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Create change

Understanding the socio-economic challenges for energy storage uptake

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Executive Summary

Australia today is experiencing massive changes across its energy generation landscape. With the need to transition to a low carbon future and rising electricity prices, energy has become an extremely contested topic, both in our Parliament and across society. The current political debate and lack of bi-partisan support suggests there is no clear way forward for achieving the transition. And the situation is compounded with the increasing proportion of renewable energy feeding into the grid with no clear policy to support such an initiative over the longer term. As part of this bold new world, energy storage is tipped to emerge as a natural complement to the ambitious renewable targets being set across Australia. However, with its inherent infancy, the true potential of energy storage is yet to be identified. Therefore, it is timely to understand the risks and opportunities for this new emerging industry for Australia, as many international counterparts view our country as a test bed for this innovation and commercial models associated with it.

This work package of research undertaken between December, 2016 and February, 2017 aimed to identify the socio-economic drivers and barriers for energy storage in Australia by combining the results of a literature review, focus groups, interviews, case studies and a national survey. The literature review examined consumer responses to a range of smart grid technologies that had relevance and pricing mechanisms including solar Photo Voltaic (PV) panels, smart meters, cost reflective pricing and energy efficiency measures. Based on the literature review, Australia is not the only country seeing large transformations in how electricity is produced and managed, this is a global transition, but with local characteristics. Fellow advanced economies such as New Zealand, United Kingdom, Germany and Japan have all investigated the social drivers and barriers for associated smart grid technologies. What is clear however, is that there is little research in understanding the socio-economic drivers for energy storage.

Telephone interviews with 19 key representatives from across the energy sector helped to identify key issues and opportunities for energy storage in Australia. The major concern that arose across all interviews was that of safety with a noticeable lack of standards for all parts of the energy storage supply chain. This also included expressed concerns for the environment if batteries were not responsibly recycled. Although battery storage installation standards are currently under development in Australia, there was some concern that an early negative incident may have serious ramifications for deployment of energy storage in Australia. Many likening the opportunity of such an occurrence to the earlier failure of the federal government's "Home Insulation Program" otherwise known as the "Pink Batts Affair" under Prime Minster Rudd which resulted in four deaths.

This theme also arose in the focus groups that were conducted in Brisbane (2) and Melbourne (4) with 56 participants across all ages.

Utility scale storage was less commonly referred to than battery storage but when it arose the discussion tended to focus on the role of pumped hydro as a technology. It was recognised as an established technology that was relatively cheap when compared to all other forms of storage. It was noted that it is a very location specific technology, with mixed feelings about whether the issues of competing land use and lack of available water because of Australia being a dry continent could create social licence issues that would prevent its ultimate deployment. Either way, the interviews revealed that some industry and government representatives saw opportunities for utility scale storage across Australia that could ultimately help address security of supply issues in specific geographic locations. Similar themes were also reflected in the national survey.

Another common theme was the financial considerations that might enable or impede energy storage or for householders. It is clear that many Australians are hurting from the sharp rise in electricity prices that has occurred over the past five years. With deregulation of the electricity retail market, changing Feed in Tariff Schemes (FiTs) and other Time of Use tariffs (TOU) there has developed an underlying mistrust of the government and associated energy industry by many Australians. This has resulted in an expectation that individual consumers, who can afford home battery storage units, may simply elect to become independent of the grid through purchasing a battery as a way of managing costs and gaining more control over their home energy. Most participants were of the view that early battery storage deployment will likely correlate with solar PV ownership, especially as many householders were losing the premium FiTs. Despite this potential new business model for householders and others, there was recognition that the current price of battery storage units was still prohibitive for most but a downward trend in the retail price was promising for future outlooks. This was coupled with the opportunity for various incentives both at the government and retail level to push battery storage penetration.

The national survey (N=1015) confirmed the themes that arose in the interviews and focus groups. Key factors that were identified as influencing a decision to purchase a home battery storage unit included reduction in electricity costs, its purchase costs and safety features. What was also evident is that most Australians do not understand much about energy storage and how it relates to energy generation more broadly. Although, most are familiar with the concept of car and commonly used lithium-ion batteries used in computers and mobile phones. There is a clear opportunity for improved communication about the role that storage might play in Australia's energy future but this would be enhanced if combined with more concerted efforts to improve energy literacy of the

Australian public more broadly. However, with a lack of bi-partisan support and clear strategy for Australia's transition to a low carbon future this may be challenging.

Like other national surveys ours confirmed that Australians prefer renewable (n=594, 59%) energy but associate increased costs with its deployment. When presented with a choice between higher and lower renewables being the most likely scenario in 2030 respondents were split with 39% (n=397) indicating that a lower mix of renewables was likely, 35% (n=355) indicating that a higher mix was likely in 2030 and 26% (n=263) did not know. Gender, age, level of education, belief in climate change and an individual's view on the likelihood of rising electricity costs were all significant predictors of preferences towards a higher or lower mix of renewable energy in Australia's 2030 energy generation mix. For example, older males tended to expect a lower renewable scenario as did those who felt the cost of electricity would continue to rise. Conversely, those with post-graduate level education and a belief in climate change felt a higher renewable energy scenario was likely.

Despite the number of positive indications for Australians to consider the use of energy storage as part of the new low carbon energy future the inherent mistrust in government and industry will need to be addressed. An important component will be reducing the contested nature of political debate and try to find bi-partisan support for a way forward. Communicating the strategy for transitioning to a low carbon future and the role for renewable technologies and energy storage will be critical as part of this. For in spite of the lack of trust in government to date, most Australians looked to government to play a role in the future energy mix of 2030.

Key Findings

- Australians are deeply concerned with the sharp rise in electricity prices over the past few years and they hold governments and energy providers, in particular retailers, directly responsible for this.
- There is a lack of trust in governments and electricity retailers which needs to be addressed and enabling a bi-partisan approach to energy would be welcomed by the Australian public
- While storage is still seen to be an emergent industry, there is a growing level of interest from householder in the benefits it may bring, although most felt storage was currently unviable.
- Many Australians feel they do not know enough about energy storage to make an informed decision about whether to purchase a home unit or not.
- There is an opportunity for governments to build energy literacy across Australia, including information on storage, and the range of energy generation technologies.

- Currently the lack of standards for batteries, both in relation to safety and environmental impacts are of concern to many across the energy sector and need to be addressed as a priority. Safety concerns also extended to first responders in the case of fires in homes or other buildings.
- Communicating how the safety and environmental aspects of home battery storage units are being managed will be an essential element for ensuring and maintaining a social licence to operate for the industry.
- To avoid the unintended consequences of policy interventions, a clear strategy for the proposed deployment of energy storage, including consistency around the types of incentives offered, is required, alongside monitoring of consumer led uptake.

1. Introduction

Over the last decade Australia has spent AUD$39.5 billion on clean energy investment (Bloomberg New Energy Finance 2016). As part of this, solar photo voltaic (PV) installations have grown from 8MW to 5,400MW of capacity (Australian PV Institute 2016). This growth has primarily been fuelled by the residential sector and supported through various state and federal schemes including generous Feed-in-Tariffs (FiTs) and Renewable Energy Certificates (RECs). The resultant 1.58 million PV installations nationwide include penetration rates as high as 30% of dwellings in some states, for example Queensland and South Australia, followed by Western Australia -23.8%, Victoria – 14.7%, New South Wales 14.6%, Australian Capital Territory 13.5%, Tasmania 12.7% and the Northern Territory 10% (Australian PV Institute 2016). This development has been widely accepted as successful, particularly in displacing thermal generation while meeting environmental and renewable energy targets within the short term (Chapman, McLellan & Tezuka 2016).

However, concerns have been raised in relation to inaccurate spatial and temporal discounting[1] given the lack of long term targets, but also due to wider social inequality that has resulted from a variety of environmental policies (Hobman & Frederiks 2014). Such suggestions have been primarily associated with the cost distributions of solar, where uniform tariffs, which are not means tested, have regressively taxed low socio-economic and vulnerable groups to fund subsidies or 'middle class welfare' for more affluent demographics (Nelson, Simshauser & Nelson 2012; Simpson & Clifton 2016).

Although electricity bill concerns have reduced in some parts of Australia, with the cessation of many of the generous FiT schemes, there still exists overwhelming concern that electricity prices will become a financial burden within households (Agnew & Dargusch 2016). Further complicating the phasing out of FiT schemes is the subsequent access to grid virtual energy storage (Mulder, Ridder & Six 2010). In response to growing electricity affordability concerns, we are beginning to see Australians turn their attention to various energy storage opportunities such as batteries (Agnew & Dargusch 2016; Colmar Brunton 2015).

With the inherent infancy of energy storage, it is timely to understand how consumers, industry and policy makers are responding to the technology. This report first summarises some of the emergent literature around societal attitudes to storage. It then reviews related research into consumer responses to a range of energy technologies and pricing mechanisms including solar PV's, smart meters, cost reflective pricing and energy efficiency measures and details behavioural theories that are relevant to this study. The desktop review informed six focus groups that were conducted with a

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[1] The idea of short-sightedness for costs/benefits that are near and immediate, but conversely far-sighted when costs/benefits are further away into the future. i.e. time inconsistency of cost/benefit analysis (Hobman & Frederiks 2014)

cross section of the general public in both Melbourne and Brisbane and interviews were conducted with a range of stakeholders to understand the status of storage in Australia. Key themes emerging from the literature review, focus groups and interviews were then used to design a national survey. The results of which are presented in Section 8. Following this, the key findings arising from this work package are presented.

2. Existing Energy Storage Applications and Examples

With the growing public interest in energy storage and subsequent concerns around the related social and policy impacts, there has been a rise in the number of publications that focus on energy storage across the world. For example, in New Zealand, concerns over energy security and increasing demand for electricity have suggested there is growing support for in-front of the meter solutions. However, due to the negative perceptions of battery storage as an emergent and untried technology - with insufficient power, energy capacity and perceived high costs - battery storage is seen to hold low likelihood of deployment compared with conventional thermal generation (Kear & Chapman 2013).

Similarly, the United Kingdom (UK) has also indicated strong support for energy storage - both behind and in front of the meter. Drivers attributed to garnering support include both avoided distribution network costs and reduced consumer bills (Grünewald et al. 2012). Unfortunately to date there has been little evidence of research being undertaken to understand the public's view on energy storage in the UK (DBIS 2016). In Germany, during face-to-face interviews with existing PV owners (N=532), the addition of a battery system was seen as a social obligation, contributing to the success of the nation's energy system transformation. Other drivers included higher independence from energy suppliers and increased self-consumption (Gährs et al. 2015). In contrast, another German study (N=141) investigated the everyday perceptions of hydrogen storage. Based on survey responses, batteries were perceived as familiar but dirty compared to other energy storage technologies such as fly wheels - traditional, simple and clean; and hydrogen storage - clean, modern and fascinating (Zaunbrecher et al. 2016).

Further afield, behind-the-meter options indicate a discord in perceptions and attitudes towards battery storage. For example, in Rwanda, maintenance and technical knowledge gaps have adversely affected battery life and systems costs, leading to negative perceptions towards batteries (Crossland, Anuta & Wade 2015). In contrast, following the Fukushima nuclear disaster in Japan, domestic battery storage adoption has generally been met with strong satisfaction as it is seen as a necessary component of emergency preparedness (Abe et al. 2015).

Based on the studies outlined above, it is clear that with the growing international trend to move towards clean reliable energy most often supplied by renewable energy, the emergent energy storage industry is poised for a revolution. How society responds to the various types of storage technologies available will be very locale specific, influenced by a range of factors - not least what is happening with energy generation in individual countries. As part of this, attention must be given to the implementation pathways for storage. Particularly with the large uncertainty currently facing the sector, given deregulation and discords between national and state jurisdictions. This is most obvious with no current standards for residential lithium ion system design, battery enclosure ventilation, maintenance testing performance and system documentation (Standards Australia 2016).

Furthermore, the uptake of energy storage holds the potential to blur distinctions between the once clear boundaries of 'products' and 'services' for energy and other sectors. This may result in creating large complexity for consumers, where the risk of rapid market development could possibly "erode existing ombudsman jurisdiction, effectiveness and reputation" (Benevenuti 2016, p. 78). This is in contrast with the Australian Energy Market Commission's view that battery storage and "the functions it performs are not different to other types of technology and can be accommodated within the existing regulatory framework", where existing "competitive market frameworks currently in place will allow consumer preferences to drive how the sector develops" (AEMC 2015, p. i). However, even with the time lag in policy, the development of energy storage is already underway around the world and is expected to see strong similarities in adoption with other smart grid enabling technologies.

3. Socio-technical uptake of other Smart Grid technologies

When considering the potential uptake of energy storage in Australia, there are a number of lessons that can be drawn upon from the previous roll out of energy related technologies and initiatives. For example, smart meters, solar PV cells, energy efficiency and changing tariff structures through cost reflective pricing. Each of these have relevance for energy storage uptake as they represent new technologies and innovations that have challenged the way that householders use and interact with their home energy. As well lessons can be learned from the different financial structures that have incentivised or constrained market penetration. A summary of the key findings from research documenting societal responses to these issues are detailed below.

3.1 Solar PV

The path dependency of societal solar uptake has changed significantly within Australia in the last two decades, and can be characterised into three eras - Pre-FiT, Premium FiT and Low FiT - where each is influenced by different demographic variables and attitudes towards solar. These are summarised in Figure 1 below.

Explanatory Variables

Era	Period	Demographic Profile	Attitude Profile
Pre-FiT Era	1992	Low solar penetration mainly off-grid non-domestic applications where economic factors are secondary considerations (Watt 2009). 66% of all successful applicants of PV Rebate Program (PVRP) from 2000-09 are from medium-high or high socio-economic postal areas. Large upfront costs excludes many low to medium income households from program (Macintosh & Wilkinson 2011).	Solar holds high acceptance with educated males and households with children. Early grid-connected adopters are motivated by self-sufficiency, energy-independence and environmental values (CSIRO 2009; Gardner, Carr-Cornish & Ashworth 2008). Higher levels of education and skilled occupations allowing access to internet are more likely to find it easier to access information on PV systems and apply for rebates (Macintosh & Wilkinson 2011).
Premium-FiT Era	2008 – 2012	Large grid connected domestic solar uptake by predominately educated individuals aged 35-74 - with a significant share over 53 - living in detached/semi-detached owner occupied dwellings and employed in a wide range of industries with moderate gross household income (Acil Allen 2013; Seed Advisory 2011)	Strong support for solar from all demographics. Payment preferences similar between age, income and gender. Actual objective knowledge of solar is much lower than perceived subjective knowledge (Romanach, Contreras & Ashworth 2013). Attitude-behaviour gap exists towards purchases of products as consumer ecological values and attitudes do not necessarily materialize into green product purchases (Claudy, Peterson & O'Driscoll 2013).
Low-FiT Era	2017	Slowdown of domestic capacity uptake which is now characterised by families where number of bedrooms and the type of dwelling are significant explanatory variables for uptake. Variables such as over 55, tertiary education and financial capacity become less significant compared to previous eras (Sommerfeld et al. 2017). Declining domestic volumes offset by growth in business solar (Origin Energy 2016).	Solar almost unanimously accepted as a social good and most popular option towards achieving clean energy policies (Cass 2016). Double identity by younger demographics who are environmentally concerned but also indifferent given frictional challenges and situational pressures (Stanes, Klocker & Gibson 2015). Mixed opinions on supporting renewables through electricity tariffs (Simpson & Clifton 2016). Growing disbelief in solar as a cost-effective solution to reducing electricity consumption (Colmar Brunton 2015).

Figure 1: Summary of Solar PV deployment in Australia

The Australian experience with Solar PV has both similarities and differences with the rest of the world. Much like Pre-FiT in Australia, the United States has seen cash incentives and rebates experience higher behind the meter solar uptake through to 2009 (Sarzynski, Larrieu & Shrimali 2012). Similarly, there also exists overwhelming support for solar and wind in the United States, where reduced utility bills and the environment are seen as driving factors towards installing solar (Pew Research Center October, 2016). In the United Kingdom, drivers such as self-sufficiency, bill savings and protection from higher energy prices are evident alongside barriers such as installation cost and lack of trustworthy information. However, unlike Australia, which has decoupled solar uptake with Premium-FiTs, there still remains a strong correlation between solar uptake and FiTs (Balcombe, Rigby & Azapagic 2014). Other European countries such as Germany, Belgium and Portugal, have also shifted away from FiTs to a system of self-consumption to mitigate against the public costs of solar, but also to reduce the negative impact that solar exerts on the stability of the grid (Lorenzi & Silva 2016). In contrast, in Japan the financial burdens of solar PV installations are diminished by a cross-selling business model where new homes[2] with solar enhances the creditworthiness of customer as well as reducing solar installation costs by 10% compared to retrofit systems (Mukai et al. 2011; Strupeit & Palm 2016).

Understanding the drivers and uptake of solar PV help to inform considerations for storage uptake in a number of ways. Firstly, there are many who believe the early market for battery storage in Australia will be those homes with solar PV. In particular, those households who have recently lost their Premium FiT's and are experiencing the true cost of electricity within their jurisdictions. Secondly, many of the early adopters of technology are those who invested in solar and are therefore likely to be interested in the emergent battery technologies. Finally, understanding the influence of the various incentive schemes that promoted PV can help to inform considerations around finance options for energy storage both at the individual and or community level.

3.2 Smart Meters

Advanced Metering Infrastructure (AMI) or smart meters, enable two-way communication of information about energy use and are seen as critical infrastructure for successful deployment of battery storage and cost reflective pricing. Unfortunately, due to the forced government roll out of smart meters in Victoria, the early Australian experience with smart meters has been less than positive. Research has shown that some Victorians hold strong public resentment of the roll out due to issues over lack of information, choice and public consultation during the deployment of smart meters in the state (Hall, Jeanneret & Rai 2016; Victoria Auditor-General 2015). Such opposition has forced the Victorian government to allow distributors "to charge customers who refuse a smart meter a manual reading fee" (Victoria Auditor-General 2015). This has been further complicated by growing health and safety, compatibility, privacy, security and cost concerns, both within Australia and abroad, post implementation (Hess 2014; Lamech 2014). Similarly, social concern and heightened opposition have forced utilities in the USA to create opt-out provisions[3] and new business models through monthly fees[4] in conjunction with restrictions around meter readings to maintain acceptance with customers who wish to retain analogue meters (Hess 2014; Todd, Cappers & Goldman 2013). Krishnamurti et al. (2012) suggests that with such opposition, there has been a

[2] 90% of all homes sold in Japan are newly produced and homes depreciate rapidly. (Strupeit & Palm 2016)

[3] In the town of Fountain, Texas, opponents gained enough signatures to hold a ballot where one measure included requiring replacement of the new digital meters with old analogue meters, citing the need to stop spying by "Big Brother" (Hess 2014)

[4] The California Public Utilities Commission responded to public opposition by approving an opt-out provision that allowed customers to keep their analogue meters for an initial fee (US$65) and an additional monthly fee (US$10/month) (Hess 2014)

number of misperceptions evidenced with the roll out of smart meters within the USA. These include (Krishnamurti et al. 2012);

1. Smart meters, and their perceived benefits such as appliance information are often associated with enabling technologies such as Integrated House Displays and smart thermostats, leading to dissatisfaction when these enabling technologies are not included.
2. Concerns over loss of control due to assumed direct load control capabilities within smart meters, irrespective of the fact that this requires further enabling technologies to stop electricity flow.
3. Most adopters assume that installation of smart meters would produce immediate consumer benefits, even though financial benefits are conditional.

Contrasting such experiences, a UK Department of Energy & Climate Change survey indicated that the majority of customers with smart meters indicated they held little to no concern about their smart meter, with only a few feeling that they had been disadvantaged enough to desire changes to their devices (DECC 2015). That said, although the opportunities available with smart meters were recognised, customers in the UK also felt that the rise in energy prices had offset any potential bill savings by the changes facilitated by smart meters (Buchanan et al. 2016). Feedback also indicates that after an early engagement period with devices, long term usage dropped off considerably as devices lost their novelty factor as they stopped offering new information and usage progressed from discursive consciousness[5] to a practical consciousness[6] (Hargreaves, Nye & Burgess 2013).

3.3 Cost Reflective Pricing

Another key element that may facilitate battery storage uptake will be the adoption of cost reflective pricing and changing patterns of demand. With existing flat rate tariffs, there is little motivation for shifting load with batteries (Khalilpour & Vassallo 2016). Although historical responses to such initiatives have been met with inherently human tendencies to resist change, recent empirical evidence suggest that there is growing support among Australians for more cost reflective pricing (Deloitte 2013; Hall, Jeanneret & Rai 2016; Stenner et al. 2015). There exists however, large differences in support for different tariff types depending on demographical factors such as income, education, household type and rental status (Stenner et al. 2015). Furthermore, perceptions around other cost reflective pricing concepts such as time sensitive flight and accommodation prices were seen to play an influential role towards understanding different tariffs (Hall, Jeanneret & Rai 2016). Unfortunately, irrespective of perceived support and interest for cost-reflective pricing, electricity consumption for most of the Australian population still remains price inelastic and relatively unresponsive to price signals (Hobman et al. 2016). Such price inelasticity,

[5] Level of consciousness that allows individuals to reflect on and tell rational stories about their actions (Giddens 1984).
[6] Automatic, habitual knowledge about how to 'go-in' in the world without having to make new decisions at each moment (Giddens 1984).

ultimately produces winners and losers across all households with the institution of different tariff structures, irrespective of demand response, creating further concern for social inequality for policy makers (Simshauser & Downer 2014). This poses a moral dilemma whether a non-zero sum framework is obtainable given "bounded rationality", and the search for immediate satisfaction choices instead of overall spatial and temporal optimal ones (Simon 1955).

3.4 Energy Efficiency Measures

Often referred to as low hanging fruit towards a low carbon future due to the negative cost of emissions abatement, energy efficiency measures across Australia have been critical in reducing electricity consumption nationwide (Energetics 2016). Although there has been a strong drive by both governments and utilities around the world to promote energy efficiency behaviours, this has met with mixed results. Such mixed results have mainly stemmed from gaps between actual and expected financial benefits from energy efficiency measures. This is because rising energy prices might often outweigh expected savings, or that the scope of the intervention is insufficient to significantly relieve worries about fuel costs (Chan & Ma 2016). In the case of residential heating, there exists overwhelming consensus that interventions improve household perceived warmth, satisfaction and room usage, all while strengthening perceived autonomy and consolidating the meaning of the home as a safe haven (Willand, Ridley & Maller 2015). However, unlike other enabling technologies, resident attitudes can often be predictors to adoption of energy efficient behaviours, whereas subjective norms[7] and perceived behaviour controls[8] are generally found to be weak predictors of intentions to conserve energy (Scott, Jones & Webb 2014). In the US, there also exists large demographical distinctions based on gender, political affiliation and socio-economic status towards perceptions and attitudes between government and utility led energy efficiency campaigns (Craig 2016; Craig & Allen 2014). The divide between government led and utility led initiatives may also hold true for energy storage initiatives in Australia, particularly where individuals hold low levels of trust in either institution. Understanding the factors that influence individual attitudes through the national survey will be helpful to inform salient messages and communication around the expected need and subsequent investment in different scales of energy storage.

4. Models of acceptance

4.1 Diffusion of Innovation Theory

Much has been written about the uptake and acceptance of new technologies and innovations. Possibly the most well-known is Rogers' (1962) "Diffusion of Innovation Theory". In his original

[7] What important others think that residents should do.

[8] The extent to which individuals feel that they have control over whether or not to have household energy efficiency intentions (Scott, Jones & Webb 2014).

theory Rogers showed that adoption tends to fit a bell curve that compartmentalises individuals by their speed of adoption into one of five groups. Innovators, the earliest adopters, comprise approximately 2.5% of the population. Early adopters follow (13.5% of the population), then the early majority (34%), late majority (34%) and laggards (16%). Rogers (1995) subsequently argued that diffusion of new technologies into a market will occur through a socialisation process which follows an S-curve. It starts with a slow initial penetration, followed by a period of rapid growth and then slower growth as the technology becomes more familiar and the market becomes saturated. The figure below plots the adopters along their likely position on the diffusion curve.

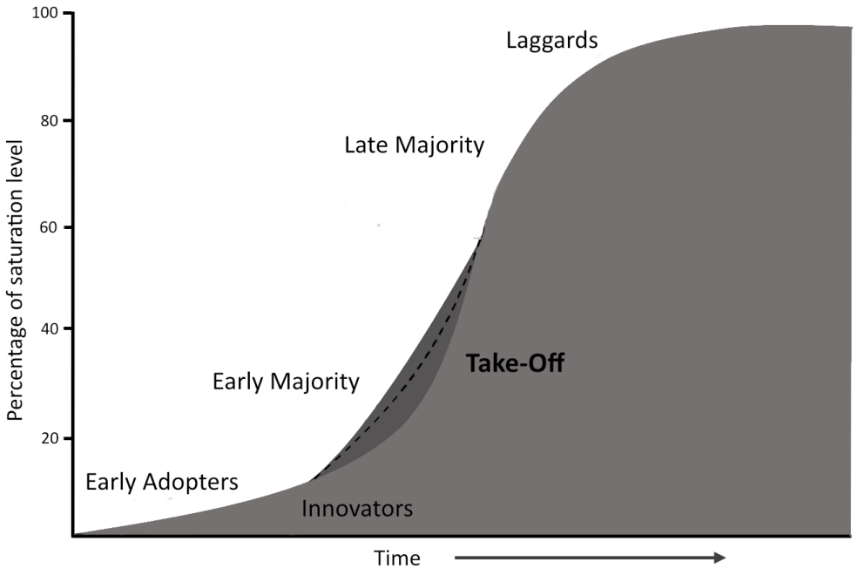

Figure 2 Graphical representation of Rogers' (1995) technology diffusion to market

Rogers (1995) suggests an individual's willingness to adopt a technology will be influenced by a number of characteristics. These include the individual's awareness, interest, evaluation and trials of the technology. In Rogers' model, individuals first learn about a technology and its function. Based on their evaluations - either positive or negative - they will choose to either accept or reject the technology. If they choose to adopt and implement the technology they will seek out supportive statements to confirm their choice was a good one. Continued support for the technology reinforces further adoption. On the other hand, if they received negative messages they are likely to discontinue with that technology. Similarly, if an individual first rejects a technology and finds supportive messages around the decision to reject they continue with the rejection. However, if there is no support to reject the technology, the individual may later decide to adopt the new technology (Gardner & Ashworth 2008).

4.2 Technology Acceptance Framework

More recently, theories from the field of social psychology have been used to explain and predict the social acceptance of pro-environmental innovations. Understanding why consumers support or resist sustainable technology at early phases of its introduction can lead to more acceptable designs and implementation of technology (Huijts, Molin & van Wee 2014), and more effective, targeted information and communication strategies (Huijts, Molin & Steg 2012; Zaunbrecher et al. 2016). One of the more advanced theories that provides a model to identify causal links between intentions and acceptance is the technology acceptance framework (TAF) (Huijts et al. 2013; Huijts, Molin & Steg 2012; Huijts, Molin & van Wee 2014). It combines two well-known theories as well as constructs of trust and fairness, to understand citizens' acceptance of new energy technologies (see Figure 3). The first of those theories is the theory of planned behaviour (Ajzen, Icek 1991) which proposes that 'attitudes', 'subjective norms' and 'perceived behavioural control' influences acceptance. According to this theory, an individual is more likely to accept a new technology if they evaluate its costs, benefits and risks positively (i.e. attitude), their family and friends have a similar opinion about it (i.e. subjective norms) and they believe they have the capability to use or manage the technology (i.e. perceived behavioural control). In terms of home battery storage, perceived behavioural control would be feeling as though you have sufficient skills and knowledge to use the product, that you can afford the product and have the space in your home to install it.

The second theory integrated into the TAF is the norm activation model (Schwartz, Shalom H 1977; Schwartz & Howard 1981) which states that personal norms or feelings of moral obligation influence intentions and behaviour. Different personal norms drive people to use sustainable technologies for a variety of reasons including benefiting the environment, reducing their electricity costs or being less dependent on the grid. The TAF model proposes two determinants of personal norms. The first is 'problem perception' which refers to the evaluation of the adverse consequences of not acting. For example, the consequences of not using a more environmentally friendly energy source could be air pollution and climate change (Huijts, Molin & van Wee 2014). The second factor is 'outcome efficacy' which is a belief that your actions can be effectual and they will contribute to effective solutions to the problem (Huijts, Molin & Steg 2012).

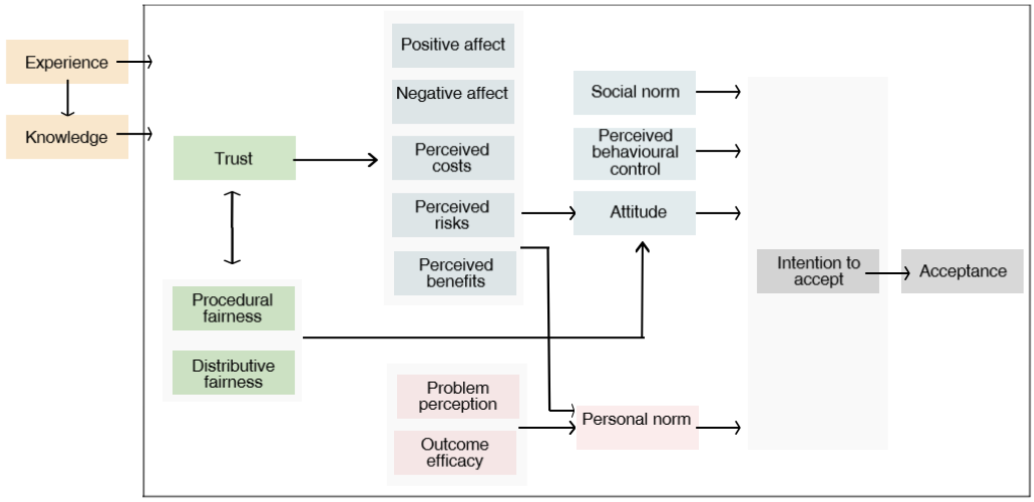

Figure 3 Schematic of the technology acceptance model (Huijts, Molin & Steg 2012) incorporating the theory of planned behaviour (blue boxes), the norm activation model (pink boxes) and constructs of trust and fairness (green boxes)

While only recently formulated, the TAF model has been shown to usefully explain intention to act in favour of and against a community hydrogen fuel station, with most variables significantly contributing to the model (Huijts, Molin & van Wee 2014). Perhaps not surprisingly, personal norm was the strongest predictor of intention to act favourably and against the technology, which highlights the importance of one's moral obligations in determining pro-environment action. The next two strongest determinants for intention to act favourably were positive affect and perceived effects (costs, benefits, risks) of the technology and those for intention to act against were negative affect and trust in the industry.

The model provides useful insights to apply at the householder level to understand likely attitudes towards energy storage, in particular battery storage, that can be installed at the household level. Many of the variables explained in the TAF model helped to inform the national survey which is detailed in the methods section below.

5. Methods

To better understand current societal attitudes towards storage in Australia we employed a mixed methodology. Focus groups were conducted with a cross section of the public to inform a larger national survey. At the same time a series of interviews were undertaken with several key stakeholders who had background knowledge and experience with storage. Interview participants were representatives from government, industry, academia and Community Service Organisations (CSO). This section details the various recruitment processes and methodology of analyses used.

5.1 Interviews

A number of key stakeholders were recruited to participate in telephone interviews. Initially participants were purposefully recruited through the position they held within organisations that had a relationship to energy storage. Snowball sampling was then used to grow the pool of interview participants with those being interviewed suggesting others who would be relevant to the study. Overall 17 interviews with 19 participants were undertaken. Representatives include 4 from CSO's, 1 non-government organisation, 4 state government departments, 1 federal government department, 1 local government department, 6 industry representatives and 2 ministerial advisers. All interviews were audio-recorded and subsequently transcribed. Manual coding was used to identify the key themes arising from the interviews and these are detailed in Section 6. A copy of the interview questions can be found at Appendix A.

5.2 Focus Groups

Focus groups were conducted in both Brisbane (2) and Melbourne (4). Participants were recruited using a mix of processes including placing an advertisement in a university and the Australian Technology Association newsletter. A CSO being used to recruit one group of participants, and a recruitment agency also being employed to ensure a balance of age and gender was reached for the balance of focus groups. In total, there were 58 participants of which 23 were male (40%) and 35 (60%) female. Participants' levels of age and education are detailed in Table 1 Age and education of focus group participants below. Of the total group there were 22 (38%) participants who had solar PV installed. Participants were also asked if they subscribed to Green Power. Two (3%) participants were subscribers, 37 (64%) did not subscribe and 19 (33%) reported they did not know.

Table 1 Age and education of focus group participants

AGE	**No.**	**%**
18-35	23	40.4%
36-50	12	21.1%
51-64	11	19.3%
>65	11	19.3%
LEVEL OF EDUCATION	**No.**	**%**
High School or <	14	24.1%
Trade certificate/apprenticeship	1	1.7%
Diploma	10	17.2%
Bachelor's	18	31.0%
Post-graduate	15	25.9%

The focus groups lasted for 2.5 hours and a facilitator guided the discussion while a note taker recorded the key points of the discussion. The focus groups were also audio-recorded to ensure accuracy of the notes. The run sheet for the focus groups can be found in Appendix C. All information was subsequently analysed to identify the key themes arising from the discussions and the results are documented in Section 7.

5.3 Survey

To further elaborate on the Australian general public's current knowledge and understanding of energy storage a national survey was developed. The items in the survey were based on the information that arose from the desktop research and literature review, interviews, focus groups and the scenarios developed by Work Package 1. After pilot testing, the final survey comprised of 43 questions divided into four areas including:

1. Demographics
2. Current energy usage and living arrangements that might influence energy usage
    a. General
    b. Solar PV
    c. Home Battery Storage
3. Variables associated with socio-psychological theories of technological acceptance – for example the Technology Acceptance Framework (TAF) (Huijts, Molin & Steg 2012) including Theory of Planned Behaviour (Ajzen, I 1991) and Norm Activation Model (Schwartz, S. H. 1977)
4. Scenarios from Work Package 1 and examples of community and utility scale storage.

Demographic questions asked respondents their age, gender, postcode, relationship status, whether they had dependent children, their country of origin, whether they were of Aboriginal and/or Torres Strait Island origin, the level of their highest educational attainment, their occupational status, the industry they had spent most of their career life in, their estimated household income and the political party they voted for in the last election.

There were eleven questions that measured respondents' energy usage. Seven questions were about general usage and asked about the types of energy sources they use at home[9]; the size of their last electricity bill (amount and time period); how financially difficult it is to pay their electricity bills[10]; how often they experience electricity supply problems (a. power outages, b. supply disturbances (Never [1] to Almost Always [6])) and about their living arrangements to allow us to

[9] Responses included: Electricity, Gas (mains), Gas (bottled), Solar hot water, Solar PV, I do not have access to mains power, Other?
[10] Including an option to indicate those who do not pay energy bills

better explain their usage. These questions included how many bedrooms were in their home (1 to 5 or more), how many people were usually home during peak electricity periods (0 to 5 or more), and what type of residence they had (free standing/detached/semi-detached/room in a shared residence) and the ownership model (own/rent/live with family). This latter question was included to determine whether participants' living arrangements allowed them to install the various energy options (solar PV panels, gas (bottled, mains), home battery storage units).

Two further questions asked participants about their solar PV status. Options included whether they had installed solar PV in their home, whether they had solar PV but did not install it themselves (e.g. renting or purchased a home with a solar PV) and whether they did or did not intend to install solar PV in the future. Participants who indicated they had solar PV were also asked the year it was installed. It was hoped that this information could be cross-referenced with their home state or territory, to better determine the impact of various incentives, including FiT's, on solar PV uptake. Two final energy usage questions were about home battery storage. One asked participants whether they had a home battery storage unit and the response options were similar to those given above for solar PV ownership. The final question asked participants to rate the importance of ten finance options (Not at all important [1] to Extremely important [5]) if they were to purchase a home battery storage unit.

There were eleven questions that measured variables associated with the TAF, to better explain why participants were likely to be more or less accepting of home battery storage units and to a lesser extent solar PV. Eight questions specifically addressed acceptance of home battery storage, which can be mapped against the schematic of the TAF model in Figure 3. These were:

- **KNOWLEDGE**[11]: "To what extent are you familiar with home battery storage and could explain it to a friend?" (Not at all familiar [1] to Extremely familiar [5])
- **TRUST**: "If there is a large increase in the use of home battery storage in Australia, to what extent would you trust the following groups to act in the best interest of the consumer?" Participants were asked to rate the extent to which they would trust the following agencies (Not trustworthy [1] to Extremely trustworthy [5]): Federal Government, State Government, Electricity sector organisations, Manufacturers of energy storage technology, Retailers of energy storage technology, Installers of energy storage technology.
- **COST, RISKS, BENEFITS**: "How important are the following factors in determining whether or not you would purchase a home battery storage unit?" Participants were asked to rate (Not at all important [1] to Extremely important [5]) the importance of eleven items that

[11] Item similar to (Agnew & Dargusch 2016)

represented either a potential cost (e.g. "Its purchase cost"), risk (e.g. "Its safety features") or benefit (e.g. "It reduces your dependence on the grid").

- **ATTITUDE**: "What is your attitude to home battery storage? Please mark your response along the continuum from 1 [representing most negative] to 6 [representing most positive]." There were four dimensions used to measure participants attitude: Very negative to Very positive, Very unwise to Very wise, Very unimportant to Very Important, Not at all useful to Very useful[12].
- **SOCIAL NORMS**: participants were asked the extent to which they agreed (Strongly disagree [1] to Strongly agree [5]) that 1) people important to me and 2) people in my community would find it good if they installed a home battery storage unit[13].
- **PERCEIVED BEHAVIOURAL CONTROL**: five items were used to determine whether participants had the resources available to them to install a home battery storage unit (e.g. finances, space) (Strongly disagree [1] to Strongly agree [5])[14].
- **PERSONAL NORMS**: "How strongly do you feel a personal obligation to use environmentally friendly energy sources and methods? Please mark your feelings on the continuum from 1 to 6" (Not at all obliged [1] to Very obliged [6])
- **PROBLEM PERCEPTION**[15]: "To what extent do you think that the following problems will arise in the next 20 years as a result of the burning of fossil fuels for electricity?" Participants rated (Definitely not [1] to Definitely [6]) the extent the probability of five events occurring: Air pollution, Depletion of coal and oil, Climate change, Loss of biodiversity, Increasing energy costs.

Another question asked participants how important a set of costs, risks and benefits were to them in in determining whether they purchased, or intended to purchase, solar PV. Only participants who previously indicated they had already purchased or were intending to purchase a solar PV were given this question. Responses and formatting were similar to that of the battery question above (COST, RISKS, BENEFITS). Two additional questions, more broadly associated with attitudes towards technology uptake, tested a) six items from Heath and Gifford's (2006) Free Market Ideology Scale, which measures the degree to which participants believe that markets should be allowed to exist unrestrained by government regulations and b) Roger's (1962) Diffusion of Innovation theory using Noppers, Keizer, Bockarjova and Steg's (2015) Consumer's Adoption Stage scale. In the latter question participants were asked to select the characterisation of a certain adopter segment that

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[12] Wise, important and useful dimensions taken from (Huijts, Molin & van Wee 2014)
[13] Items taken from (Korcaj, Hahnel & Spada 2015)
[14]Items similar to those used by Korcaj, Hahnel & Spada 2015)
[15] Items taken from (Huijts, Molin & van Wee 2014)

fitted them best in regards to the purchasing of new technology: innovators/early adopters, early majority, late majority or traditionalists.

Finally, the questionnaire included items from the Scenarios from Work Package 1. There were six questions about Australia's renewable energy and energy storage use in 2030 where participants were asked to consider the *energy mix*, *grid reliability option* and *developmental pathway* they think is a0 most likely and b) they would prefer in 2030 (see questions 36 to 41 in Appendix F). Participants were also asked to consider two larger-scale forms of energy storage – a community-scale battery storage project and a utility-scale pumped hydro storage project. For both, participants were asked to rate the extent to which a) they and b) their friends and family thought they were a good idea (Strongly disagree [1] to Strongly agree [5]). Finally, participants were asked to indicate which they felt was the better of the two options and to give reasons for their answers.

All Likert scales also included a 'don't know' option included.

Procedure

A market research company (Q & A Research[16]) was engaged to survey a representative sample of the Australian public (N=1,015) between the 17th and 21st February, 2017. The median time taken to complete the survey was 13.92 minutes. Key characteristics of the sample matched those of the Australian population (ABS 2017) including age and gender, proportion of the sample from each state and territory and employment status (see Appendix D for a complete list). There was an equal split across gender and across three age brackets of 18 to 34 years, 35 to 54 years and 55 plus years (refer Table 2). The mean age of respondents was 47.84 years (SD = 16.46 yrs). Sixty-five percent (65%) of respondents were in a relationship, with 50% of those married and 26% had dependent children (18 yrs or younger). Seventy-five percent (75%) of participants were born in Australia with the rest mainly born in Europe (12 %; UK = 8%), Asia (8 %) and New Zealand (3 %). Participants identifying as Aboriginal and/or Torres Strait Islanders made up 1.6% of the sample. There was a relatively even split between the proportion of participants whose highest level of education was high school (i.e. years 10, 11, 12; 30%); trade/certificate/diploma level (36%); and bachelor/postgraduate (34%). Of those able to work, 67 per cent were in full time work, 25 per cent were in part time work and nine per cent were unemployed. Just over half of the sample (53.8%) had a household income of below $75,000; and compared to the Australian population, our sample had fewer people in the upper household income ranges (i.e. more than $125,000; see Appendix D).

[16] https://qandaresearch.com.au

Table 2 Age and gender of sample

	Male		Female	
Age	**Freq.**	**%**	**Freq.**	**%**
18 - 34 yrs	152	15.0	144	14.2
35-54 yrs	175	17.2	177	17.4
55+ yrs	187	18.4	180	17.7
Total	514	50.6	501	40.3

6. Interview results

Those stakeholders who participated in an interview were asked a range of questions about what they thought was the future of storage in Australia the key themes that arose from these interviews are summarised below and detailed in Appendix B .

6.1 Most frequently occurring themes

Based on all responses by interviewees the most frequently mentioned topic was around safety concerns in relation to the use of energy storage (N=106). This was followed by discussions around the market (N=64) and social (N=52) factors. Other themes included policy and regulation (N=54), information about different types of energy storage technology (N=52) and the role of government in the process (N=32).

A wide range of energy storage technologies were mentioned, with batteries (N=10), pumped hydro (N=11), flywheels (N=4) and hot water (N=6) being those most frequently mentioned. When discussing utility scale, in-front of the meter solutions, size was seen as an important factor. Location was also important and similarities were drawn with renewables that individual opportunities would emerge based around the specific location and resource availability. Pumped hydro was also seen as the type of storage that could help deal with additional security issues that might be cause through different faults in the system. As well as being much cheaper than many other forms of storage. The two quotes below highlight some of this thinking.

> *For example, now already today for remote communities, solar, batteries, diesel generator backup is cheaper than diesel in its own right, just because the transport costs for diesel are so high. So, already without government subsidies and assistance and that, there is certain subsets in the renewables sector already are more compelling alternatives to tradition sources already.* Interview 016

> *what I'm saying is unless you can build chunks of 1, 2 , 3 GWh who cares, and lets face, there's lots of really big batteries being built around the world... that's where the synchronous machines, particularly like pumped storage make sense, not only do you deal*

with the intermittency of renewables but you also start to deal with the ability to provide inertia because there is a big rotating machine, and also being a synchronous machine, they can provide fault level Interview 015

The main factors encapsulating energy storage concerns included the need for safety standards (N=35), considerations around the environment and climate change (N=15), recycling issues (N=15) and safety/fire concerns (N=17). The quote below clearly highlights the concerns around standards.

There was a lot of talk when we first spoke to Standards Australia about which standard should we focus on, and the reason we did installation rather than product was, well, we don't really do much in the market. So it is all - there have been batteries coming into the market, and the more critical thing is to make certain that we actually have these batteries installed appropriately, safely and by skilled people, and we actually understand where they're installed, so that's why we've gone with the installation. Interview 002

In relation to the market, the topics that arose included the need for smart meters (N=16), fear of rapid development (N=12), pricing issues both in relation to cost of the technology but also the price of electricity (N=9) and the need for cost reflective pricing to really make energy storage more attractive. Social concerns were around the desire for independence (N=15), a recognition of the lack of understanding about storage more generally (N=16) and the need for social responsibility so as not to replicate the issues that arose with incentivising solar PV in Australia (N=10). Other notable topics mentioned included the opportunities for dual functioning batteries in the form of electric cars (N=19) as well the need for considerations of the regulatory framework and/or structure surrounding the energy storage industry (N=19).

We literally have a twentieth century regulatory framework system in a world that's twenty-first century world, where a whole range of possibilities are not only possible, but inevitable and beneficial for everybody involved. Interview 006

6.2 Drivers of energy storage

The major themes that arose from the interviews around the current drivers for storage show that participants clearly saw individual preferences (N=70) being an important consideration, financial considerations were the next most frequently occurring theme (N=60), along with knowledge of products (N=114) and finally 'other' (N=13) more generic drivers (refer to Appendix B). Key factors that arose as drivers within the individual preferences theme included the need for independence (N=15); the ability to go off-grid (N=12); energy storage being complementary to already installed rooftop solar PV (N=10); dissatisfaction with electricity companies (N=10) and energy security (N=9).

All of these responses seemed to reflect a recognition of the strong drive by many individuals to take back an increased level of control over their energy supply.

> *So the fact that prices are so high and also the poor behaviour by retailers – with all the stories about gold plating for networks and all of that sort of stuff has – breeds this sort of mistrust – in the energy sector and flows onto wanting independence, like "I just want to go off grid because I don't want to give my – you know money to those companies, I don't trust them."* Interview 009

The theme of financial considerations related mainly to finding ways to mitigate against rising electricity costs (N=16), the emerging opportunities for electricity trading and arbitrage (n=8) and the impact of new tariff structures creating more opportunities (N=9). However, there was some recognition that not everyone would be likely to have the technical knowhow, motivation or interest in being so involved in their personal electricity supply.

> *It's more flexible…. So, it just takes all that risk away from you because you know what your input costs are. It's interesting on so many levels. It's such an interesting development and I think that's why it's coming forward so fast, because it's not just of interest to people who are thinking about reducing emissions, it's just is such a liberating technology on so many ways.* Interview 012

Other notable factors included those related to products such as the marketing spin and/or hype (N=10) currently utilised by major battery retailers as a driver for energy storage uptake.

> *Probably the other broader thing that has impacted is, I think, we can't underestimate the, I suppose, the Tesla implications, people have got excited about the… Tesla batteries are the sexy looking batteries, yeah, the fickle consumers will want the concept of new technologies, so digital media is becoming more and increasing prevalent, so people want the new gismo as part of their household future.* Interview 002

6.3 Barriers to energy storage

On the flip side, in relation to the barriers for energy storage within Australia, financial (N=35) and individual (N=25) factors were also identified as the main barriers. Other barriers include policy and regulation (N=23) and technology (N=10).

Financial factors such as cost (N=13) and justifying investment (N=10) ranked highest alongside other individual factors such as lack of understanding/trust (N=9), location requirements (N=5) and home ownership (N=5). This reflects the dilemma that although energy storage presents the opportunity for individual and financial drivers, there also exists large financial and individual hurdles which must be alleviated before the individual drivers can be realised. Currently, the cost of storage was seen as the largest barrier as for many the economic returns did not payback over an acceptable time period. However, it was recognised that the price of batteries was reducing.

> *If it's not economic there'll be still some people who just want to have - be off grid, or have their own control, or choice, but at the end of the day it's really hard to make it stack up and really hard to then justify the investment decision. Interview 002*

Within policy and regulation, standards coverage and/or regulation (N=6) and the regulatory model for networks (N=9) were seen as primary barriers for energy storage uptake.

> *I think the application process for provision to connect (battery storage units) definitely needs to be streamlined. It can vary between networks from 24 hours to 65 days. And telling your customer that has just bought a system that they have to wait 65 days until they are allowed to connect or not, is a long time. Interview 007*

From the interview themes, it is clear there are definite opportunities on the horizon for energy storage. However, the legacy issues that emerged in response to the sharp rise in electricity prices mean many individuals are cautious about trusting both government and industry led initiatives. Energy storage, sits firmly in the middle of this, presenting both a way for individuals to become independent of the established regimes but at the same time means they may need to invest significant capital without the necessary guaranteed returns. This was further highlighted in the focus group discussions with a range of representatives from the general public.

7. Focus Group Results

The focus group discussions held in Brisbane and Melbourne were recorded and subsequently transcribed, in addition to notes being taken throughout the discussions. The results are summarised below and reflect the patterns that emerged from the discussion guide which can be found at Appendix C.

7.1 Energy in Australia

When asked what they knew about energy in Australia, all groups responded that it was expensive. Most knew that Australia was heavily dependent on coal (5/6) but there was also an acknowledgement that Australia was in a state of transition. With references made to the blackouts in South Australia and the imminent closure of Hazelwood power station participants expressed concerns over reliability of supply (4/6). There was much disgruntlement with the lack of long term energy policy planning in relation to climate change threats and that energy has become such a politically contested topic. The quotes below represent some of the early points raised.

> *(Electricity) Is one of the most expensive parts of day to day living apart from your rent or mortgage. Australia is still tied to the fossil fuel industry, yet we have so much potential for renewables*. FG6

> *Just on the confusion - with the Queensland government forging ahead with the Adani coal mine - while simultaneously declaring support for 50% renewables by 2030, in the same government*. FG2

Solar was generally met with strong support with 22/58 participants having installed solar PV panels or were renting a house with solar PV panels installed. When asked about their motivation for installing solar the environment was mentioned in four of the six groups. However, the ability to take up feed in tariffs (6/6), reduce electricity bills (6/6), and safe guard against future energy price increases (3/6) as well as energy security (4/6) were seen as primary factors for adopting solar PV panels.

> *Energy costs were increasing dramatically, so it was future proofing for us, and we also were sick of summer and getting air conditioning which I wasn't prepared to get unless we had solar to offset our electricity costs and use*. FG2

> *Economic, pure and sweet, looked too good to be true, but when I looked into, it obviously was economical, it was 15% return, can't do better than that. The only problem now is I can't put more panels on otherwise I lose my FiT.* FG3

These early discussions easily led into the potential opportunities and barriers for energy storage which are detailed below.

7.2 Energy Storage

When asked about what they knew or heard about energy storage the most common response was batteries (6/6) with many responding "Tesla" and the "Powerwall". Pumped hydro was mentioned in four of the groups and was recognised as a mature technology. However, participants tended to relate best to battery storage as they felt it was something they could utilise in their homes - depending on the price. Participant knowledge of batteries was mixed. Most mentioned phone, computer and car batteries and there was some discussion around the different types of chemical batteries in particular lead acid and lithium-ion. The discussions also ventured into electric vehicles and the role that they might play in balancing a household's electricity supply and demand.

The questions that arose in relation to battery storage included whether there were established safety standards both for importing as well as installing batteries (6/6). Similarly, when battery IP ratings were discussed, concerns were expressed around what the safe operating temperatures of batteries were (6/6), the risks of fire and water hazards and what might happen to a battery storage unit in a bush fire (2/6). Participants were also interested in the look and feel of the batteries, wanting to know what size the batteries came in and how much room would be needed in their back yard if they were to install a battery. Whether they could install a battery unit in a garage or whether it might need a separate garden shed (6/6). There was also some interest expressed in the type of maintenance required (4/6) and whether batteries would create any unwanted noise (either running or when being installed). Discussions also ranged into the environmental impacts of batteries, whether they could be recycled (6/6/) and what resources were required over the longer term to sustain a large battery industry.

7.3 Information and communication about batteries

Participants were interested to learn more about the various options available to them in relation to purchasing a battery and whether such a purchase would benefit them financially and/or have a reasonable payback period. Most acknowledge they had limited knowledge about energy storage and felt they would actively seek out information from trusted sources. These sources included both friends and family and others in the community who they expected to be knowledgeable on the topic. The participants also expressed a need to see information that could easily compare the different products available and what would be involved in installing one of them. Overall lack of credible information and leadership were challenges which must be addressed. The quotes below reflect the lack of information but general interest in the topic.

Wide range of sources, you'd want to hear it from people you knew, advertisements, articles in many newspapers, to almost change the culture to be more welcoming of the technology. FG4

Standardized information method. Just to look a list, and see some sort of method for deciding best solution. (apples and apples comparison) If a claim is made, they better prove it. If we put onus back on suppliers, then there is accountability. FG3

7.4 Financing investment in batteries

When discussing the different financial models for integrating batteries with home electricity, most participants expressed a preference for a set and forget type. Many participants appeared motivated to invest in battery storage if it could either reduce their electricity bill or it allowed them to go off-grid and be independent of the electricity retailer and industry more broadly. Recognition of how fast the landscape changes with new technologies, participants acknowledged their fears that the new battery technologies of today will likely be very quickly redundant, and so they expressed a desire around not wanting to lock in a specific technology too early. Therefore, choosing to delay their purchase to be able to invest in a more polished future product (6/6). That said, most respondents thought that batteries would follow the uptake path of solar PV panels in Australia and felt that the more affluent Australians will become the early adopters of battery storage creating some concerns over social equity issues as was seen with the solar PV FiTs.

Even if there is an incentive, some people will have caution because I'm not going to invest yet. If I wait 5-10 years, I will be getting a better unit that is also cheaper and more reliable, and all those bad businesses will have gone bust. FG2

The current product is not the product of the future. I just seem to think they're going to get smaller and they're going to get better. FG5

There was no clear indication of the preferred incentives for batteries or if it was felt they were necessary. However, tax breaks, FiTs, leasing and rebates were all discussed and perceived somewhat favourably. Ultimately, the economic rationality and financial flexibility that enhanced long term affordability of batteries, were considered suitable drivers for adoption. However, concerns were expressed for the financially and socially vulnerable with recognition that Solar PV Fit's had ultimately penalised those who were unable to afford the solar panels.

What's your incentive here, you're going to pay more, no that's not an incentive, and that's the problem that you can't give incentives to people that are going to see themselves paying more. FG3

8. Survey results

As detailed in the Methods Section (Section 5) the survey covered a wide range of topics. Here we detail the results relevant to the current project. As electricity prices was an issue that frequently arose across both focus groups and interviews the survey responses are expanded upon first.

8.1 Electricity bills and ability to pay

The average quarterly electricity bill (for those of the sample paying for electricity, n=936) was \$373.74 with a standard deviation value of \$266.58. There were 16 participants who reported paying \$0.00 and further analysis showed that 15 of these participants had solar PV panels. Shown in Figure 4 is the percentage of participants with and without solar PV panels by their quarterly electricity bill. Evident in this figure is that a higher proportion of participants with solar PV panels were paying the lowest amounts (up to \$200) and conversely, a higher proportion of participants without solar PV panels were paying between \$201 and \$600. For both groups, participants paying more than \$1001 per quarter all reported having three or more people at home during peak periods. The mean quarterly electricity bill of participants with and without solar PV panels was \$311.47 (SD=\$282.35) and \$392.87 (SD=\$258.75), respectively.

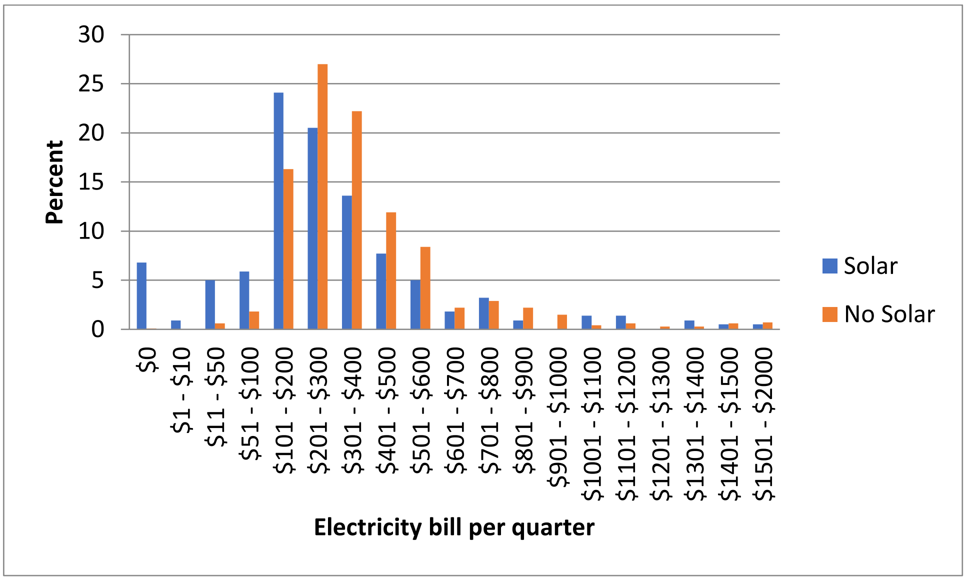


Figure 4 Electricity bill per quarter with and without solar

Further analysis by State and Territory is shown in Table 3 and Figure 5 below. Although it shows a spread of bill prices across Australia, caution must be taken with interpretation of these results. The small sample size for Northern Territory and Tasmania would skew the data. Further interrogation of the price data confirmed a trend that on average those living in smaller houses tended to have lower electricity bills and as the number of people at home during peak electricity periods increased, so too did their bills (as described above). A similar trend was also revealed when the energy mix data was interrogated with those living in an electric and bottled gas house (Mean=$458.77) or all-electric house (Mean= $421.85) having the highest bills. All prices reduced substantially for all energy mixes after that.

Table 3 Average quarterly electricity bills by State and Territory

State / Territory	Mean	SD	N	min	max	Median
NSW	$388.22	$243.27	259	$0.00	$1,590.00	$310.00
Victoria	$338.45	$222.68	222	$0.00	$1,500.00	$300.00
Queensland	$429.63	$322.43	184	$0.00	$1,935.00	$359.00
South Australia	$410.81	$262.34	75	$0.00	$1,400.00	$350.00
Western Australia	$282.14	$260.19	111	$0.00	$1,551.00	$223.00
Tasmania	$373.22	$211.11	23	$150.00	$900.00	$340.00
Northern Territory	$751.44	$508.82	9	$16.00	$1,500.00	$890.00
ACT	$332.25	$209.65	53	$25.00	$1,073.00	$300.00

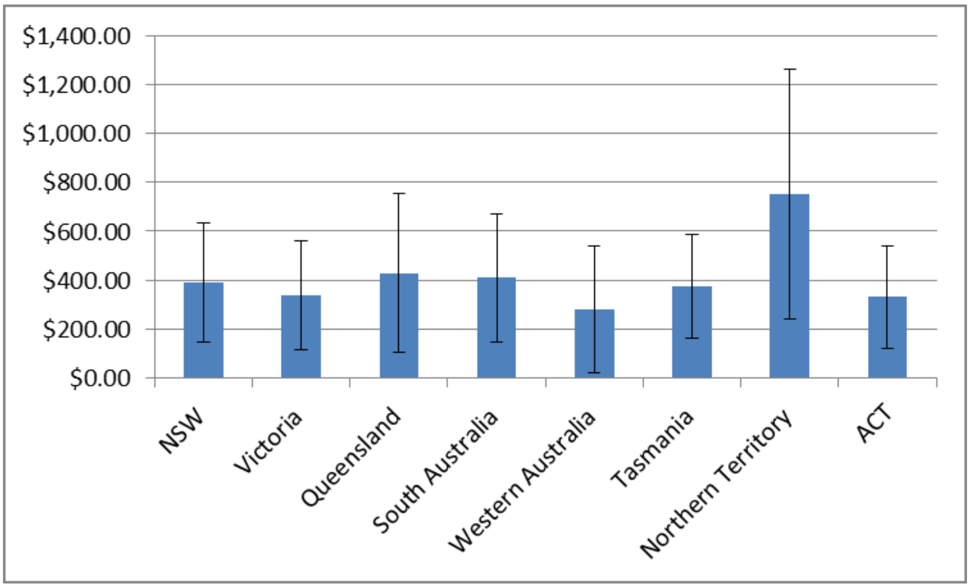


Figure 5 Average quarterly electricity bill by State and Territory

Most respondents (n=592, 58.3%) reported that paying their electricity bill was never a problem for them. Twenty-two percent (22%, n=224) reported that they sometimes found it hard to pay their electricity bill when it becomes due. With smaller numbers (approximately 6%) who always struggled to pay their electricity bills or pre-paid them. Further investigation also confirmed that the size of household income does impact on respondents' ability to pay as illustrated in the figure below.

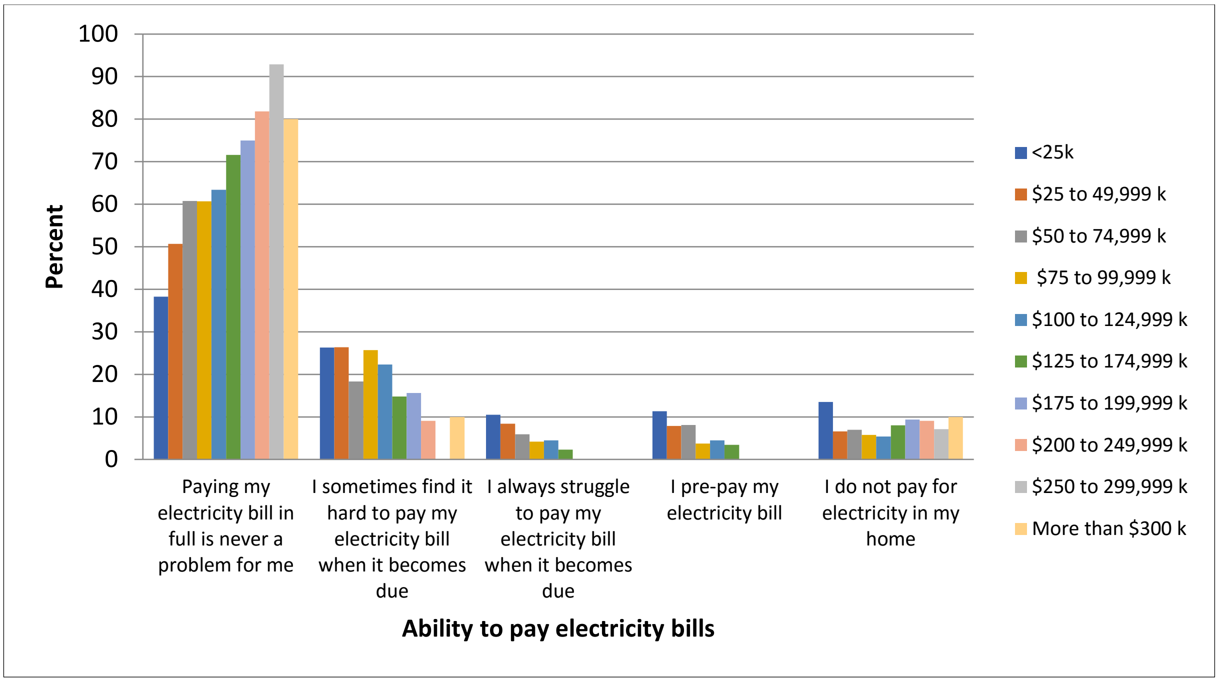


Figure 6 Respondents' ability to pay electricity bills based on combined household income

8.2 Solar PV Ownership Status

During the telephone interviews, many participants suggested that early battery storage deployment would most likely follow that of early solar PV uptake. This section provides an overview of responses that relate to solar PV and confirms some of that hypothesis. Of the total sample, 19% had installed solar PV panels to supply their house and an additional 6% had a house that had solar PV which they had not made the purchase decision about. Twenty percent (20%) suggested they intended to purchase solar panels in the next 5 years while 33% had no intention of purchasing solar PV panels. A further 17% did not know and 7% provided other open ended reasons around this question.

Table 4 Current status in relation to solar PV ownership

Current status in relation to solar PV ownership	Freq.	Percent
I have solar PV panels installed to supply my household	190	18.7
My house has solar PV panels installed but I did not make the purchase decision	56	5.5
I intend to install solar PV panels within the next 5 years	190	18.7
I do not intend to install solar PV panels	333	32.8
I do not know	174	17.1
Other	72	7.1
Total	1015	100.0

Analysis of the "other" responses showed that the majority of these respondents were unable to purchase solar PV because they were renting and therefore had no influence over the decision (n=42). However, several made mention that they would like to purchase solar PV if they moved and were buying their own home. The other key response area was around some form of restriction (n=29) that prevented them from purchasing outright. These were either around an inability to afford the purchase where solar PV was still considered expensive or it may have been around ownership, body corporate rulings or even issues around shading that made the purchase of solar PV not justified. Example quotes of these open-ended responses are listed below:

- *I'd love to install solar technology but sadly we are renting so cannot do it*
- *I live in a 6 storey apartment block so it is not possible at this time.*
- *I intend to move to a house I'll build and install solar panels within the next 5 years.*
- *I'm interested in solar panels but want to do more research.*
- *Council owned trees prevent me from installing solar as they block my roof of sunlight.*

8.3 Solar PV Purchasing

Participants who had installed their PV system were asked to indicate the year that they purchased their solar PV system and the responses are shown in the figure below. The sharp rise in installations during years post 2009 reflect the introduction of higher incentives from various state governments.

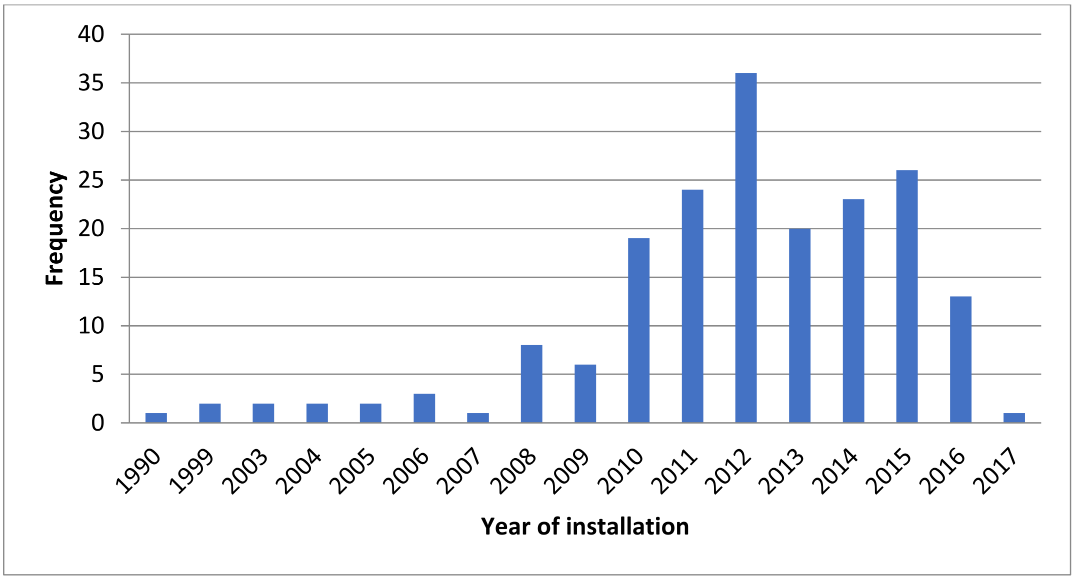


Figure 7 Year of installation of solar PV panels

Based on the solar installation year and comparing that with State based data, an estimate of the impact of solar incentives could be predicted. Incentives were segregated into four categories:

- PVRP – Representing pre-2008 when the PV Rebate Program was available
- Premium FiT's – Representing FiTs of more than 40c/kWh, typically from 2009-2012.
- Moderate FiT's – Representing FiTs between 10-40c/kWh, typically from 2012-14.
- Low-FiT's – Representing FiTs less than 10c/kWh, most offered by retailers and typically post-2014.

The response categories are detailed across states and territories in Figure 8 below to provide some indication of the influence of FiT's in purchase decisions. The analysis shows that in some states uptake (SA and QLD) diminished over time with reducing FiTs. However, others saw an increase (NSW and WA) or similar uptake (VIC) post Premium FiTs.

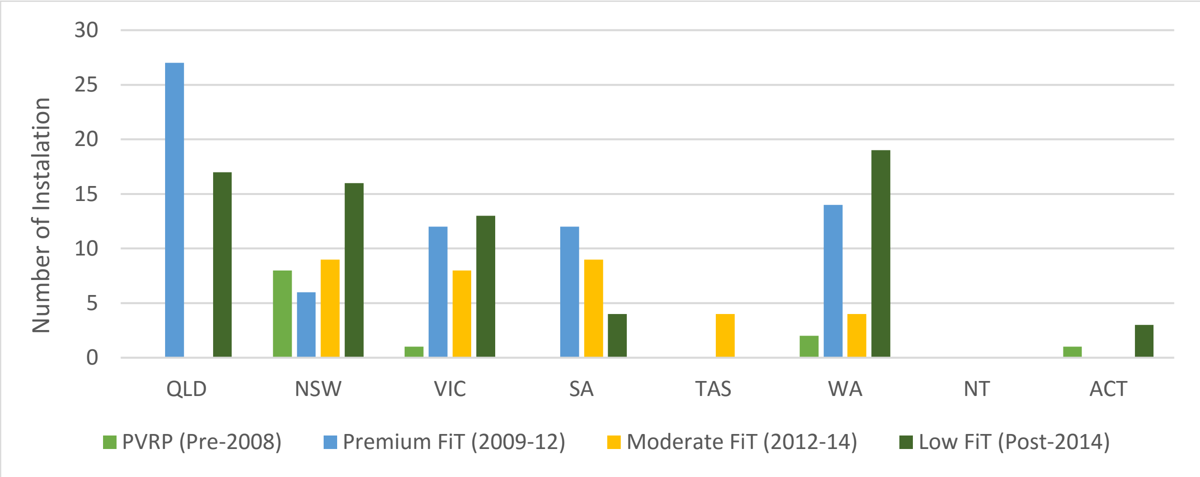


Figure 8 Distribution of solar PV uptake over time periods and Feed in Tariffs (FiTs)

The diminishing uptake may indicate a level of saturation within states like South Australia and Queensland who already have high penetration rates. Another factor might include the phasing out of Premium FiTs directly onto Low FiTs in QLD, which spurred an increased level of solar uptake in 2012. For states with increased or similar solar uptake, factors such as falling technology costs and rising electricity costs might be the drivers that pushed solar PV uptake post Premium FiTs. Unfortunately, the dataset for TAS, NT and ACT was not comprehensive enough to determine differences in uptake between eras.

It must also be noted that there exist a few inconsistencies across the time periods for different states, as jurisdictions phased out premium and moderate FiT at different times. This is most evident in Queensland, where it changed directly from Premium FiTs to Low FiTs in 2012. Other inconsistencies include time differences between approval and installation which are not captured in the data. As a result, installation dates on the border of each time period were assumed to have held approval a maximum of one year earlier.

Respondents with, or intending to purchase solar PV (N=380), were asked a number of questions around what factors influenced their decision to purchase. The responses were based on Likert scale response where 1 = not at all important to 5= extremely important. The mean responses are detailed in Table 5 below.

Table 5 Factors influencing Solar PV purchase decision (Scale 1 – 5)

Factors influencing purchase decision	Mean	Std. Dev.	N
It reduced your electricity costs	4.57	0.83	370
The better control it gave you over your electricity	4.25	0.91	370
Its purchase cost	4.23	1.00	374
The availability of feed-in-tariffs	4.12	1.04	365
The availability of a subsidy (e.g. lump sum) that made it more affordable	4.05	1.22	365
It reduced your dependence on the grid	4.05	1.12	366
Its safety features	4.03	1.11	362
Its benefits to the environment (e.g. reduce GHG emissions)	3.91	1.16	374
It improved the value of your home	3.89	1.12	368
The availability of Renewable Energy Certificates	3.48	1.35	328
The way it looked on your home	2.70	1.41	369
You liked what it said about you	2.63	1.45	355

8.4 Battery Storage Knowledge and Current Status

Respondents were asked "To what extent are you familiar with home battery storage and could explain it to a friend?" The pie graph below (Figure 9) gives a breakdown of responses. The results confirm that the majority of individuals have very little knowledge of home battery storage with 41% not at all familiar and 29% only slightly familiar.

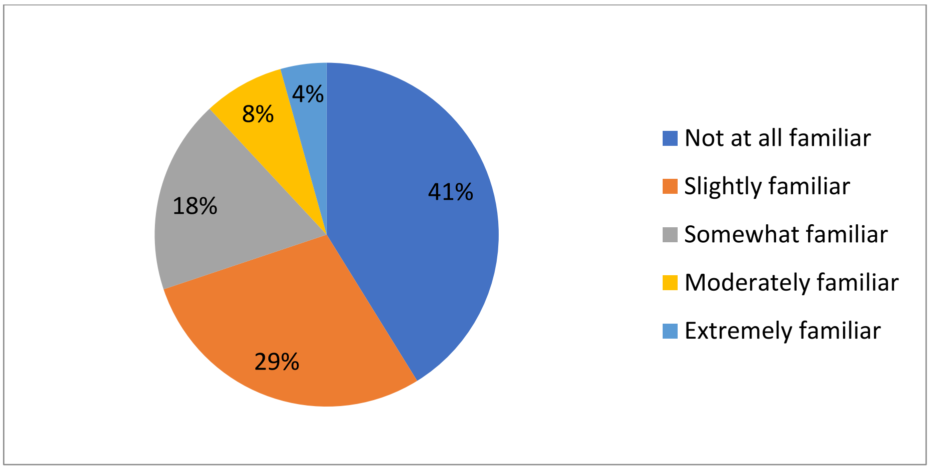


Figure 9 Knowledge of home battery storage

When asked to indicate their current status in relation to home battery storage ownership, only 2% owned a home battery storage unit and a further 14% indicated they were intending to purchase one. Another 23% were interested but were not intending to purchase, while 11% had no interest or intention to purchase one. Thirty-eight percent (38%) felt they did not know enough about battery storage to make a decision and another 12% were unsure.

Building on Rogers' (1962) "Theory of Diffusion" a question was asked around individual responses to technology adoption and this was compared with intention to purchase a battery storage unit. Although the technology adoption question only had four response categories, Figure 10 below clearly shows that those who classify themselves as early adopters or part of the early majority are more likely to own, or intend to own, a battery storage system.

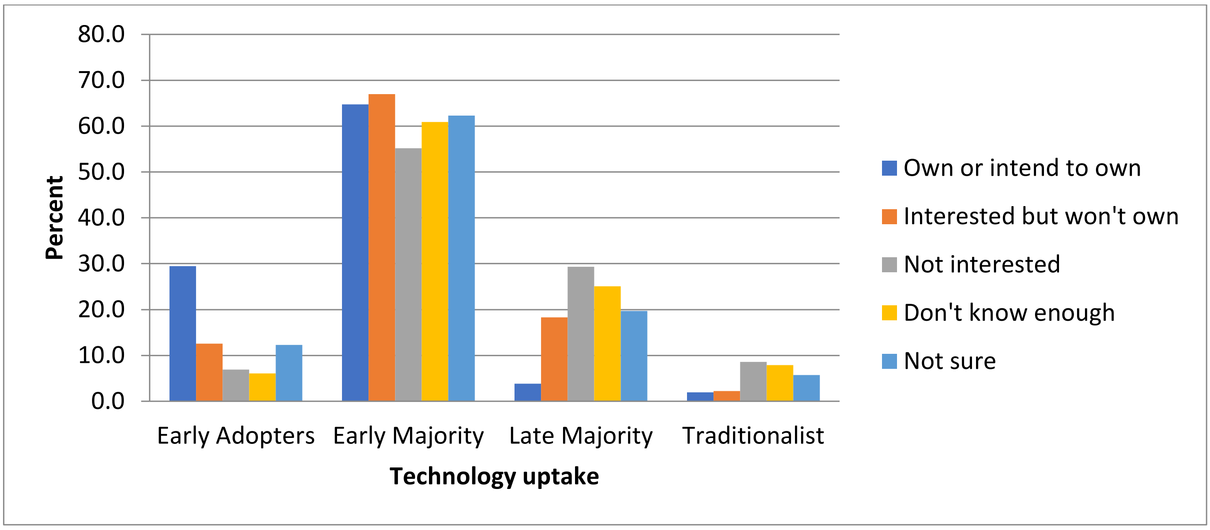
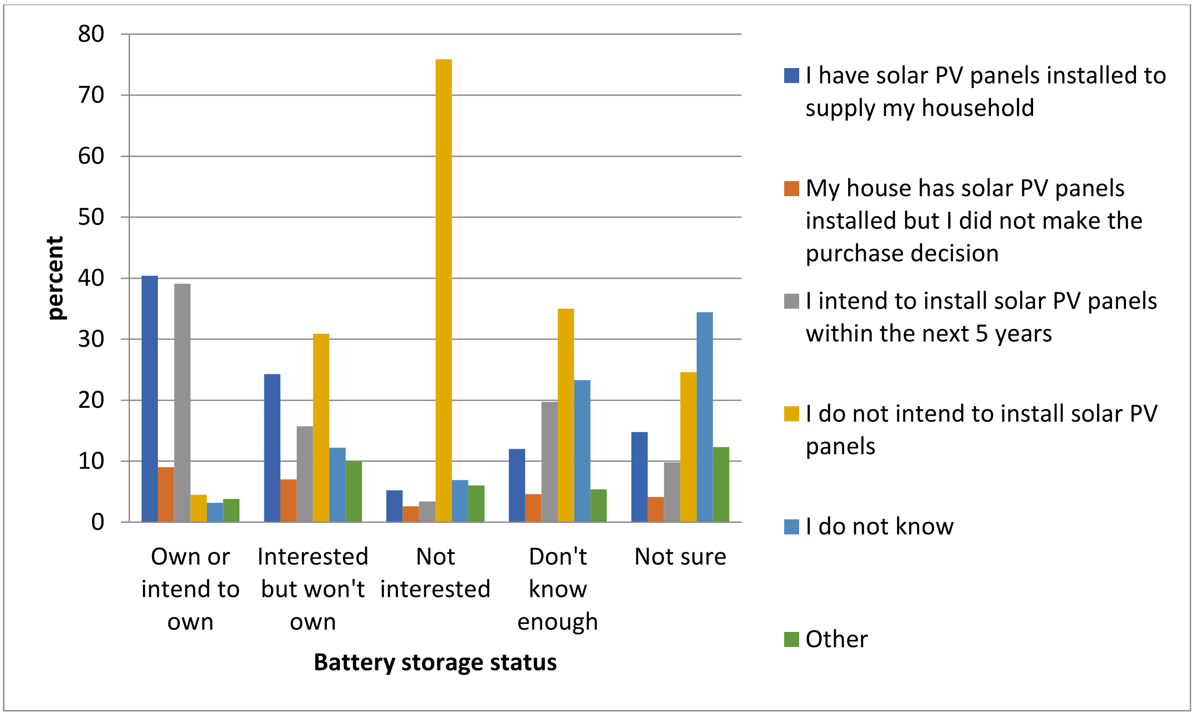


Figure 10 Battery storage status: Technology adoption

When comparing solar PV status and purchasing intention with battery storage status and purchasing intention, the figure below appears to confirm the thinking that arose in interviews. That is, that the diffusion of battery storage into society would follow the path of the solar PV panels (i.e. those with solar PV already being installed being more likely to install battery storage). It also suggests that there could be some reticence to purchase based on a lack of knowledge and this suggests there may be an opportunity to educate more Australian about the role that storage might play, based on the ACOLA study, through a concerted communication and engagement plan. Regardless it will be clear that the cost benefit analysis will need to be clearly explained to gain and maintain trust of the lay public.



8.5 Battery Storage Purchasing Intentions

Respondents were asked to identify the level of influence various factors that arose from the focus groups might influence their purchasing decision using a Likert scale (1 = not at all important to 5= extremely important). Between 10 and 16% responded with the don't know choice but mean responses of the rest of the sample are shown below. The numbers again clearly reflect the impact of rising electricity costs on individuals with it being the number one factor influencing purchase decision (mean=4.43). Other important factors included the purchase cost of the storage unit and its safety features. Control over electricity and reduced dependence on the grid reinforces the theme of individuals perhaps not trusting those supplying their energy and their motivation to detach themselves from them.

Table 6 Factors influencing home battery storage purchase decision (Scale 1 – 5)

Factors influencing purchase decision	Mean	Std. Dev.	N
It reduces your electricity costs	4.43	0.93	905
Its purchase cost	4.35	1.01	907
Its safety features	4.25	1.01	903
The better control it gives you over your electricity	4.15	0.97	896
The availability of a subsidy (e.g. lump sum) that made it more affordable	4.13	1.04	886
It reduces your dependence on the grid	4.09	1.05	889
Its end-of-life recyclability	3.82	1.17	851
Its benefits to the environment (e.g. reduce greenhouse gas emissions)	3.78	1.20	903
It improves the value of your home	3.68	1.28	885
Disturbances it might cause to your home (e.g. noise, space, heat)	3.68	1.24	873
The way it looks in your home	3.06	1.37	879
You like what it says about you	2.56	1.43	845

8.6 Reliability of Electricity Supply

Reliability and security of supply is also considered a critical consideration for householders. This is particularly since the South Australian blackout and the national discussion around the integration of renewables into the grid as their market share increases. Across the energy sector there has also been an ongoing discussion about whether individuals would happily accept a lower reliability standard for reduced electricity prices. Respondents were asked two questions around how often they experienced power outages (including planned and unplanned blackouts) (see Figure 11) and supply disturbances (flickers, dimming, interruptions) (see Figure 12).

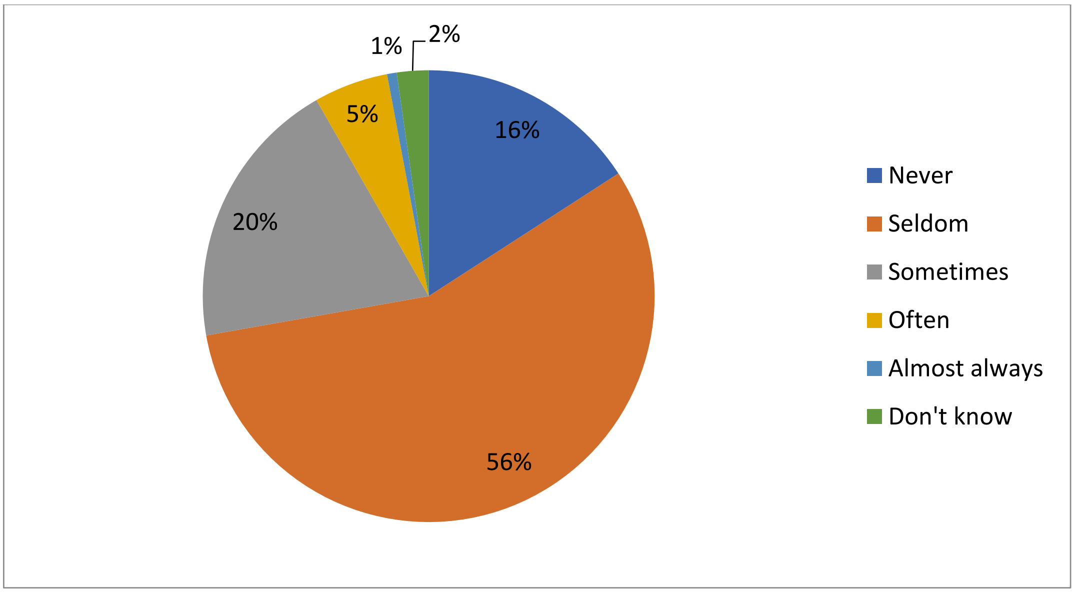


Figure 11 Frequency of power outages in percentage

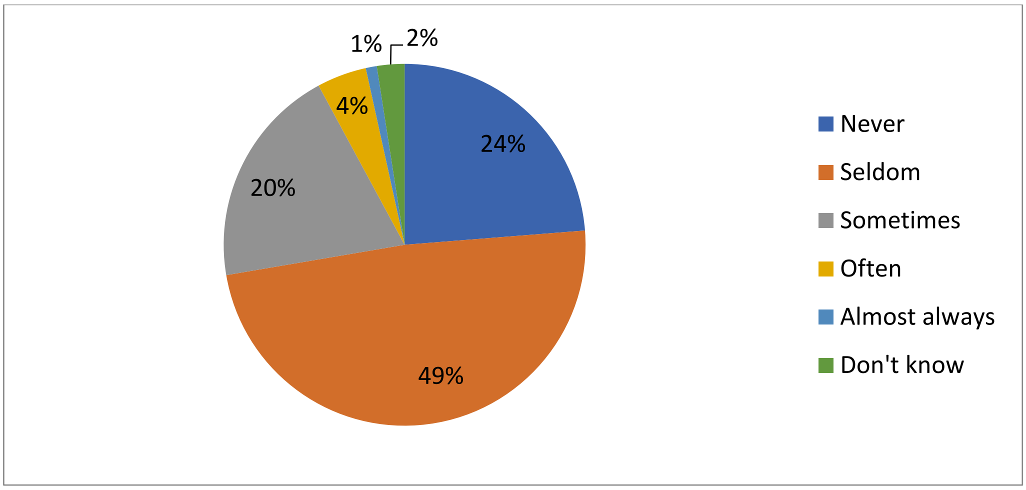


Figure 12 Frequency of supply disturbances in percentage

The results suggest that Australia's electricity supply is relatively reliable with 16% reporting never experiencing a blackout and a further 56% suggesting they seldom do so. Given that it is well known that some states have experienced issues with security of supply (i.e. South Australia and Tasmania) we subsequently analysed these first question on power outages by breaking down responses by state. The results are shown in Table 7 and Figure 12. The responses clearly reflect the recent issues in South Australia.

Table 7 Power outages by state and territory

	Never	Seldom	Sometimes	Often	Almost always	Don't know	Number
NSW +ACT	21.3	57.4	13.9	4.1	0.6	2.7	338
Victoria	15.9	58.1	17.5	4.1	0.4	4.1	246
Queensland	16.7	62.1	18.2	2	0.5	0.5	198
South Australia	0	33.3	47.4	16.7	1.3	1.3	78
Western Australia	11.6	55.4	23.1	6.6	1.7	1.7	121
Tasmania	2	17	3	1	0	0	23
Northern Territory	9.1	18.2	36.4	36.4	0	0	11

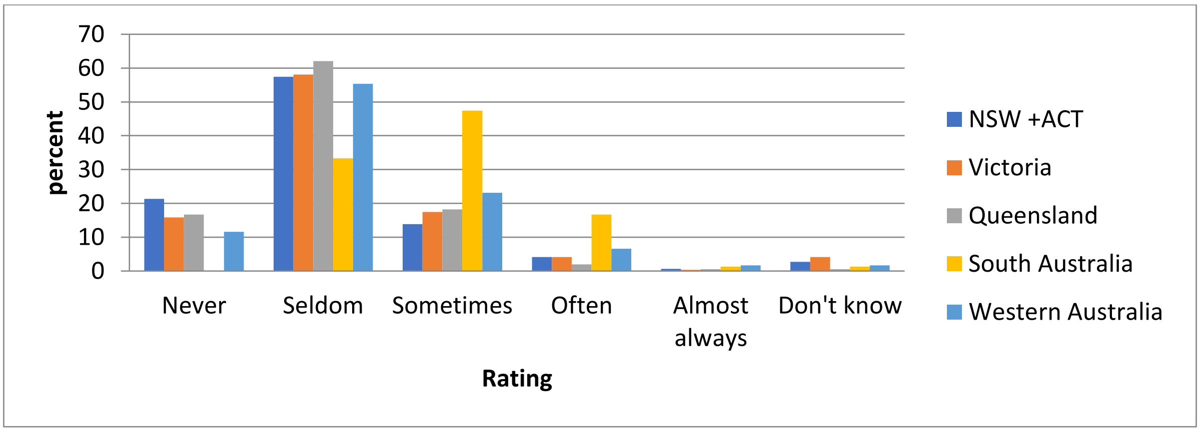


Figure 13 Power outages by state and territory

8.7 Levels of Trust

Based on the literature review it was clear that trust was an important element for home battery storage uptake. Respondents were asked "If there is a large increase in the use of home battery storage in Australia, to what extent would you trust the following groups to act in the best interest of the consumer?" (Likert scale of 1= not trustworthy and 5=extremely trustworthy and also a don't know option). The mean responses confirm that levels of trust in the federal and state governments and electricity sector organisations were low, with slightly lower trust expressed for electricity sector organisations (retailers) (see Figure 14). Manufacturers and installers of energy storage technology were trusted the most with retailers of energy storage technology the next most trusted. This low level of trust in government is most likely linked to the frequent and substantial changes to electricity policy over the past decade.

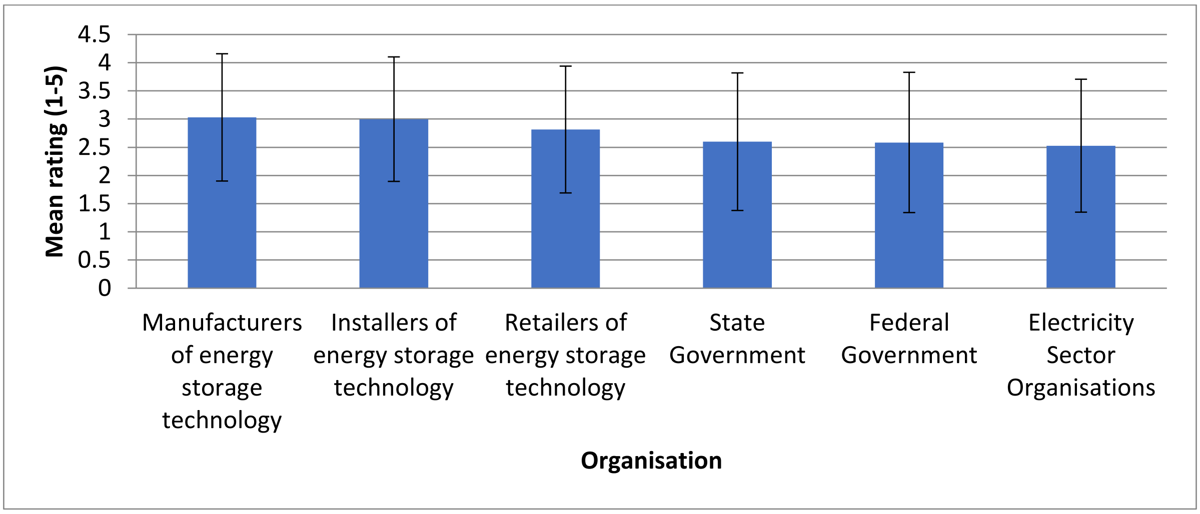


Figure 14 Levels of trust in organisations to act in the best interest of the consumer
Note: Error bars are standard deviation amounts

Finally, within the survey it became apparent there was an underlying mistrust of the government that emerged in relation to how they would manage storage uptake and to act in the best interests of the consumer. This type of response to government also emerged as part of the open commentary box when thinking about the scale of energy storage.

> *Government needs to stop ripping people off like the current reduction of tariff buy-back reduced from $0.33 to now $0.08. **** they cannot leave anything good alone. It was working out so well for us now it is hardly worth having the solar panels. Don't trust any government project as it always turns to ****. Not very happy at all*. ID 247
>
> *Recent events in South Australia have clearly proven that "Renewable" Energy sources as a stand alone do not work and do not have the capacity for storage. Battery storage is dangerous as most consumers have no idea on both maintaining and storing these items.*

Replacement costs will be exhorbitant, with limited warranty on the items. Initial costs may be cheaper via subsidies however, those subsidies will not allow for replacement. This is very similar to the ceiling insulation issues during the Rudd Government Stimulus Programme in 2008/2010. ID 581

8.8 Scenarios

Based on the scenarios developed in Work Package 1, participants were asked to build what they felt would be a likely and preferred scenario for Australia's renewable energy and energy storage use in 2030. The decision making involved evaluating three factors expected to influence Australia's use of energy and energy storage in 2030 and deciding how likely each was as well as to identify which was each individuals most preferred option. The three factors to select from included:

- *The mix of energies*: what the coal, gas and renewable energy mix would be to supply Australia's energy needs in 2030 compared with today's generation mix. The choice was a lower renewables energy mix (Coal: 25%, Gas: 21%, Renewable energies: 54%) or a higher renewables energy mix (Coal: 5%, Gas: 18%, Renewable energies: 77%).
- *Grid reliability*: how the reliability of the power in the grid will be maintained in 2030, considering Australia's increasing use of intermittent renewable energies. Whether through having an appropriate level of stored energy or suitable levels of coal and gas generation?
- *The development pathway for energy storage technology:* Energy storage technology has the potential to advance in different ways and this will affect the types of technology developed and the sites used to locate larger-scale energy storage technologies. Choices were one of three pathways that involved either: the law of demand and supply, market demand subject to environmental and social constraints, or advancement through government influence.

Outcomes were arranged according to participants' likely and preferred energy mix and are shown in Tables 8 and 9.

Renewables penetration by 2030

Table 8 shows that the sample was fairly evenly split regarding their views on the *likely* future energy mix – with 39% (N=397) of participants indicating that a lower mix was likely, 35% (N=355) indicating that a higher mix was likely in 2030 and 26% (N=263) did not know. In comparison Table 9 shows that considerably more people *preferred* a higher (N=594, 59%) than a lower energy mix (N=196, 19%) in 2030 with similar numbers not knowing which they preferred (N=255, 22%). This preference for higher renewables is evidenced in attitudinal surveys from both across Australia and internationally which seems to demonstrate society's preference for a clean green future. However, it appears that many are more pragmatic in what they think will transpire as further analysis of the data indicated that almost 40% (N=238) of those who preferred a higher energy mix in the future, felt that a lower renewables future was more likely based on their choices.

Likelihood

For grid reliability, sixty percent of those who reported that higher renewables were more likely to be used in the future also reported that it would be more likely that “Significant energy storage will be required to manage the intermittent nature of most renewables”. Conversely, 60% of those who said that lower renewables were more likely reported that “Coal and gas power generation will be used to cover any extended periods when the supply of renewable energy is low” would be the more likely scenario (see Table 8). Interestingly, a similar number from both the lower (45%) and higher (44%) renewables ‘likely’ groups reported that it would be more likely that “Storage technologies will advance according to demand, so the cheapest forms will be added when and where it is needed and subject to environmental constraints and social acceptance”. So there appears the public perceive there to be both a lower and higher renewables route to energy storage usage in the future. Those advocating the lower renewables route as being most realistic, suggest that coal and gas will likely play an important role in bolstering the reliability of the grid. While those who suggest a higher renewables route are more likely to consider energy storage the means by which the grid will be stabilised. Advocates for both routes believe that storage technologies will most likely advance according to market demand, subject to environmental constraints and social acceptance. Only a smaller proportion think it is likely that the advancement of energy storage use and technology will be guided by the government.

Table 8: A scenario for Australia’s renewable energy and energy storage use in 2030 based on perceptions of likelihood for a lower or higher renewables energy mix

		Likely in 2030		
		Lower renewables (397)	**Higher renewables (355)**	**don't know (263)**
Grid reliability likely				
	Coal & gas	60% (237)	27% (96)	16% (42)
	Energy storage	29% (116)	60% (212)	23% (60)
	don't know	11% (44)	13% (47)	61% (161)
Development path likely				
	Corporate/consumer preferences	20% (81)	21% (74)	8% (22)
	Supply/demand & cheapest form added subject to env constrainst and social acceptance	45% (180)	44% (157)	18% (48)
	Government influence	18% (71)	23% (83)	8% (22)
	Don't know	16% (65)	12% (41)	65% (171)

Preference

In terms of preference for the advancement of energy use and storage, as previously reported, nearly 60% of the sample preferred a higher renewables mix in 2030 and nearly three quarters of this group preferred that energy storage rather than coal and gas bolster grid reliability (see Table 9). Further, nearly half of the preferred higher renewables group also preferred that "Storage technologies will advance through government influence, causing the development of novel technologies, the location of large-scale storage sites in areas with low impact on the local environment and heritage and that benefit regional communities". In contrast, 56 per cent of participants who preferred a lower renewables energy mix, also preferred that coal and gas bolster the reliability of the grid. A considerable proportion of the lower renewables group (34%) preferred that energy storage play a role in supporting grid reliability. In terms of their preferred development path for storage technology, 35 per cent of the lower renewables 'preferred' group desired that "Storage technologies will advance according to demand, so the cheapest forms will be added when and where it is needed and subject to environmental constraints and social acceptance".

There appears to be a relatively clear route for advancement of energy use and storage for the large proportion of our sample who prefer higher renewables which involves the use of energy storage for grid reliability and government influence of its growth. The lower renewables route is less clear. There is a preference for coal and gas to maintain the grid, but also to a lesser extent energy storage. Market forces subject to environmental and consumer concerns are the preferred means of advancement for energy storage, but government influence and corporate/consumer preferences remain influential.

Table 9: A scenario for Australia's renewable energy and energy storage use in 2030 based on perceptions of preference for a lower or higher renewables energy mix

		Prefer in 2030		
		Lower renewables (196)	**Higher renewables (594)**	**don't know (255)**
Grid reliability prefer				
	Coal & gas	56% (109)	16% (97)	12% (26)
	Energy storage	34% (66)	74% (437)	22% (50)
	don't know	11% (21)	10% (60)	66% (149)
Development path prefer				
	Corporate/consumer preferences	22% (43)	15% (88)	6% (13)
	Supply/demand & cheapest form added subject to env constrainst and social acceptance	35% (69)	29% (171)	14% (32)
	Government influence	24% (46)	45% (266)	12% (26)
	Don't know	19% (38)	12% (69)	68% (154)

8.9 Significant variables impacting preferences (Chi Squared Analysis)

Further analysis of the preference data was undertaken to elucidate if different demographics influenced the preferences of respondents. Gender, age and level of education were all significant predictors of preference, as was the respondent's belief in climate change and whether they believed the cost of electricity was likely to continue to rise. These analyses are detailed below.

Preferred energy mix and gender

While a similar proportion of males and females preferred high renewables in 2030 (M=57.6%, F=59.5%), a considerably higher proportion of males compared to females preferred lower renewables in 2030 (M=23.3%, F=15.2%). The difference in proportion was significant ($\chi^2(2, N = 1015) = 13.46, p < 0.01$).

Preferred energy mix and age groups

The percentage of participants aged 18-34y, 35-54y and 55+ as a function of preferred energy mix in 2030 is shown in Figure 15. While a similar proportion of all age groups preferred higher renewables (Y=59.5%, M=58%, O=58.3%), more of the older group preferred lower renewables in 2030 (Y=17.2%, M=15.1%, O=25.1%) and fewer of this age group responded with 'don't know' (Y=23.3%, M=27%, O=16.6%). (The differences in proportions are significant, $\chi^2(4, N = 1015) = 19.29, p < 0.01$.) Given that this older generation has grown up with thermal generation and is more familiar with this type of generation this result is not surprising. The growth in renewables has really only occurred in the last ten years and so it is feasible to believe that younger respondents are more likely to prefer the cleaner generation types.

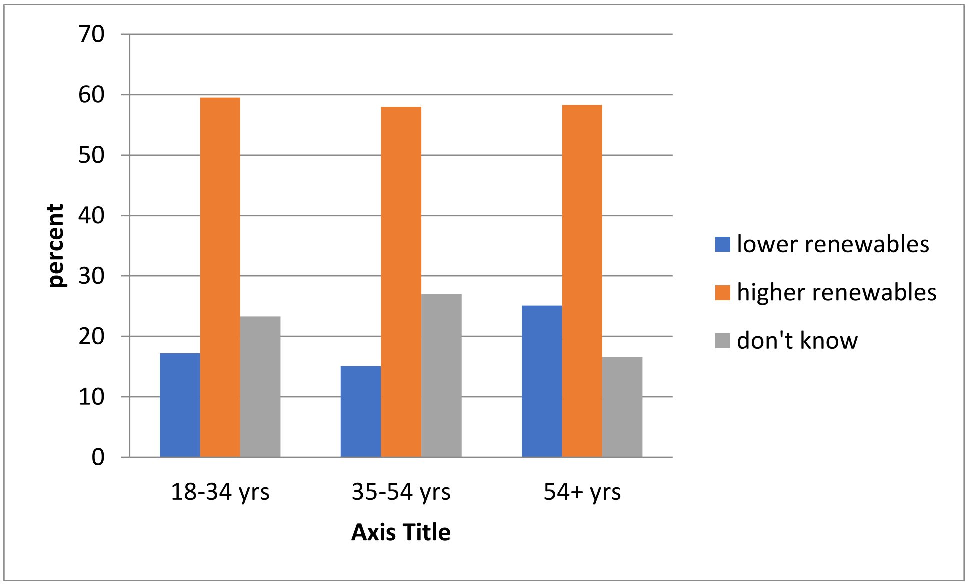


Figure 15 Age group as a factor of preferred energy mix

Preferred energy mix and education

The percentage of participants educated up to Year 12, up to Cert 4/adv Dip, and up to Post Doc as a function of preferred energy mix in 2030 is shown in Figure 16. In regards to a preference for higher renewables in 2030 the more educated groups had a stronger preference for higher renewable energy penetration (LE: 50.5%, ME: 56%, HE: 68.3%). As well, there were more respondents from the least educated group that said they did not know the answer to the question, and conversely fewer in the higher educated group (LE: 28.7%, ME: 24.2%, HE: 14.2%) . The differences in proportions are significant, $\chi^2(4, N = 1015) = 26.69$, $p < .001$. This is perhaps not surprising and may imply that those with higher education levels have a stronger belief in the science of climate change and therefore the need for a low carbon energy supply which is most often represented as renewable energy.

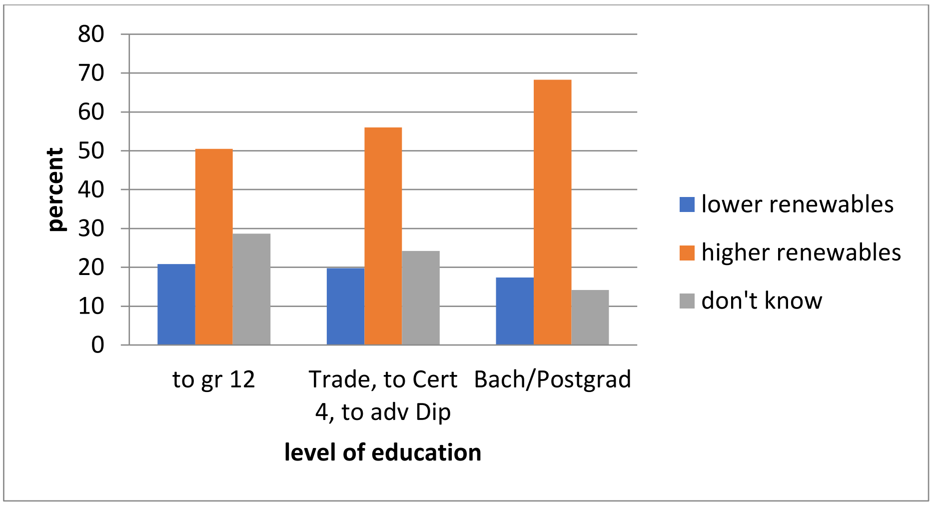


Figure 16 Education as a factor of preferred energy mix

Preferred energy mix and perspectives on climate change

The percentage of participants who believe that climate change will unlikely, probably, or most likely to occur as a function of preferred energy mix in 2030 is shown in Figure 17. There was a higher proportion of people in the 'least likely' to believe climate change group and a lower proportion of people in the 'most likely' group who preferred a lower renewable energy mix (L: 52.6%, P: 22.7%, H: 12.7%). Conversely, those who most strongly believed that climate change would occur preferred a higher renewable energy mix (L: 26.8%, P: 50.6%, H: 73.6%). All of these differences in proportions are significant, $\chi^2(4, N = 1015) = 122.68$, $p < .001$.

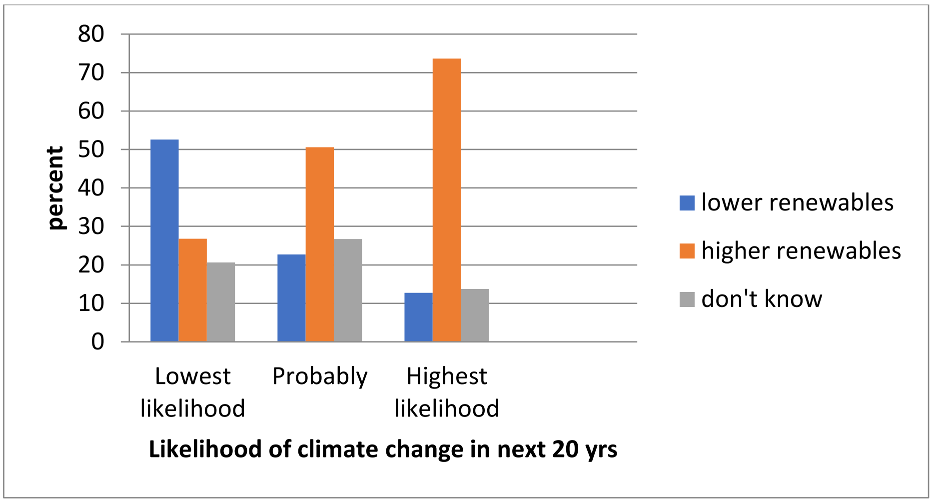


Figure 17 Views on climate change as a factor of preferred energy mix

Preferred energy mix and perspectives on increasing energy costs

The percentage of participants who believed that electricity costs will unlikely, probably, and most likely increase as a function of preferred energy mix in 2030 is shown in Figure 18. Those who prefer a lower renewable energy mix were more likely to think that energy charges will not increase (L:46.7%, P: 24.4%, H: 16.2%), while those who prefer a higher renewable energy mix thought it was probable or likely to increase (L: 31.1%, P: 48.3%, H: 68.9%). All of these differences in proportions are significant, $\chi^2(4, N = 1015) = 55.31$, $p < .001$. This result seems to confirm that most individuals associate renewable energy with a much higher costs of electricity. With the changing landscape of the levelised costs of electricity for the different forms of generation it may be an important area to include in communication. Clearly demonstrating the various costs could help to empower individuals in their energy choices.

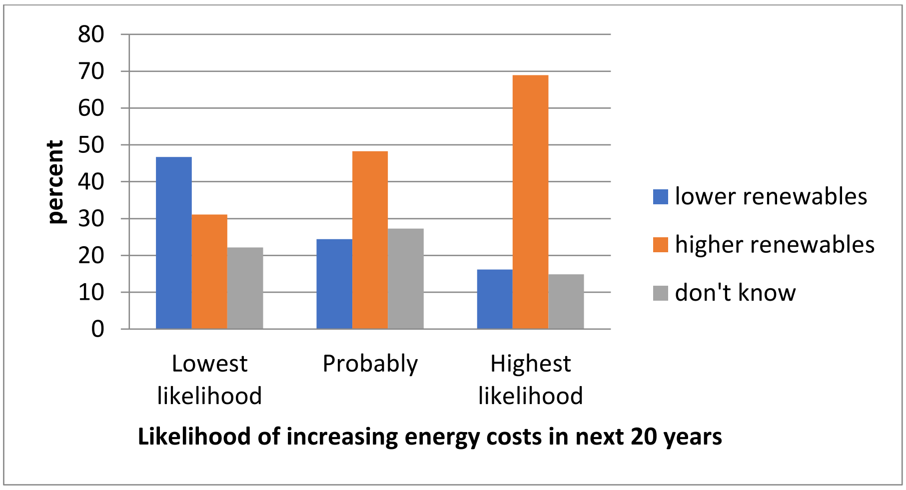


Figure 18 Views on future energy costs as a factor of preferred energy mix

8.10 Community scale and utility scale energy storage

From this study it is clear that one of the big challenges for understanding energy storage uptake is the scale at which it might occur. Although much of the immediate relevance of energy storage for the general public is at the household battery level, there are many industry and academic representatives who recognise and advocate for larger energy storage options. Recognising this, and to better understand individual attitudes to storage, we provided participants with two scenarios that described both a community scale (battery) and a utility scale (pumped hydro) storage option. Participants were asked whether they felt the storage sounded like a good idea and whether they felt their friends and family would support that choice to test the influence of social norms on responses. Analysis suggests that respondents were slightly more supportive of the community scale battery option (Mean=4.08, SD=.85) compared with the utility scale pumped hydro option (Mean=3.82, SD=.96). They were also more likely to think that their friends and family would support the community scale battery, although this was to a lesser degree than the overall individual responses. The open ended comments were coded to find the key themes that emerged from each participant based on whether they preferred the community scale battery option (n=541) or the utility scale pumped hydro option (n=469). Analysis showed that a small group (n=3) of participants misread the question and thought that the pumped-hydro storage option would only be in Victoria, which was not the intention.

Results suggest that key support for the community storage option was around the benefits use of batteries would bring in reducing costs (n=68) and secondly, that it would be much easier to manage and implement than a pumped hydro storage project (n=25). Overall, for those participants who supported the battery option felt that it offered greater flexibility and would be useful at other community levels. The quotes below represent those who were most supportive of community scale storage options.

> *Despite creating jobs & generating economic benefits, the utility-scale project results in too many negative environmental impacts. If the community-scale project was rolled out to increasingly larger numbers of homes the positive benefits would be numerous & grow exponentially. ID 525*

I think option 2 is too expensive to get support and it will need this partnering with energy companies with the government - the companies may not be trustworthy enough or like the government control in this option. ID 322

This option has the potential to grow and, with appropriate legislation, could even be made mandatory for all new buildings, thus indefinitely increasing its capacity, whereas the other is forever limited. ID 159

Opportunities for the how distant future? I think in the near future the battery storage project in homes and businesses would help people like me who have days with no money at all and continue to struggle with bills, including electricity. Anything that will reduce the cost ASAP will be wonderful and good for the environment. The hydro-electric power plant will take many years with squabbling greenies and fors and against in different quarters. It will take an eternity to build but once it's done it will be well worth it. ID 537

Those that were more supportive of the pumped hydro storage option felt that it would create jobs (n=26), be less costly (n=17) and overall be easier to implement and manage (n=13). Conversely, some expressed concerns around the availability of water and finding sites with enough space to build such projects (n=42) and the costs involved (n=11). The comments below emerge from those with more positive attitude towards pumped hydro.

I think the hydro-electric power plant is a good idea because hydro-schemes already exist and are under utilised. Secondly, they only need to kick in when required during peak seasonal periods. It also focuses on the use of higher renewable sources and less use of carbons. This has greater benefits for the environment as a whole. It is also a cleaner way of producing energy needs. ID 550

I think the utility scale is needed to provide fair and equitable access. Otherwise, those least able to afford it will find themselves paying the highest costs for their energy usage as they wont be able to participate in things like household solar or stored energy. I also think there may be pushback to large scale construction projects, but I think it is definitely preferable to building coal fired power stations. ID 576

1000 community-based batteries seems insignificant relative to the population and energy demands of Australia. Also, having these contingency measures stored in privately owned businesses and homes just strikes me as counter intuitive. ID 878

The implementation of a hydro-electric power plant would offer more future opportunities because it would bring employment opportunities and stability to Victoria as well as save households money in the long run.

It sounds like, if the infrastructure needed for option two, is not an environmental issue, then the rewards and results that are able to be reaped from this project would service a larger number of people and therefore be more economical.

8.11 Exploring factors affecting acceptance

One objective of the survey in this project was to better understand psychosocial factors that influence participants' intention to purchase a home battery unit. Based only on correlations, results indicate support for Huijt and colleague's (Huijts et al., 2012, 2013, 2014) Technology Acceptance Model. Underpinning their model is the theory of planned behaviour (Ajzen, 1991) and the norm activation model (Schwartz, 1977, 1981). The former theory suggests that we can better predict the way a person will act if we know a) their attitudes about it, b) their beliefs about how people close to them will view their behaviour (social norms), and c) their perceptions about their own ability to perform the behaviour (perceived behavioural control). It also suggests that attitudes are the formed after considering the costs, risks and benefits of a given behaviour. Our results show that medium-sized and statistically significant correlations exist between each of these variables and intention to accept a battery home unit (refer Figure 19).

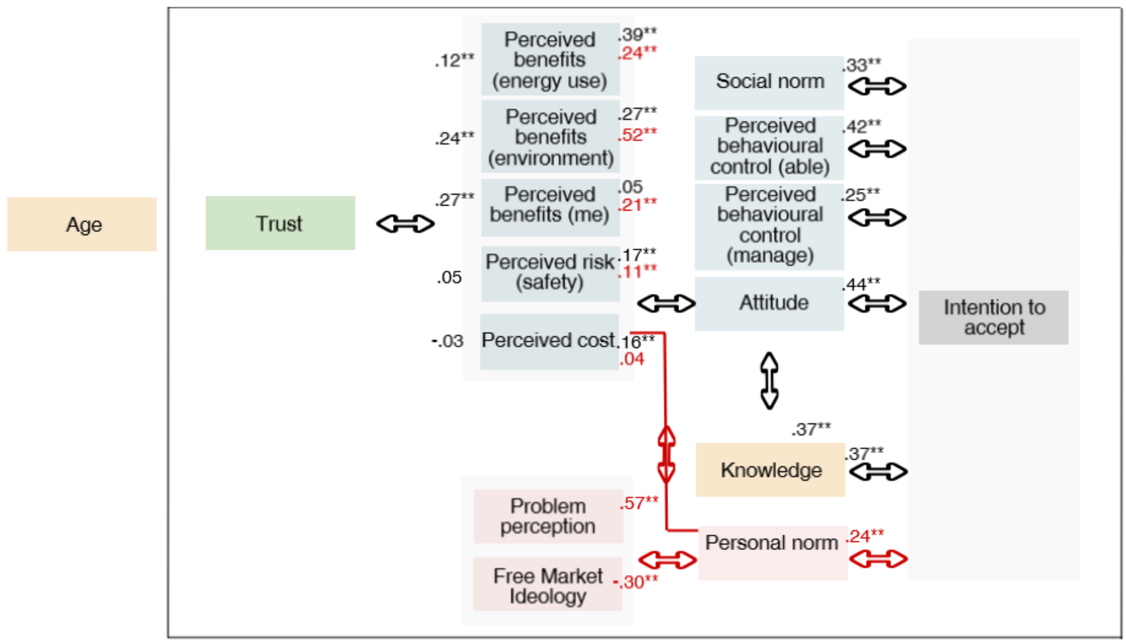


Figure 19 Correlations between variables included in the Technology Acceptance Model

The social norm variable (2 items collapsed: people who are important to me and people in the community would think it a good idea if I purchased it) and intention to accept variable was correlated at *r* = .33. The perceived behavioural control items were found to represent two factors: 1) able – to what extent participants' home was suitable, they could decide the changes they made in their house, they could afford storage and they felt it was easy for them (3 items collapsed); 2) manage – to what extent a home battery would fit with their lifestyle and would not require too much adjustment to how they used power (2 items collapsed). As might be expected, having a living arrangement that physically allowed an individual to install a battery and also to afford it was more highly correlated with intention to act (*r*=.42) than management issues associated with the battery (*r*=.25).

Those people who had a more positive attitude (i.e. thought it was a more positive, wiser, useful and important) toward home battery units were also found to have a stronger intention to purchase a unit (*r*=.44). Factors positively associated with 'attitude' were: a view that home battery units would provide energy use benefits (3 items collapsed: reduce electricity costs, give better control over energy use, reduces dependence on grid) (*r*=.39); would benefit the environment (*r*=.27); would be safe (*r*=.17); and their purchase cost was suitable (*r*=.16).

The second theory informing the Technology Acceptance Model is the norm activation model, which asserts that a person's norms influence their pro-environmental behaviour. An antecedent of this is an awareness of the environmental problem. Our results showed that participants who more strongly felt obligated to use environmentally friendly energy sources and methods (personal norm) were also more likely to have an intention to accept (*r*=.24). The strength of this correlation wasn't as high as those for attitude, perceived behavioural control (able) or social norm.

There was a large positive correlation between personal norm and problem perception (5 items collapsed: the extent to which participants believed air pollution, depletion of coal and oil, climate change, loss of biodiversity and increasing energy cost will arise in the next 20 years as a result of the burning of fossil fuels (e.g. coal, oil) for electricity) (*r*=.57). A strong positive correlation also existed between personal norm and perceived benefits (environment), r=.52, which means that those people who were more likely to purchase a battery because of its benefits to the environment, were also those who felt more obligated to use environmentally friendly energy sources and methods. There was also a medium-sized negative correlation between personal norm and free market ideology, which assesses the degree to which the participant believes a free market system has a positive or negative effect on the environment (6 items collapsed), *r*= -.30. This correlation demonstrates that those who are more likely to support free market ideology are less likely to feel obligated to use environmentally friendly energy sources and methods.

Together these results appear to show that variables from both theories influence intention to accept a home battery unit, but that those from the theory of planned behaviour have a stronger association. We also found the knowledge of home battery storage had a medium-sized positive correlation with attitude and with intention to accept. In the TAM model, trust of institutions was advocated as being an antecedent to one's perceptions of the costs, benefits and risks associated with attitude toward acceptance. We found that small to medium-sized correlations existed between trust (in government and the energy sector – six items collapsed as statistically shown to represent one factor) and the perceived *benefits* only. The largest of these were between trust and a benefit associated with self-identity – that is, the extent to which owning a home battery unit would add to one's self-identity and social status.   Perhaps it is not surprising that trust in agencies who are encouraging the rollout of home battery storage would be associated with a better view of its benefits.

A multiple regression analysis revealed that the above variables accounted for R^2 = .34, F(15,468)=16.36,p<.001. The adjusted R^2 value of .32 indicates that nearly a third of the variability in intention to purchase a home battery storage unit; and this was the result of five statistically significantly variables: Perceived Behavioural Control (Able) (β=.26, p<.001), Social Norm (β=.18, p<.001), Knowledge (β=.17, p<.001), Attitude (β=.17, p=.01), and Perceived Behavioural Control (Manage) (β=.14, p=.01). Again, indicating that the variables associated with the theory of planned behaviour were more able to predict intention to purchase, than those of the norm activation model.

9. Case Studies

As part of the investigation, a number of case studies were identified where energy storage has already been deployed around Australia.   A summary of three of these are included below.

9.1 Bundaberg Christian College

Bundaberg Christian College is an independent day school that provides a dynamic and production learning community for student from K to Year 12. The schools mission of equipping students to make a positive impact on the world around them is most evident with their April 2016 installation of 732 solar panels (194kW) around the school to reduce their electricity consumption from 330MWh to 130MWh/yr.

Figure 20: Bundaberg Christian Colleges' Solar Array (Source: GEM Energy)

> *Schools are perfectly made for solar, in the sense our usage starts to climb at 8, and starts to decrease at 3, perfectly correlating with our solar production.* Business Manager, Bundaberg Christian College

But instead of stopping at just solar panels, they have gone one step further by also installing 30 Hitachi Lead Acid batteries (250kWh) to become the largest hybrid solar installation in Australia. The resulting battery addition has helped the school to get reclassified off demand tariffs by further reducing their annual electricity consumption to 75MWh by storing their excess solar generation for self-consumption during the night.

> *We have a lot of sun in Queensland and a lot of roof space and schools, so if we can install more solar and use it more broadly, there are opportunities there, it just has to become viable.* Business Manager, Bundaberg Christian College

The whole endeavour has cost the school approximately $650,000, but also reduced their electricity costs by 80%, giving them a payback of around seven years. For purposes of energy security during extended periods of low solar exposure, the system remains grid connected. The projects exposure has also led to strong interest from several other schools across Australia.

Figure 21: Bundaberg Christian College Students standing inside battery container (Source: BCC)

9.2 Jayne and Cathy

Jayne and Cathy are a couple who live in the north-east of Melbourne. For many years, they had been battling with constantly unpredictable and inconvenient grid drop-outs resulting from their Single Wire Earth Return line connection. To combat such electricity reliability concerns, in February 2016, they ended up self-funding from their superannuation, the installation of a 6.6kW Solar and 32kWh of Lead-Gel batteries system on their property. To accommodate the batteries, they have had to upgrade their carport into an insulated double car garage to house the temperature sensitive lead-gel batteries. During the summer the household air conditioning is used to cool the garage so that the batteries don't overheat. Alongside their initial energy security drivers, they also attribute a desire to become more self-sufficient, mitigate against rising power costs as well as becoming more environmentally conscience.

> *Having control of where our power comes from has made us extremely aware of our own energy consumption. It was also satisfying to watch our TV and see everyone around us in darkness. – Cathy*

Figure 22 Jayne and Cathy's house with solar panels, inverter and battery system (Source: Jayne and Cathy)

To complement their hybrid setup, they also have a petrol generator as a system backup. Their system is still grid connected but have strong intentions to go off grid in the near future with a few minor changes to their setup. They are continuing their pursuit of self-sufficiency and have recently added a wood-fire backup to their electric hot-water system as there is no gas within their area. They also intend to add solar hot water later this year.

Their choice of battery technology came from extensive research. They found that although the newer technologies were impressive on the surface, concerns around space requirement, cost, maintenance as well as the general lack of the long-term experience were significant factors against adopting these new technologies. Salt based batteries were considered unsuitable due to load characteristics. Lithium-ion batteries were much more expensive than lead, and were found to hold too many safety issues associated with them.

Lead batteries have been around for 100 years, and everyone knows how they work - Jayne

Although having been a very exhausting, expensive and time-consuming experiment for the both of them, Jayne and Cathy are extremely satisfied with the outcomes as it has improved their daily lives significantly knowing they are not at the mercy of electricity drop outs and future price rises.

9.3 Alkimos Beach Battery Storage Trial

Alkimos Beach, on the surface, is a typical northern suburb of Perth, not too dissimilar from the numerous community developments situated across Australia, thriving with young families and working households. The Alkimos Beach Battery Storage Trial is led by Synergy in collaboration with Alkimos Beach development partners Lendlease and LandCorp with additional funding from ARENA. These organisations have come together to trial a new innovative approach to community battery storage at Alkimos – virtual energy storage.

Figure 23 Alkimos Community Storage Battery Container (Source: Synergy)

Residents are not directly connected to the shipping container sized battery (1.2MWh of Lithium Ion batteries) that sits alongside their community, but they virtually deposit and withdraw credits in the battery through excess rooftop solar production for a small monthly subscription cost of $11/month (36.1680 cents per day) by participating in the specifically designed time-of-use Peak Demand Saver Plan trial. This allows them to bank excess rooftop solar production when the sun is shining, that would otherwise spill to the market. These banked production units can then be withdrawn during the evening when household consumption generally peaks, but the solar panels are not producing electricity. It effectively allows residents to virtually increase their self-consumption of solar and reduce their overall electricity bills.

The 'virtual account' is reset at the end of each day, such that excess solar credits do not roll over but are accumulated and settled at the Renewable Energy Buyback Scheme rate (7.135c/kWh) at the end of the billing period. In the case where credits are exhausted prior to the end of the peak period, residents are charged the relevant time-of-use rate of 47.85c/kWh during peak events (4pm-8pm). This is considerably higher thanthe Peak Demand Saver Plan Off-peak rate of 25.603c/kWh which they would be charged during any other part of the day. Comparatively, customers on the standard Home Plan tariff are charged a rate of 26.4740 all day every day. The Peak Demand Saver Plan model provides the residents with a financial incentive to match their excess solar production during the day with evening electricity consumption.

> *Cost saving was a significant factor in participating in the trial. We have been able to save 50% on our electricity bills. At the same time, we have learnt how to use our appliances around the new rules, because it is a little different now with a battery as opposed to before. But luckily for us, the big behaviour change was actually when we got the solar panels, with the battery you have a little bit more flexibility, but obviously you have to know how it works. It's not just set and forgot, there are rules behind it, mostly coming from the power provider. Alkimos Beach Resident 1*

However, the project hasn't been without a few hiccups along the way. Last year Perth experienced an untypically long, cold and rainy winter which affected the residents' solar credit production. This meant that residents often were not producing enough credits to offset their increased energy consumption. As a result, some residents noticed their bills had increased.

> *Last winter we noticed that our electricity bill had gone up almost 80%. But we weren't surprised because we had noticed that our heating had gone up because of the long cold winter. It also rained a lot, so we were not producing a lot of solar, unfortunately. But that's something you can't control. Other than that, we have been satisfied with the trial. Alkimos Beach Resident 2*

While on the surface it might seem counter intuitive for Synergy, as an electricity gentailer, to participate in a trial that reduces customers' electricity bills, it is part of a bigger plan to save money by reducing infrastructure spending, which can then be passed on to the customer as well as trialling innovative and relevant product offerings to meet customer needs. For Lendlease, the project is a part of a strong vision to become the new benchmark for sustainability, working towards carbon neutral communities, with the battery storage trial being just one of many innovative and strategic infrastructure initiatives they are delivering at Alkimos Beach.

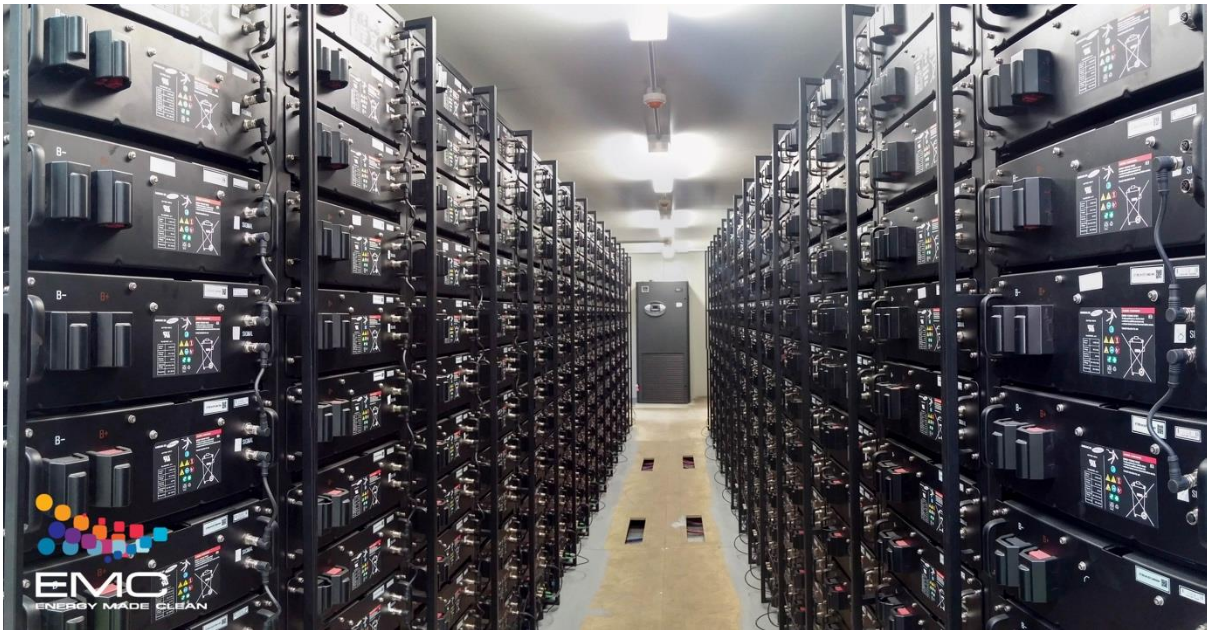


Figure 24 Inside the Alkimos Community Battery Container – EMC Lithium-Ion Batteries (Source: Synergy)

10. Conclusions

Given the importance of energy to Australia's economic and societal well-being, combined with the politicisation of all things energy related, there are a number of conclusions that can be drawn from this study. What is clear from this research is that Australians are deeply concerned with the sharp rise in electricity prices over the past few years and they hold governments and energy providers, in particular retailers, directly responsible for this. While storage is still seen to be an emergent industry, there is a growing level of interest from householder in the benefits it may bring. Both through providing more flexibility to manage the cost of electricity as well as provide individuals with greater control over the way they use energy. This is particularly prevalent with the recent blackout events in South Australia and the announced closure of Hazelwood power station, where concerns are emerging over the reliability of Australia's energy supply. The growing level of interest in storage is demonstrated through the case studies in this report as well as other anecdotal evidence that emerged from the study including fringe of grid and remote operations. There is a proportion of the population, householders and some industry, that are implementing storage for a multitude of reasons.

While it is recognised that battery storage, in most instances, is not commercially viable right now. With individuals feeling the pinch of rising electricity costs, combined with their mistrust in government and energy providers, it seems there will be uptake of home battery storage units, for those who can afford it. Individuals feel it will provide them with greater control over their electricity supply. Some even suggested they would consider disconnecting from the grid and going it alone all together if they had the opportunity. As mooted by those who were interviewed and focus group participants the survey showed that those most likely to be the early adopters of battery storage will be those with existing solar PV installations.

Alongside the growing interest in battery storage there was also a number of concerns which have high relevance for governments across all levels. Currently the lack of safety standards around batteries was seen as a real concern. Several individuals, likened the negative potential of the absence of standards for batteries in Australia to that of the earlier "Home Insulation Program" of the federal government. Colloquially known as the "Pink Batts Scandal" it resulted in the death of four individuals. Similar concerns were also expressed in relation to the management of the environmental impacts of batteries, particularly at the end of their life. Although it is recognised that progress in developing standards is being made, this needs to become a high priority for all involved in the industry not only to allay societal safety concerns but also provide more certainty for the industry as well.

The need for safety standards was also alluded to around the potential dangers for first responders at household fires and other emergencies. Concerns were raised about emergency workers being told not to attempt to put out fires if lithium-ion batteries were installed because of the chance for explosions. In cities or other built up areas, this was felt to have potential dire consequences for homes adjacent to those with installed batteries. Similarly, there were concerns raised around how insurance companies might respond to householders installing batteries moving forward. The registered database of batteries was seen as an important first step in helping to allay safety concerns for first responders. Although, it is not clear how definitive these safety concerns are, early attention by industry and government to address the concerns raised will be critical. Communicating how the safety and environmental aspects of home battery storage units are being managed will be an essential element for ensuring and maintaining a social licence to operate for the industry.

The results from the survey also suggest that there may be some reticence in purchasing battery storage units because of a lack of knowledge about them. It also confirmed a lack of understanding of the role that energy storage, at different levels of scale, might play in Australia's future energy mix. If government believes that energy storage has an important role in securing a part of Australia's future energy mix, communication of how it works, the benefits it can bring and the investment required will also be an important element for successful deployment. However, this lack of understanding is not just specific to energy storage and speaks more broadly to the lack of energy literacy of most Australians. Given the critical nature of energy, the politicisation, and the contestation that surrounds the options for transitioning to a low carbon supply, communication and engagement of the public on the topic of all things energy, to include energy storage, could be very helpful in regaining trust in both government and the energy industry more broadly. When questioned about storage, participants easily recognised lithium-ion batteries and talked about the "hype" around Tesla as one of the well-known battery storage brands. They also expressed concerns around the environmental impacts of pumped hydro if not managed well and ensuring understanding of these technologies will be a critical part of gaining support of them.

Directly coupled to the value proposition for home battery storage units will be the availability of various pricing structures. It is clear that TOU pricing will help to drive energy consumption behaviours off peak and allow individuals who have flexibility to capitalise on their alternative use of electricity. This clearly speaks to the need for proactive collaboration between government and industry to ensure benefits can be achieved, but also to ensure those from low socio-economic groups are not disadvantaged by new modes of pricing. Similarly, it was very evident how government incentives and FiT's drove the uptake of solar PV. We are already seeing a number of incentives being offered for batteries in some states. To avoid the unintended consequences of policy interventions, a clear strategy for the proposed deployment is required alongside monitoring of consumer led uptake. This should help manage the security of supply issues currently being experienced in some localities.

In addition to batteries utility scale storage was also seen as a viable in front of the meter option. Some suggesting that pumped-hydro, in the right geographic location, could be extremely valuable as large scale storage at the GWh size. When compared with other storage options it was seen as a viable alternative to address issues around faults and inertia in the system. It was also seen as more economical if the right resources were available but there was some recognition around social license to operate issues that could arise if not managed well.

Although with current perceptions of battery technology being out of reach financially, because solar PV is still generally met with strong support and the introduction of energy storage options adds to its appeal, there is likely to be continued uptake of various batteries across Australia. Concerns were expressed over the speed that which this might occur. Therefore, ongoing monitoring of this emergent industry was deemed essential. Whether this is through the database or other means it seems an essential activity that could be managed through active collaboration between government and industry. Transparently sharing this information may also help to rebuild trust in the government and energy sector which will be critical for transition Australia to a low carbon future. Regardless, policy certainty around such an emergent industry will be essential for all stakeholders involved, but it was recognised that there will be a range of opportunities that could emerge as summarised in this quote below.

*…I don't think there will any one solution, I suspect you find that all the solutions will be deployed. You will find behind the meter, you will find in front of the meter. The early adopters will go behind the meter because they want to…*Interview 015

11. Key Findings

- Australians are deeply concerned with the sharp rise in electricity prices over the past few years and they hold governments and energy providers, in particular retailers, directly responsible for this.
- There is a lack of trust in governments and electricity retailers which needs to be addressed and enabling a bi-partisan approach to energy would be welcomed by the Australian public
- While storage is still seen to be an emergent industry, there is a growing level of interest from householder in the benefits it may bring, although most felt storage was currently unviable.
- Many Australians feel they do not know enough about energy storage to make an informed decision about whether to purchase a home unit or not.
- There is an opportunity for governments to build energy literacy across Australia, including information on storage, and the range of energy generation technologies.
- Currently the lack of standards for batteries, both in relation to safety and environmental impacts are of concern to many across the energy sector and need to be addressed as a priority. Safety concerns also extended to first responders in the case of fires in homes or other buildings.
- Communicating how the safety and environmental aspects of home battery storage units are being managed will be an essential element for ensuring and maintaining a social licence to operate for the industry.
- To avoid the unintended consequences of policy interventions, a clear strategy for the proposed deployment of energy storage, including consistency around the types of incentives offered, is required, alongside monitoring of consumer led uptake

Glossary and Acronyms

FiT - Feed-in-Tariff

PV – Photovoltaic

REC – Renewable Energy Certificates

kW - Kilowatt

MW – Megawatt

kWh – Kilowatt-hour

MWh – Megawatt-hour

CSO – Community Service Organisation

BCC – Bundaberg Christian College

TAF – Technology Acceptance Framework

References

Abe, N, Ishio, J, Katatani, T & Mukai, T 2015, 'Consumer Perceptions and Acceptance of PV Systems with Energy Storage', in *Solar Energy Storage*, Academic Press, pp. 273-88, DOI 10.1016/b978-0-12-409540-3.00012-8.

ABS 2017, *Australian Demographic Statistics*, viewed 20 February 2017, <http://www.censusdata.abs.gov.au/census_services/getproduct/census/2011/quickstat/0>.

Acil Allen 2013, *Drivers of Domestic PV Uptake: Characteristics of households with solar photovoltaic systems*, <http://www.acilallen.com.au/cms_files/ACILAllenSolarPhotovoltaic2013.pdf>.

AEMC 2015, *Integration of Energy Storage Regulatory Implications Final Report*, <http://www.aemc.gov.au/Major-Pages/Integration-of-storage/Documents/AEMC-Integration-of-energy-storage,-final-report>.

Agnew, S & Dargusch, P 2016, 'Consumer preferences for household-level battery energy storage', *Renewable and Sustainable Energy Reviews*.

Ajzen, I 1991, 'The theory of planned behavior. ', *Organizational Behavior and Human Decision Processes*, no. 50, pp. 179–211.

Ajzen, I 1991, 'The theory of planned bejavior', *Organizational Behavior and Human Decision Processes*, vol. 50, pp. 179-211.

Australian PV Institute 2016, *Solar Map, funded by the Australian Renewable Energy Agency*, viewed 28 November 2016, <http://pv-map.apvi.org.au/analyses>.

Balcombe, P, Rigby, D & Azapagic, A 2014, 'Investigatin the importance of motivations and barriers related to microgeneration uptake in the UK', *Applied Energy*, vol. 130, pp. 403-18.

Benevenuti, J 2016, *Consumer access to external dispute resolution in a changing energy market*, <https://www.ewon.com.au/content/Document/EDR Access Report_Public.pdf>.

Bloomberg New Energy Finance 2016, 'Six Energy Policy Issues Australia Must Address', in *Australian Clean Energy Summit 2016*, Sydney.

Buchanan, K, Banks, N, Preston, I & Russo, R 2016, 'The British public's perception of the UK smart metering initiative: Threats and opportunities', *Energy Policy*, vol. 91, pp. 87-97.

Cass, D 2016, *Securing renewables How batteries solve the problem of clean electricity*, <http://www.tai.org.au/sites/defualt/files/P234 renewables and battery storage FINAL.pdf>.

Chan, C & Ma, T 2016, 'Energy Efficiency Housing in South Australia – A Gap Analysis between the Expected and Actual Benefits', *Procedia Engineering*, vol. 164, pp. 446-52.

Chapman, AJ, McLellan, B & Tezuka, T 2016, 'Residential solar PV policy: An analysis of impacts, successes and failures in the Australian case', *Renewable Energy*, vol. 86, pp. 1265-79.

Claudy, MC, Peterson, M & O'Driscoll, A 2013, 'Understanding the Attitude-Behavior Gap for Renewable Energy Systems Using Behavioral Reasoning Theory', *Journal of Macromarketing*, vol. 33, no. 4, pp. 273-87.

Colmar Brunton 2015, *Queensland Household Energy Survey 2015: Insights Report*, <https://www.ergon.com.au/__data/assets/pdf_file/0020/206417/2015-Queensland-Household-Energy-Survey-full-report-2015.pdf>.

Craig, CA 2016, 'Energy consumption, energy efficiency, and consumer perceptions: A case study for the Southeast United States', *Applied Energy*, vol. 165, pp. 660-9.

Craig, CA & Allen, MW 2014, 'Enhanced understanding of energy ratepayers: Factors influencing perceptions of government energy efficiency subsidies and utility alternative energy use', *Energy Policy*, vol. 66, pp. 224-33.

Crossland, AF, Anuta, OH & Wade, NS 2015, 'A socio-technical approach to increasing the battery lifetime of off-grid photovoltaic systems applied to a case study in Rwanda', *Renewable Energy*, vol. 83, pp. 30-40.

CSIRO 2009, *Intelligent Grid: A value proposition for distributed energy in Australia*, <www.aph.gov.au/DocumentStore.ashx?id=1fb6cc0b-94a5-467a-a5b0-e0a85acd9d36>.

DBIS 2016, *Public attitudes to Energy Storage*, <http://www.sciencewise-erc.org.uk/cms/assets/Uploads/energy-storage-final.pdf>.

DECC 2015, *Smart Metering Early Learning Project: Consumer survey and qualitative research*, London, <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/407545/5_Smart_Metering_Early_Learning_Project_-_Consumer_survey_and_qual_research_-_Technical_Report_FINAL.pdf>.

Deloitte 2013, *Online Consumer Survey Report*, <http://talkingpower.com.au/wordpress/wp-content/uploads/SAPN-Consumer-Survey-Report-1.0.pdf>.

Energetics 2016, *Modelling and analysis of Australia's abatement opportunities Report to the Department of the Environment*, <https://www.environment.gov.au/system/files/resources/b8540c8a-8a31-4aba-a8b5-63cc46466e33/files/modelling-and-analysis-australias-2030-abatement-opportunities.pdf>.

Gährs, S, Mehler, K, Bost, M & Hirschl, B 2015, 'Acceptance of Ancillary Services and Willingness to Invest in PV-storage-systems', *Energy Procedia*, vol. 73, pp. 29-36.

Gardner, J & Ashworth, PN 2008, 'Towards the Intelligent Grid: A Review of the Literature', in P Droege (ed.), *Urban Energy Transition: From Fossil Fuels to Renewable Power*, Elsevier, Oxford, pp. 283-308.

Gardner, J, Carr-Cornish, SG & Ashworth, PN 2008, 'Exploring the acceptance of a domestic distributed energy market in Australia', *Australasian Journal of Environmental Management*, vol. 15, no. 2, pp. 93-103.

Giddens, A 1984, 'Outline of the Theory of Structuration', in *The Constitution of Society*, The Polity Press, Cambridge.

Grünewald, PH, Cockerill, TT, Contestabile, M & Pearson, PJG 2012, 'The socio-technical transition of distributed electricity storage into future networks—System value and stakeholder views', *Energy Policy*, vol. 50, pp. 449-57.

Hall, NL, Jeanneret, TD & Rai, A 2016, 'Cost-reflective electricity pricing: Consumer preferences and perceptions', *Energy Policy*, vol. 95, pp. 62-72.

Hargreaves, T, Nye, M & Burgess, J 2013, 'Keeping energy visible? Exploring how householders interact with feedback from smart energy monitors in the longer term', *Energy Policy*, vol. 52, pp. 126-34.

Heath, Y 2006, 'Free-Market Ideology and Environmental Degradation: The Case of Belief in Global Climate Change', *Environment and Behavior*, vol. 38, no. 1, pp. 48-71.

Hess, DJ 2014, 'Smart meters and public acceptance: comparative analysis and governance implications', *Health, Risk & Society*, vol. 16, no. 3, pp. 243-58.

Hobman, EV & Frederiks, ER 2014, 'Barriers to green electricity subscription in Australia: "Love the environment, love renewable energy … but why should I pay more?"', *Energy Research & Social Science*, vol. 3, pp. 78-88.

Hobman, EV, Frederiks, ER, Stenner, K & Meikle, S 2016, 'Uptake and usage of cost-reflective electricity pricing: Insights from psychology and behavioural economics', *Renewable and Sustainable Energy Reviews*, vol. 57, pp. 455-67.

Huijts, NMA, De Groot, JIM, Molin, EJE & van Wee, B 2013, 'Intention to act towards a local hydrogen refueling facility: Moral considerations versus self-interest', *Transportation Research Part A: Policy and Practice*, vol. 48, pp. 63-74.

Huijts, NMA, Molin, EJE & Steg, L 2012, 'Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework', *Renewable and Sustainable Energy Reviews*, vol. 16, no. 1, pp. 525-31.

Huijts, NMA, Molin, EJE & van Wee, B 2014, 'Hydrogen fuel station acceptance: A structural equation model based on the technology acceptance framework', *Journal of Environmental Psychology*, vol. 38, pp. 153-66.

Kear, G & Chapman, R 2013, ''Reserving judgement': Perceptions of pumped hydro and utility-scale batteries for electricity storage and reserve generation in New Zealand', *Renewable Energy*, vol. 57, pp. 249-61.

Khalilpour, KR & Vassallo, A 2016, 'Technoeconomic parametric analysis of PV-battery systems', *Renewable Energy*, vol. 97, pp. 757-68.

Korcaj, L, Hahnel, UJJ & Spada, H 2015, 'Intentions to adopt photovoltaic systems depend on homeowners' expected personal gains and behavior of peers', *Renewable Energy*, vol. 75, pp. 407-15.

Krishnamurti, T, Schwartz, D, Davis, A, Fischhoff, B, de Bruin, WB, Lave, L & Wang, J 2012, 'Preparing for smart grid technologies: A behavioral decision research approach to understanding consumer expectations about smart meters', *Energy Policy*, vol. 41, pp. 790-7.

Lamech, F 2014, 'Self-Reporting of Symptom Development From Exposure to Radiofrequency Fields of Wireless Smart Meters in Victoria, Australia: A Case Study', *Alternative Therapies*, vol. 20, no. 6, pp. 28-38.

Lorenzi, G & Silva, CAS 2016, 'Comparing demand response and battery storage to optimize self-consumption in PV systems', *Applied Energy*, vol. 180, pp. 524-35.

Macintosh, A & Wilkinson, D 2011, 'Searching for public benefits in solar subsidies: A case study on the Australian government's residential photovoltaic rebate program', *Energy Policy*, vol. 39, no. 6, pp. 3199-209.

Mukai, T, Kawamoto, S, Ueda, Y, Saijo, M & Abe, N 2011, 'Residential PV system users' perception of profitability, reliability, and failure risk: An empirical survey in a local Japanese municipality', *Energy Policy*, vol. 39, no. 9, pp. 5440-8.

Mulder, G, Ridder, FD & Six, D 2010, 'Electricity storage for grid-connected household dwellings with PV panels', *Solar Energy*, vol. 84, no. 7, pp. 1284-93.

Nelson, T, Simshauser, P & Nelson, J 2012, 'Queensland Solar Feed-In Tariffs and the Merit-Order Effect: Economic Benefit, or Regressive Taxation and Wealth Transfers', *Economic Analysis & Policy*, vol. 42, no. 3, pp. 277-301.

Noppers, EH, Keizer, K, Bockarjova, M & Steg, L 2015, 'The adoption of sustainable innovations: The role of instrumental, environmental, and symbolic attributes for earlier and later adopters', *Journal of Environmental Psychology*, vol. 44, pp. 74-84.

Origin Energy 2016, 'Growth of business solar', paper presented to Australian Clean Energy Summit 2016, Sydney.

Pew Research Center October, 2016, *The Politics of Climate*.

Rogers, E 1962, *Diffusion of Innovations*, 1st Edition edn, The Free Press, New York, NY.

Rogers, E 1995, *Diffusion of Innovations*, 4th Edition edn, The Free Press, New York, NY.

Romanach, L, Contreras, Z & Ashworth, PN 2013, *Australian householders' interest in the distributed energy market*, CSIRO, <http://apvi.org.au/wp-content/uploads/2013/11/CSIRO-Survey-Report.pdf>.

Sarzynski, A, Larrieu, J & Shrimali, G 2012, 'The impact of state financial incentives on market deployment of solar technology', *Energy Policy*, vol. 46, pp. 550-7.

Schwartz, SH 1977, 'Normative influences on altruism', in L Berkowitz (ed.), *Advances in experimental social psychology*, Academic Press, New York, vol. 10, pp. 221–79.

Schwartz, SH & Howard, JA 1981, 'A normative decision making model of altruism', *Altruism and helping behavior*, pp. 89-211.

Scott, FL, Jones, CR & Webb, TL 2014, 'What do people living in deprived communities in the UK think about household energy efficiency interventions?', *Energy Policy*, vol. 66, pp. 335-49.

Seed Advisory 2011, *SRES Uptake: Postcode Demographics and Penetration Rates Final Report to the Australian Energy Markets Commission*, <http://www.aemc.gov.au/getattachment/a3157c70-7188-44d1-9c5e-dcc2f168d9f1/Seed-Advisory-report-on-the-demographic-characteri.aspx>.

Simon, HA 1955, 'A Behavioural Model of Rational Choice', *The Quarterly Journal of Economics*, vol. 69, pp. 99-118.

Simpson, G & Clifton, J 2016, 'Subsidies for residential solar photovoltaic energy systems in Western Australia: Distributional, procedural and outcome justice', *Renewable and Sustainable Energy Reviews*, vol. 65, pp. 262-73.

Simshauser, P & Downer, D 2014, 'On the inequity of flat-rate electricity tariffs', *AGL Applied Economic and Policy Research*, vol. Working Paper No.41.

Sommerfeld, J, Buys, L, Mengersen, K & Vine, D 2017, 'Influence of demographic variables on uptake of domestic solar photovoltaic technology', *Renewable and Sustainable Energy Reviews*, vol. 67, pp. 315-23.

Standards Australia 2016, *Energy Storage Standards Consultation Paper 1*, <http://www.standards.org.au/OurOrganisation/News/Documents/Standards Australia Energy Storage Consultation Paper.pdf>.

Stanes, E, Klocker, N & Gibson, C 2015, 'Young adult households and domestic sustainabilities', *Geoforum*, vol. 65, pp. 46-58.

Stenner, K, Frederiks, E, Hobman, EV & Meikle, S 2015, *Australian Consumers Likely Response to Cost-Reflective Electricity Pricing*, CSIRO.

Strupeit, L & Palm, A 2016, 'Overcoming barriers to renewable energy diffusion: business models for customer-sited solar photovoltaics in Japan, Germany and the United States', *Journal of Cleaner Production*, vol. 123, pp. 124-36.

Todd, A, Cappers, P & Goldman, C 2013, *Residential Customers Enrollment in Time-based Rate and Enabling Technology Programs*, Smart Grid Investment Grant Consumer Behavior Study Analysis, <https://emp.lbl.gov/sites/all/files/lbnl-6247e.pdf>.

Victoria Auditor-General 2015, *Realising the Benefits of Smart Meters*, <http://www.audit.vic.gov.au/publications/20150916-Smart-Meters/20150916-Smart-Meters.pdf>.

Watt, M 2009, *National Survey Report of PV Power Applications in Australia 2008*.

Willand, N, Ridley, I & Maller, C 2015, 'Towards explaining the health impacts of residential energy efficiency interventions - A realist review. Part 1: Pathways', *Soc Sci Med*, vol. 133, pp. 191-201.

Zaunbrecher, BS, Bexten, T, Wirsum, M & Ziefle, M 2016, 'What is Stored, Why, and How? Mental Models, Knowledge, and Public Acceptance of Hydrogen Storage', *Energy Procedia*, vol. 99, pp. 108-19.

Appendix A Proposed Interview Questions

Research Questions

Understanding the socio-economic challenges for energy storage uptake

1. Tell me a little about yourself and your role or interest in energy storage
2. What do you understand by the term energy storage?
3. What has been your involvement in energy storage, if at all up to now?
4. What do you believe are the key drivers for energy storage in Australia at the moment?
5. How has this changed over the years?
6. What do you believe might be some of the impediments for energy storage in Australia?
7. How has this changed over the years?
8. What are the important policy considerations for storage uptake in Australia?
9. Describe what you believe will be the most likely deployment scenario for energy storage uptake in Australia?
10. Can you summarise for me what you believe are the main points of our discussion?
11. Is there anything you think I should have asked and have not?
12. Is there someone you think that we should interview for this research project?

Appendix B Summary of Interview Themes

Table AB.1 Key themes emerging on energy storage

Theme	Topics Discussed	No.	No.
Social	Lack of Understanding	16	52
	Cultural Independence	15	
	Social Responsibility	10	
	Service vs Good	5	
	Consumer Production Obligation vs Sovereignty	3	
	Intergenerational Costs/Benefits	3	
Energy Storage Technologies	Batteries	11	52
	Pumped Hydro	11	
	Hot Water	6	
	Grid Level/Distribution	6	
	Flywheel	4	
	Compress Air	3	
	Chemical	3	
	Electricity Storage	2	
	Molten Salt	2	
	Heat Pump	1	
	Hydrogen	1	
	Ammonia Dissociation	1	
	Grid Movement of Electricity	1	
Government	Leadership	13	32
	Domestic/International Commitments/Policies	12	
	Intervention/Miscommunication	7	
Market	Smart Meters	16	64
	Price Remuneration/Disenfranchisement	13	
	Fear of rapid development	12	
	Tariffs/Cost Reflective Pricing	11	
	Market Led	4	
	Supplier competition	4	
	Price of Carbon	2	
	Electricity Market Death-Spiral	1	
	Locality based incentives	1	
Concerns	Standards	35	106
	Safety/Fire Concerns	17	
	Recycling	15	
	Environment/Climate Change	15	
	Energy Security	14	

Theme	Topics Discussed	No.	No.
	Insurance Risk	7	
	Technology race producing wrong technology	2	
	Unethical Mining	1	
Policy and Regulation	Regulatory Framework/Structure	19	54
	Behind/Front of the meter Ownership and Control	11	
	Network Integration	10	
	Decentralised Model	7	
	Deregulation/Testing Ground for Batteries	7	
Other	Two function batteries (EV's)	19	28
	Independent Voice/information	4	
	Battery Database	3	
	Technology Revolution	2	

Table AB.2 Drivers of energy storage themes emerging

Theme	Drivers	No.	No.
Financial	Mitigating against rising electricity costs	16	60
	Tariff Structures	9	
	Electricity Arbitrage/Trading	8	
	Reducing Battery Price Signal	6	
	Premium FiT rolling off	4	
	Market Dynamics	3	
	Subscription Service	3	
	Competition in battery price market	3	
	Replacing diesel	2	
	Subsidies	2	
	Defer augmentation	2	
	Capital Improvement	1	
	Price differences between FiT and retail prices	1	
Product	Marketing Spin/Hype/Sexiness	10	14
	Software and control systems	2	
	Brand Association	2	
Individual	Independence	15	70
	Going Off-Grid	12	
	Dissatisfaction with electricity companies	10	
	Solar Compliment	10	
	Energy Security/Reliability	9	
	Environmentally Sustainable	10	
	Bragging Rights	3	
Other	Part of Technological Progress/Revolution	6	13
	Government Policies	5	
	Building Ratings	1	
	Enabler of Energy Future	1	

Table AB.3 Barriers of energy storage emerging

Theme	Barrier	No.	No.
Financial	Cost	13	35
	Justifying Investment	10	
	Business Model Complexities	5	
	Payback Period	4	
	Existing Subsidies	2	
	Low Electricity Prices	1	
Policy and Regulation	Regulatory model for networks	8	23
	Standards Coverage/Regulation	8	
	Stable Energy Policy	3	
	Network Connection Issues	3	
	Monopolistic Concerns	1	
Individual	Lack of understanding/trust	9	25
	Home Ownership	5	
	Location Requirements	5	
	Inner City Hurdles	3	
	Electricity Consumption Patterns	3	
Technology	Major Negative Incident	3	10
	Quality Issues	3	
	Technology Complexity	3	
	Association with other batteries (phones etc.)	1	

Appendix C Focus Group

Table AC.1 Focus Group Discussion Guide

Time	Item	Responsible
10 minutes	Welcome, introductions, objectives, guidelines for discussion – Chatham house etc.	Peta
20 minutes	<u>Knowledge of storage</u> Who has heard about energy storage? What do you know? • Can you describe different types of storage? • How storage works?	Peta/All
15 minutes	<u>Solar PV</u> Who has purchased solar PV? How long ago? Impressions? Motivations for purchasing? Green power? Perceptions on large vs small scale solar?	Peta/All
30 minutes	<u>Different types of storage</u> Describe different types of storage? Ascertain individual responses to each? • Positives and negatives • Issues and concerns	Peta/All
20 minutes	<u>Grid connections</u> Describe the different types of connections and pros and cons of each • Behind the meter • In front of the meter • Electric vehicles Identify different responses Motivations and preferences for different models	Peta/All
15 minutes	<u>Role of incentives</u> Discuss various ways to incentivise • Subsidies • Cost reflective tariffs • Low interest loans? • Leasing? • Tax breaks	Peta/All
20 minutes	<u>Possible scenarios</u> Briefly describe the three scenarios that have been developed and identify which the participants is most realistic. What they think will be needed to achieve any of them	Peta/All
15 minutes	<u>Closing statement, thank you and gift voucher</u> Is there anything else you would like to say about the topic to the EWG of the project Thanks to all for participating, project finalisation, feedback to participants. Hand out Gift Vouchers	Peta/All/Semso

Table AC.2 Focus Group Demographics

	No.	%
GENDER		
Male	24	41.4%
Female	34	48.6%
Total	58	100%
AGE		
18-35	23	39.6%
35-50	13	22.4%
51-64	11	19%
65+	11	19%
LEVEL OF EDUCATION		
High School or <	14	24.1%
Trade Certificate	1	1.7%
Diploma	10	17.3%
Bachelors	18	31%
Postgraduate	15	25.9%
SOLAR PV STATUS		
Installed	22	37.9%
Not Installed	36	62.1%
GREEN POWER SUBSCRIPTION		
Yes	2	3.4%
No	37	63.8%
Unknown	19	32.8%

Appendix D Survey Analysis

Table AD.1 Sample Characteristics that match those of the Australian population

	ABS[17]	Current study
Age bracket x gender		
Female 18-34 yrs	15%	14%
Female 35-54 yrs	17%	17%
Female 55+	18%	18%
Male 18-34 yrs	16%	15%
Male 35-54 yrs	17%	17%
Male 55+	17%	18%
Relationship status		
Married	49%	50%
Separated / divorced	11%	9%
Widowed	6%	4%
States and Territories		
NSW +ACT	34%	33%
Victoria	25%	24%
Queensland	20%	29%
South Australia	7%	8%
Western Australia	11%	12%
Tasmania	2%	2%
Northern Territory	1%	1%

[17] ABS demographics: 3101.0 - Australian Demographic Statistics, Jun 2016; 3310.0 Marriages and Divorces, Australia, 2015; 3412.0 - Migration, Australia, 2014-15; 2011 Census QuickStats: http://www.censusdata.abs.gov.au/census_services/getproduct/census/2011/quickstat/0; 6523.0 Household Income and Wealth, Australia, 2013–14; 6227.0 - Education and Work, Australia, May 2016

Country of birth		
Australian residents born overseas	28%	25%
UK	5%	8%
NZ	3%	3%
China	2%	1%
India	2%	2%
Philippines	1%	0.4%
Vietnam	1%	0.6%
Italy	0.8%	0.5%
South Africa	0.8%	0.4%
Malaysia	0.7%	1.1%
Germany	0.5%	0.8%
Education		
Year 10 or below	20%	11%
Year 11 or equivalent	5%	4%
Year 12 or equivalent	18%	15%
Trade certificate or Apprenticeship		7%
Certificate 1 or 2		3%
Certificate 3 or 4	18%	11%
Advanced diploma /diploma	10%	15%
Bachelor or honours degree	20%	23%
Postgraduate degree (e.g. Masters, PhD)	6.0%	11%
Employment (total in labour force)		
Full-time	60%	67%
Part-time	29%	25%

Unemployed	6%	9%
Dwelling structure		
Separate house	76%	70%
Number of bedrooms		
1 Bedroom	5%	7%
2 bedrooms	19%	19%
3 bedrooms	44%	40%
4 or more bedrooms	30%	34%
Household income		
Less than $25 k	12%	13%
$25 to 49,999 k	21%	22%
$50 to 74,999 k	15%	18%
$75 to 99,999 k	11%	19%
$100 to 124,999 k	11%	11%
$125 to 174,999 k	16%	9%
$175 to 199,999 k	4%	3%
$200 to 249,999 k	5%	2%
$More than 250 k	5%	2%

Appendix E Copy of survey

ACOLA AUSTRALIAN COUNCIL OF LEARNED ACADEMIES

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Please read through some information about the survey below before continuing.

Project Overview
This research project intends to advance understanding of socio-economic challenges for energy storage acceptance and use. The main aim is to identify the social drivers and barriers, and the publicly perceived risks and benefits of achieving energy storage uptake.

It is one of four work packages of a larger project being funded by the Australian Council of Learned Academies (ACOLA) (http://www.acola.org.au/index.php/projects/esp) and the Office of the Chief Scientist of Australia (http://www.chiefscientist.gov.au), who have partnered to deliver a project examining the opportunities and challenges of widespread deployment and uptake of energy storage technologies in Australia. In addition to the University of Queensland, other research institutions delivering into the project include the Academy of Technology, Science and Engineering and the University of Technology Sydney.

What is energy storage?

- "Energy storage" is an umbrella term for many different technologies that allow energy to be captured, stored and then used at another time.
- Some energy storage technologies are designed for use in the home, other types are used to support the energy use of communities, and still others are used to support the energy supply of large regions.
- This survey will mainly focus on home battery storage.

Home battery storage involves the use of a battery to store energy for use when required. It allows you to obtain electricity at a time when it is relatively inexpensive or abundant, store it, and then use it at a time when electricity is expensive or unavailable.

What is involved?
You are invited to respond to an online survey which will take up to 20 minutes of your time. We are keen to access the views of a range of Australians and you do not need to be an expert in this field.

Do I have to be part of this program?
Completion of the online survey is completely voluntary and you are free to withdraw at any time without prejudice or penalty. If you wish to withdraw from the study your information will be removed from the study. We would like to encourage you to participate in the study as your participation will ensure that we understand your opinion about battery storage as well as your preferred options in regard to the configuration and delivery of it.

Please tick the appropriate box:

- ◯ **Yes** **I have reviewed the information above and I agree to participate in this online survey**
- ◯ **No** **Sorry, I do not wish to participate in this online survey**

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Would you like to receive a copy of the summary findings on conclusion of the study?

Thank you for your agreement to participate in this research.

- ◯ Yes
- ◯ No, I do not wish to recieve a summary of the findings

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Firstly, what is your age?

[ ] years of age

What is your gender?

- ◯ Male
- ◯ Female

What is the postcode of your home address?

Postcode: [ ]

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What is your relationship status?

- ◯ Married
- ◯ In a relationship
- ◯ Not in a relationship
- ◯ Divorced/Separated
- ◯ Widowed

Do you have any dependent children?

- ◯ Yes
- ◯ No

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How old are your children?

Child 1: ____ years old

Child 2: ____ years old

Child 3: ____ years old

Child 4: ____ years old

Child 5: ____ years old

Child 6: ____ years old

In what country were you born?

- ( ) Australia
- ( ) Other (please specify)

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Are you Aboriginal or Torres Strait Islander origin?

(For persons of both Aboriginal and Torres Strait Islander origin, mark both boxes)

- [ ] No
- [ ] Yes, Aboriginal
- [ ] Yes, Torres Strait Islander

Which best describes your highest level of education you have completed?

- ( ) Year 10 or below
- ( ) Year 11 or equivalent
- ( ) Year 12 or equivalent
- ( ) Trade certificate or Apprenticeship
- ( ) Certificate I or II
- ( ) Certificate III or IV
- ( ) Advanced Diploma / Diploma
- ( ) Bachelor or Honours degree
- ( ) Postgraduate degree (e.g. Masters, PhD)
- ( ) Other (please specify)

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Are you Aboriginal or Torres Strait Islander origin?

(For persons of both Aboriginal and Torres Strait Islander origin, mark both boxes)

- ☐ No
- ☐ Yes, Aboriginal
- ☐ Yes, Torres Strait Islander

Which best describes your highest level of education you have completed?

- ○ Year 10 or below
- ○ Year 11 or equivalent
- ○ Year 12 or equivalent
- ○ Trade certificate or Apprenticeship
- ○ Certificate I or II
- ○ Certificate III or IV
- ○ Advanced Diploma / Diploma
- ○ Bachelor or Honours degree
- ○ Postgraduate degree (e.g. Masters, PhD)
- ○ Other (please specify)

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Which of the following best describes your occupational status?

- ○ Student
- ○ Household duties
- ○ Employed – Part Time
- ○ Employed – Full Time
- ○ Self-employed
- ○ Unemployed not looking for work
- ○ Unemployed looking for work
- ○ Retired
- ○ Not able to work
- ○ Other (please specify)

What industry have you spent most of your career life in?

How much is your estimated household income?

- Less than $25,000
- $25,000 to $49,999
- $50,000 to $74,999
- $75,000 to $99,999
- $100,000 to $124,999
- $125,000 to $174,999
- $175,000 to $199,999
- $200,000 to $249,999
- $250,000 to $299,999
- More than $300,000

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How much was your last electricity bill?

(Please give amount and time period)

Amount

$

Time period

- Per month
- Per quarter
- Per half yearly
- Annually

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When thinking of your response to new technology, which best describes you?

- ◯ I closely follow new technology and take risks by being the first to purchase it. I see the potential advantages in new technology and am one of the first to make use of its advantages and to profit from it.
- ◯ I am interested in new technology but at the same time I am pragmatic. I like to take time and be persuaded by the advantages. My decisions are (mainly) based on the recommendations of existing users.
- ◯ I am not thrilled by new technology, but rather appreciate security. It is safe to purchase products when it has been on the market for some while and offers obvious advantages.
- ◯ I am traditional and have little affinity with new technology. I do not like changes in life and I purchase products only when the existing model I use is not produced anymore.

Which best describes your situation in relation to your electricity bill?

- ◯ Paying my electricity bill in full is never a problem for me
- ◯ I sometimes find it hard to pay my electricity bill when it becomes due
- ◯ I always struggle to pay my electricity bill when it becomes due
- ◯ I pre-pay my electricity bill
- ◯ I do not pay for electricity in my house

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What is your current living arrangement?

- ◯ Privately owned house (free standing)
- ◯ Privately owned apartment/townhouse/unit (etc.)
- ◯ Renting a house
- ◯ Renting an apartment/townhouse/unit (etc.)
- ◯ Renting a room in shared accommodation
- ◯ I live with my family
- ◯ Other (please specify)

How many bedrooms are there in your household?

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5 or more

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Generally speaking, how many people are in your household during peak electricity periods? (4pm to 8pm)

- 0
- 1
- 2
- 3
- 4
- 5 or more

Which energy sources do you use in your household?

(Tick as many as apply)

- Electricity
- Gas (mains)
- Gas (bottled)
- Solar hot water
- Solar PV (rooftop)
- Others – Please specify
- I do not have access to mains power

How often do you experience the following electricity supply problems in your household?

	Never	Seldom	Sometimes	Often	Almost always	Don't know
Power outages (incl. planned & unplanned, blackouts)						
Supply disturbances (e.g. flickers, dimming, interruptions)						

What is your current status in relation to solar PV panel ownership?

- I have solar PV panels installed to supply my household
- My house has solar PV panels installed but I did not make the purchase decision
- I intend to install solar PV panels within the next 5 years
- I do not intend to install solar PV panels
- I do not know
- Other (please specify)

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In what year did you install your solar PV panels?

(YYYY)

How important were the following factors in influencing your purchase (or intended purchase) of solar PV panels?

	Not at all important	Slightly important	Somewhat important	Moderately important	Extremely important	Don't know
Its purchase cost						
Its benefits to the environment (e.g. reduce greenhouse gas emissions)						
Its safety features						
The better control it gave you over your electricity						
The availability of feed-in-tariffs						
It reduced your dependence on the grid						
The availability of a subsidy (e.g. lump sum) that made it more affordable						
You liked what it said about you						
It reduced your electricity costs						
It improved the value of your home						
The availability of Renewable Energy Certificates						
The way it looked on your home						

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To what extent are you familiar with home battery storage and could explain it to a friend?

- Not at all familiar
- Slightly familiar
- Somewhat familiar
- Moderately familiar
- Extremely familiar

What is your current status in relation to home battery storage ownership?

- I already own a home battery storage unit
- I am intending to purchase a home battery storage unit
- I am Interested in home battery storage but do not intend to buy one
- Not interested and have no intention of buying one
- I do not know enough about battery storage to make a decision
- I am not sure

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0% 100%

27. How important are the following factors in determining whether or not you would purchase a home battery storage unit?

	Not at all important	Slightly important	Somewhat important	Moderately important	Extremely important	Don't know
Its purchase cost						
Disturbances it might cause to your home (e.g. noise, space, heat)						
Its benefits to the environment (e.g. reduce greenhouse gas emissions)						
Its safety features						
The better control it gives you over your electricity						
It reduces your dependence on the grid						
The availability of a subsidy (e.g. lump sum) that makes it more affordable						
You like what it says about you						
It reduces your electricity costs						
It improves the value of your home						
Its end-of-life recyclability						
The way it looks in your home						

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0% 100%

If there is a large increase in the use of home battery storage in Australia, to what extent would you trust the following groups to act in the best interest of the consumer?

	Not trustworthy	Slightly trustworthy	Somewhat trustworthy	Moderately trustworthy	Extremely trustworthy	Don't know
Federal government						
State government						
Electricity sector organisations						
Manufacturers of energy storage technology						
Retailers of energy storage technology						
Installers of energy storage technology						

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What is your attitude to home battery storage?

Please mark your response along the continuum from 1 to 6.

Very negative					Very positive
1	2	3	4	5	6
○	○	○	○	○	○

Very unwise					Very wise
1	2	3	4	5	6
○	○	○	○	○	○

Very unimportant					Very important
1	2	3	4	5	6
○	○	○	○	○	○

Not at all useful					Very useful
1	2	3	4	5	6
○	○	○	○	○	○

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To what extent do you agree with the following statements?

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Don't know
Many people who are important to me would find it good if I installed a home battery storage unit	○	○	○	○	○	○
Many people in my community would find it good if I installed a home battery storage unit	○	○	○	○	○	○
My home is suitable for the installation of a home battery storage unit	○	○	○	○	○	○
Financing a home battery storage unit is possible for me	○	○	○	○	○	○
I can decide what changes I make to my home to install a home battery storage unit	○	○	○	○	○	○
Managing a home battery storage unit does not fit with my lifestyle	○	○	○	○	○	○
Using a home battery storage unit would require too much adjustment to the way I use power	○	○	○	○	○	○

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AUSTRALIAN COUNCIL OF LEARNED ACADEMIES

The University Of Queensland
AUSTRALIA

If you were to purchase a home battery storage unit what kind of finance options would be most important to you?

	Not at all important	Slightly important	Somewhat important	Moderately important	Extremely important	Don't know
Provides you with immediate cost savings						
Allows you to own the battery system						
Does not require an upfront payment						
Does not require a fixed term contract						
It is cheaper in the long term						
Allows the energy company to manage your electricity usage						
Allows you to afford the technology						
Allows you to pay off the battery system through monthly instalments						
The energy company is responsible for all the battery system maintenance and repairs						
The initial cost of the battery is recoverable						

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AUSTRALIAN COUNCIL OF LEARNED ACADEMIES

The University Of Queensland
AUSTRALIA

If you were to purchase a home battery storage unit what kind of finance options would be most important to you?

	Not at all important	Slightly important	Somewhat important	Moderately important	Extremely important	Don't know
Provides you with immediate cost savings						
Allows you to own the battery system						
Does not require an upfront payment						
Does not require a fixed term contract						
It is cheaper in the long term						
Allows the energy company to manage your electricity usage						
Allows you to afford the technology						
Allows you to pay off the battery system through monthly instalments						
The energy company is responsible for all the battery system maintenance and repairs						
The initial cost of the battery is recoverable						

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0% 100%

To what extent do you agree or disagree with the following statements?

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
An economic system based on free markets and unrestrained by government interference automatically works best to meet human needs	○	○	○	○	○
I support the free-market system, but not at the expense of environmental quality	○	○	○	○	○
The free-market system may be efficient for resource allocation, but it is limited in its capacity to promote social justice	○	○	○	○	○
The preservation of the free market system is more important than localised environmental concerns	○	○	○	○	○
Free and unregulated markets pose important threats to sustainable development	○	○	○	○	○
The free-market system is likely to promote unsustainable consumption	○	○	○	○	○

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0% 100%

Which political party did you vote for at the last national election

- ○ Australian Democrats
- ○ Australian Greens
- ○ Australian Labor Party (ALP)
- ○ Liberal Party (LIB)
- ○ National Party
- ○ One Nation
- ○ I am a swinging voter
- ○ Other (please specify)

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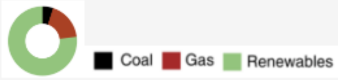
Which of the following two energy mixes do you believe is more **likely** in 2030?

- ◯ **Lower renewables**
  Coal: 25%
  Gas: 21%
  Renewable Energies: 54%

- ◯ **Higher renewables**
  Coal: 5%
  Gas: 18%
  Renewable Energies: 77%



- ◯ Don't know

If you could choose, which of the following two energy mixes would you **prefer** in 2030?

- ◯ **Lower renewables**
  Coal: 25%
  Gas: 21%
  Renewable Energies: 54%

- ◯ **Higher renewables**
  Coal: 5%
  Gas: 18%
  Renewable Energies: 77%

- ◯ Don't know

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Which of the following two options do you believe is more **likely** in 2030?

- ◯ Coal and gas power generation will be used to cover any extended periods when the supply of renewable energy is low
- ◯ Significant energy storage will be required to manage the intermittent nature of most renewables
- ◯ Don't know

If you could choose, which of the following two options would you **prefer** in 2030?

- ◯ Coal and gas power generation will be used to cover any extended periods when the supply of renewable energy is low
- ◯ Significant energy storage will be required to manage the intermittent nature of most renewables
- ◯ Don't know

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Which of the following three options do you believe is more **likely** in 2030?

- Storage technologies will advance according to corporate / consumer preferences
- Storage technologies will advance according to demand, so the cheapest forms will be added when and where it is needed and subject to environmental constraints and social acceptance
- Storage technologies will advance through government influence, causing the development of novel technologies, the location of large-scale storage sites in areas with low impact on the local environment and heritage and that benefit regional communities
- Don't know

If you could choose, which of the following three options would you **prefer** in 2030?

- Storage technologies will advance according to corporate / consumer preferences
- Storage technologies will advance according to demand, so the cheapest forms will be added when and where it is needed and subject to environmental constraints and social acceptance
- Storage technologies will advance through government influence, causing the development of novel technologies, the location of large-scale storage sites in areas with low impact on the local environment and heritage and that benefit regional communities
- Don't know

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In the final question you are asked to consider two examples of larger-scale forms of energy storage. The first is a community-scale project and the second to a utility-scale storage project. You will be asked your opinion regarding each type of storage.

A. Community-Scale Battery Storage Project
The Federal government proposes partnering with an energy company to develop a microgrid of batteries involving the installation of 1000 batteries in homes and businesses in a State of Australia. The installation of 5kW and 7.7kWh batteries will reduce energy costs to the consumer, and support the grid during times of peak demand.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Don't know
This energy storage idea sounds like a good idea	○	○	○	○	○	○
My friends and family are likely to support it	○	○	○	○	○	○

B. Utility-Scale Energy Storage Project
The Federal government proposes partnering with energy companies to construct a pumped hydroelectric power plant with a generation capacity of nearly 3,000 MW – which is about enough capacity to power half of the electricity requirements in Victoria. A number of remote areas are proposed. Two concrete reservoirs (dams) will be built located at different elevations as well as interconnection infrastructure and hydraulic turbine units. The estimated cost is in excess of $2 Billion. Water and environmental approvals and support from local community, and other stakeholders will be required.

In periods of high demand, electricity will be generated by releasing the stored water through turbines into a lower reservoir. Water is then pumped back to the upper reservoir during off-peak hours using electricity from the grid. The benefits of this project are the achievement of social/political goals of greater renewables and carbon reduction.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Don't know
This energy storage idea sounds like a good idea	○	○	○	○	○	○
My friends and family are likely to support it	○	○	○	○	○	○

In your opinion, which of the two large-scale storage projects offers more opportunities for the future?

- Community-Scale Battery Storage Project (installation of 1000 batteries in homes and businesses)
- Utility-Scale Energy Storage Project (hydro-electric power plant)

Please give reasons for your answer.

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Thats the end of the survey thank you for your participation in this research.

Press 'Next' to submit your results.

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Appendix F Additional analyses from survey

Table AF.1 How many bedrooms in house & mean electricity bill

	Mean	SD	N	min	max	Median
I bedroom	$303.86	$207.70	59	$16.00	$1,080.00	$240.00
2 bedrooms	$288.99	$182.32	187	$25.25	$1,200.00	$265.00
3 bedrooms	$366.95	$220.37	367	$10.00	$1,500.00	$313.00
4 bedrooms	$461.34	$329.03	261	$19.00	$1,935.00	$370.00
5 or more bedrooms	$505.98	$337.97	45	$46.00	$1,500.00	$400.00

Table AF.2 Number of people at home during peak periods & mean electricity bill

	Mean	SD	N	min	max	Median
0 people	$158.11	$64.26	9	$50.00	$270.00	$152.00
1 person	$261.61	$151.23	186	$10.00	$900.00	$240.00
2 people	$336.63	$194.99	353	$19.00	$1,200.00	$300.00
3 people	$424.12	$268.36	162	$60.00	$1,600.00	$350.00
4 people	$507.17	$335.55	138	$20.00	$1,800.00	$400.00
5 or more people	$594.48	$374.79	71	$46.00	$1,935.00	$459.00

Table AF.3 Size of electricity bills in mixed fuel & solar PV homes

	Mean	SD	N	min	max	Median
Electricity only	$421.85	$277.48	297	$16.00	$1,700.00	$350.00
Electricity + Solar PV only	$362.50	$322.58	58	$19.00	$1,800.00	$300.00
Electricity + Gas (B) only	$458.77	$294.76	74	$10.00	$1,600.00	$390.00
Electricity + Gas (B) + Solar only	$302.14	$213.24	22	$20.00	$899.00	$241.50
Electricity + Gas (M) only	$348.71	$226.25	369	$25.25	$1,935.00	$300.00
Electricity + Gas (M) + Solar PV only	$292.67	$213.69	64	$32.00	$1,350.00	$250.00
Electricity + Gas (M) + Gas (B) only	$316.35	$162.17	20	$20.00	$600.00	$303.50

Table AF.4 Size of electricity bills in mixed fuel and solar PV homes in relation to how many people at home during peak periods.

0 to 2 people at home during peak periods						
	Mean	SD	N	min	max	Median
Electricity only	$339.58	$193.79	185	$16.00	$1,200.00	$300.00
Electricity + Solar PV only	$309.62	$234.92	42	$19.00	$1,100.00	$267.50
Electricity + Gas (B) only	$357.81	$169.21	47	$10.00	$957.00	$350.00
Electricity + Gas (B) + Solar PV only	$251.73	$166.36	15	$20.00	$570.00	$240.00
Electricity + Gas (M) only	$289.17	$166.17	204	$25.25	$900.00	$258.50
Electricity + Gas (M) + Solar PV only	$224.70	$162.19	40	$32.00	$750.00	$166.00
Electricity + Gas (M) + Gas (B) only	$287.78	$124.00	9	$99.00	$560.00	$280.00
3 or more people at home during peak periods						
	Mean	SD	N	min	max	Median
Electricity only	$557.72	$336.39	112	$115.00	$1,700.00	$460.00
Electricity + Solar PV only	$501.31	$464.97	16	$46.00	$1,800.00	$335.00
Electricity + Gas (B) only	$634.52	$377.88	27	$223.00	$1,600.00	$510.00
Electricity + Gas (B) + Solar only	$410.14	$273.16	7	$167.00	$899.00	$350.00
Electricity + Gas (M) only	$422.31	$266.12	165	$60.00	$1,935.00	$350.00
Electricity + Gas (M) + Solar PV only	$405.96	$243.00	24	$174.00	$1,350.00	$340.00
Electricity + Gas (M) + Gas (B) only	$339.73	$190.61	11	$20.00	$600.00	$350.00

Table AF.5 Current status in relation to home battery storage ownership

Battery Storage Status	Freq.	Percent
I already own a home battery storage unit	18	1.8
I am intending to purchase a home battery storage unit	138	13.6
I am Interested in home battery storage but do not intend to buy one	230	22.7
Not interested and have no intention of buying one	116	11.4
I do not know enough about battery storage to make a decision	391	38.5
I am not sure	122	12.0
Total	1015	100.0

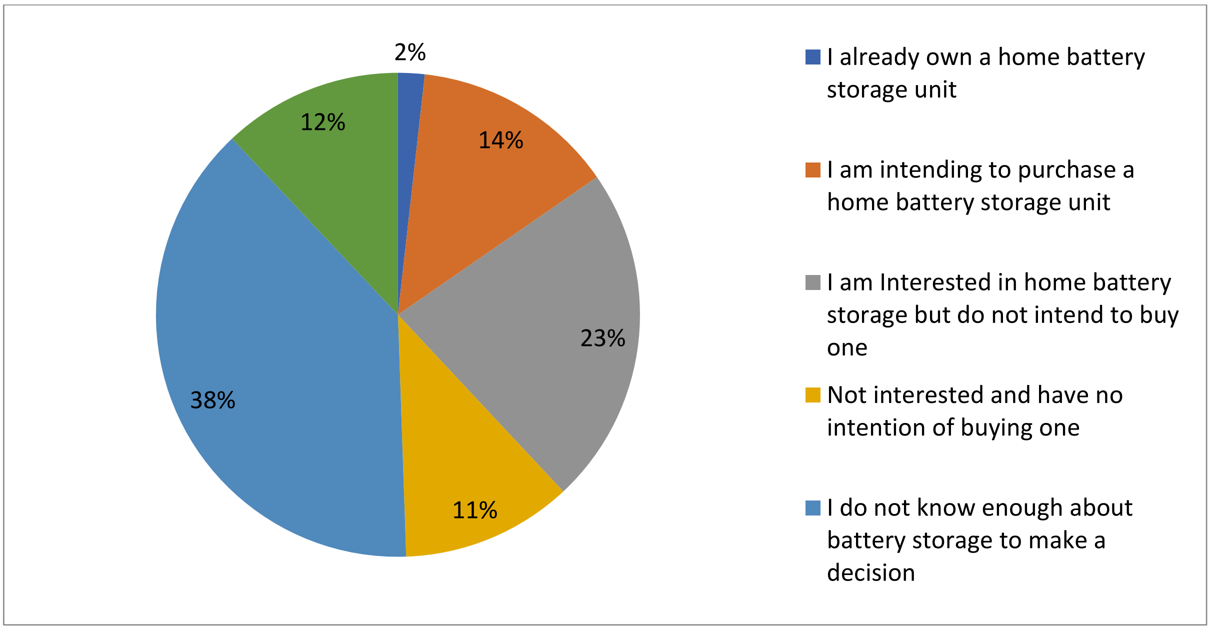

Figure AF.1 Current status in relation to home battery storage ownership

Figure AF.2 Factors influencing potential purchase of a home battery storage unit

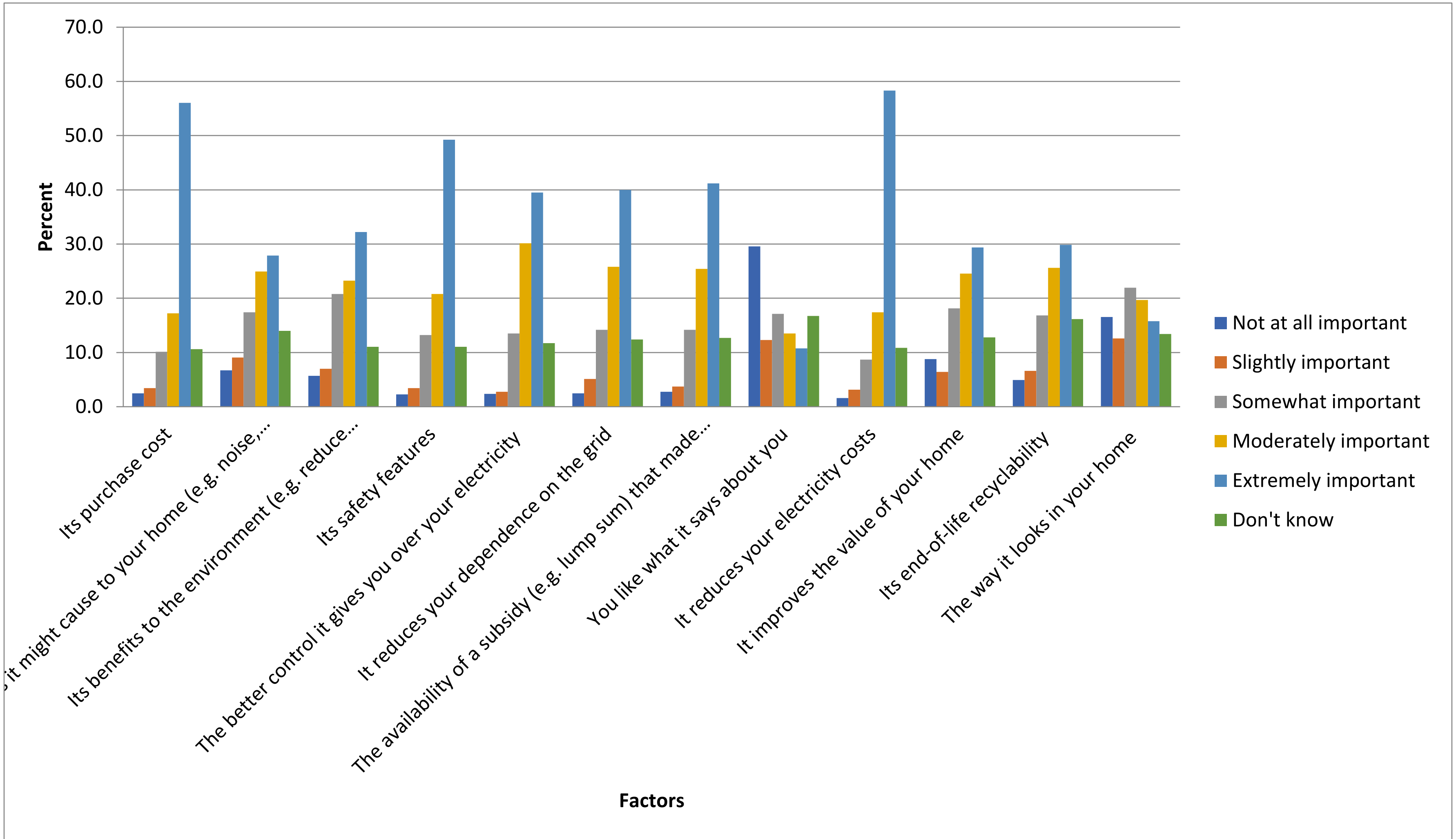

Figure AF.3 Drivers and barriers for battery storage adoption