Likelihood to Purchase Integrated SSPV & BESS and Expected System Costs



Colmar Brunton (2019) identifies an intention-behaviour gap in the take-up of SSPV and BESS, suggesting that around only one-third will follow through with their purchase. This take-up rate may be a result of the disconnect between cost expectations and actual installation costs. It may also be an indication of why the take-up of BESS has been slow to date, even with the desire of householders to purchase the technology.

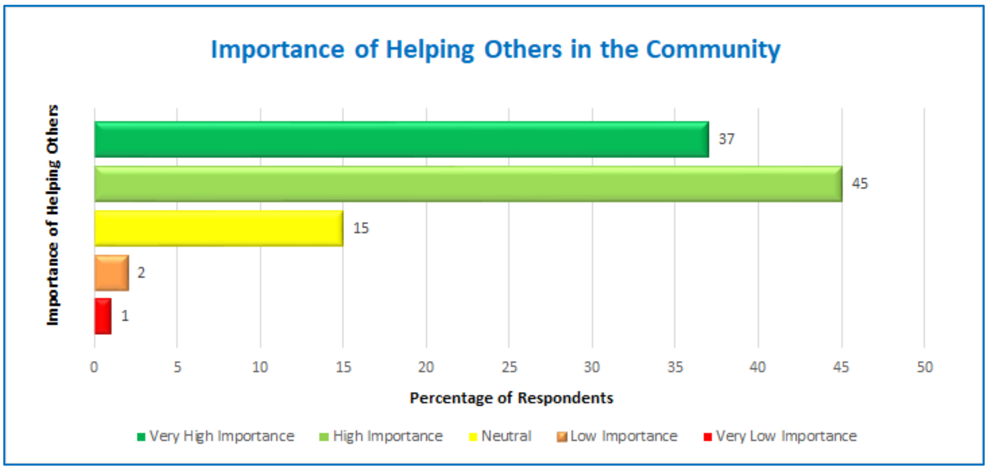
5.4. Sharing energy resources

5.4.1. Importance of helping the community

Following disaster events, George (2013) found a propensity for the community to share, but also observed cracks in the community's solidarity, as well as feelings of entitlement to assistance. This research used survey question (SQ) SQ9, '*Generally, how would you rate the importance you place on helping others in your local community?*', as an indicator of respondent's willingness to share. Responses across an 11-point scale were categorised into five (5) levels of importance which included, very low importance (0-1), low importance (2-3), neutral (4-6), high importance (7-8) and very high importance (9-10).

Most respondents placed very high importance (37%) or high (45%) on helping the community, with 15% neutral, 2% low importance and only 1% placing very low importance on assisting – see Figure 17. These results suggest that respondents place significant importance in helping others in their community with 82% registering a high or very high importance. If the importance of helping others in the community metric is used as an indicator of willingness to share, it could be concluded that this cohort would be willing to share their stored energy resources with the broader community in the aftermath of a disaster, based on these results.

Figure 17 – Importance of helping others in the community



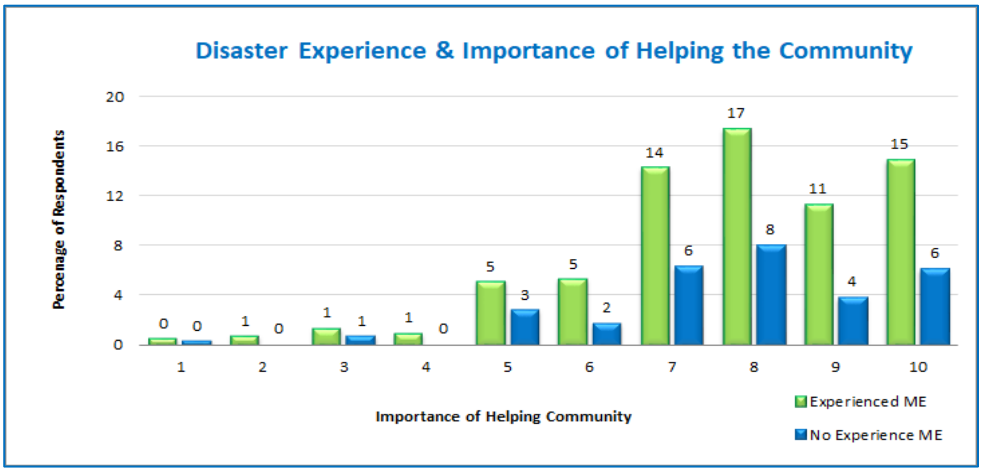
However, given that the notion of 'sharing' in this context is largely a hypothetical situation for respondents, most of whom have not invested in SSPV and BESS themselves, it is reasonable to assume that a potential exists for an intention-behaviour gap to be uncovered in practice, and these results are not a definitive indicator of sharing behaviour. Further factors need to be investigated before 'importance to help the community' could be used as an indicator sharing with any level of confidence.

5.4.2. Experience sharing resources

Experience of disasters has been found to influence social capital, reinforcing social trust and participation (Witvorapong et al., 2015; Joerin et al., 2012; Yamamura, 2010). Consequently, this research sought to determine if there was any relationship between respondents having experienced a disaster and the importance they placed on helping others in the community. To determine if there was any relationship between these variables, responses were compared for SQ7 *(Have you ever experienced an extended power outage following damage to the electricity network from a cyclone, severe storm or major flooding?)* and SQ9 *(Generally, how would you rate the importance you place on helping others in your local community?)*.

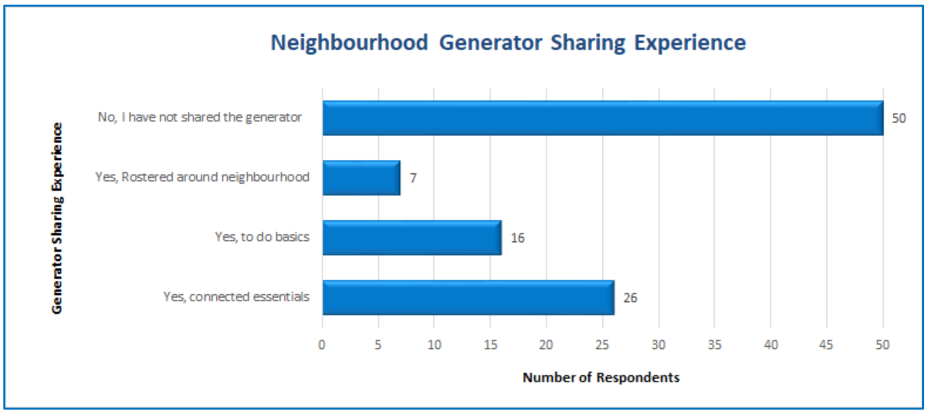
More respondents had experienced a disaster than those who had not, with 71% of respondents reporting they had experienced a disaster and 29% with no experience of a disaster – see Figure 18. There was an indication that those respondents who had experienced a disaster, were more inclined to place significance on helping others in the community. The majority of those who had not experienced a disaster were also likely to help their community.

Figure 18 – Disaster experience and importance of helping the community



Further, to establish if a relationship between experience and sharing exists, sharing behaviours of those respondents with a generator was investigated. Respondents who indicated they had a generator in SQ10, were also asked SQ11, '*Have you ever used your mobile or back-up generator to support your neighbours following a natural disaster or other extended outage?*', with results shown in Figure 19.

Figure 19 – Neighbourhood generator sharing experience



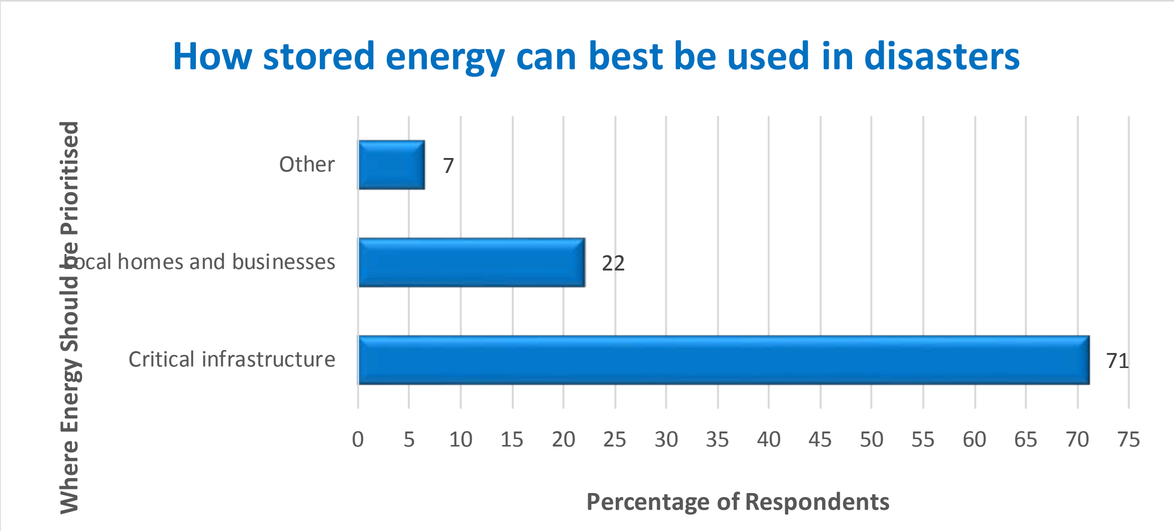
Greater than 50% of generator owners indicated they had not shared their generator in the aftermath of a disaster. Whilst it is acknowledged there may be a range of reasons for these respondents' lack of sharing, these results may be an indicator of a contradiction between respondent intent to help the community and their actual behaviour when the situation arises, identifying a potential intention-behaviour gap.

Where respondents had shared their generator, or been the recipient of someone sharing their generator, there was overwhelming positive sentiment towards this behaviour and the sense of community and social capital that it created. R92 experienced a six-day outage following Cyclone Yasi but their '*neighbour got a generator and threw an extension cord over the fence, bless them*'. R137 had a similar experience where during a week-long outage, '*neighbours really supported each other sharing generators that were taken from property to property to allow everyone access to essentials from time to time'*. R27 '*hooked our fridge to our neighbour's generator'* and R58 was '*lucky enough to gain access to a generator to run the fridges for several days'*. There were no indications of negative sentiment with generator sharing.

5.4.3. Who should benefit from sharing of stored energy resources?

In the aftermath of a disaster, it can be difficult to prioritise where resources are best allocated for the greater good. In this regard, the survey asked respondents, who should benefit from shared energy resources. SQ20 asked respondents '*Where do you think the electricity stored in batteries across the community should be used to best support the community during a disaster recovery?*', with three options made available to select, those being, critical infrastructure (CI); local homes and businesses (LHB); and other. Most respondents (71%) supported allocation of shared energy to CI, with 22% supporting the prioritisation of LHB and the remainder (7%) identifying other allocations – see Figure 20.

Figure 20 – How the stored energy can best be used in Disasters



Whilst strong support was demonstrated for prioritisation of CI (including powering hospitals, sewerage, street and traffic lights, etc.), there was recognition from many (R60; R309; R380) that CI should already have resilience capacity, leading them to be more likely to support LHB needs over CI. Support for prioritising CI was strong in verbatim comments as well as statistical results. R407 showed a preference for shared resources to support CI saying, '*you can live without a PlayStation but not without a hospital or water treatment plant!*'. A focus on supplying common pooled resources was evident with R293 pointing out that '*the electrical and telecommunications networks are a public good, and I think that if you share in them you should give back in times of genuine need*'. R494 says, '*I'd be happy to help support critical infrastructure, but my neighbours can fend for themselves*'. R259 gives priority to resupplying CI but highlights people have different views and suggests, *'having an option to get critical infrastructure back online should be a given. I realise not everyone in our communities may share this ethic and so perhaps some sort of reward enticement may need'.*

Not everyone supported this notion with 22% stating that stored energy could best be used to support local homes and businesses following disaster. R493 opposes the view of prioritising CI saying, *'I personally* *wouldn't want to sacrifice the necessities in my home for street lights'*. Prioritisation for LHB was strong with R273 advocating for '*supporting local families. Assisting elderly and families with children*' and to *'improve the quality of life for other local residents*' (R288).

R60 is also an advocate of supporting LHB in disasters and touts the broader benefits this sort of scheme might bring saying, '*the creation of microgrids to enable households and businesses to share excess or stored capacity with their surrounding neighbours via an opt in/opt out arrangement is a great idea, not just to provide resilience in the event of disasters, but as a means to promoting community engagement (particularly with energy consumption/management awareness) and strengthening community bonds'.*

The connection to community demonstrated by R60 is not always shared. In fact, the 'every man for himself' mentality and the divide between the 'haves and have not's' is often more prevalent in times of disaster. Economic inequality has reportedly stifled collective action in the past (Yamamura, 2010), and a correlation between disaster preparedness and economic status has been well established (Witvorapong et al., 2015; Edwards, 1993). These views can reinforce the isolation and impacts felt by those without financial means. These sentiments can, and have been, extrapolated to the ownership of resources such as SSPV and BESS and leading to resentment, fuelling feelings of entitlement and heightening expectations of assistance.

This divide is evident in several the respondent's verbatim comments and challenges the notion of utilising privately-owned energy resources as a common pool resource to be used for the greater good. Often these views are founded on a belief that others don't want to make an investment, rather than, they lack the economic means or face some other barrier to investing. These polarising views are evidenced in R243s comments, who seems to mirror this view stating that, *'people have worked hard to pay for those and should not be disadvantaged because others don't, or won't, buy one'.*

A different concern is raised by R407, who as an owner of SSPV, shared an alternate view of how society looks negatively upon those with these resources, saying, '*the idea of sharing is noble enough...(but) we are derided as parasites in society and blamed to some of the ills of the general power supply. That is not generating goodwill among solar power users. Improving treatment of those with solar panels would help* *with their attitude to sharing'.* R407s comments emphasises the divide between the 'haves and have's not' but paints a different portrait into why those with means may choose not to share beyond the return on investment argument.

The opposing views regarding energy sharing for the common good, have ignited discussions around the DNSP control of the resource and the establishment of mandatory sharing arrangements. The opposing views provided by respondents, highlights the importance of investigating this notion further.

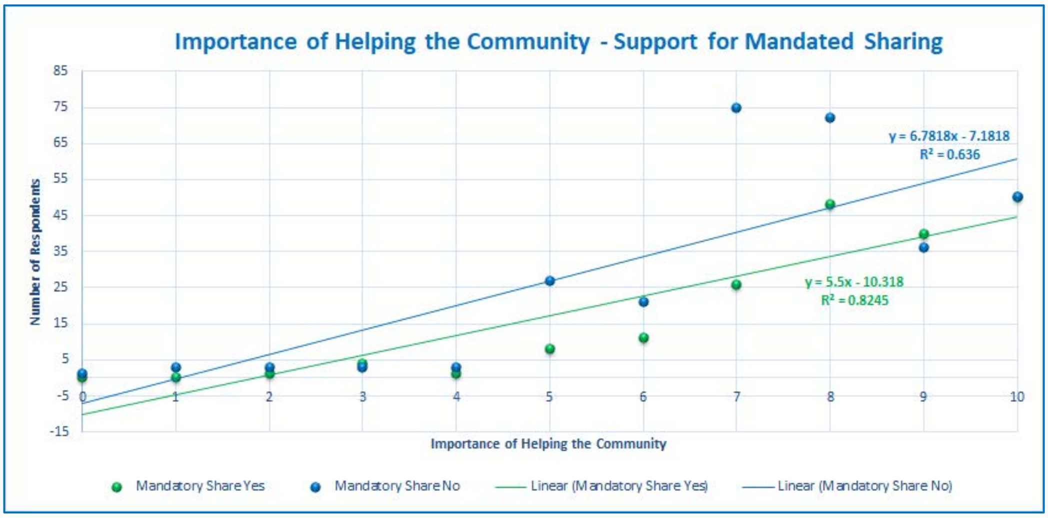
5.4.4. Is there support for mandated sharing of stored energy resources?

Mandated sharing as a concept is based in the idea of ensuring enough resources are available for the common good in times of need. Only 39% of respondents supported the mandated sharing of privately-owned stored energy resources in the aftermath of a natural disaster, with a 61% majority of respondents, proponents of non-mandated sharing.

The results indicate a positive relationship between helping the community from both supporters and detractors of mandated sharing – see Figure 21. Proponents of mandated sharing principally indicated a high or very high importance towards helping their communities. As well, a stronger relationship was demonstrated, between the importance placed in helping the community and positive support for mandated sharing. One might expect that those proponents of mandated sharing would also be more inclined to help their community.

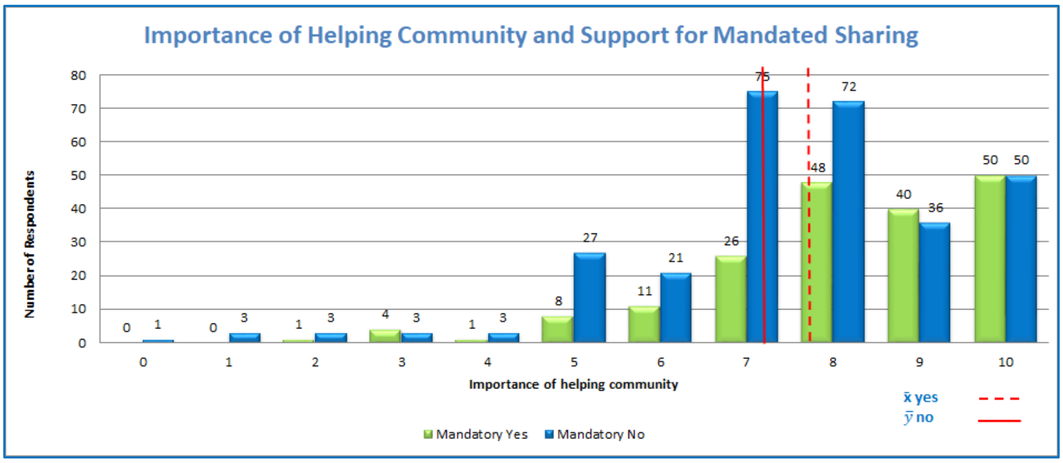
Whereas, the results depicted a weaker relationship between those supporting non-mandated sharing and the importance these respondents placed on helping their community. When a linear comparison is made of the importance placed on helping the community and likely support for the mandated sharing of stored energy resources, a greater distortion is revealed, indicating a presence of bias in the results. Overall, people disagreed with mandating the sharing of stored energy.

Figure 21 – Importance of helping the community and likely support for mandated sharing – linear comparison



These differences become more apparent in Figure 22 where the man scores of supporters and detractors of mandatory sharing are compared. Proponents of mandatory sharing have a mean 'importance of helping the community' score of 8.2. Not surprisingly, detractors of mandatory sharing (61%), recorded a mean score of 7.5 for the importance they placed on helping their community.

Figure 22 – Importance of helping the community and support for mandated sharing of energy resources



If importance of helping the community is indicative of a respondent's propensity to share, these results would suggest that although respondents are willing to share their energy resources, they do not wish to be told when and how much they should share. They prefer to retain control over this decision. Strong feelings were expressed in this regard by respondents in their verbatim commentary, suggesting that mandatory sharing of private resources was autocratic, with R247 stating that, '*compulsory sharing feels a bit Stalinesque*'. R302 agreed stating *'forcing the sharing of a privately-owned resources smells a little like*

COMMUNISM'. R348 does not support mandatory sharing saying, '*I would like to think that in a community, people would share voluntarily, let's not get too big brotherish'.*

Others highlight equity concerns relating to the financial expense they have outlaid and either, not receiving the full benefit of that, or others obtaining benefit off the back of their investment. R269 highlights this point stating, '*residences and businesses have to outlay significant capital in order to take advantage of battery technology, and still need to pay daily connection fees. It seems rude to force these people to surrender their battery access when the grid fails'*. R291 said, *'I shouldn't be 'forced' to share my battery reserves with someone who hasn't installed their own'.*

These previous comments seem to be focused at other residents in the neighbourhood, but R438 raises apprehensions about the DNSP's benefiting, stating, '*I would not want an energy company to be able to use my energy storage without my consent'.* R454 agrees simply stating, '*Ergon should not control it'*.

On the other hand, R317 highlights circumstances where proponents of mandating the sharing of resources identify exceptions that may need to be considered for individual households stating, *'privately owned batteries might be needed for patient health'.* This is certainly the case for R391 who has SSPV and BESS and states that*, 'my storage basically is required daily for air-conditioning because of a medical condition of my seriously ill wife'.* Ultimately, R488 summarises the sentiments of most detractors of mandatory sharing saying, *'I love to share, but I don't think it should be compulsory to do so'*.

5.5. Conserving energy - What would the community give up?

It is understood that for SSPV and BESS to provide a resilience option, some level of conservation and rationing would need to be adopted by the population to improve the longevity of the supply from BESS. To obtain an understanding of conservation willingness, SQ17 asked, '*What type of electrical equipment would you be willing to avoid or reduce using to ensure you could share your battery system during disaster events?'*, with respondents free to make multiple selections from the options available. These results could be considered in isolation and be compared to the benefits that electricity brings which were identified in SQ6. Given the number of response options available in SQ17, some alignment was required to support the comparison of results with the benefit options previously explored in SQ6. To facilitate this comparison, each electrical equipment option from SQ17 was assigned a classification for analysis, aligned to the benefit options from SQ6 – see Table 2.

Table 2 – Categorisation of electrical equipment to avoid or reduce – alignment to benefit options

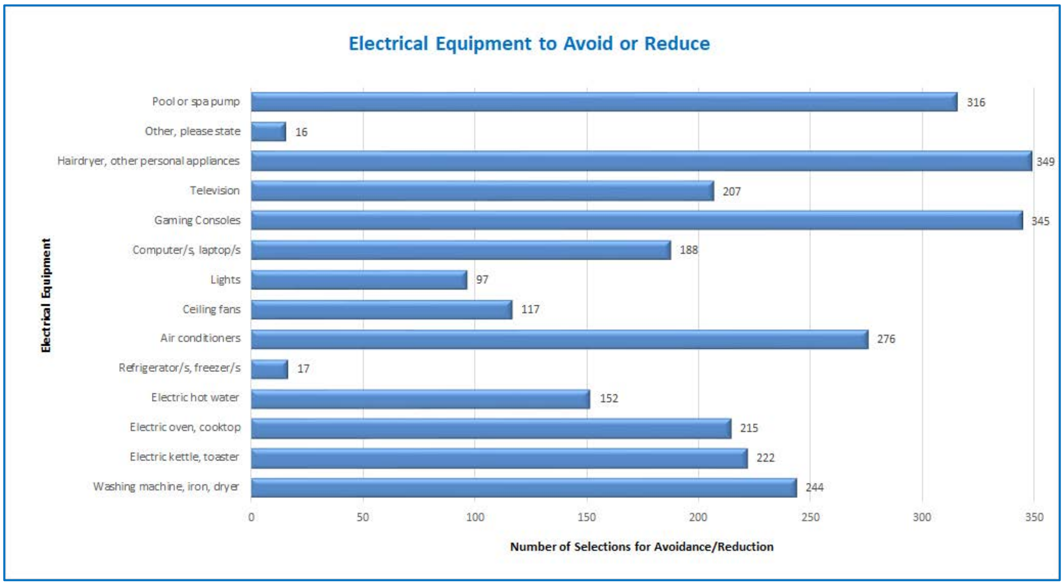
Electrical Equipment Willing to Avoid or Reduce	Responses	Electricity Benefit Category
Washing machine, iron, dryer	244	1 – Basic services
Electric kettle, toaster	222	1 – Basic services
Electric oven, cooktop	215	1 – Basic services
Electric hot water	152	1 – Basic services
Refrigerator/s, freezer/s	17	1 – Basic services
Air conditioners	276	2 - Comfort
Ceiling fans	117	2 - Comfort
Lights	97	3 – Lighting and Security
Computer/s, laptop/s	188	4 – Connectivity
Gaming consoles	345	5 – Entertainment
Television	207	5 - Entertainment
Business outcomes and productivity*	11	6 – Business Outcomes
Hairdryer, other personal appliances	349	7 - Other
Other, please state (included medical equipment, power tools etc.)	16	7 - Other
Pool or spa pump	316	8 – Pool and spa pump

Note: Business outcomes and productivity were removed from the benefit comparison to focus on household benefits.

The electrical equipment that respondents indicated they were most willing to reduce or avoid were hairdryers and other personal appliances (349); gaming consoles (345) and pool or spa pumps (316) – see Figure 23. Behind that, a reduction or avoidance in the use of air conditioners (276); washing equipment such as washing machines, irons and driers (244); electric kettles and toasters (222) and electric cooktops and ovens (215). Entertainment equipment such as televisions (207) followed by computers and laptops (188), as well as electric hot water (152) were more reluctantly reduced or avoided.

The electrical equipment least likely to be avoided or reduced were reported to be ceiling fans (117), lighting (97) and understandably, only a handful of respondents would forego their refrigeration equipment (17). A small number of respondents indicated they would conserve use of 'other' equipment (16) with verbatim comments identifying items such as power tools as falling into this category.

Figure 23 – Electrical equipment to avoid or reduce in the aftermath of a disaster



Interestingly, in our modern digital world, entertainment was not considered critical in the aftermath of a disaster. It was more important for respondents to be connected to the internet with several respondents reporting this need was driven by the desire to communicate with family and friends and access information relating to restoration efforts as important (R223; R514).

One area that stands out from these results, is responses relating to comfort appliances, such as ceiling fans and air conditioning. These devices fall in the mid-range of what respondents would forego. Only 57% of respondents indicated that they would forego using air conditioning, indicating that 43% of respondents would likely continue to use this equipment following a disaster event. Although more than twice as many respondents indicated foregoing air-conditioning in favour of ceiling fans, this still represents 43% of the group and a large energy load placed on stored energy if the indicated level of air-conditioning was retained. This presents concerns for the level of BESS capacity required to support this consumption.

Worse, the use of air conditioners by some could create an ‘every man for himself’ behavioural response, resulting in residents with storage using their air-conditioning because others were doing so. Some research has identified instances where seeing others use excessive energy can generate conflict (Leygue et al., 2014). Rethnayaka et al., (2015) found that being part of this sort of sharing arrangement can motivate behavioural change towards energy use and insight competitive use behaviours.

Several respondents highlighted concerns related to sharing equity in their verbatim comments with R68 noting that, '*This would only work if others were considerate of being conservative of the amount of energy they use...I wouldn't want to give up using my AC when it resulted in another customer using their AC'.* R344 also expressed concern regarding the fairness of sharing energy where it was made '*available for other users to run their aircons if I've chosen not to run mine'*. Other respondents firmly only supported the use of basic services in emergencies, suggesting that, '*batteries should only be used to power fridges and fans*' (R274). R297 agrees with rationing during disasters saying that people should avoid using '*power excessively - for example, air conditioners running on shared energy would be atrocious, and people already abuse those in summers as it is*'.

The desire for comfort was raised by several respondents who had experienced disaster events. A word cloud was created from the supplementary comments associated with SQ7 to see important trends in the commentary – see Appendix 7 . Discomfort experienced in the hot tropical hot conditions in the aftermath disasters was highlighted with commentary regularly mentioning 'no air-conditioning, no fans, hot, humid and uncomfortable' several times by respondents. Given these feelings of discomfort were so prevalent in their recollection of their disaster experience, it could be inferred that households will turn to comfort providing equipment such as fans and air-conditioning to make the ordeal more bearable.

The comments, coupled with the statistical survey results, suggest that people may not conserve energy if shared arrangements were established, particularly if they were the benefactor of the shared energy supplied by others. This excessive use behaviour could be exacerbated where there is no visible indicator of the amount energy being used by the benefactor premise prompting them to conserve energy. More concerning, is the potential for a retaliatory use of electrical equipment by those with SSPV and BESS, based on the belief that others were not conserving the energy they are providing.

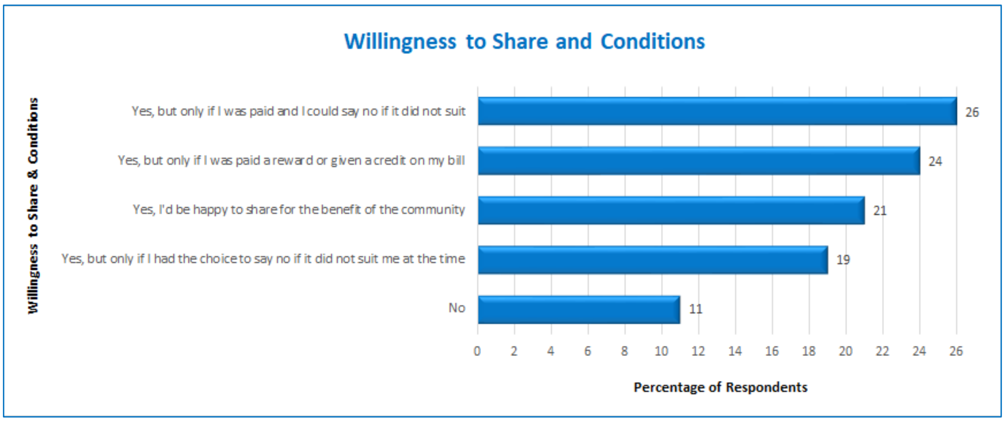
5.6. Willingness to share - conditions and incentives

5.6.1. Willingness to share

Previous results indicate variability in the desire to share energy resources. Policy often employs conditions and incentives designed to ignite adoption of technologies or to reduce negative sentiment associated with activating policy. SQ14 asked respondents (n-483), '*If you have a battery system, or had one in the future, would you consider allowing Energex or Ergon Energy to access it (together with batteries from other premises) if there is a problem with power supply in your area?*'. This question aimed to ascertain respondent's willingness to share and to identify potential conditions and incentives, that might need to be introduced, to facilitate the adoption of the energy sharing option.

Most respondents were favourable to sharing (89%) with only 11% not supporting sharing – see Figure 24 – including R427 who had very strong views regarding sharing saying, '*it's up to every individual to supply their own solar and battery backup... somebody wants power security, OK let them buy it like I had to. No one gets my power, at any cost!'.* Another 19% indicated they would share if given the choice to opt-out if it did not suit. 21% were happy to share, without indicating any conditions that would need to be applied to access, or incentives required as compensation.

Figure 24 – Willingness to share and acceptable conditions



More than a quarter of respondents (26%) indicated they wanted compensation for sharing their stored energy and wanted to retain control over the decision to share. The remaining 24% indicated they would share if they were paid a reward or given a rebate on their electricity bill. The results showed that almost half of the respondents wanted choice in participating and half of the respondents were looking for some sort of financial incentive to participate in a shared arrangement. Further questioning sought to understand more about the incentives these respondents would require enticing participation.

One concern research has identified when resources are shared, is that people can free-ride (Leygue et al., 2014; Engel, 2011;), leading to resentment and challenges when trying to get the collective to conserve resources. Whilst these concerns have been raised in this study, some believe that shared arrangements are worth pursuing regardless, because with appropriate sharing arrangements and participation, the 'sharing power economy' can deliver vital financial benefits and efficient energy use across the community (Mahmood et al., 2017). These benefits beyond the individual are those that establish broader community resilience and help to fast-track community and economic recovery in the aftermath of an event.

5.6.2. Conditions and Incentives

There is significant evidence demonstrating the positive effects that incentives play in enticing technology adoption and behaviour change and the value derived through sharing these resources (Qi et al., 2017). A good example in the energy industry is the feed-in-tariffs offered for the adoption of SSPV. An increase in the willingness to share, or a reduction in negative sentiment expressed towards sharing, may be achieved through the implementation of the right incentive scheme.

Respondents who indicated in SQ14, that they expected some sort of incentive to participate (n=239), were asked SQ15, '*What is the minimum reward you would accept?*'. The results are outlined in Figure 25.

Figure 25 – Minimum Acceptable Reward to Participate

When given options, people will generally select the larger or advantageous reward, from those on offer (Yunshu et al., 2018). The rewards offered to respondents in the survey were all equal to, or higher than, the current rate charged for electricity, except for the 'nominal value of the energy' reward which is equal to the regional feed-in-tariff currently offered in Queensland. The nominal cost of energy (approx. 10c/kWh) was selected by 9% of respondents, with the option of a premium rate higher than the current cost of electricity charged (more than 28c/kWh) preferred by 17% of respondents. R142 expected to be a rewarded a premium stating that participants *'should be compensated if it is accessed and not at the same amount'*. The nominal rate, plus a reward when the system is accessed, was selected by 18% including R195 who indicated they would '*be happy to share as long as my household's immediate needs were being met. I would also want to have the ultimate right to say yes/no re use'*. The reward likely to generate the highest level of compensation for respondents would be a quarterly flat rate, which would be paid irrespective of if the system was accessed. Surprisingly, only 14% of respondents chose this reward.

Many respondents (43%) indicated they would accept the same as they are currently charged for electricity (approx. 28c/kWh) as a reward. Whether this is based on what respondents deem fair, or the complexity of determining the 'best incentive option', is unclear from the results. The tendency for humans to be affected by default or status-quo biases, or ambiguity aversion, taking a 'go with what you know' approach, in the face of complex decision-making may explain this result (Frederiks et al., 2015). Alternatively, they may feel the same as R205 who supported sharing supply with the community and indicated that compensation was not the primary driver saying, '*if I could gain a financial benefit it would be appreciated to offset the set-up costs but not an influence on my decisions'*.

Contrary to these results, respondent feedback through verbatim comments, indicated expectations of a higher level of compensation than was generally opted for in the survey. The lack of incentives to adopt the technology currently was highlighted with R310 pointing out that, '*there is no incentive for private house owners to invest in a personal battery system that may be used as you intend. If you wish that there should be an investment into such a system, then that requires some incentivisation*'. Equity in the pricing schemes currently offered through FiTs generated some negative sentiment towards compensation for sharing and highlights a lack of understanding in the tariff price structure. R344 stated that '*selling it to Ergon at 10c MWh for them to on sell at 28c MWh seems dubious in the extreme*'. The need to incentivise or compensate households to encourage participation and permit 'intrusive control' is necessary according to Zhou et al. (2018). This view and the findings from our survey are reinforced in the results from the recent

AusNet trial which showed that, respondents not only expressed a willingness to share, but had an expectation that they be compensated for doing so (2018).

These results suggest there may be a discrepancy between respondent intention to share in the aftermath of a disaster and their likely actual behaviour. This contradiction could be explained by social desirability bias. Sauro (2016) suggests that self-reporting can lead to distortion of survey results through social desirability and conformity bias. Social desirability and conformity bias emerge when respondents have a propensity for overrepresenting socially desirable traits and underrepresenting those that may be deemed socially undesirable (Krumpal, 2013). Simply put, respondents tend to provide socially acceptable responses, rather than true and accurate responses aligned to their likely behavioural responses (Sauro, 2016; Fisher, 1993). A desire to be perceived in a positive light that reflects social and cultural norms drives this behaviour (Lang, 2012). This potential bias makes the task of determining the viability of sharing SSPV and BESS difficult. Achieving behavioural change where there is an intention-behaviour gap is a complex process and offering incentives may result in minor curtailment by customers at best (Anda & Temmen, 2014; Snape et al., 2011) but are unlikely to drive substantial behaviour change.

These results indicate a strong need to incentivise households to encourage them to increase community capacity and improve resilience, but strategies detailing how to incentivise resilience are yet to emerge and more clarity around suitable levels of compensation needs to be examined.

6. Research limitations and future research opportunities

6.1. Research limitations

A limitation of this research may have been in failing to establish the financial means of respondents. Whilst assumptions can be made, understanding this factor might help to determine the influence of financial capability and willingness to invest in the technology. In addition to willingness to invest, it would be useful to understand the different perspectives of those in the community 'who have, verses those who have not', and the likelihood of each group to share their respective resources with the broader community to support resilience. Given the increased likelihood that those with financial means can afford to install SSPV and

BESS and would make up most owners, it would be useful to determine if those with greater financial means would be more or less likely to share these precious resources with others in community in the aftermath of a disaster? Additionally, it would be interesting to know if there was a difference in perspectives regarding the mandating of sharing amongst these groups, potentially revealing that those without the means to support themselves may expect higher or lower levels of mandated sharing by those with the resources.

Survey design could have been improved by aligning the options for electricity benefits under SQ6 and electrical appliances that respondents would be willing to avoid or reduce in SQ17. This would have allowed direct comparison between the data sets to determine if there was a correlation between the benefits most missed by respondents and the equipment they were willing to avoid. This may have helped to further establish intent and may be considered if this research was to be replicated. However, this would only provide an understanding of intent, not actual avoidance or conservation behaviour, which may provide a more fruitful focus for future research.

The hypothetical nature of the sharing scenario put to respondents in this research, limits the ability to conclusively establish if respondents would act to share their energy resources in the aftermath of a natural disaster. To resolve this limitation, a spatial and temporal expansion of the handful of SSPV and BESS trials on the network that have been introduced to date, would provide a foundation for behaviour observation, exposing any intension-behaviour gaps and the significance of these on this resilience option.

The limitations identified could form the foundation of future investigative opportunities to establish a better understanding of householder's behavioural responses and the policy and education mechanisms required to accelerate the transition to a sharing economy to support network resilience.

6.2. Future research opportunities and recommendations

The study seeks to offer analytical support to policy makers and academics in their quest to develop strategies for the expansion of SSPV and BESS and its integration into the electricity network to build resilience. This analysis represents an important initial step towards identifying some of the challenges that adopting SSPV and BESS as a network resilience solution may present and understanding the likely behaviours that householders may demonstrate under a sharing scheme. Still, several opportunities remain open for further academic investigation including:

- Understanding the causality between SSPV and BESS investment and household consumption and sharing behaviours.
- Conducting an extensive practical trial of SSPV and BESS to assist in determining the 'rules' to be established to support a sharing regime and help to uncover trends in actual consumption and sharing behaviours.
- Delve deeper into the types of incentives required to shape energy conservation and sharing behaviours.

Although there is scope for further investigation to be conducted, this research has exposed the opportunity to make several recommendations to address some of the barriers for adoption of the technology and to help to shape consumption behaviours, including:

- Develop information that is readily available and written in simple language to explain SSPV and BESS technology and the role that this technology can play in daily life, as well as the resilience these systems can provide. This work could be led by the DNSP's who are considered by many as 'trusted advisors' on energy matters and an independent authority from retailers who are seen to be only interested in sales. Information could educate individuals and inform purchase decisions.
- Utilise community Emergency Services Days to demonstrate SSPV and BESS systems, provide information and answer questions about these systems and the role they could play in providing individual and community resilience. These events are held annually in communities across Queensland to help inform the community about preparation and response to a range of emergencies. They are designed to build individual and community resilience through information and education.
- DNSPs should fast-track the rollout of digital meters, particularly to lower-income and vulnerable customers, to help these customers to understand when and how they are using electricity, and which appliances are the most 'energy hungry'. Readily available consumption information,

coupled with conservation advice via a structured program, could help to raise awareness of residential energy consumption and facilitate conservation behaviours. This would assist these customers to reduce their energy bill as well as shape the behaviours that support energy conservation and SSPV and BESS as a resilience option.

- Consideration should also be given to expanding the range of incentives available to support the take-up rates of SSPV and BESS technology and associated network trials. Prioritisation could be given to lower-income families through an expansion of the Solar for Public Housing Trial and to expand the current trial rebate scheme for rental properties. This would assist in opening the technology up to those groups who currently face the most significant barriers to adoption and assist lower-income families to reduce their household energy bills.
- Creation of video content focussing on energy conservation behaviours, particularly following disaster events. The focus of these communications could be on 'energy thirsty' devices and wasteful behaviours, to help educate the community. These communications could be supported via a range of channels including social media, traditional websites and media avenues, as well as used at school and community events to expand the reach of these messages across the community.
- Adopt innovative ways to educate consumers on energy consumption and conservation. The use of virtual reality could be adopted to demonstrate a typical residential household and the electrical devices within, coupled with a SSPV and BESS. Participants could experience using different appliances to experience the energy required to power these devices and the impact that this has on their stored energy in their BESS. This 'reality' could function to inform and educate and ultimately to help shape energy usage behaviours.
- DNSPs could consider launching a series of microgrids trials in 'islanded' communities where the focus is on sharing SSPV and BESS resources. Trials such as this would provide several benefits including:
    - the provision of valuable data for the DNSP on network impacts from operating this technology in a dynamic environment;

- providing individual households access to this technology or to the benefits derived from sharing the energy across the community;
- provide households insight into their individual energy consumption, potentially leading to changed behaviours and a reduction in their electricity bills;
- providing the DNSP and broader industry with visibility of the community SSPV and BESS and the capacity required to support community sharing of energy with the community's consumption behaviours;
- provide the opportunity to trial various incentive schemes and operating protocols to determine their effectiveness and to seek feedback from the community on their preferences; and
- ultimately determine if SSPV and BESS could provide an option for network resilience based on the trials.

Investigating the opportunities for further research and progressing the recommendations, aims to serve the ultimate goal of supporting the take-up of SSPV and BESS and determining if the use of these technologies could indeed provide a practical level of network resilience for the distribution network, beyond the theoretical ideal currently being explored through the technical lens.

7. Conclusions and implications

Electricity supply is vital for community response and recovery in the aftermath of a disaster. Everything from disaster response coordination, communication, public lighting and safety, as well as the provision of health services, basic household operations and the economic recovery of the community relies on electricity to function. This dependency highlights the need for resilient distribution networks. The notion that SSPV and BESS might contribute to network resilience has become a popular avenue of investigation with the growing uptake of the technology. Beyond the technical challenges to make the distribution network ready and reaching the required uptake of the technology to have sufficient storage capacity, a third factor relating to householders' willingness to share stored energy with community remains largely unknown.

This prompts the question, are Queenslander's likely to share their stored energy resources and contribute to the resilience of the network? The results of this research indicate that this is a divisive question. The research took the position that responses relating to 'helping the community' could be used as an indicator for likelihood to share energy resources. Although there was significant support for helping the community, there was no conclusive evidence indicating that respondents would share their energy resources when survey ratings and verbatim comments were considered. If verbatim comments also contribute towards an indicator of willingness to share, respondents seem unlikely to share their stored energy resources when needed, or they are likely to express considerable levels of negativity towards the network utility and their neighbours if forced to do so.

The findings of this research indicate the potential for social desirability bias in responses, resulting in an intention-behaviour gap where there is a stated intention to help the community, yet households may choose not to participate, or may hoard their energy supplies. The contention that the DNSPs should provide a resilient network rather than relying on community or privately-owned assets remains. Concerns were also raised that neighbours may free-ride off those who have invested in SSPV and BESS, with such behaviour generating resentment and retaliatory increased consumption behaviours across the community. Uncovering these perceptions is vital to the formation of future energy policy and to inform the strategic role, that the sharing of stored residential energy resources, could play in the future of a resilient network. The implications of these findings indicate that more work is needed in this area.

These findings contribute to academic research and policy design in several ways. Firstly, it exposes the gap between the priorities academia and industry have focussed on, in approaching this dilemma with a technical lens, and the need to also adopt a social science view to introduce a viable solution for network resilience using SSPV and BESS. Further, it emphasises the complexity of applying theoretical concepts in a practical sense and the need to align technical and social design.

It assists to bring clarity to the types of conditions and incentives the community may expect to receive to participate in a sharing scheme. It reinforces that SSPV and BESS is an emerging technology of interest, with little understanding of the technology across the community, but a deep desire to know more. It identifies the opportunities for education and communication around the technology itself and the role it can play in providing resilience opportunities. The findings provide the impetus to expand SSPV and BESS trials on the network, in an endeavour to deliver the community firsthand experience and to provide the network with valuable technical and behavioural data. It provides policy makers insight into the behavioural practices of residents that policy and incentives will have to overcome, emphasising policy design founded in social and behavioural elements rather than a purely technical and regulatory view.

Finally, these findings demonstrate the polarising views that exist around who is responsible for network resilience, how this might be achieved, and the role to play by individual households in the community. R385 provides a very balanced perspective on the issue and what is required to implement this resilience option, stating, *'I think shared community storage is the way of the future and I am behind it 100%, though it must be implemented carefully - if we are fronting the cost of supply and installation it needs to be beneficial and worthwhile to join a shared network and as such motivate people to adopt the technology'*.

This research provides a foundation to better understand the community's motivations and some of the challenges that policy makers and network utilities face, even if they overcome the technical challenges on the network and enough storage capacity is reached across the community. This research demonstrates that the success or failure of utilising SSPV and BESS as a resilience option, will ultimately depend on human behaviour, not the technical capability of the network or the take-up rate of the technology. Whilst these factors are important, they could be achieved independently, with household behaviours rendering them ineffective. Irrespective of stated intentions to share, actual behaviour in the aftermath of a disaster could be quite different from the stated intension. R401s position typifies this contradiction, highlighting the challenges that the intention-behaviour gap exposed might present, stating, '*why does a group of people doing the right thing need to support people who can't be bothered. Remember, God helps those who help themselves, God help those who don't*'.

References

Abron, P., Steenkamp, M., Cornell, V., Cusack, L. and Gebbie, K. 2016. Measuring disaster resilience in communities and households: Pragmatic tools developed in Australia. *International Journal of Disaster Resilience in the Built Environment*, vol. 7, no. 2, p.p. 201-215.

Abron, P. 2014. Developing a model and tool to measure community disaster resilience. Disaster Resilient Australia: Get Ready. *Australian Journal of Emergency Management,* vol. 29, no. 4, p.p. 12-16.

Agnew, S., Smith, C. and Dargusch, P. 2018. Casual loop modelling of residential solar and battery adoption dynamics: A case study of Queensland, Australia. *Journal of Cleaner Production*, vol. 172, p.p. 2363-2373.

Agnew, S. and Dargusch, P. 2017. Consumer preferences for household-level battery energy storage. *Renewable and Sustainable Energy Reviews*, vol. 75, p.p. 609-617.

Agnew. S. and Dargusch, P. 2015. Effect of residential solar and storage on centralized electricity supply systems. *Nature Climate Change*, vol. 5, p.p. 315318.

Ajzen, I., Brown, T. C. and Carvajal, F. 2003. Explaining the discrepancy between intentions and actions: The case of hypothetical bias in contingent valuation. *Personality and Social Psychology Bulletin*, vol. 30, no. 9, p.p. 1108-1121.

Ajzen, I. and Fishbein, M. 1980. *Understanding Attitudes and Predicting Social Behaviour.* Prentice-Hall. New Jersey, USA.

Aldrich, D. P. and Meyer, M. A. 2015. Social capital and community resilience*. American Behavioural Scientist,* vol. 59, no. 2, p.p. 254-269.

Anda, M. and Temmen, J. 2014. Smart metering for residential energy efficiency: The use of community based social marketing for behaviour change and smart grid introduction. *Renewable Energy*, vol. 67, p.p. 119-127.

Antoun, C., Couper, M. P. and Conrad, F. G. 2017. Effects of mobile versus PC web on survey response quality: A crossover experiment in a probability web panel. *Public Opinion Quarterly*, vol. 81, no. S1, p.p. 280-306.

Antoun, C., Katz, J., Argueta, J. and Wang, L. 2018. Design heuristics for effective smartphone questionnaires. *Social Science Computer Review*, vol. 36, no. 5, p.p. 557-574.

AusNet Services. 2018. *Sharing Solar with Neighbours Keeps the Lights on*. 7 March 2018 Viewed online on 7th March 2018 at https://www.ausnetservices.com.au/Misc-Pages/Links/About-Us/News-Room/News-Room-2018/Sharing-Solar-with-Neighbours-Keeps-the-Lights-on

Australian Bureau of Statistics (ABS). 2016. Dwellings – Dwelling Structure. *2016 Census QuickStats.* Viewed online on 1st January 2019 at: http://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/3?opendocument

Australian PV Institute. 2019a. *Mapping Australian Photovoltaic installations*. Viewed online at: http://pv-map.apvi.org.au/historical#6/-20.082/137.114

Australian PV Institute. 2019b. *Australian PV Installations 2007-Present*. Viewed online on 24th March 2019 at: http://pv-map.apvi.org.au/animation

Australia's Guide. 2016. *Australia's Guide Queensland Geography*. Viewed online on 1st January 2019 at: https://www.australias.guide/qld/geography/

Aijazi, O. 2015. Social repair and structural inequity: Implications for disaster recovery practice. *International Journal of Disaster Resilience in the Built Environment*, vol. 6, no. 4, p.p. 454-467.

Bell, W. P. and Foster, J. 2017. Using solar PV feed-in tariff policy history to inform a sustainable flexible pricing regime to enhance the diffusion of energy storage and electric vehicles. *Journal of Bioeconomics*, vol. 19, p.p. 127-145.

Bie, Z, Lin, Y., Li, G. and Li, F. 2017. Battling the extreme: A study on the power of system resilience. *Proceedings of the IEEE*, vol. 105, no. 7, p.p. 1253-1266.

BloombergNEF (BNEF). 2019. Australia to Be Largest Residential Storage Market in 2019. *Bloomberg Finance*. 22 January 2019. Viewed online on 22nd January 2019 at: https://about.bnef.com/blog/australia-largest-residential-storage-market-2019/

Brennan, M. A., Barnett, R. V. & Baugh, E. 2007. Youth involvement in community development: Implications and possibilities for extension. *Journal of Extension*, vol. 45, no. 4.

Burger, J. and Gochfeld, M. 2014. Perceptions of personal and governmental actions to improve responses to disasters such as Superstorm Sandy. *Environmental Hazards*, vol. 13, no. 3, p.p. 200-210.

Chamlee-Wright, E. and Storr, V. H. 2011. Social capital as collective narratives and post-disaster community recovery. *The Sociological Review*, vol. 59, no. 2, p.p. 266-282.

Carrington, M. J., Neville, B. A. and Whitwell, G. J. 2014. Lost in translation: Exploring the ethical consumer intention-behaviour gap. *Journal of Business Research*, vol. 67, no. 1, p.p. 2759-2767.

Chitnis, M. and Sorrell, S. 2015. Living up to expectations: estimating direct and indirect rebound effects for UK households. *Energy Economy*, vol. 52, p.p. 100-116.

Colmar Brunton. 2019. *Queensland Household Energy Survey Report 2018.* Insights Report. Viewed online on 8th April 2019 at: https://www.talkingenergy.com.au/33323/documents/102571

Colten, C. E., Kates, R. W. and Laska, S. B. 2008. Community resilience: lessons from New Orleans and Hurricane Katrina. *Community and Regional Resilience Initiative Research Report 3.* Viewed online on 28th November 2018 at: http://resilientus.org/wp-content/uploads/2013/03/FINAL_COLTEN_9-25-08_1223482263.pdf

Cook, C., Heath, F. and Thompson, R.L. 2000. A meta-analysis of response rates in web- or internet-based surveys. *Educational and Psychological Measurement*, vol. 60, no. 6, p.p. 821-836.

Couper, M.P. 2000. Web surveys – A review of issues and approaches. *Public Opinion Quarterly*, vol. 64, p.p. 464-494.

Cox, R. S. and Perry, K. E. 2011. Like a fish out of water: Reconsidering disaster recovery and the role of place and social capital in community disaster resilience. *American Journal of Community Psychology*, vol. 48, p.p. 395-411.

Cutter, S. L., Burton, C. G. and Emrich, C. T. 2010. Disaster resilience indicators for benchmarking baseline conditions. *Journal of Homeland Security and Emergency Management*, vol. 7, no. 1, article 51.

Davies, J., Foxall, G. and Pallister, J. 2002. Beyond the intention-behaviour mythology: an integrated model for recycling. *Marketing Theory*, vol. 2, p.p. 29-113.

Deloitte. 2016. The economic cost of the social impact of natural disasters. *Deloitte Access Economics*. Australian Business Roundtable for Disaster Resilience and Safer Communities. Viewed online on 24th November 2018 at: http://australianbusinessroundtable.com.au/assets/documents/Report%20-%20Social%20costs/Report%20-%20The%20economic%20cost%20of%20the%20social%20impact%20of%20natural%20disasters.pdf

Deng, G. and Newman, P. 2017. Assessing the impact of solar PV on domestic electricity consumption: Exploring the prospect of rebound effects. *Energy Policy*, vol. 110, p.p. 313-324.

Deutschlander, C. 2009. *Surveying Fundamentals for Business Analysts*. Management Concepts Incorporated, Vienna, VA, USA.

Edwards, M. L. 1993. Social location and self-protective behaviour: Implications for earthquake preparedness. *International Journal of Mass Emergencies and Disasters*, vol. 11, p.p. 293-303.

Egli, D. S. 2013. Beyond the storms: Strengthening preparedness, response, & resilience in the 21st Century. *Journal of Strategic Security*, vol. 6, no. 2, p.p. 32-45.

Energy Queensland Limited (EQL). 2018. *Energising Queensland Communities: Energy Queensland Annual Report 2017-18*. Viewed online on 21st October 2018 at: www.energyq.com.au/annualreport

Engel, C. 2011. Dictator games: a meta study. *Experimental Economics*, vol. 14, no. 4, p.p. 583-610.

Ergon Energy and Energex (Ergon & Energex). 2019. *An Overview: Our Regulatory Proposals 2020-25.* January 2019. Viewed online on 31st January 2019 at: https://www.talkingenergy.com.au/39176/documents/96904

Ergon Energy. 2018. *Distribution Annual Planning Report 2018-19 to 2022-23*. Viewed online on 11th November 2018 at: https://www.ergon.com.au/__data/assets/pdf_file/0018/720234/Ergon-DAPR-2018.pdf

Fahey, C. 2003. Working with communities' to 'build social capital' – Reflecting on old and new thinking about volunteers. *The Australian Journal of Emergency Management*, vol, 18, no. 4, p.p. 12-17.

Fan, W. and Yan, Z. 2010. Factors affecting response rates of the web survey: A systematic review. *Computers in Human Behaviour*, vol. 26, p.p. 132–139.

Fisher, R. J. 1993. Social desirability bias and the validity of indirect questioning. *Journal of Consumer Research*, vol. 20, no. 2, p.p. 303-315.

Frank, P. 2018. Me, my family or the public good? Do inter-role conflicts of consumer-citizens reduce their ethical consumption behaviour? *International Journal of Consumer Studies*, vol. 42, p.p. 306-315.

Frederiks, E.R., Stenner. K. and Hobman, E. V. 2015. Household energy use: Applying behavioural economics to understand consumer decision-making and behaviour. *Renewable and Sustainable Energy Reviews*, vol. 41, p.p. 1385-1394.

Friel, B. 2005. Building social capital. *Government Executive*, vol. 37, no, 18, p. 82. *Floodlines*. State Library Queensland (SLQ), Brisbane, Australia.

Fricker, R.D. and Schonlau, M. 2002. Advantages and disadvantages of Internet research surveys: Evidence from the literature. *Field Methods*, vol. 14, p.p. 347-367.

Fukuyama, F. 2000. Social capital and civil society. *International Monitory Fund*, Working Paper WP/00/74. Viewed online on 24th November 2018 at: https://poseidon01.ssrn.com/delivery.php?ID=420125003002078012090012082066119092064020034023025001122048124043078114096008114041102095090094120074100006041048042005064000071028080017105024072088009073022108084092069118087078102006021028073&EXT=pdf

Gao, H., Chen, Y., Xu, Y. and Liu, C. C. 2016. Resilience-oriented critical load restoration using microgrids in distribution systems. *IEEE Transactions on Smart Grid*, vol. 7, no. 6, p.p. 2837-2848.

George, N. 2013, 'It was a town of friendship and mud': 'flood talk', community and resilience. *Australian Journal of Communication*, vol. 40, no. 1, p.p. 41-56.

Ghanem, D. A., Mander, S. and Gough, C. 2016. "I think we need to get a better generator": Household resilience to disruption to power supply during storm events. *Energy Policy*, vol. 92, p.p. 171-180.

Gholami, A., Shekari, T., Aminifar, F. and Shahidehpour, M. 2016. Microgrid scheduling with uncertainty: the quest for resilience. *IEEE Transactions on Smart Grid*, vol. 7, no. 6, p.p. 2849-2858.

Giddings, B. and Park, M., 2012. Eco-efficiency rebound effects associated with household energy using products. In: Israsena, P., Tangsantikul, J., Durling, D., (Eds.) Proceedings of Design Research Society 2102, vol. 2, p.p. 623–639.

Glaser, P. 2012. Respondents Cooperation: Demographic Profile of Survey Respondents and Its Implication. In: Gideon L. (eds) *Handbook of Survey Methodology for the Social Sciences*. Springer, New York, NY.

Grootaert, C. 1998. Social capital: the missing link? *The World Bank Social Development Family Environmentally and Socially Sustainable Development Network*. Social Capital Initiative Working Paper No. 3. Viewed online on 24th November 2018 at: http://siteresources.worldbank.org/INTSOCIALCAPITAL/Resources/Social-Capital-Initiative-Working-Paper-Series/SCI-WPS-03.pdf

Grimmer, M. and Miles, M.P. 2016. With the best of intentions: a large sample test of the intention-behaviour gap in pro-environmental consumer behaviour. *International Journal of Consumer Studies*, vol. 14, p.p. 2-10.

Hall. E., Sanchez. T., Stephenson. R., Stein, A. D., Sineath, R. C., Zlotorzynska, M. and Sullivan, P. 2019. Randomised controlled trial of incentives to improve online survey completion among internet-using men who have sex with men. *Journal of Epidemiology Community Health*, vol. 73, p.p. 156-161.

Havas, L., Ballweg, J., Penna, C. and Race, D. 2015. Power to change: Analysis of household participation in a renewable energy and energy efficiency programme in Central Australia. *Energy Policy*, vol. 87, p.p. 325-333.

Hedges. A. 2008. *Random Number Generator/Picker.* https://andrew.hedges.name/experiments/random/

Joerin, J., Shaw, R., Takeuchi, Y. and Krishnamurthy, R. 2012. Assessing community resilience to climate-related disasters in Chennai, India. *International Journal of Disaster Risk Reduction*, vol. 1, p.p. 44-54.

Jongerden, M. R., Huls, J., Remke, A. and Haverkort, B. R. 2016. Does your domestic photovoltaic energy system survive grid outages? *Energies*, vol. 9, no. 736, p.p. 1-17.

Iarossi, G. 2006. *Power of Survey Design: A User's Guide for Managing Surveys, Interpreting Results, and Influencing Respondents.* World Bank Publications. Viewed online on 14th October 2018 at: http://ebook.central.proquest.com./lib/murdoch/detail.action?docID=459526

International Institute of Business Analysis (IIBA). 2006. *A Guide to the Business Analysis Body of Knowledge*, p. 177.

Irwin, C. W., & Stafford, E. T. (2016). *Survey methods for educators: Collaborative survey development (part 1 of 3),* (REL 2016–163). Washington, DC: U.S.

Keusch, F. 2012. How to increase response rates in list-based web survey samples. *Social Science Computer Review*, vol. 30, no. 3, p.p. 380-388.

Krumpal, I. 2013. Determinants of social desirability bias in sensitive surveys: a literature review. *Quality and Quantity*, vol. 47, no. 4, p.p. 2025-2047.

Lang, P. 2012. *Social Desirability and Environmental Valuation*. New edition. Chapter 3 – Social desirability. *JSTOR.* Viewed online at: www.jstor.org/stable/j.ctv9hj9w7

Lavrakas, P. J. (2008). *Encyclopedia of survey research methods* Thousand Oaks, CA: Sage Publications, Inc., doi: https://dx-doi-org.libproxy.murdoch.edu.au/10.4135/9781412963947

Leslie, L. L. 1972. Are high response rates essential to valid surveys? Social Science Research, vol. 1, no. 3, p.p. 323-334.

Leygue, C., Ferguson, E., Skatova, A. and Spence. A. 2014. Energy sharing and energy feedback: affective and behavioural reactions to communal energy displays. *Frontiers in Energy Research*, vol, 2, article 29, p.p. 1-12.

Linnenluecke, M. K. and McKnight, B. 2017. Community resilience to natural disasters: the role of disaster entrepreneurship. *Journal of Enterprising Communities: People and Places in the Global Economy*, vol. 11, no. 1, p.p. 166-185.

Linnenluecke, M. and Griffiths, A. 2010. Beyond adaptation: Resilience for business in light of climate change and weather extremes. *Business and Society*, vol. 49, no. 3, p.p. 477-511.

Luden, S. M., Rohaizat, M. and Arbon, P. 2017. The association between social cohesion and community disaster resilience; A cross-sectional study. *Health and Social Care in the Community*, p.p. 1-11.

Mahmood, D., Javaid, N., Ahmed, I., Alrajeh, N., Niaz, I. A. and Khan, Z. A. 2017. Multi-agent-based sharing power economy for a smart community. *International Journal of Energy Research*, vol. 41, p.p. 2074-2090.

Manfreda, K. L., Bosnjak, M., Berzelak, J., Haas, I., & Vehovar, V. 2008. Web surveys versus other survey modes. *International Journal of Market Research*, vol. 50. p.p. 79–104.

Masud-All-Kamal, M. D. and Monirul Hassan, S. M. 2018. The link between social capital and disaster recovery: evidence from coastal communities in Bangladesh. *Natural Hazards*, vol. 93, p. p. 1547–1564.

Matthews, E. 2016. Neighbourly sharing: mini-grid in Mooroolbark. *Renew*. 1 October 2016. Viewed online on 23rd March 2019 at: https://renew.org.au/renew-magazine/solar-batteries/5730/

McLennan, B. and Handmer, J. 2014. Sharing responsibility in Australian disaster management: Final report for the sharing responsibility project. *Bushfire Corporative Research Centre,* RMIT University. Viewed online on 21st January 2019 at: http://www.bushfirecrc.com/sites/default/files/sharingresponsibilityfinal_report.pdf

Miles, S. B. 2015. Foundations of community disaster resilience: Well-being, identity, services and capitals. *Environmental Hazards*, vol. 14, no. 2, p.p. 103-121.

Montoya, M., Sherick, R., Haralson, P., Neal, R. and Yinger,R. 213. Islands in the storm. *IEEE Power and Energy Magazine*, July-August 2013, p.p. 33-39.

Morley, P., Russell-Smith, J., Sangha, K. K., Sutton, S. and Sithole, B. 2018. Evaluating resilience in two remote Australian communities. *Procedia Engineering*, vol. 121, p.p. 1257-1264.

Muller, S. C. and Welpe, I. M. 2018. Sharing electricity storage at the community level: An empirical analysis of potential business models and barriers. *Energy Policy*, vol. 118, p.p. 492-503.

Murphy, B. L. 2007. Locating social capital in resilient community-level emergency management. *Natural Hazards*, vol. 41, p.p. 297-315.

Nair, C. S. & Adams, P. 2009. Survey platform: A factor influencing online survey delivery and response rate. *Quality in Higher Education*, vol. 15, no. 3, p.p. 291-296.

Norris, F. H., Stevens, S. P., Pfefferbaum, B. Wyche, K. F. and Pfefferbaum, R. L. 2008. Community resilience as a metaphor, theory, set of capabilities, and strategy for disaster readiness. *American Journal of Community Psychology*, vol. 41, p.p. 127-150.

OECD. 2019. *Environmental Performance Reviews Australia*. Viewed online on 23rd March 2019 at: http://oe.cd/epr-australia

Okafor, E. 2010. Dynamic islanding improving electric service reliability with energy storage. *American Electric Power*. Proceedings of the paper presented at the Sandia National Laboratories. Viewed online on 1st March 2019 at: https://www.sandia.gov/ess-ssl/docs/pr_conferences/2010/okafor_aep.pdf

Opdyke, A., Javernick-Will, A. and Koschmann, M. 2017. Infrastructure hazard resilience trends: an analysis of 25 years of research. *Natural Hazards*, vol. 87, p.p. 773-789.

Palizban, O., Kauhaniemi, K. and Guerrero, J. M. 2014. Microgrids in active network management – Part I: Hierarchical control energy storage, virtual power plants, and market participation. *Renewable and Sustainable Energy Reviews*, vol. 36, p.p. 428-439.

Pantelli, M. and Mancarella, P. 2015. Influence of extreme weather and climate change on the resilience of power systems: Impacts and possible mitigation strategies. 2015. *Electric Power Systems Research*, vol. 127, p.p. 259-270.

Panteli, M., Trakas, D. N., Mancarella, P. and Hatziargyriou, N. D. 2017. Power system resilience assessment: Hardening and smart operational enhancement strategies. *Proceedings of the IEEE,* vol. 105, no. 7, p.p. 1202-1213.

Papies, E. K. 2017. Situating interventions to bridge the intention-behaviour gap: A framework for recruiting nonconscious processes for behaviour change. *Social Personal Psychological Compass*, vol. 11, p.p. 1-19.

Paraschiv, D. C. 2013. Timing in a web based survey: An influential factor of the response rate. *The Proceedings of the International Conference "Marketing - from Information to Decision*, 6th ed, p.p. 200-209.

Pazzaglia, A. M., Stafford, E. T., & Rodriguez, S. M. 2016. *Survey methods for educators: Analysis and reporting of survey data (part 3 of 3),* (REL 2016–164). Washington, DC: U.S.

Petkovic, M. 2018. Queensland solar is booming and pushing down daytime electricity prices. *Renew Economy*. 31st October 2018. Viewed on 31st October 218 at: https://reneweconomy.com.au/queensland-solar-is-booming-and-pushing-down-daytime-electricity-prices-87209/

Petrovcic, A., Petric, G. & Manfreda, K. L. 2016. The effect of email invitation elements on response rate in a web survey within an online community. *Computers in Human Behaviour*, vol. 56, p.p. 320-329.

Qi, W., Shen, B., Zhang, H. & Shen, Z. J. M. 2017. Sharing demand-side energy resources: a conceptual design. *Energy*, vol. 135, p.p. 455-465.

Queensland Fire and Emergency Service (QFES). 2017. *Queensland State Natural Hazard Risk Assessment 2017*. Part A. 30 June 2017. Viewed online on 21st October 2018 at: https://www.disaster.qld.gov.au/cdmp/Documents/Emergency-Risk-Mgmt/QLD-State-Natural-Risk-Assessment-2017-Part-A.pdf

Queensland Government (Qld Govt). 2019a. Critical Infrastructure. *Safeguarding Queensland*. Viewed online on 23rd March 2019 at: http://www.safeguarding.qld.gov.au/criticalinfrastructure/index.htm

Queensland Government (Qld Govt). 2019b. *Queensland Disasters.* Viewed online on 23rd March 2019 at: https://www.qld.gov.au/community/disasters-emergencies/queensland-disasters

Queensland Government (Qld Govt.). 2019c. *Energy Concessions – Solar for rentals trial*. Viewed online on 1st March 2019 at: https://www.qld.gov.au/community/cost-of-living-support/concessions/energy-concessions/solar-for-rentals-trial

Queensland Government (Qld Govt). 2018. *Interest free loans for solar and storage – about the program*. https://www.qld.gov.au/community/cost-of-living-support/concessions/energy-concessions/solar-battery-rebate/about-the-program

Queensland Government (Qld Govt.). 2017. *Queensland Strategy for Disaster Resilience: Making Queensland the Most Disaster Resilient State in Australia*. Viewed online on 24th March 2019 at: https://www.qra.qld.gov.au/sites/default/files/2018-10/queensland_strategy_for_disaster_resilience_2017_0.pdf

Rathnayaka, A. J. D, Potdar, V. M., Dillon, T. and Kuruppa, S. 2018. Framework to manage multiple goals in community-based energy sharing networks in smart grid. *Electrical Power and Energy Systems*, vol. 73, p.p. 615-624.

Rich, J. L., Chojenta, C. and Loxton, D. 2013. Quality, rigour and usefulness of free-text comments collected by a large population based longitudinal study – ALSWH*. PLoS ONE,* vol. 8, no. 7.

Rivera, J. D. and Nickels, A. E. 2014. Social capital, community resilience, and faith-based organizations in disaster recovery: a case study of Mary Queen of Vietnam Catholic Church. *Risk, Hazards and Crisis in Public Policy*, vol. 5, no. 3, p.p. 178-211.

Ryan, K., Gannon-Slater, N. and Culbertson, M. J. 2012. Improving survey methods with cognitive interviews in small- and medium-scale evaluations. *American Journal of Evaluation*, vol. 33, p.p. 414-430.

Sauermann, H. and Roach, M. 2013. Increasing web survey response rates in innovation research: An experimental study of static and dynamic contact design features. *Research Policy,* vol. 42 p.p. 273– 286.

Sauro, J. 2016. 9 Biases that affect survey responses. *Measuring U – Survey Biases*. Viewed online on 20th March 2019 at: https://measuring.com/survey-biases/.

Sekitou, M., Tanaka, K. and Managi, S. 2018. Household electricity demand after the introduction of solar photovoltaic systems. *Economic Analysis and Policy*, vol. 57, p.p. 102-110.

Shang, D. 2017. Pricing of emergency dynamic microgrid power service for distribution resilience enhancement. *Energy Policy*, vol. 111, p.p. 321-335.

Shaw-Williams, D., Susilawati, C. and Walker, G. 2018. Value of residential investment in photovoltaics and batteries in networks: A techno-economic analysis. *Energies*, vol. 11, p.p. 1022-1047.

Sheeran, P. and Webb, T. L. 2016. The intention-behaviour gap. *Social and Personality Psychology Compass*, vol. 10, no. 9, p.p. 503-518.

Siganto, T. 2019. 'Summer of disasters' reveals the cost of climate change for Queensland taxpayers. *ABC News Online*. Viewed online on 6th April 2019 at: https://www.abc.net.au/news/2019-02-19/climate-change-and-the-cost-of-qlds-summer-of-disasters/10826122

Singh-Peterson, L., Salmon, P., Baldwin, C. and Goode, N. 2015. Deconstructing the concept of shared responsibility for disaster resilience: A Sunshine Coast case study, Australia. *Natural Hazards*, vol. 79, p.p. 755-774.

Skopik, f. 2014. The social smart grid: Dealing with constrained energy resources through social coordination. The Journal of Systems and Software, vol. 89, p.p. 3-18.

Snape, J. R., Irvine, K. N. and Rynikiewicz, C. 2011. Understanding energy behaviours and transitions through the lens of a smart grid Agent Based Model. *Energy efficiency first: The foundation of a low-carbon society - Proceeding of ECEEE 2011 Summer Study*. ECEEE, p.p.1919–1930

Soetanto, R., Mullins, A. and Achour, N. 2017. The perceptions of social responsibility for community resilience to flooding: the impact of past experience, age, gender and ethnicity. *Natural Hazards,* vol, 86, p.p. 1105-1126.

Su, W., Liu, M., Zeng, S., Streimikiene, D., Balezentis, T. and Alisauskaite-Seskiene, I. 2018. Valuating renewable microgeneration technologies in Lithuanian households: A study on willingness to pay. *Journal of Cleaner Production*, vol. 191, p.p. 318-329.

Tarhan, C., Aydin, C. and Tecim, V. 2016. How can disaster resilience be built using sustainable development? *Procedia Social and Behavioural Sciences*, vol. 216, p.p. 452-459.

The State of Queensland (Queensland Treasury). 2019a. *Population growth, Queensland, September quarter 2018*. Queensland Government Statistician's Office. Viewed online on 24th march 2019 at: http://www.qgso.qld.gov.au/products/reports/pop-growth-qld/pop-growth-qld-201809.pdf

The State of Queensland (Queensland Treasury). 2019b. *Queensland Thematic Maps – Population Estimates*. Viewed online on 24th March at: https://statistics.qgso.qld.gov.au/qld-thematic-maps

The State of Queensland (Queensland Treasury). 2018. Population by age and sex, regions of Queensland 2017. *Queensland Government Statistician's Office*. Viewed online on 18th December 2018 at: http://www.qgso.qld.gov.au/products/reports/pop-age-gender-reg-qld/pop-age-gender-reg-qld-2017.pdf

The State of Queensland (Department of the Premier and Cabinet). 2017. *More Jobs for Queensland with Higher Growth*. Media Statement. Viewed online on 18th December 2018 at: http://statements.qld.gov.au/Statement/2017/6/13/more-jobs-for-queensland-with-higher-growth

Walton, R. 2015. Residential energy storage: The industry's next big thing. *Utility Drive*, Deep Dive. Viewed online on 23rd March 2019 at: https://www.utilitydive.com/news/residential-energy-storage-the-industrys-next-big-thing/406789/

Wang, Y., Chen, C., Wang, J. and Baldick, R. 2016. Research on resilience of power systems under natural disasters – a review. *IEEE Transactions on Power Systems*, vol. 31, no. 2, p.p. 1604-1613.

Willis, G. B. 2016. Questionnaire pretesting. In Wolf, C., Joye, D., Smith, T. W., & Fu, Y. *The SAGE Handbook of Survey Methodology,* p.p. 359-381. London.

Witvorapong, N., Muttarak, R. and Pothisiri, W. 2015. Social participation and disaster risk reduction behaviours in Tsunami prone areas. *PLoS ONE*, vol. 10, no. 7, p.p. 1-20.

Wolsink. M. 2012. The research agenda on social acceptance of distributed generation in smart grids: Renewable as common pool resources. *Renewable and Sustainable Energy Reviews*, vol. 16, p.p. 822-835.

WordItOut. 2019. *Word Cloud Creator*. Created online on 24th February at: https://worditout.com/word-cloud/3631562/private/4f87f82db062b30a1e1c57a1eac415c9

Yamagata, Y., Murakami, D., Minami, K., Arizumi, N., Kuroda, S., Tanjo, T. and Maruyama, H. 2017. Electricity self-sufficient community clustering for energy resilience. *Energies*, vol. 9, no. 543, p.p. 1-13.

Yamamura, E. 2010. Effects of interactions among social capital, income and learning from experiences of natural disasters: A case study from Japan. *Journal of Regional Studies,* vol. 44, no. 8, p.p. 1019-1032.

Yazdaine, M., Densing, M. and Wokaun, A. 2018. The nationwide characterisation and modelling of local energy systems: Quantifying the role of decentralised generation and energy resources in future communities. *Energy Policy*, vol. 118, p.p. 516-533.

Yilmaz, K. 2013. Comparison of quantitative and qualitative research traditions: epistemological, theoretical, and methodological differences. *European Journal of Education*, vol. 48, no. 2, p.p. 311-325.

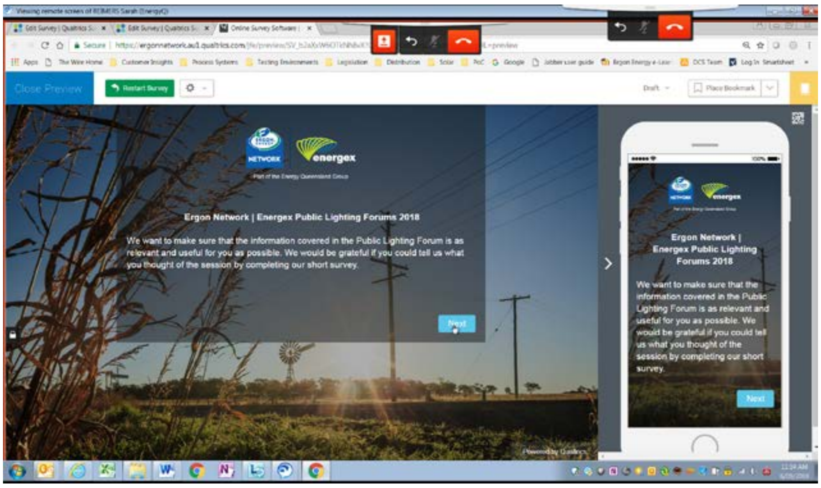
Yunshu, F., Gold, J. I. and Long, D. 2018. Ongoing, rational calibration of reward-driven perceptual biases. *eLife*, vol. 7, p.p. 1-26.

Zhou, Y., Panteli, M., Moreno, R. and Mancarella, P. 2018. System-level assessment of reliability and resilience provision from microgrids. *Applied Energy*, vol. 230, p.p. 274-392.

Zhou, Y., Wu, J. and Long, C. 2018. Evaluation of peer-to-peer energy sharing mechanisms based on a multiagent simulation framework. *Applied Energy*, vol. 222, p.p. 993-1022.

Appendices

Appendix 1 – Research Survey Questions



Technology and community resilience

Solar, batteries and home energy management systems are increasingly giving Queenslander's greater flexibility and choice in how they access and use energy.

In the future these new technologies could also boost the resilience of our communities by giving us options to maintain and safely restore the power supply when there is damage to our electricity network from cyclones, severe storms, major flooding and other events.

We'd like to learn what you think about Ergon Energy and Energex tapping into these technologies, which are owned by our customers, to support the security and reliability of the local power supply and, ultimately, the resilience of your community.

As a thank you for completing this survey, we'll put you into the draw to win one of six $50 Visa Debit Gift Cards. *Terms and conditions.

This initiative is being conducted in partnership with Murdoch University. Learn more here.

You can find out more about integrated solar photovoltaic (PV) and battery storage systems here.

The survey will only take you around 10 minutes to complete. Taking part in this research survey is voluntary and you can stop taking part at any time without explanation or prejudice. Clicking on the 'Take the Technology and Community Resilience Survey' button below indicates your consent to participate in this survey. If at any time you do not wish to continue with the survey, just close the browser window to exit.

Thank you in advance. And good luck with the prize draw.

Take the Technology and Community Resilience Survey

Technology and Community Resilience Survey

1 — 2 — 3 — 4 — 5 — 6

Q1. What is your postcode?

* If postcode entered outside Qld, the following will appear in a window.

We would like to thank you for your interest in our survey.

You have indicated you are not a resident of Queensland. Unfortunately, the survey is only open to Queensland residents.

Q2. Which one of the following age groups do you fall into?

- ☐ Under 18 years
- ☐ 18 – 19
- ☐ 20 – 24
- ☐ 25 – 29
- ☐ 30 – 34
- ☐ 35 – 39
- ☐ 40 – 44
- ☐ 45 – 49
- ☐ 50 – 54
- ☐ 55 – 59
- ☐ 60 – 64
- ☐ 65 – 69
- ☐ 70 – 74
- ☐ 75 – 79
- ☐ 80 – 84
- ☐ 85 – 89
- ☐ 90 or above
- ☐ Prefer not to answer

* If age entered is 'Under 18 years', the following will appear in a window.

We would like to thank you for your interest in our survey.

You have indicated you are less than 18 years of age. Unfortunately, the survey is only open to Queensland residents over 18 years of age.

Q3. Are you a resident or a resident and business operator? SELECT ALL THAT APPLY

- ☐ Residential customer
- ☐ Small business customer (electricity bill less than $15,000 per year)
- ☐ Medium or large business customer (electricity bill greater than $15,000 per year)

Q4. What are the benefits that electricity provides that you miss most, or are most important to you, when waiting for the power to be restored during an outage? SELECT YOUR TOP TWO

- ☐ Basic services (refrigeration, cooking, hot water, water supply, etc.)
- ☐ Business outcomes and productivity (as relevant)
- ☐ Comfort (fans, air conditioning, heating, etc)
- ☐ Connectivity (internet & telecommunications)
- ☐ Entertainment (television, music, etc)
- ☐ Lighting and security
- ☐ Pool and spa pumps
- ☐ Other please specify

Q5a. Have you ever experienced an extended power outage following damage to the electricity network from a cyclone, severe storms or major flooding? SELECT ONE

- ☐ Yes
- ☐ No
- ☐ Can't recall

*Question only for those who answer 'yes' to Q5a.

Q5b. If yes, let us know a little about your experience.

____

____

____

Q6. Generally, how would you rate the importance you place on helping others in your local community?

0 Not at all important	1	2	3	4	5	6	7	8	9	10 Extremely important
○	○	○	○	○	○	○	○	○	○	○

Q6a. Do you have any of the following in your home or business? SELECT ALL THAT APPLY

- ☐ Solar panels (solar PV)
- ☐ Another renewable energy source (wind turbine. etc)
- ☐ Integrated battery energy storage system
- ☐ Mobile or back-up generator
- ☐ No, I don't have any of these

*Question only for those who selected 'Yes' in question 5a and 'mobile or back-up generator' in question 6a.

Q6b. Have you ever used your mobile or back-up generator to support your neighbours following a natural disaster or other extended outage?

- ☐ Yes, I have 'connected' a neighbour's essential items to our back-up power supply
- ☐ Yes, I have rostered my mobile generator around the neighbourhood (to keep freezers cold)
- ☐ Yes, I have invited neighbours to do basic activities, like use the fridge, at our house/business
- ☐ No, I have not shared the generator

*Question only for those who selected 'No' in question #6a.

Q6c. How likely are you to purchase an integrated solar and battery system in the future?

0 Not likely at all	1	2	3	4	5	6	7	8	9	10 Extremely likely
○	○	○	○	○	○	○	○	○	○	○

*Question only for those who selected 'No' in question #6a.

Q6d. How much would you expect to pay for an integrated <u>solar</u> and <u>battery</u> system to meet your premise's daily needs? SELECT ONE

- ☐ Up to $5,000
- ☐ Between $5,000 and $10,000
- ☐ Between $10,000 and $15,000
- ☐ Between $15,000 and $20,000
- ☐ Between $20,000 and $25,000
- ☐ More than $25,000

*Question only for those who do not currently have a system Q6a.

Q7. What do you see as the potential barriers to you purchasing a battery system in the future? SELECT ALL THAT APPLY

- ☐ The cost for a system is too high to achieve a reasonable financial return
- ☐ I don't have financial capacity to invest in this type of technology
- ☐ I'm a renter or live in a unit/apartment so can't install this sort of system where I live
- ☐ I don't know enough about them or know a reputable installer to know where to start
- ☐ I don't know enough about my electricity use to know if one is worthwhile
- ☐ I'm worried about the safety aspects
- ☐ I believe that the technology and the choice in brands/model will improve, so I'd rather wait
- ☐ I'm not sure how much maintenance they require and who can service them
- ☐ The tariffs available do not incentivise an investment in a system
- ☐ I have a mobile generator to provide power during interruptions
- ☐ Other, please specify

Q8a. If you have a battery system, or had one in the future, would you consider allowing Energex or Ergon Energy to access it (together with batteries from other premises) if there is problem with the power supply in your area?

- ☐ Yes, I'd be happy to share for the benefit of the community
- ☐ Yes, but only if I was paid a reward or given a credit on my bill
- ☐ Yes, but only if I had the choice to say no if it did not suit me at the time
- ☐ Yes, but only if I was paid and I could say no if it did not suit
- ☐ No

*Question only for those who answer 'yes' to be 'paid' in Q8.

Q8b. What is the minimum reward you would accept? SELECT ONE

- ☐ The normal value of the energy alone (approx. 10c/kWh)
- ☐ The same as I'm charged for my electricity (approx. 28c/kWh)
- ☐ Higher than the rate I'm charged for my electricity (more than 28c/kWh)
- ☐ The normal energy rate, plus a reward, every time my system is accessed (say between $1-5)
- ☐ A standard quarterly flat-rate regular payment even if it was not accessed (say $10-$50 a quarter)

*Question only for those who answer ‘yes’ Q8.

Q9. How long would you expect, while the storm damage repairs were underway, to share the electricity from your battery system? SELECT ONE

☐ For a couple of hours to half a day only

☐ For 1 - 2 days on and off

☐ Up to a week on and off (if it was able to recharge)

☐ For as long as required on and off (if it was able to recharge)

*Question only for those who answer ‘yes’ Q8a.

Q9. What type of electrical equipment would you be willing to avoid or reduce using to ensure you could share your battery system during disaster events? SELECT ALL THAT APPLY

☐ Lights

☐ Air conditioners

☐ Ceiling fans

☐ Computer/s, laptop/s

☐ Refrigerator/s, freezer/s

☐ Electric hot water

☐ Electric kettle, toaster

☐ Washing machine, iron, dryer

☐ Hairdryer, other personal appliances

☐ Electric oven, cooktop

☐ Television

☐ Gaming consoles

☐ Pool or spa pump

☐ Other, please state

Q11. Do you think that sharing stored electricity in battery systems should be made compulsory in disaster events for the greater good of the community?

☐ Yes

☐ No

Q12. Where do you think the electricity stored in batteries across the community should be used to best support the community during a disaster recovery?

☐ Critical infrastructure – powering hospitals, sewerage, street and traffic lights, etc.

☐ Local homes and businesses – powering my immediate neighbourhood

☐ Other, please specify

Q13. Would you like to expand on your response to any of the questions asked or share any other thoughts you have about the opportunity of using privately-owned energy storage or batteries for community resilience in the future?

Thank you for completing our research survey.

To go into the draw to win one of six $50 Visa Debit Gift Cards, **please enter your contact details here.** Terms and conditions.

Name:

Phone number:

Email:

Would you mind if we contacted you personally to explore some of your ideas further?

- ☐ Yes, I'd be happy to continue the conversation. Please use my contact details above.
- ☐ No thank-you.

SUBMIT

Appendix 2 – Research Background Letter & Competition Terms and Conditions

Research survey introductory letter

The future of energy technology and community resilience

Solar, batteries and home energy management systems are increasingly giving Queenslander's greater flexibility and choice in how they access and use energy.

In the future, these new technologies could also boost the resilience of our communities, by providing options to maintain and safely restore the power supply when there is damage to our electricity network from cyclones, severe storms, major flooding and other events.

You are invited to take part in a Queensland-based research project about emerging energy technologies, like solar PV and batteries, and how these technologies might contribute to community resilience in times of disaster.

If you agree to be involved in this research, you will be invited to complete an online survey. The survey contains questions about your views on these emerging technologies and how they might support your community's resilience in times of disaster.

The study is being conducted by Kate Austin and survey results will contribute to her Renewable Energy Dissertation project as part of the Master of Renewable Energy and Sustainability at Murdoch University. This research is supported by Energy Queensland. Kate is a Master's student at Murdoch University and an employee of Energy Queensland.

Taking part in this research survey is completely voluntary and you can stop taking part at any time without explanation or prejudice. If you do not wish to continue with the survey at any time, just close the browser window to exit.

Your responses will remain anonymous. We will only collect a limited amount of personal details and the research team (including Ergon Energy Network, Energex, Energy Queensland and Murdoch University) will only use this in a statistical manner and will not be used for any marketing or sales purposes.

If you have any questions about the research, please contact Kate Austin or Dr Farhad Shahnia.

Research Principle Investigator: Kate Austin
Email: kate.austin@energyq.com.au
Phone: (07) 4727 5708

Research Supervisor: Dr Farhad Shahnia
Email: F.Shahnia@murdoch.edu.au
Phone: (08) 9360 7429

Appendix 3 – Competition Terms and Conditions & Correspondence

Survey Competition Terms and Conditions

Terms and Conditions

1. Information on how to enter the Technology and Community Resilience Survey competition forms part of these Terms and Conditions.

2. The competition is run by Energy Queensland Limited (Energy Queensland) ABN 96 612 353 583.

3. The competition commences 8am, 15th October, 2018 and runs for 8 weeks; closing at 10pm, Sunday 9th December 2018.

4. Entry into the competition is automatic after registering on the Talking Energy site and completing the Technology and Community Resilience Survey. To be eligible, participants must be over 18 years of age and residents of Queensland.

5. A maximum of one entry is permitted per participant.

6. The prize consists of one (1) of six (6) $50 Visa gift cards, plus the cost of registered delivery to a Queensland address nominated by each winner.

7. The prize is not transferable or exchangeable and cannot be taken as cash.

8. The winners will be randomly selected at the end of the competition period.

9. The winner will be contacted via the email provided during the registration process. Delivery address details will be requested for the delivery of the prize.

10. If the prize remains unclaimed by Friday 14th December 2018, Energy Queensland may choose another winner in order to distribute the prize at its absolute discretion.

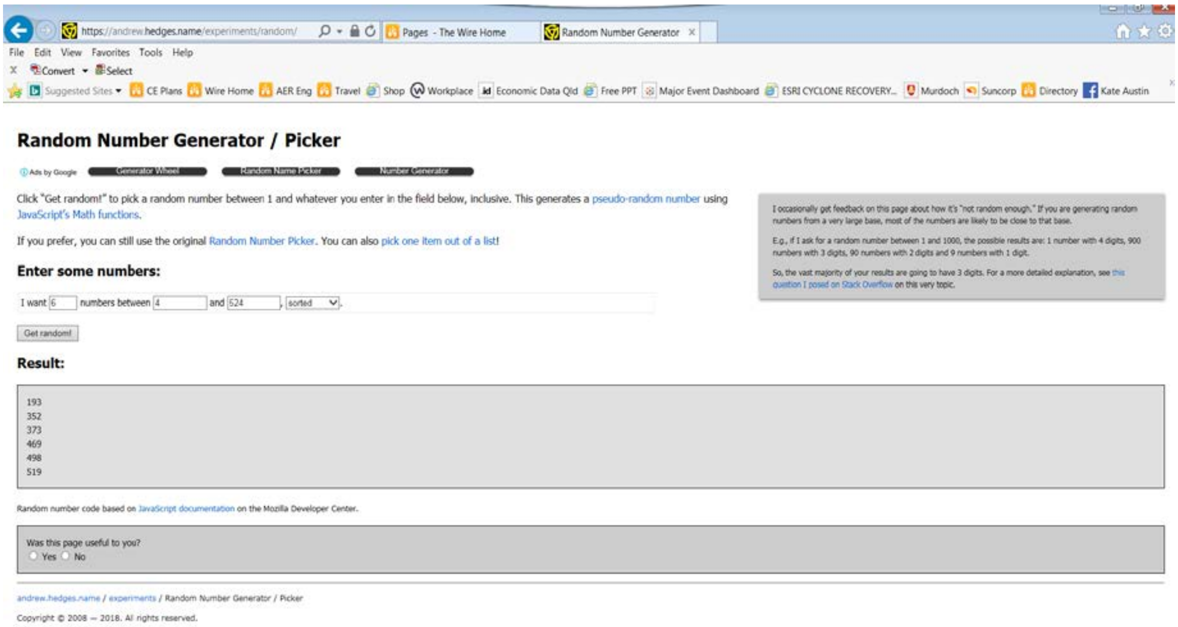
11. Energy Queensland's decision is final and binding and no correspondence will be entered into. Energy Queensland reserves the right to alter the Terms and Conditions of the competition at any time at its discretion.

12. Employees from across the Energy Queensland Group and their immediate families, and agencies and/or companies associated with this promotion are ineligible to enter. Immediate family includes spouses, defacto spouses, parents, natural or adopted children and siblings (whether natural or adopted by a parent).

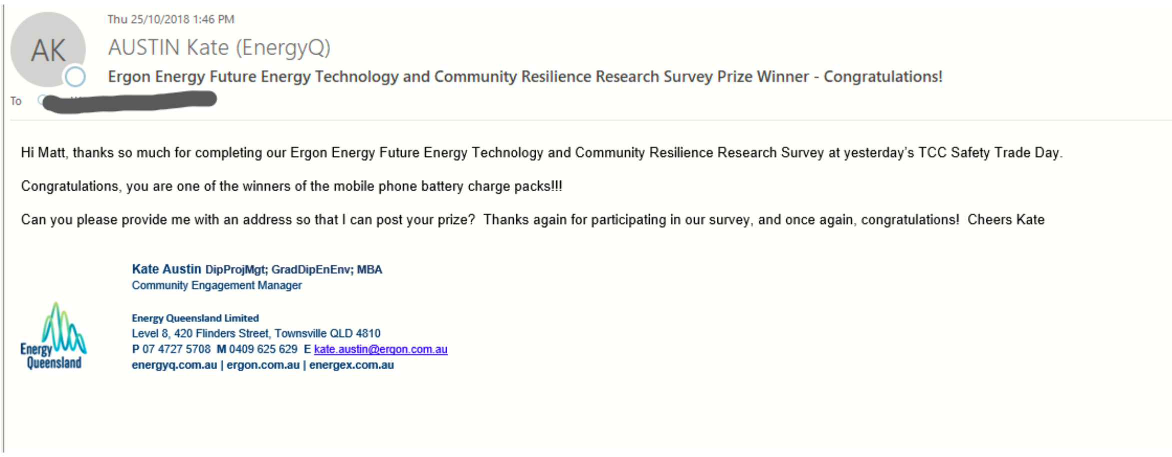
13. In no circumstances will Energy Queensland be liable for any loss, damages, loss of profit, revenue, business reputation or opportunity or other costs which may be sustained by an entrant, or any other person, in relation to this competition.

Energy Queensland Limited is collecting personal information to conduct this competition, and may for this purpose, disclose such information to third parties, including but not limited to agents, contractors, service providers and prize suppliers (and also where required by law or in accordance with the Privacy Act 1988 (Cth)). If we are not provided with all or part of the personal information requested, participants may not be able to enter the competition. Energy Queensland Limited will use and handle the personal information in accordance with Energy Queensland Limited's Privacy Policy, which is available at www.energyq.com.au(External link). All entries become the property of Energy Queensland Limited. All entrants agree that Energy Queensland Limited may use the entry for future promotional marketing, and publicity purposes, subject to the restrictions applying to use of personal information under the Privacy Act 1988 (Cth). By entering this competition, Participants agree to Energy Queensland Limited's Privacy Policy., which is available at www.energyq.com.au . Energy Queensland Limited will not disclose entrant's personal information to any entity outside of Australia.

Winners selected using an online random number generator



Notification email to a winner of an event incentive



Thu 25/10/2018 1:46 PM

AK AUSTIN Kate (EnergyQ)

Ergon Energy Future Energy Technology and Community Resilience Research Survey Prize Winner - Congratulations!

To [redacted]

Hi Matt, thanks so much for completing our Ergon Energy Future Energy Technology and Community Resilience Research Survey at yesterday's TCC Safety Trade Day.

Congratulations, you are one of the winners of the mobile phone battery charge packs!!!

Can you please provide me with an address so that I can post your prize? Thanks again for participating in our survey, and once again, congratulations! Cheers Kate

Kate Austin DipProjMgt; GradDipEnEnv; MBA
Community Engagement Manager

Energy Queensland Limited
Level 8, 420 Flinders Street, Townsville QLD 4810
P 07 4727 5708 M 0409 625 629 E kate.austin@ergon.com.au
energyq.com.au | ergon.com.au | energex.com.au

Energy Queensland

With compliments slip enclosed with battery power pack

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

ERGON ENERGY NETWORK | energex
Part of the Energy Queensland Group

The future energy technology and community resilience research survey

Hi Matt, thanks for taking part in our Future Energy Technology and Community Resilience research survey. Congratulations on being one of our lucky winners of a mobile battery pack! We thank you for your participation in our research survey and hope that you find the battery pack useful. Cheers Kate

Appendix 4 – Survey Promotion

Example of push emails to Talking Energy Subscribers

Initial survey email: Sent Monday 22nd October

Technology and community resilience survey

Dear Subscriber,

Thank you for being part of the conversation about the future of energy in Queensland.

To continue this conversation, we want to hear your views about how new energy technologies, like solar, batteries and other emerging technologies, could help when there is damage to our electricity networks from cyclones, severe storms, major flooding and other events.

We'd like to learn what you think about Ergon Energy and Energex tapping into these technologies, which are owned by our customers, to support the security and reliability of the local power supply and, ultimately, the resilience of your community.

This initiative is being conducted in partnership with Murdoch University.

Go into the $50 lucky prize draw

The survey will only take you about 10 minutes to complete. So **take the survey** today.

And as a thank you for completing this survey, we'll put you into the draw to win one of six $50 Visa Debit Gift Cards. *Terms and conditions.

Take the Technology and Community Resilience Survey

We look forward to continuing the conversation with you.

Yours truly
Ergon Energy Network and Energex

Time’s Running Out email – 1 week to go sent Friday 30th November.

Last chance to win a $50 Visa Debit Gift Card

Dear Subscriber,

Thanks for joining the conversation on the future of energy in Queensland. Over ### Queenslanders have already had their say in our Technology and Community Resilience Survey.

The survey will help inform our thinking about how the energy technologies that are owned by our customers, like solar and batteries, could support the security and reliability of the local power supply and, ultimately, the resilience of your community.

Haven’t completed the survey yet?

Take the Technology and Community Resilience Survey

If you take the **Technology and Community Resilience Survey** by Sunday, 26 November 2018, we’ll put you in the draw to win one of six $50 Visa Debit Gift Cards. *Terms and conditions.

We’re shaping the future of energy together.

Yours truly

Ergon Energy Network and Energex

Gift card winner announcement on website – Tuesday, 11th December

Talking Energy

About us | Energex site | Ergon site | Home | Search | Sign In | Register

Home » Technology & Community Resilience Survey

Technology & Community Resilience Survey

Thanks for your feedback Queensland!

Thanks for taking part in our Future Energy Technology and Community Resilience research survey. Your feedback will help to inform us about emerging energy technologies, like solar PV and batteries, and how these technologies might contribute to community resilience in times of disaster.

Congratulations too to the lucky winners of the $50 Visa debit cards. The winners are:

- Rod from Kippa-Ring
- Stewart from Flinders View
- Lee from Abergowrie
- Frank from Broadwater
- Erin from West Rockhampton
- Sharni from Ayr

The Future Energy Technology and Community Resilience survey is now closed.

The results of the survey will be available in 2019.

Who's listening

Kate Austin

Senior Community Engagement Advisor
Energy Queensland

Email kate.austin@energyq.com.au

Document Library

- Terms and Conditions (14.9 KB) (pdf)
- Research Background Letter (70.7 KB) (pdf)

Life Cycle

Survey Open
Opened 25th November 2018

Survey Closes
Midnight 9th December 2018

Survey Findings
2019

Examples of emails sent to Talking Energy subscribers and other social media and internal communications

Ergon Energy & Energex's Talking Energy platform

Talking Energy

The future of energy technology and community resilience

Dear Subscriber,

Thank you for being part of the conversation about the future of energy in Queensland. To continue this conversation, we want to hear your views about future energy technologies and community resilience to support natural disasters like cyclones, severe storms, major flooding and other events.

This survey is being conducted as part of a research piece for a Master in Renewable Energy and Sustainability. Your views are extremely valuable to us, and the information collected from this survey will inform us about emerging energy technologies, like solar PV and batteries, and how these technologies might contribute to community resilience in times of disaster.

Qualtrics, a leading customer experience provider will be conducting the survey on our behalf. The survey will take about 10 minutes to complete.

$50 Visa Debit gift card prize draw

To say thanks for helping us out with this research we are giving away six (6) $50 Visa Debit gift cards. So take the Technology and Community Resilience Survey today and you could be a $50 Visa Debit gift card winner (Terms and Conditions apply). Hurry, the survey closes at midnight on 9th December 2018.

Take the Technology and Community Resilience Survey

We look forward to continuing the conversation with you.

Yours truly
Ergon Energy Network and Energex

You're receiving this email because you are a registered participant on Talking Energy.
Powered by EngagementHQ
Unsubscribe

Talking Energy — Home | About us | Energex site | Ergon site | Search | Sign in | Register

Home » Technology & Community Resilience Survey

Technology & Community Resilience Survey

Thanks for your feedback Queensland!

Thanks for taking part in our Future Energy Technology and Community Resilience research survey. Your feedback will help to inform us about emerging energy technologies, like solar PV and batteries, and how these technologies might contribute to community resilience in times of disaster.

Congratulations too to the lucky winners of the $50 Visa debit cards. The winners are:

- Rod from Kippa-Ring
- Stewart from Flinders View
- Lee from Abergowrie
- Frank from Broadwater
- Erin from West Rockhampton
- Sharni from Ayr

The Future Energy Technology and Community Resilience survey is now closed.

The results of the survey will be available in 2019.

Who's listening
Kate Austin
Senior Community Engagement Advisor
Energy Queensland
Email kate.austin@energyq.com.au

Document Library
- Terms and Conditions (14.9 KB) (pdf)
- Research Background Letter (70.7 KB) (pdf)

Life Cycle
- Survey Open — Opened 25th November 2018
- Survey Closes — Midnight 9th December 2018
- Survey Findings — 2019

Energex and Ergon Social Media Promotion

Ergon Energy
October 24, 2018

In conjunction with Murdoch University, we're conducting a study into how tech like solar PV and batteries might contribute to community resilience in times of disaster, and we'd love to hear from you. Solar, batteries and home energy management systems are giving many Queenslanders greater flexibility and choice in how they access and use energy. In the future, these technologies could potentially boost community resilience by providing options to maintain and safely restore power supply when natural disasters or other events damage our network. What's your view?
https://bit.ly/2yv1H0q

You, Laura Males and 3 others — 2 Shares

Energex
December 6, 2018

Last chance to win a $50 Visa Debit gift card!

It's your last chance to win a $50 Visa debit gift card and join the conversation on the future of energy in Queensland with our Technology and Community Resilience Survey.

The survey will help to inform us about emerging energy technologies, like solar PV and batteries, and how these technologies might contribute to community resilience in times of disaster.

Haven't completed the survey yet? Take the Technology and Community Resilience Survey here https://bit.ly/2Uiu2QV before it closes on Sunday 9th December to be in the final draw for one of six $50 Visa Debit gift cards (Terms and Conditions apply
and can be found at https://bit.ly/2UhvanP).

4

Want to have your say on emerging technologies?

23/10/2018 12:00 AM — Customer News

Solar, batteries and home energy management systems are increasingly giving Queenslander's greater flexibility and choice in how they access and use energy.

In the future, these new technologies could also boost the resilience of our communities, by providing options to maintain and safely restore the power supply when there is damage to our electricity network from cyclones, severe storms, major flooding and other events.

We're conducting a research project in conjunction with Murdoch University and we're keen to know what Queenslanders like you think about emerging energy technologies, like solar PV and batteries. We're particularly interested to hear your thoughts on how these technologies might contribute to community resilience in times of disaster. Complete our survey and have your say.

Story Contact: AUSTIN Kate (EnergyQ)

Emergency Services Days and Community Events

Kate Austin
November 4, 2018

It was great to be able to meet so many wonderful people from the Townsville community today at our annual Cyclone Sunday event. Talking to people about the importance to Stay Line Aware this storm season!

Jacque Cann, Laura Males and 18 others · 7 Comments

Kate Austin
October 21, 2018

We are out in the community at Laidley at the Lockyer Regional Council Emergency Services Day. Our Gatton crew have been sharing our Stay Line Aware campaign messages which is perfect timing given this afternoons storm cells.

Lorraine Muller, Angela Cullen and 21 others · 2 Comments

Kate Austin is with Ryan Campbell.
October 24, 2018

Our Community Engagement team and Herbert field staff are sharing our Stay Line Aware and electrical safety messages with some 1,500 Townsville City Council staff at their Trade Safety Day. This is a great initiative to encourage everyone to take a moment to think of safety.

Jacque Cann, Michael Dohy and 12 others · 3 Comments

Personal Social Media Promotion – Facebook and LinkedIn

Kate Austin shared a post.
October 25, 2018

Please take some time to complete my research survey on Future Energy Technology and Community Resilience. Please also feel free to share far and wide! Thanks!

Ergon Energy
October 24, 2018

In conjunction with Murdoch University, we're conducting a study into how tech like solar PV and batteries might contribute to community resilience in times of disaster, and we'd love to hear from you. Solar, batteries and home energy management systems are giving many Queenslanders greater flexibility and choice in how they access and use energy. In the future, these technologies could potentially boost community resilience by providing options to maintain and safely restore power supply when natural disasters or other events damage our network. What's your view? https://bit.ly/2yv1H0q

Kate Austin liked **Dean Condon**'s comment on this

Kate Austin
DipProjMgt; GradDipEnEnv; MBA Community Engagement Manager at Energy Queens...
3mo

I'm a Master's student at Murdoch University and I'm in the final stages of completing my Master of Renewable Energy and Sustainability. My final assessment piece is a research project in conjunction with Ergon Energy and Energex about future energy technologies and community resilience. I'm inviting Queenslanders to complete my research survey and forward it on far and wide to your networks across Queensland. Participants can go into the draw to win one of six $50 Visa gift cards (T&Cs apply). But hurry, the survey closes 9th December. Thanks so much for your support! #energy #sustainability #research #renewableenergy

https://lnkd.in/g9iqGP3

Kate Austin
DipProjMgt; GradDipEnEnv; MBA Community Engagement Manager at Energy Qu...
4mo

Solar, batteries and home energy management systems are increasingly giving Queenslander's greater flexibility and choice in how they access and use energy. I'm conducting a Queensland-based research project with Energy Queen ...see more

Technology & Community Resilience Survey
talkingenergy.com.au
The Future of Energy Technology and Community Resilience Solar, batteries and home ene...

Kate Austin shared a post.
December 6, 2018

LAST CHANCE TO WIN!!! Yes folks, our Future Energy Technology and Community Resilience survey will close at midnight on Sunday, 9th December. So get in quick for your chance to have your say and go into the draw to win!

Ergon Energy
December 6, 2018

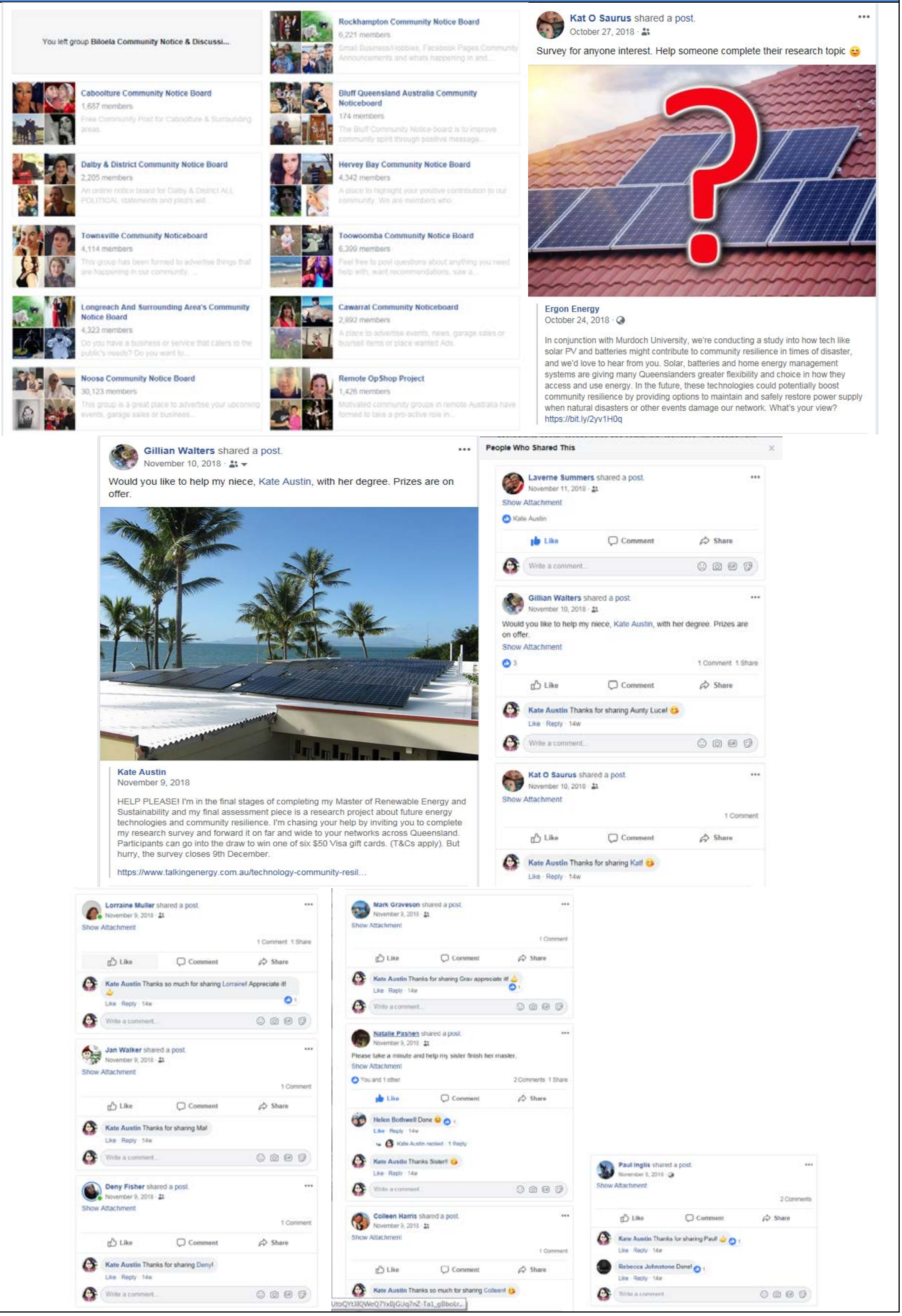
Last chance to win a $50 Visa Debit gift card!

It's your last chance to win a $50 Visa debit gift card and join the conversation on the future of energy in Queensland with our Technology and Community Resilience Survey.

The survey will help to inform us about emerging energy technologies, like solar PV and batteries, and how these technologies might contribute to community resilience in times of disaster.

Haven't completed the survey yet? Take the Technology and Community Resilience Survey here https://bit.ly/2Uiu2QV before it closes on Sunday 9th December to be in the final draw for one of six $50 Visa Debit gift cards (Terms and Conditions apply and can be found at https://bit.ly/2UhvanP).

Promotoed on Community Facebook Sites & Shared by Family and Friends
Shared by Family and Friends

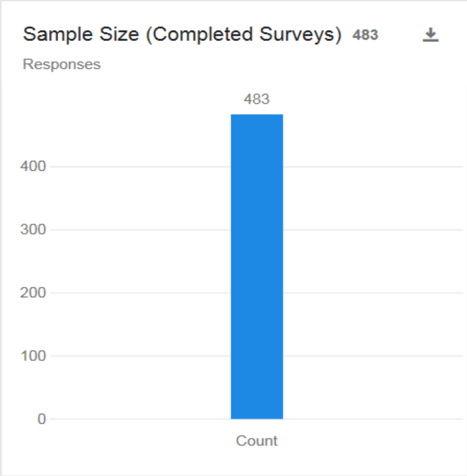


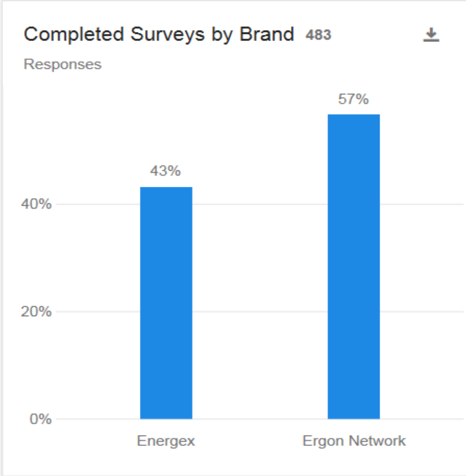
Appendix 5 – Analysis Plan

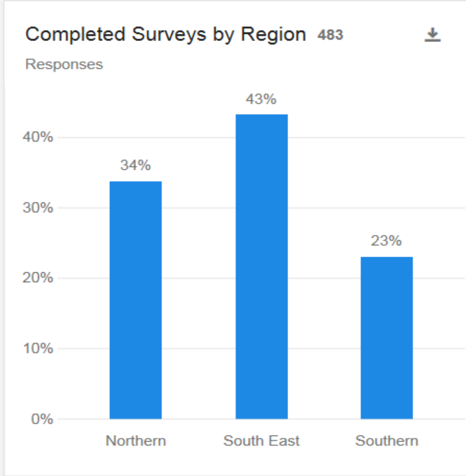
Aim of Focus Area Analysis	Research Topic Question	Survey Question/s	Potential Analysis Methods	Potential Method of Presentation
Establish Respondent Demographics	Valid response qualifying question to confirm resident of State of Queensland.	SQ2. Which state or territory do you currently live in? ~ Queensland ~ New South Wales ~ Victoria ~ Tasmania ~ South Australia ~ Western Australia ~ Northern Territory ~ ACT ~ None of the above	Qualifier - Not displayed	Qualifier - Not displayed
Establish Respondent Demographics	Valid response qualifying question to confirm resident of State of Queensland.	Q3. What is your postcode?	Frequency Distribution	Tableau heat map- via postcode Aligned to Qld
Establish Respondent Demographics	Valid response qualifying question to confirm age 18 years or over	Q4. Which of the following age groups do you fall into? ~ 18-19 ~ 20-24 ~ 25-29 ~ 30-34 ~ 35-39 ~ 40-44 ~ 45-49 ~ 50-54 ~ 55-59 ~ 60-64 ~ 65-69 ~ 70-74 ~ 75-79 ~ 80-84 ~ 85-89 ~ 90+ ~ Prefer not to answer	Mean Median Frequency Distribution	Vertical bar chart
Establish Respondent Demographics	Establishes context about how the respondent is answering the survey - as a resident, business owner or both.	Q5. Are you a resident or a resident and business operator? (select all that apply) ~ Small business customer (electricity bill less than $15,000 per year) ~ Medium or large busienss customer (electricity bill greater than $15,000 per year)	Frequency Distribution	Horizontal bar chart
Helps to establish a baseline for how respondents use electricity and how they prioritise the use. This can be used to determine if there is a correlation between energy priorities and willingess to do without or if an intension-behaviour gap may exist.	2. Are Queenslander's willing to share their household electricity resources following a natural disaster or major event to support the restoration of the electricity network to their community?	Q6. What are the benefits that electricity provides that you miss most, or are most important to you, when waiting for the power to be restored during an outage? (select your top two) ~ Basic services (refrigeration, cooking, hot water, water supply, etc.) ~ Entertainment (television, music, etc.) ~ Comfort (fans, air conditioning, heating, etc.) ~ Connectivity (internet & telecommunications) ~ Lighting and security ~ Business outcomes and productivity (as relevant) ~ Pool and spa pumps ~ Other please specify	Frequency Distribution	Horizontal stacked bar graph - first and second preferences
Helps to establish context of expeirences which may influence respondent intention-behavour decision-making across latter survey questions. Helps to understand what volume of respondents have experienced an outage following a disaster event.	2. Are Queenslander's willing to share their household electricity resources following a natural disaster or major event to support the restoration of the electricity network to their community?	Q7. Have you ever experienced an extended power outage following damage to the electricity network from a cyclone, severe storm or major flooding?	Frequency Distribution	Horizontal bar chart
Helps to establish context for the respondents expeirences including the types of events they have experienced and stand out conditions which may influence their intention-behavour decision-making across latter survey questions. Helps to establish what respondents' expectations might be in relation to these types of events and the 'impacts' they experience.	2. Are Queenslander's willing to share their household electricity resources following a natural disaster or major event to support the restoration of the electricity network to their community?	Q8. Let us know a little about your experience.	Analysis of verbatim comments	Word Cloud Vebatim quotes in report
Helps to establish how important sharing and helping the community is to the respondents. This will help to provide a baseline for repondents intension to help.	1. Do Queenslander's feel a social obligation towards supporting the resilience of their community and the electricity distribution network as a critical piece of infrastructure?	Q9. Generally, how would you rate the importance you place on helping others in your local community? ~ Very Low Importance (0-1) ~ Low Improtance (2-3) ~ Neutral (4-6) ~ High Importance (7-8) ~ Very High Importance (9-10)	Frequency Distribution	Vertical bar chart
This will help to establish a context for the number of respondents who have components to establish resilience. It will also help to establish the take up rate of new technology against which the premise of solar PV and BESS providing resilience.	2. Are Queenslander's willing to share their household electricity resources following a natural disaster or major event to support the restoration of the electricity network to their community?	Q10. Do you have any of the following in your home or business? (select all that apply) ~ Solar panels (solar PV) ~ Another renewable energy source (wind turbine. etc) ~ Integrated battery energy storage system ~ Mobile or back-up generator ~ No, I don't have any of these	Frequency Distribution	Horizontal bar graph
Reflection of existing sharing behaviours of those who have some resilience capability - help to shape insights into stated intent verses actual behavioural intent.	1. Do Queenslander's feel a social obligation towards supporting the resilience of their community and the electricity distribution network as a critical piece of infrastructure? Are Queenslander's willing to share their household electricity resources following a natural disaster or major event to support the restoration of the electricity network to their community?	Q11. Have you ever used your mobile or back-up generator to support your neighbours following a natural disaster or other extended outage? ~ No, I have not shared the generator ~ Yes, I have 'connected' a neighbour's essential items to our back-up power supply ~ Yes, I have invited the neighours to do basic activities, liek use the fridge, at our house/business ~ Yes, I have rostered my mobile generator around the neighbourhood (to keep freezers cold)	Frequency Distribution	Horizontal bar graph
An indicaton of the viability of PV solar and BESS as a network resilience option - based on the likley take-up derived from a stated intension of willingness to buy.	2. Are Queenslander's willing to share their household electricity resources following a natural disaster or major event to support the restoration of the electricity network to their community?	Q12. How likely are you to purchase an integrated solar and battery system in the future? ~ Extremely Unlikely (0-1) ~ Unlikely (2-3) ~ Neutral (4-6) ~ Likely (7-8) ~ Extremely Likely (9-10)	Frequency Distribution	Horizontal bar graph
Help to demonstrate the viability of PV solar and BESS as a resilience option. Help to identify if there is an information/education gap around costs of technologies - which could further influence the potential take-up rate or propensity to share (based on a cost/benefit analysis).	2. Are Queenslander's willing to share their household electricity resources following a natural disaster or major event to support the restoration of the electricity network to their community?	Q13. How much would you expect to pay for an integrated solar and battery system to meet your premise's daily needs? ~ Up to $5,000 ~ Between $5,000 and $10,000 ~ Between $10,000 and $15,000 ~ Between $15,000 and $20,000 ~ Between $20,000 and $25,000 ~ More than $25,000	Frequency Distribution	Horizontal bar graph

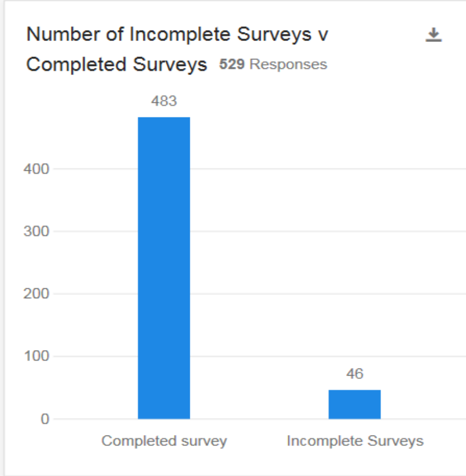
Establish stated intent for sharing and possible conditions and incentives needed to facilitate adoption.	Q3. If they are willing to share, are there any potential conditions that may need to be met and/or do they expect some form of incentive or compensation in return?	Q14. If you have a battery system, or had one in the future, would you consider allowing Energex or Ergon Energy to access it (together with batteries from other premises) if there is a problem with power supply in your area? ~ Yes, but only if I was paid and could say no if it did not suit ~ Yes, but only if I was paid a reward or given a credit on my bill ~ Yes, I'd be happy to share for the benefit of the community ~ Yes, but only if I had hte choice to say no if it did not suit me at the time ~ No	Frequency Distribution	Horizontal bar graph
Establish stated intent for sharing and expectations around conditions, limitations and/or incentives.	Q3. If they are willing to share, are there any potential conditions that may need to be met and/or do they expect some form of incentive or compensation in return?	Q15. What is the minimum reward you would accept? ~ The same as I'm charged for my electricity (approx. 28c/kWh) ~ The normal energy rate, plus a reward, every time my system is accessed (say between $1-5) ~ Higher than the rate I'm charged for my electricity (more than 28c/kWh) ~ A standard quarterly flat-rate regular payment even if it was not accessed (say $10-$50 a quarter) ~ The normal value of the energy alone (approx. 10c/kWh)	Frequency Distribution	Horizontal bar graph
Help to establish intent around duration respondents are willing to rationalise their consumption/share their resources	Q3. If they are willing to share, are there any potential conditions that may need to be met and/or do they expect some form of incentive or compensation in return?	Q16. How long would you expect, while the storm damage repairs were underway, to share the electricity from your battery system? ~ For a couple of hours to half a day only ~ For 1-2 days on and off ~ Up to a week on and off (if it was able to recharge) ~ For as long as required on and off (if it was able to recharge)	Frequency Distribution	Horizontal bar graph
Help to establish intent around reducing energy load to facilitate sharing. Help to establish if there is an intension-behaviour gap around electrical equipment usage and using sustainable levels of energy to faciliate sharing.	Q3. If they are willing to share, are there any potential conditions that may need to be met and/or do they expect some form of incentive or compensation in return?	Q17. What type of electrical equipment would you be willing to avoid or reduce using to ensure you could share your battery system during disaster events? ~ Hairdryer, other personal appliances ~ Gaming Consoles ~ Pool or spa pump ~ Air conditioners ~ Washing machine, iron, dryer ~ Electric kettle, toaster ~ Electric oven, cooktop ~ Television ~ Computer/s, laptop/s ~ Electric hot water ~ Ceiling fans ~ Lights ~ Refrigerator/s, freezer/s ~ Other, please state	Frequency Distribution	Horizontal bar graph
Helps to establish identified barriers which can help to identify areas where information, education, incentives and policy design may aleviate some barriers and facilitate uptake of the technology. Can establish areas of future research.	2. Are Queenslander's willing to share their household electricity resources following a natural disaster or major event to support the restoration of the electricity network to their community?	Q18. What do you see as the potential barriers to you purchasing a battery system in the future? (select all that apply) ~ The cost for a system is too high to achieve a reasonable finanical return ~ I believe that the technology and the choice in brands/model will improve, so I'd rather wait ~ I don't have financial capabitiy to invest in this type of technology ~ I'm a renter or live in a unit/apartment so can't install this sort of system where I live ~ The tariffs availble do not incentivise an investment in a system ~ I'm not sure how much maintenance they require and who can service them ~ I don't know enough about them or know a reputable installer to know where to start ~ I don't know enough about my electricity use to know if one is worthwhile ~ I'm worried about the safety aspects ~ Other, please specify ~ I have a mobile generator to provide power during interruptions	Frequency Distribution	Horizontal bar graph
Helps to identify the level of support for mandating use of personal systems to support broader community concerns such as critical infrastructure.	Q3. If they are willing to share, are there any potential conditions that may need to be met and/or do they expect some form of incentive or compensation in return?	Q19. Do you think that sharing stored electricity in battery systems should be made compulsory in disaster events for the greater good of community?	Frequency Distribution	Vertical bar chart
Helps to identify if there is a propensity for the community to support other people like them or only focus on critical community infrastructure.	Q3. If they are willing to share, are there any potential conditions that may need to be met and/or do they expect some form of incentive or compensation in return?	Q20. Where do you think the electricity stored in batteries across the community should be used to best support the community during a disaster recovery?	Frequency Distribution	Horizontal bar graph
Helps to establish if there is a correlation between respondents ratings on helping others vs mandating sharing.	2. Are Queenslander's willing to share their household electricity resources following a natural disaster or major event to support the restoration of the electricity network to their community? Q3. If they are willing to share, are there any potential conditions that may need to be met and/or do they expect some form of incentive or compensation in return?	Q21. Would you like to expand on your response to any of the questions asked or share any other thoughts you have about the opportunity of using privately-owned energy storage or batteries for community resilience in the future?	Analysis of verbatim comments	Vebatim quotes in report
Comparison between those experienced previous extended outage vs helping others - help to shape insights into stated intent verses actual behavioural intent. Helps to establish perceptions of energy as a 'common pool resource' that can be shared, or if individualism would	2. Are Queenslander's willing to share their household electricity resources following a natural disaster or major event to support the restoration of the electricity network to their community?	Q7. Have you ever experienced an extended power outage following damage to the electricity network from a cyclone, severe storm or major flooding? Q9. Generally, how would you rate the importance you place on helping others in your local community?	Frequency Distribution Mean Standard Deviation	Vertical bar chart Scatter diagram
Determine the strength of association between ratings on helping others vs mandating sharing	2. Are Queenslander's willing to share their household electricity resources following a natural disaster or major event to support the restoration of the electricity network to their community?	Q9. Generally, how would you rate the importance you place on helping others in your local community? Q19. Do you think that sharing stored electricity in battery systems should be made compulsory in disaster events for the greater good of community?	Frequency Distribution Mean Standard Deviation Trend	Clustered Bar Graph Scatter with trend line
Comparison of the likelihood of people purchasing SSPV & BESS and their expectations of the costs. Help to establish if those likely to purchase have any idea of costs. May identify a communication/education requirement.	3. If they are willing to share, are there any potential barriers or conditions that may need to be met and/or do they expect some form of incentive or compensation in return?	Q12. How likely are you to purchase an integrated solar and battery system in the future? ~ Extremely Unlikely (0-1) ~ Unlikely (2-3) ~ Neutral (4-6) ~ Likely (7-8) ~ Extremely Likely (9-10) Q13. How much would you expect to pay for an integrated solar and battery system to meet your premise's daily needs? ~ Up to $5,000 ~ Between $5,000 and $10,000 ~ Between $10,000 and $15,000 ~ Between $15,000 and $20,000 ~ Between $20,000 and $25,000 ~ More than $25,000	Frequency Distribution	Cluster Bar Graph (cost & likely to buy)

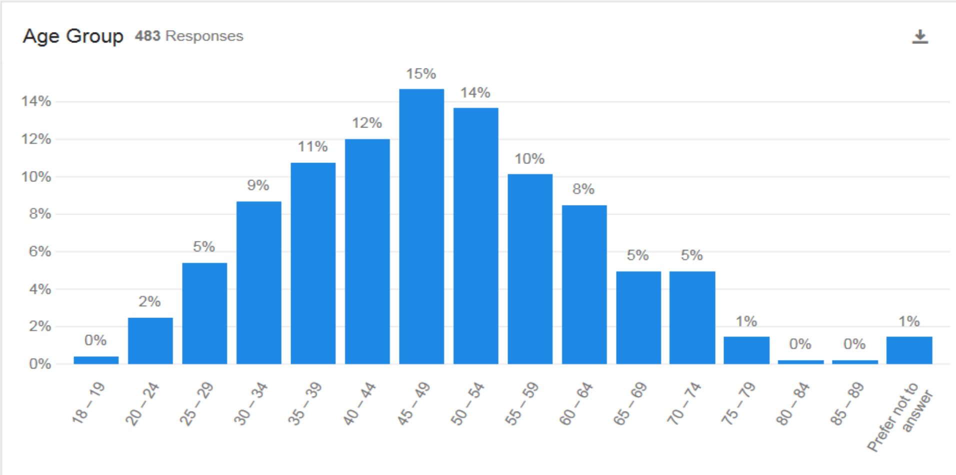
Appendix 6 – Summary of Survey Results

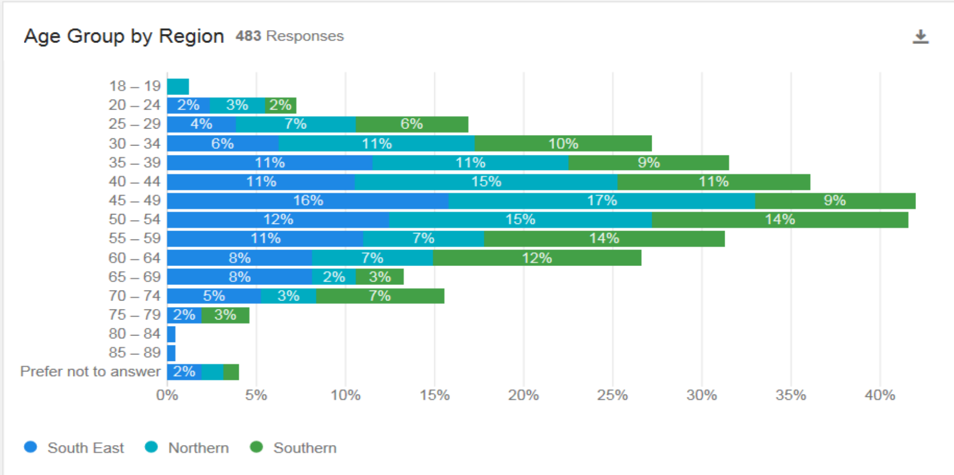




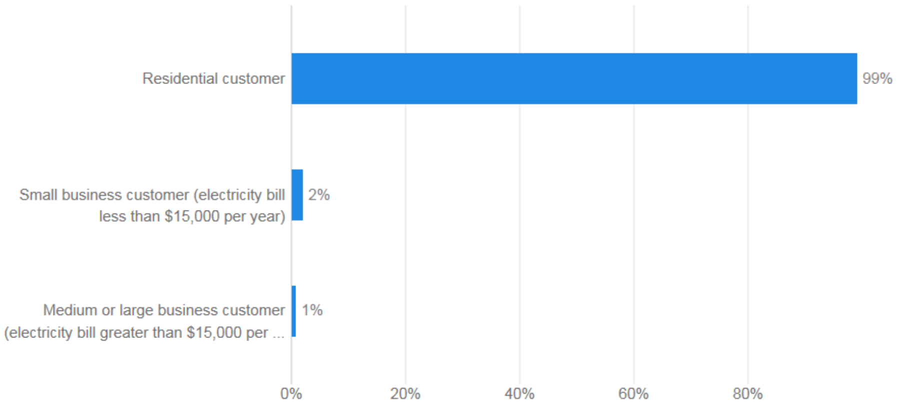




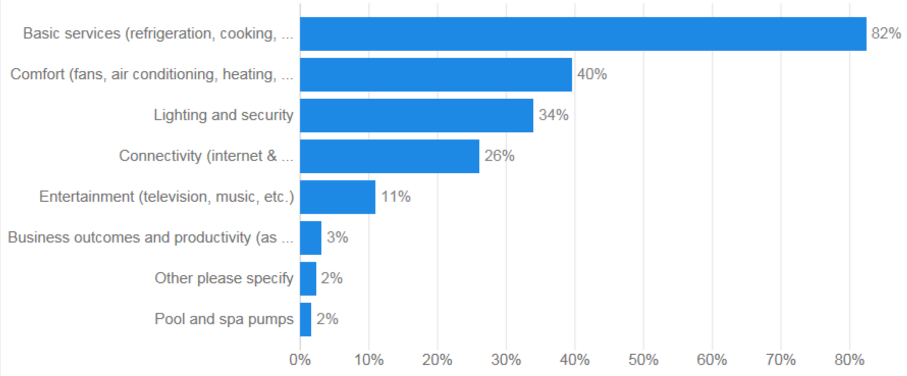




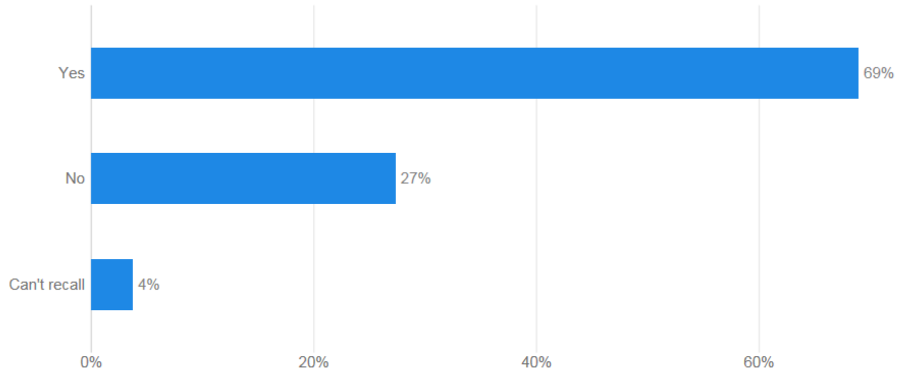
Are you a resident or a resident and business operator? **483** Responses



What are the benefits that electricity provides that you miss most, or are most important to you, when waiting for the power to be restored during an outage? **483** Responses



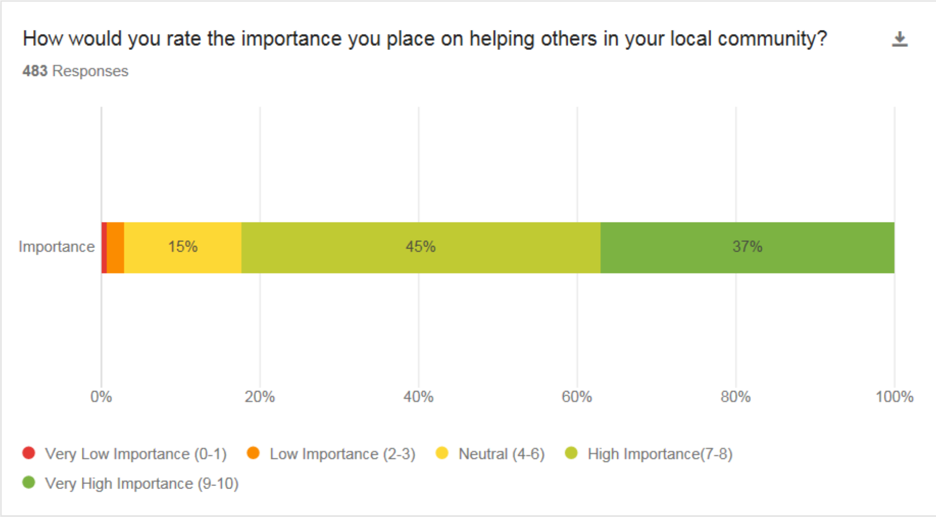
Have you ever experienced an extended power outage following damage to the electricity network from a cyclone, severe storm or major flooding? **483** Responses



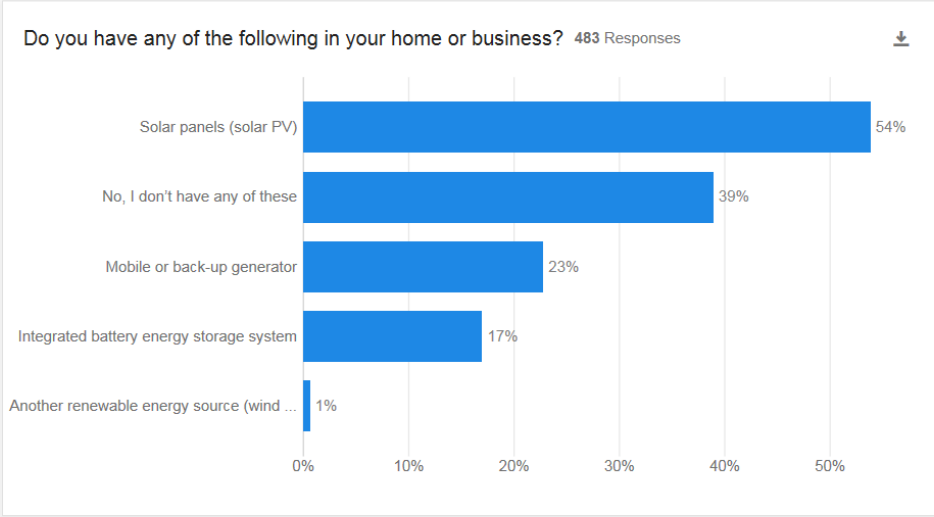
Let us know a little about your experience. **327** Responses

Southern
35 – 39
Power was off for days following a storm. Luckily we have a back up to charge phones as our son is anaphylactic so must be able to call 000, if needed.

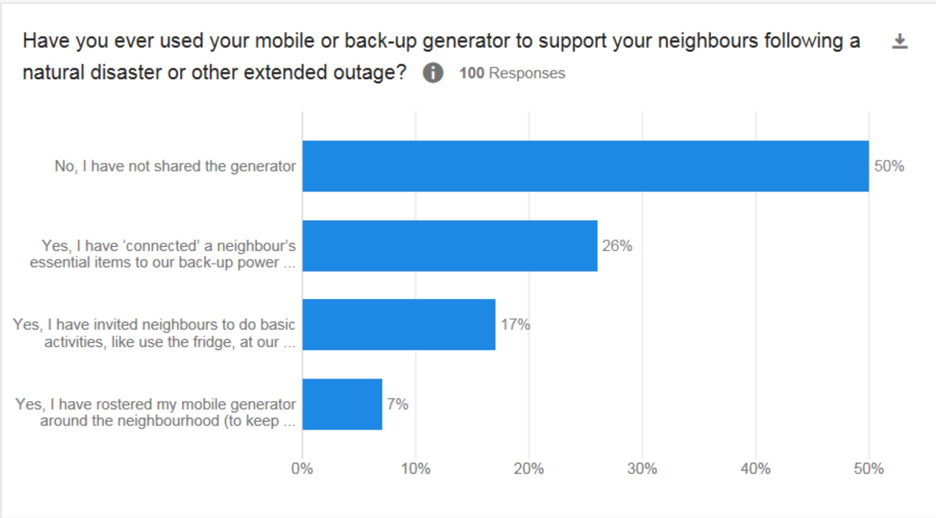
Northern
20 – 24
We had no power for 4 days; We had solar panels installed, however, no battery storage. Our inverter did not allow for the use of our energy, as we were still dependant on the grid (grid dependant, but cheaper energy). We used a generator to keep our refrigerator running, however, it was old and unreliable and went out a couple of times. The heat and humidity were factors which made the experience difficult, however, manageable through many showers throughout the day. I no longer live at this residence; and do not have solar anymore.



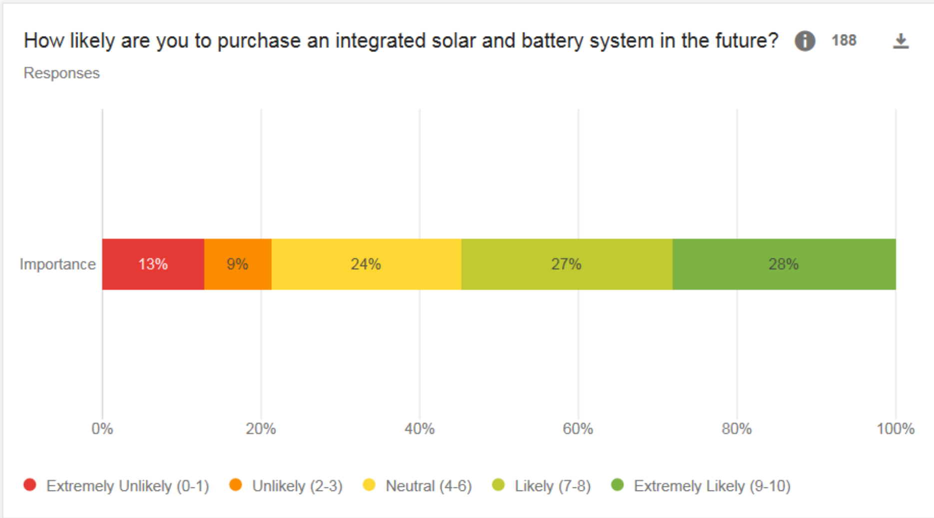
How would you rate the importance you place on helping others in your local community?
483 Responses
Importance
15%
45%
37%
0%
20%
40%
60%
80%
100%
Very Low Importance (0-1)
Low Importance (2-3)
Neutral (4-6)
High Importance(7-8)
Very High Importance (9-10)



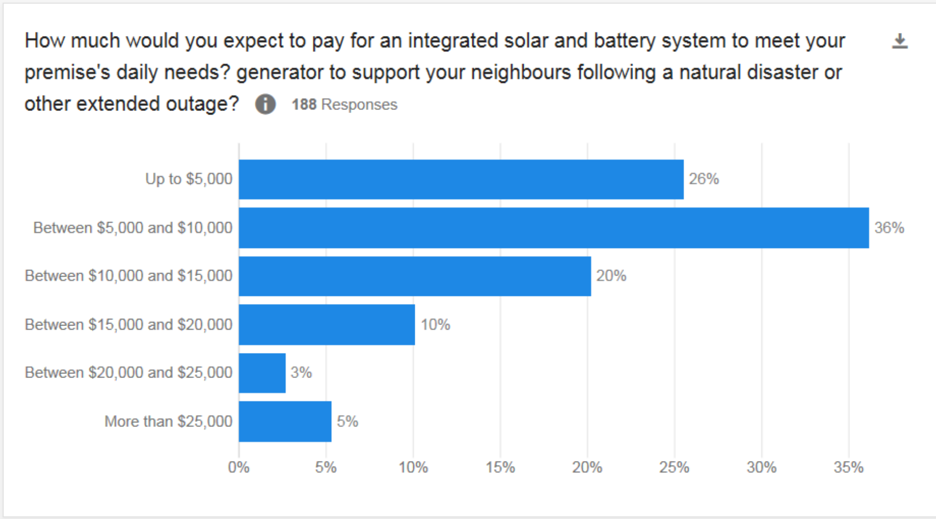
Do you have any of the following in your home or business? 483 Responses
Solar panels (solar PV)
54%
No, I don't have any of these
39%
Mobile or back-up generator
23%
Integrated battery energy storage system
17%
Another renewable energy source (wind ...
1%
0%
10%
20%
30%
40%
50%

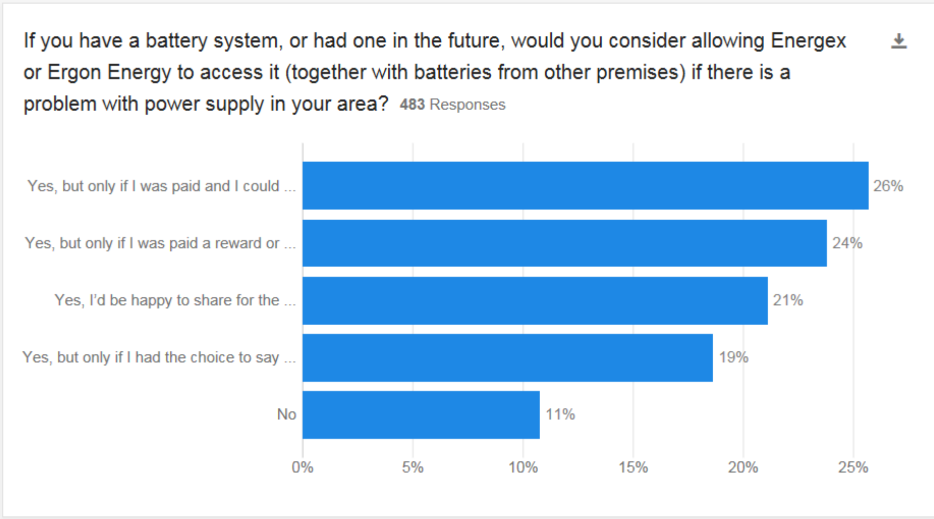


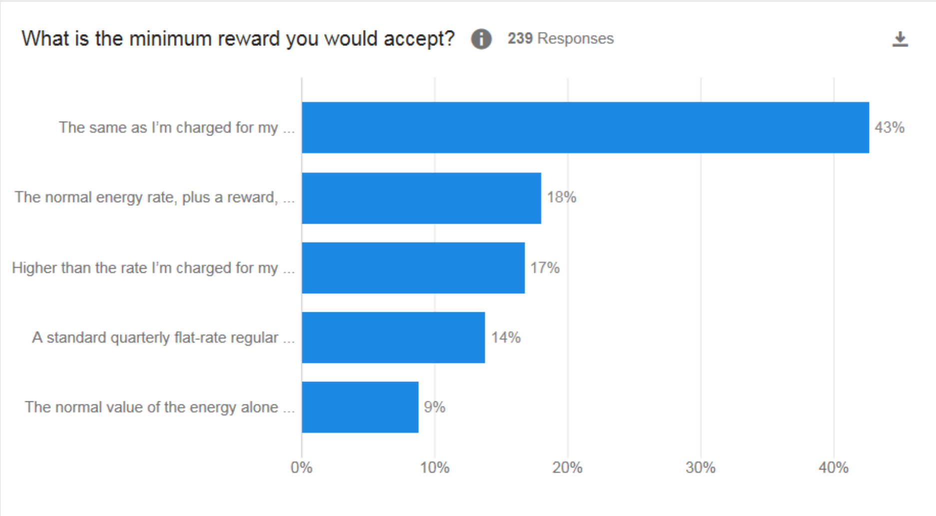
Have you ever used your mobile or back-up generator to support your neighbours following a natural disaster or other extended outage? 100 Responses
No, I have not shared the generator
50%
Yes, I have 'connected' a neighbour's essential items to our back-up power ...
26%
Yes, I have invited neighbours to do basic activities, like use the fridge, at our ...
17%
Yes, I have rostered my mobile generator around the neighbourhood (to keep ...
7%
0%
10%
20%
30%
40%
50%

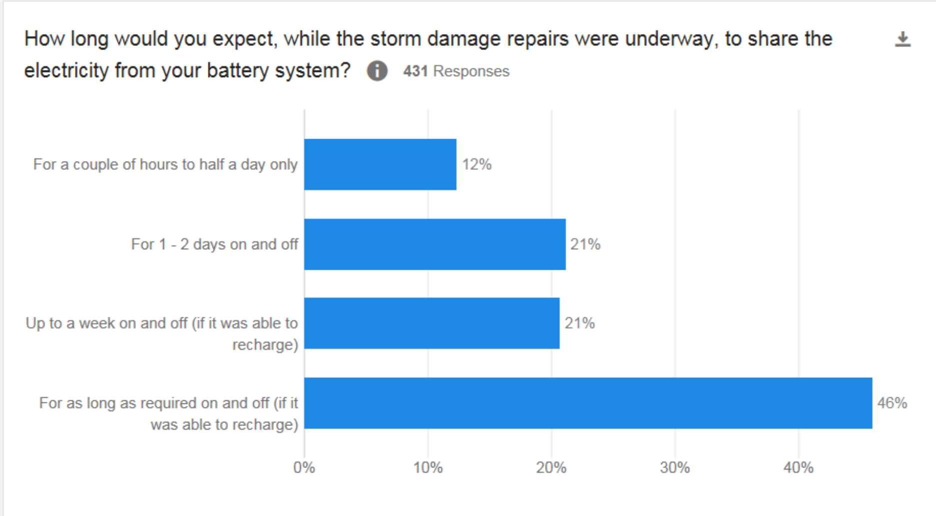


How likely are you to purchase an integrated solar and battery system in the future? 188 Responses
Importance
13%
9%
24%
27%
28%
0%
20%
40%
60%
80%
100%
Extremely Unlikely (0-1)
Unlikely (2-3)
Neutral (4-6)
Likely (7-8)
Extremely Likely (9-10)

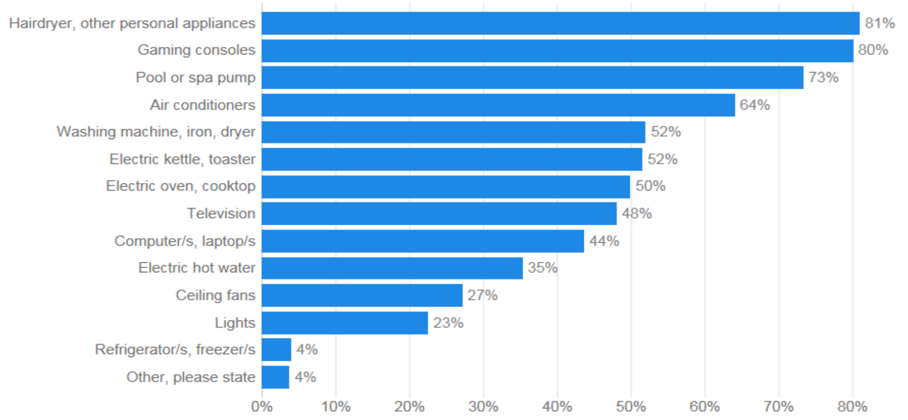

How much would you expect to pay for an integrated solar and battery system to meet your premise's daily needs? generator to support your neighbours following a natural disaster or other extended outage? 188 Responses
Up to $5,000 26%
Between $5,000 and $10,000 36%
Between $10,000 and $15,000 20%
Between $15,000 and $20,000 10%
Between $20,000 and $25,000 3%
More than $25,000 5%
0% 5% 10% 15% 20% 25% 30% 35%


If you have a battery system, or had one in the future, would you consider allowing Energex or Ergon Energy to access it (together with batteries from other premises) if there is a problem with power supply in your area? 483 Responses
Yes, but only if I was paid and I could ... 26%
Yes, but only if I was paid a reward or ... 24%
Yes, I'd be happy to share for the ... 21%
Yes, but only if I had the choice to say ... 19%
No 11%
0% 5% 10% 15% 20% 25%

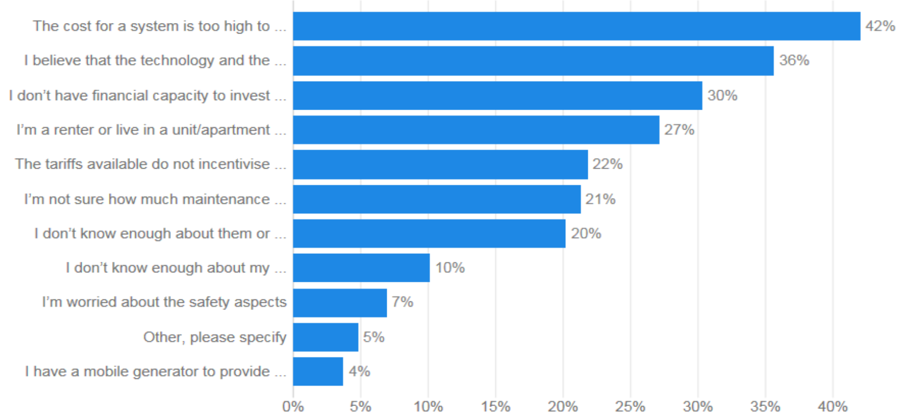

What is the minimum reward you would accept? 239 Responses
The same as I'm charged for my ... 43%
The normal energy rate, plus a reward, ... 18%
Higher than the rate I'm charged for my ... 17%
A standard quarterly flat-rate regular ... 14%
The normal value of the energy alone ... 9%
0% 10% 20% 30% 40%


How long would you expect, while the storm damage repairs were underway, to share the electricity from your battery system? 431 Responses
For a couple of hours to half a day only 12%
For 1 - 2 days on and off 21%
Up to a week on and off (if it was able to recharge) 21%
For as long as required on and off (if it was able to recharge) 46%
0% 10% 20% 30% 40%

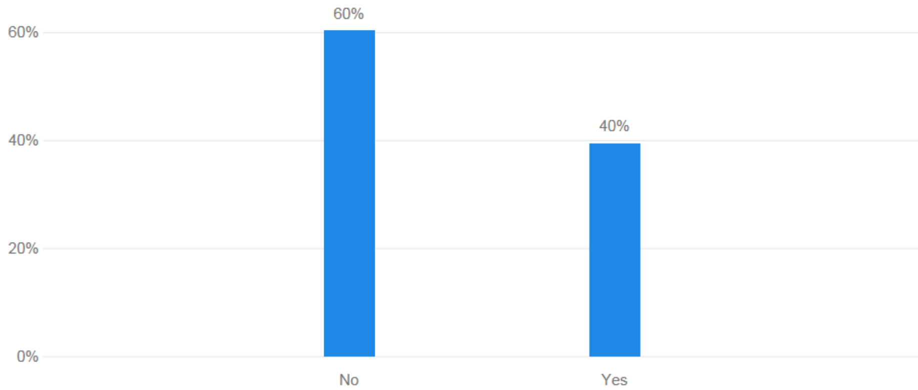
What type of electrical equipment would you be willing to avoid or reduce using to ensure you could share your battery system during disaster events? 431 Responses



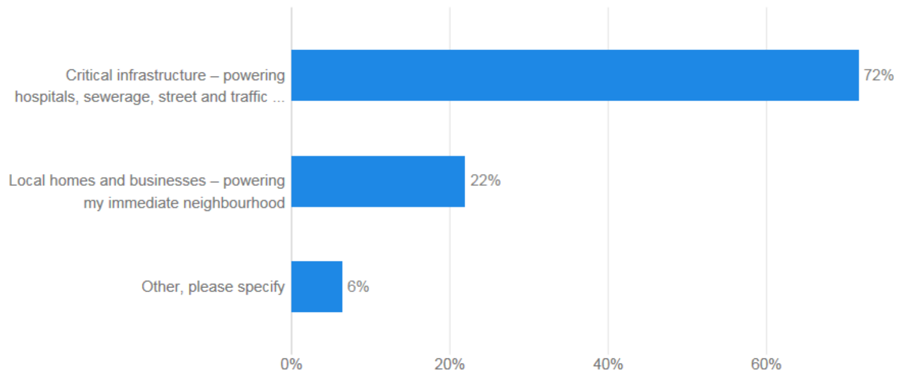
What do you see as the potential barriers to you purchasing a battery system in the future? 188 Responses



Do you think that sharing stored electricity in battery systems should be made compulsory in disaster events for the greater good of community? 483 Responses



Where do you think the electricity stored in batteries across the community should be used to best support the community during a disaster recovery? 483 Responses



Appendix 7 – Word Cloud of Respondent Outage Experiences

Created at: Word Cloud Creator.
https://worditout.com/word-cloud/3631562/private/4f87f82db062b30a1e1c57a1eac415c9