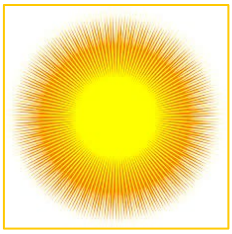

The Solar Rebound and Renewable Energy Adoption in the Sunshine

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Executive Summary

This report is presented to Energy Consumers Australia (ECA) and is designed to support energy policy goals of ensuring a secure, reliable, affordable and clean electricity system. The focus of the research is on rooftop solar, battery storage and electricity-saving in the home. The research is designed to examine the factors influencing the adoption and non-adoption of renewable energy by homeowners in the state of Queensland and analyse people's attitudes towards electricity-saving in both solar and non-solar households.

Examining electricity-saving practices by households is important for several reasons. Rising demand for energy services in households – particularly for cooling, for the increasing number of appliances and connected devices in the home – has been outpacing energy efficiency and decarbonisation gains. In order to save energy, people can invest in more efficient technologies (i.e., installing rooftop solar and battery storage, buying energy star labels) and/or use the existing technologies less (i.e., electricity-saving/curtailment behaviour). Addressing the behaviour of the household's occupant, and promoting voluntary curtailment, is challenging but it can bring public and private gains. Currently there are significant policy conversations about the renewable energy transition. Policy makers see an important role for the 'prosumer' in the energy system, which refers to a consumer that both produces and consumes energy, a consumer who strategically exchanges energy with the grid in order to meet their own demand and profit from energy arbitrage, actions that ultimately support the entire grid.

The research is organised around a number of issues, which were informed by an extensive literature review and a review of government reports. The uptake of renewable energy sources has been dramatic in Australia and the country has one of the highest per capita penetrations of rooftop solar worldwide. While the reasons for the uptake of rooftop solar are well-understood, many questions remain unanswered. One question is how consumers behave after installing rooftop solar, hence perceptions of the rebound effect and attitudes towards electricity usage are examined. Another question relates to motivations for installing battery storage and differences in cognitions between adopters and non-adopters. Attitudes towards buying energy-efficient appliances are worthy of study since efficiency is best understood as an 'economically rational' way of achieving greenhouse gas emissions. Consumer interest in prosumer scenarios, including smart meters and load-shifting, deserves more attention.

The improved understanding of consumer behaviour, based on an online survey of 609 householders, gives rise to specific recommendations for policy makers and energy retailers. For solar retailers, the success of companies' marketing strategies will depend upon selling a high-quality product, offering a wide choice and gaining the trust of the consumer through offering a high level of service. Householders need reassurance that lithium-ion batteries are the safe and technologically advanced option. New business models such as leasing offer a pathway to increasing battery storage adoption. Although some electricity users might become more active and engaged than they currently are, the view that passive electricity consumers can be transformed into active energy system participants is overly optimistic. Marketing communications that are designed to curb the solar rebound could target younger generations, those aged 18 to 55, and remind energy consumers that restraint in electricity consumption during peak periods is needed. Marketing communications that emphasise the need to unplug devices when not in use may help reduce electricity consumption. The research shows that the energy star label guides decision making. Marketing campaigns that appeal to the bill conscious consumers, particularly older generations, are likely to be effective. Money-saving appeals may encourage both efficiency (purchase-related) and curtailment behaviour. Helping householders, particularly older age groups, maintain thermal comfort is important and new energy technologies are likely to play a role in meeting people's need for personal comfort. Marketing campaigns that seek to affirm the consumer's sense of self-efficacy may be effective. For state governments that wish to accelerate the uptake of solar coupled with battery storage, initiatives could be developed to address financial barriers. These may include, for example, interest-free loans, tax deductions, subsidies and grants. On the grounds of energy justice, such incentives could be targeted at low-income households. For solar retailers, campaigns that appeal to the independence motive may increase the uptake of rooftop solar. Rooftop solar could be positioned as way of reducing motivational conflict, such as the desire to use the air-conditioner and save electricity at the same time. Battery storage campaigns should be targeted at higher socio-economic groups, and advertising appeals that are aligned with self-interest (i.e., thermal comfort) and the self-identity (i.e., the environmentally conscious and frugal person) of the target audience may be effective.

In conclusion, this research focuses on two key aspects of consumer behaviour: electricity-saving in the home and purchase-related behaviours. The research has elevated understanding of consumer behaviour in the context of homeowners in the state of Queensland. Given the complexity of consumer behaviour, it is critical that cognitions and behaviours are continuously studied and understood in order to address key challenges surrounding the energy transition.

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1. Introduction

Electricity has a vital role in people's lives. It is impossible to imagine a world without electricity. It supplies critical services, such as heating or cooling, and it can also provide entertainment, nourishment and the ability to work. Yet, despite its significant social benefit, the electricity supply system is a significant source of greenhouse gas emissions, particularly from domestic cooling and heating systems. Today, Australia's electricity system is in transition and Australia's approach to the transition is vital in ensuring a secure, reliable, affordable and clean electricity system. Consumers lie at the heart of this transition, since they desire to take greater control of their energy costs and do their bit for the environment (Finkel, 2017).

At federal level, ambitious goals have been set to reduce greenhouse gas emissions and restore Australian leadership on climate change. Plans are in place to reduce transport emissions, support more renewables by investing in the electricity grid and help communities benefit from solar banks and batteries (Australian Government, 2022). Queensland is committed to achieving zero net emissions by 2050, with an interim target to reduce emissions by 30% below 2005 levels by 2030. In relation to energy, the goal is to achieve a renewable energy target of 50% by 2030 (Queensland Government, 2022). Therefore, the measurement of consumer attitudes is important so that initiatives at both a national and a state level can be finetuned.

This study focuses on two key aspects of consumer behaviour:
Electricity-saving in the home and purchase-related behaviours

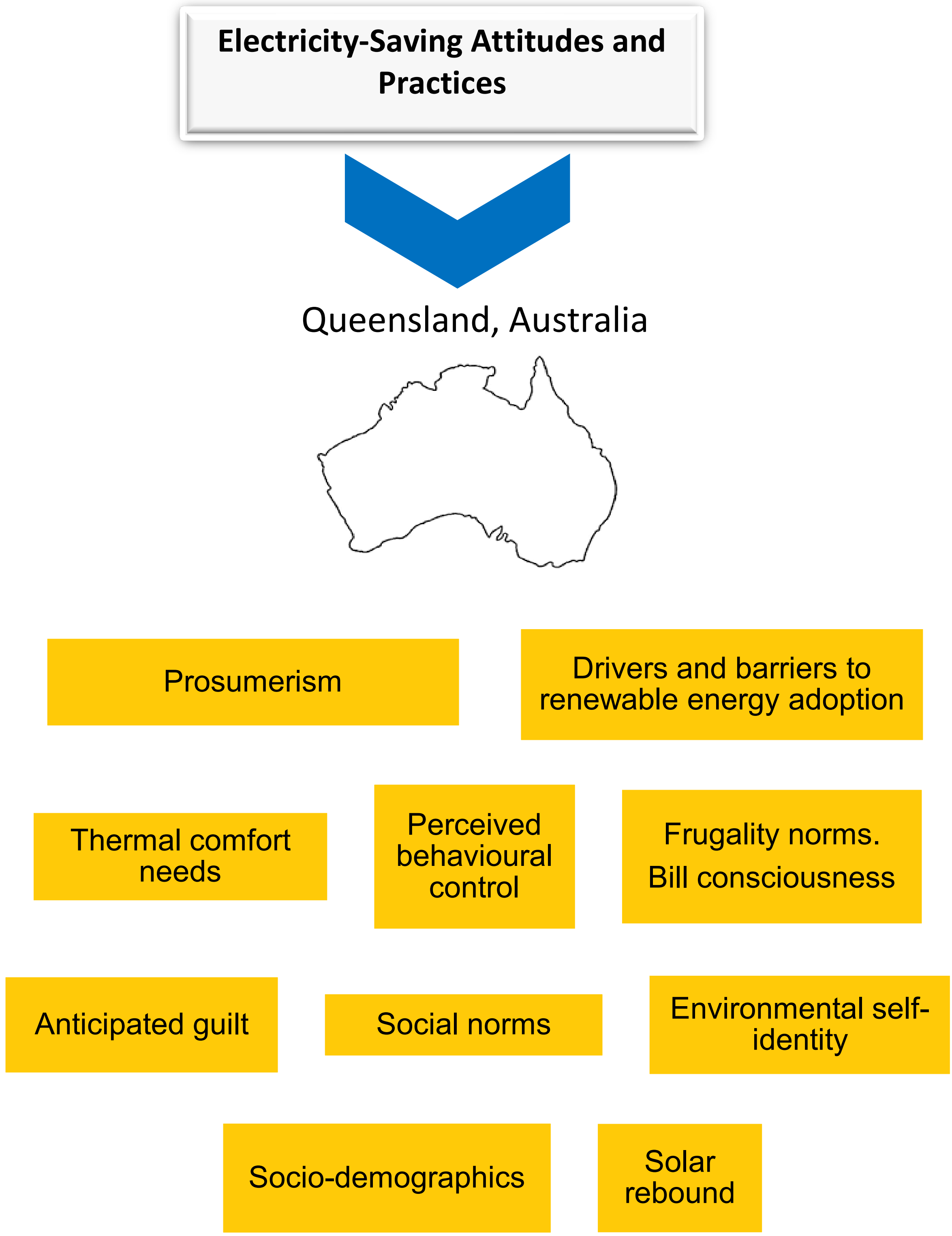
The uptake of renewable energy sources has been dramatic in Australia and the country now has the highest per capita penetration of rooftop solar worldwide (Chandrashekeran et al., 2022). While the reasons for the uptake of rooftop solar are well-understood, a central question is how consumers behave after installing rooftop solar. It is critical that consumer behaviour, given its complexity, is studied and is understood. This includes gaining insights into motivations for installing renewable energy, acceptance of, and the readiness to adopt, battery storage, particularly since the cost of the technology is forecast to decline (Nykvist, and Nilsson, 2015). Other issues of interest are perceptions of the rebound effect and electricity usage after installing rooftop solar. Attitudes towards buying energy-efficient appliances are worthy of study since efficiency is best understood as an 'economically rational' way of achieving greenhouse gas emissions. Consumer interest in prosumer scenarios, along with smart meters and load-shifting, deserves more attention, given the rhetoric around the rise of the prosumer (Skjølsvold and Lindkvist, 2015). In addition, the psychological and emotional factors that influence electricity conservation in the home are examined, such as thermal comfort need, an environmental self-identity, frugality norms, bill consciousness and anticipated guilt. These factors have the potential to influence electricity saving efforts and the willingness to engage in climate protection action.

To better regulate electricity consumption, more information on consumer behaviour is required.

This project draws on a literature review and an online survey of 609 energy consumers in the state of Queensland, Australia. A pilot study was undertaken prior to the start of the project.

The results should assist policy makers, utilities and retailers in understanding consumer behaviour, improving the deployment of renewable energy and promoting electricity-saving practices. Figure 1 summarises the scope of the study.

Figure 1: The solar rebound and renewable energy adoption in the Sunshine State



2. Methodology

2.1 Research Objectives

If Australian policy makers wish to support electricity conservation efforts and counteract climate change, it is important to determine consumer attitudes towards electricity saving and the readiness of the public to adopt rooftop solar and battery storage. Thus, this CEO project, on behalf of Energy Consumers Australia (ECA), has the objectives of:

1) investigating the consumer's willingness to adopt rooftop solar photovoltaic (PV) and battery storage, and the barriers to the adoption of battery storage.

2) examining electricity-related attitudes and practices after installing rooftop solar, such as perceptions of the solar rebound and load-shifting behaviours.

3) examining the psychological factors and motives influencing consumer decision-making in the context of energy.

4) identifying the key differences between households that have adopted battery storage and those that have not.

2.2 Research Methods

To achieve the research objectives, private households in Queensland, those who had adopted rooftop solar and those who had not, were targeted and questioned on their decisions and attitudes in relation to energy consumption. Exclusion criteria consisted of people who were not home owners, such as renters, and persons aged under 18 who were not likely to be involved in decisions about electricity in their household. The research design is best described as the quantitative method, based on the use of a household survey.

Australia has very high penetration rates for rooftop solar. It is reported that 1 in 4 detached households in South-East Queensland have installed rooftop solar photovoltaic (PV), and this adoption rate is amongst the highest in the world (Simshauser, 2016). Therefore, a decision was taken to focus on the state of Queensland. Investigating adoption on a state level offers the possibility of examining a large and authentic population. Homeowners were chosen since renters and apartment dwellers face constraints to installing rooftop solar (Chapman et al., 2016). For apartment dwellers, making decisions in a body corporate context is challenging. In general, renters do not have an incentive to make long-term investments in property improvements and landlords do not have an incentive to install solar PV since they do not pay the electricity bills. Furthermore, battery storage is a complementary technology to rooftop solar, so the sample included homeowners that had solar to better assess the potential for storage to be adopted in the future. In addition, the Queensland state is in the tropics, and the local climate of the region must be considered regarding the decision to adopt rooftop solar and battery storage.

2.3 Recruitment

A market research agency was used to recruit the households. The survey fieldwork was conducted by Qualtrics, using participants from their online research panel. All other tasks were completed by the author of this project. An online survey was designed which enabled homeowners to answer the survey questions and enter a range of data. The data collected included information on consumer behaviour such as attitudes and value, motives for the adoption of rooftop solar and battery storage, and household demographics. A sample size of 609 respondents was achieved.

2.4 Consent, privacy and ethics

Survey respondents were given a guarantee of privacy and advised that the data would be anonymized, they were informed that respondents would not be identified in scientific publications and the data would be used exclusively for research purposes. Every participant was asked for their consent to participate in the survey. Ethical approval for the study was gained from the Human Ethics Committee, at James Cook University, Townsville.

3. Research Findings

3.1 Rooftop Solar Adoption

What are the factors influencing the decision to install a rooftop solar system?

Solar PV is a mature technology, and it provides the cheapest electricity in many parts of the world, due to technological improvements, economies of scale, standardisation in manufacturing and a high learning rate. It is predicted that solar PV will be crucial in the decarbonization path compatible with the Paris agreement (Victoria et al., 2021). Rapid adoption of rooftop solar in Australia has mostly been explained by access to government subsidies, such as the premium feed-in-tariff or FiTs (Li et al., 2020). This is defined as a payment for exporting solar electricity to the grid. A premium FiT of 44c was introduced in Queensland in 2008, for a duration of 20 years, but this dropped to 8c for new customers in 2012, and has been phased out in recent times (Li et al., 2020). There are a significant number of solar PV customers who will continute to receive the old rate until the end of the scheme in 2028 (Queensland Competition Authority, 2013). The topic of rooftop solar adoption has generated a considerable body of academic work and studies have emphasised the importance of incentives, such as the feed-in tariff, and socio-demographics in motivating uptake of rooftop solar (Best et al., 2019; Esplin & Nelson, 2022; Sommerfeld et al., 2017). Other studies have revealed negative perceptions of incumbent electricity utilities and self-sufficiency motives (Agnew & Dargusch, 2017). Pro-environmental attitudes also explain intentions to adopt solar PV (Abreu, Wingartz, & Hardy, 2019).

Findings

Background data was gathered such as when the system was installed and the size of the system. Table 1 shows that half of the sample had installed rooftop solar, and half had not taken that action. The most common size chosen was a medium system, between 6kw to 9kw (see Table 2).

The sample consisted of a small percentage of early adopters (8%); approximately a quarter of the sample (27%) had installed solar when the premium feed-in tariff was available; 14% had installed solar just after the premium feed-in tariff was reduced, and approximately half of the sample were late adopters, installing solar on, or after, the years 2015 and 2020 (see Table 3).

One research objective was to investigate the motives for the adoption of rooftop solar by homeowners. Table 4 shows the reasons for installing rooftop solar. The top two drivers are the desire to save money on electricity bills and being able to access a high-quality system. Other motives are related to the quality of the service, such as having access to reliable installers/electricians and a service warranty. The altruistic motive, such as the desire to reduce environment impact by using a renewable energy source, was important. The self-sufficiency motive was also prominent. The least important factors were to make money by selling electricity back to the grid and use an innovative, high-tech system.

In relation to the future and intentions to install rooftop solar, the mean value was 3.40 and the standard deviation was 1.39, which means that most people are undecided about getting rooftop solar, and "might or might not" install solar. A total of 15% report that they are "definitely" likely to get a solar system, and 11.7% report they are "probably" likely to get a solar system (see Table 5).

TABLE 1: SOLAR SYSTEM INSTALLED

Solar System (n=609)	No	Percent
Yes	307	50.4
No	302	49.6

TABLE 2: SIZE OF ROOFTOP SOLAR SYSTEM INSTALLED

Size of System (n=307)	No	Percent
Small (5kW or under)	121	39.4
Medium (6 to 9kW)	135	44.0
Large (10 kW or over)	51	16.6

TABLE 3: PERIOD OF ADOPTION

When was the solar system installed? (n=307)	No.	Percent
2007 or before	25	8.1
Between 2008 and 2012/2013 (when the premium FiT of 44c was available)	84	27.4
Between 2013 and 2014 (when a lower FiT was available)	43	14.0
Between 2015 and 2019	96	31.3
After 2020	59	19.2

TABLE 4: FACTORS INFLUENCING THE DECISION TO INSTALL SOLAR

Factors influencing the decision to install solar (n=307)	Mean	Std Dev.
High quality system.	4.09	0.89
Save money (due to lower electricity bills).	4.07	0.96
Reliable installers / electricians.	3.95	0.91
Concern about rising electricity prices.	3.92	0.99
Service warranty.	3.92	0.93

Reducing impact of the environment by using a renewable energy source.	3.76	1.06
Make the household more self-sufficient.	3.74	0.99
Decreasing cost of solar systems	3.63	1.08
Wide choice of brands/suppliers to choose from.	3.52	1.04
Knowing the equipment is recyclable	3.46	1.09
Increase the value of my home.	3.38	1.12
Earn money from selling electricity back to the grid.	3.16	1.19
Use an innovative/high-tech system.	2.96	1.19

Note: a five 5-point importance scale was used, where 1=not at all important and 5=extremely important

TABLE 5: INTENTIONS TO INSTALL SOLAR

	No.	Percent	Mean	Std. Dev.
I am likely to get a solar system at home in the future (n=410)			3.40	1.39
Definitely yes	62	15.1		
Probably yes	48	11.7		
Might or might not	74	18.0		
Probably not	115	28.0		
Definitely not	111	27.1		

Note: a 5-point scale was used where 1= definitely not and 5= definitely yes.

3.2 Battery Storage Technology

What is the likelihood of installing battery storage? How acceptable is battery storage to consumers? How important is independence from the grid to consumers? What are the factors inhibiting the installation of battery storage?

Consistent with government policy in many countries, battery storage is defined as an energy storage technology that uses chemicals to absorb and release energy on demand (Australian Renewable Energy Agency (ARENA), 2022). Coupling energy with renewable energy generation allows that energy to be stored during times of low demand and released (or dispatched) at times of peak demand. Batteries are particularly valuable because they respond faster than other energy storage technologies, can provide flexibility and help maintain grid stability (ARENA, 2022). Solar, combined with battery storage, is needed to address the misalignment between solar output and peak electricity demand. On the other hand, customers who install batteries and remain on grid can reduce their peak demand for electricity, which helps reduce network spend and support the security of the grid (AER, 2021; Esplin & Nelson, 2022). If battery storage was configured to support the network, with supportive tariff structures and time-of-use electricity pricing, this would also help reduce network costs and improve reliability (Agnew & Dargusch, 2015). Globally, rapidly scaling up energy storage systems is seen as critical to addressing the hour-to-hour variability of wind and solar PV (International Energy Agency, 2021). There has been a trend towards lithium-ion battery technology, which have lifetimes of 5 to 15 years (AECOM, 2015). Depending on functionality that consumers are seeking, they could install small batteries to avoid consuming electricity during peak demand periods and lower total electricity bills; install medium sized batteries to maximize the use of solar electricity, using the grid only for backup; or disconnect entirely from the grid (Agnew & Dargusch, 2017).

Small-scale batteries are not yet economic, and uptake has been slow in Australia. Of the 300,000 solar PV systems installed in the NEM in 2020, less than 3% had an attached battery system and it is estimated that only 30,000 customers had installed battery systems by April 2021 (AER, 2021). High costs are a critical issue that is slowing broad market penetration of residential battery storage (Alipour et al., 2022). Despite the high costs of storage, the preconditions for battery storage adoption are seen as favourable. Supporting conditions include the recent rise in energy prices (Ludlow, 2022), community concerns about carbon emissions, and the rapid adoption of small-scale solar PV systems (AER, 2021).

Findings

In line with prior reports, this survey found that only 16% of the sample has installed battery storage, (see Table 6). However, for some solar households, the likelihood of installing batteries in the future is strong, with 15.2% reporting that they are “definitely” likely to get batteries and 29% are “probably” likely to get batteries (see Table 7). The mean value was

3.21 and standard deviation was 1.22, meaning that most respondents are unsure and ticked "might or might not" in response to this question.

One research objective was to examine the level of acceptance for battery storage. The term 'acceptance' refers to the degree that households or consumers are willing to have battery storage installed on their property and what they think and feel about it. The results indicate that acceptance is somewhat weak. The mean values ranged from 4.48 to 4.74 indicating that respondents "somewhat agreed" with the statements about battery storage acceptance (see Table 8).

Grid independence does not appear to be a motive for installing batteries. In general, respondents, including those who have storage and those who do not, indicate that they "somewhat agree" with the statement about the desire to be independent from their energy retailer (see Table 9).

The barriers to installing battery storage are reported in Table 10. Respondents report that issues such as lack of money, inadequate government subsidies and the long payback period "moderately describes" their concerns. Safety, technological change and the risk of not picking the best storage option "slightly describes" people's concerns. A feeling that battery storage is not necessary, and having no incentive to store electricity, "slighly describes" people's beliefs. Uncertainty over property tenure along with getting a premium feed-in tariff of 44c received the lowest mean scores.

TABLE 6: BATTERY STORAGE INSTALLED

Battery Installed (n=307)	No	Percent
Yes	50	16.3
No	257	83.7

TABLE 7: THE LIKELIHOOD OF INSTALLING BATTERY STORAGE

	No.	Percent
I am likely to get a battery/energy storage system at home in the future (n=551)		
Definitely not	65	11.8
Probably not	82	14.9
Might or might not	160	29.0
Probably yes	160	29.0
Definitely yes	84	15.2

Note: a 5-point scale was used where 1= definitely not and 5= definitely yes.

TABLE 8: ACCEPTANCE OF BATTERY STORAGE

Acceptance of Battery Storage (n=609)	Mean	Std Dev
I would like to use a PV battery storage system.	4.74	1.61
I consider PV battery storage systems to be sensible and sustainable.	4.74	1.50
I can imagine using a PV battery storage system.	4.61	1.59
Investing in a PV battery storage system has more advantages than disadvantages.	4.58	1.52
I can imagine investing (or have already invested) in a PV battery storage system.	4.48	1.59

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree.

TABLE 9: INDEPENDENCE MOTIVE

General Attitudes (n=609)	Mean	Std Dev
I would like to be more independent from my energy provider	4.97	1.36

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree.

TABLE 10: BARRIERS TO INSTALLING BATTERY STORAGE

Barriers /concerns about batteries (n=557)		
I/we are lacking the financial resources.	3.00	1.52
Adequate government subsidies are not available.	2.96	1.40
I don't think the investment will pay off / payback period is too long.	2.78	1.37
I am apprehensive of technological change and the risk of not picking the best storage option.	2.41	1.25
My/our house is already energy optimised.	2.02	1.16
I am concerned about safety.	2.19	1.26
Battery storage is not necessary.	2.16	1.18
I am not sure how much longer I will stay in this house.	1.96	1.27
I am getting a premium feed-in tariff of 44c for my electricity and have no incentive to store it.	1.81	1.23

Note: a 5-point scale was used where 1= does not describe my concerns, 2= slightly describes, 3=moderately describes, 4=mostly describes, and 5= clearly describes my concerns.

3.3 Prosumers and Business Models

Are consumers willing to act as prosumers? What is the response of consumers to new business models? Are consumers interested in smart meters? Are they willing to engage in load-shifting? Are they interested in time-varying tariffs?

Policy documents highlight the role of prosumers in the future grid and the benefits of distributed energy resources (DER) to the network (CSIRO, 2013). The term 'distributed energy resources' refers to a shift from a centralized grid to two-way power flows, to decentralized, community-generated energy, generally small-scale units of local generation, such as rooftop solar, battery systems, electric vehicles, smart meters, wind turbines and so forth, that are connected to the grid (ARENA, 2018). The term 'prosumer' refers to a person who consumes as well as produces energy, the prosumer is expected to strategically exchange energy with the grid, and such action helps them meet their own demand, profit from energy arbitrage, and ultimately support the entire grid (Parag & Sovacool, 2016; Esplin & Nelson, 2022). Individually, storage is largely invisible to the market, but if aggregated and operated together as a virtual power plant or microgrid, battery storage can potentially enhance the reliability of the grid and power system security (AER, 2021). Prosumer concept also overs peer-to-peer solar trading. In Australia, trials of peer-to-peer solar trading have been run, allowing energy sharing between households (Vorrath, 2016).

A smart meter measures when and how much electricity is used at a premise. It sends this information back to the energy retailer remotely, without the meter needing to be manually read by a meter reader (AER, 2022). While the roll-out of smart meters has potential benefits, including reducing retailer's operating costs, supporting and enabling better integration of distributed energy resources (DER) and providing consumers with visibility and control of their electricity consumption and costs, challenges remain, such as data privacy concerns and the issue of whether societal benefits outweigh the costs of smart meter rollout programs (Kallies et al, 2019).

Load shifting is a feature of the prosumer. Load shifting refers to shifting the demand for electricity consumption to the times during which electricity is produced (Wittenberg & Matthies, 2016). Engaging in load shifting behaviour can create economic value by lowering the cost of supply and decreasing carbon emissions. For example, solar households could export less electricity to the grid during congested periods, thereby avoiding the voltage fluctuations which the local utility has to manage, and solar households with battery storage can avoid consuming grid-supplied electricity during peak periods.

Along with load-shifting, time-varying tariffs support the rise of the prosumer. If battery storage was configured to support the network, with supportive tariff structures and time-of-use electricity pricing, this would help reduce network costs and improve reliability (Agnew & Dargusch, 2015). Energy experts argue that Australia needs to transition from fixed to dynamic tariffs, which would be lower in the day, and higher in the morning and evening peaks to incentivise rooftop owners to inject their electricity into the grid when it's more valuable (Rai, 2021).

Findings

In relation to prosumer scenario, the mean score is 5.13 and the standard deviation is 1.50, meaning that on average, respondents are "slightly likely" to install battery storage under a feed-in tariff regime. There is a sizeable segment, an estimated 26.6% of respondents, who are "moderately likely" to install battery storage (see Table 11). Overall, respondents are hesitant about acting as "prosumers".

One of the research objectives was to harness insight into consumer preferences for different business models, given the price attribute, ownership or leasing options and option to export surplus electricity back to the grid. Table 12 displays the proportion of ranked priority for the three scenarios. In relation to the top ranked option, almost one third of the sample (30.8%) are interested in full ownership. An estimated 24% of the sample are interested in leasing the lower-priced batteries, where a third-party maintains the battery and exports solar to the grid in return for a credit on the electricity bill. Only 17.7% of the sample ranked the moderately priced, self-consumption system as their first preference. Alternatively, survey participants were provided with the option to not rank the options, and 23% of respondents indicated "none of the above".

Table 13 shows that consumers' interest in smart meters is low, and most "somewhat agree" with the statement about wanting a smart meter to easily monitor their electricity usage. T-tests show that there are significant differences between older and younger age groups, with older generations scoring lower than younger generations (see Table 13b).

The survey responses show that consumers are willing to manually shift electricity use from the evening to the daytime when the sun is shining (presumably to cut their electricity bill). The mean value was 3.2 which corresponds to "about half the time". However, automatic load-shifting, through using devices such as timers or remote-controlled devices, was lower, with most respondents indicating that they "sometimes" do this (see Table 14). Respondents "somewhat agree" that they want a time-varying tariff (see Table 15).

TABLE 11: LIKELIHOOD OF INSTALLING BATTERY STORAGE UNDER A PROSUMER SCENARIO

Scenario		
Batteries can be charged by solar panels on the roof. Since they store electricity, they make solar energy less dependent on the weather and could meet a home's daily energy needs. Surplus electricity could be sent to the national grid earning money for homeowners. A feed-in tariff is a credit people can receive when excess energy I sent back to the grid. Batteries also support the grid, making it more secure and reliable. A new policy inventive, a generous feed-in tariff rate, has been introduced to promote battery storage and reward people for sharing and trading electricity. How likely would you be to install battery storage under this scenario?		
Response category (n=557)	n	%
Extremely unlikely	50	9
Moderately unlikely	28	5
Slightly likely	13	2.3
Neither likely nor unlikely	131	23.5
Slightly likely	109	19.5
Moderately likely	148	26.6
Extremely likely	78	14.0

Note: a 7-point scale was used where 1= extremely unlikely and 7= extremely likely

TABLE 12: BUSINESS MODELS

	1st	**2nd**	**3rd**	**0**
Option	*% (n)*	*% (n)*	*% (n)*	*% (n)*
Owned outright, $10,000 (after government subsidy), option to export solar and get credit	30.8 (171)	21.4 (119)	20.2 (112)	23.2 (129)
Owned outright, $8,000, limited option to export since the system is for self-consumption	17.7 (98)	40.2 (223)	18.6 (103)	23.1 (128)
Leased, discounted purchase price of $5,000, third party manages battery and exports.	24 (133)	13.5 (75)	35.7 (198)	23.4 (130)

Note: 0=none of the above.

TABLE 13: ATTITUDES TOWARDS SMART METERS

Attitude towards smart meters (n=609)		
I want to have a smart meter. Then I could easily monitor electricity usage.	4.72	1.55

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree

TABLE 13B: ATTITUDES TOWARDS SMART METERS BY AGE GROUP

	Younger (n=247)		Older (n=304)				
Statement	Mean	Std Dev	Mean	Std Dev	p	t	Cohen's d
Smart meter							
I want to have a smart meter. Then I could easily monitor my electricity usage	4.98	1.388	4.50	1.623	.001	3.708	.313

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree

TABLE 14: LOAD-SHIFTING

Electricity load-shifting behaviour (n=307)				
I turn on appliances during the day when solar PV production is high			3.21	1.45
I use a timer or delayed start function (if available) to operate appliances			1.77	1.50
I use remote-controlled devices to operate appliances			1.77	1.50

Note: a 5-point scale was used, where 1= (Almost) Never, 2=Sometimes, 3=Almost half the time, 4=Most of the time, and 5= (Almost) Always.

TABLE 15: ATTITUDES TOWARDS A TIME-VARYING TARIFF

Attitude towards a time-varying tariff (n=609)		
I want to have a time-dependent electricity tariff. Then I could at least partially transfer my consumption to the cheapest time (e.g. washing at night)	4.72	1.48

Note: A 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree.

3.4 Thermal Comfort

Do energy consumers in Queensland have a high need for thermal comfort?

The concept of thermal comfort is an important one in studies of electricity conservation (Huebner *et al.,* 2013; Yang *et al.,* 2014; Ren & Chen, 2018). Thermal comfort describes what people want from energy services, e.g. how warm or cool they expect their house to be (Stephenson *et al.,* 2015). Thermal comfort is a subjective judgement of comfort and is defined by the *American Society of Heating, Refrigerating and Air-Conditioning Engineers* (ASHRAE) as “that condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation” (ASHRAE, 2013). As such, it is influenced by personal differences such as gender (Karjalainen, (2007) and social and cultural factors (Djongyan, Tchinda, & Njomo, 2010).

Findings

The results show that consumers do not perceive a high need for thermal comfort, with most respondents indicating that they “somewhat agree” or “neither agree nor disagree” with the statements capturing thermal comfort needs (see Table 16).

T-tests were conducted to determine differences in mean responses between groups. The results show that there is no significant difference between males and females in relation to their perceptions of thermal comfort. There were significant differences between younger and older generations (see Table 16B). In contrast to younger generations, older generations are more likely to “somewhat agree” with all statements relating to thermal comfort, particularly in relation to falling asleep at night.

TABLE 16: THERMAL COMFORT NEEDS

Thermal comfort (n=609)	Mean	Std. Deviation
I find I cannot relax or work well unless the house is air-conditioned in the warmer months.	3.83	1.799
I have trouble falling asleep at night without an air-conditioner on.	3.43	1.875
While others might turn off their air-conditioners in the cooler months, my own need for being cool is high.	3.48	1.754

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree.

TABLE 16B: THERMAL COMFORT NEEDS BY AGE GROUP

	Younger (18-55) (n=247)		Older (56 plus) (n=304)				
Thermal comfort	Mean	Std Dev	Mean	Std Dev	p	t	Cohen's d
I find I cannot relax or work well unless the house is air-conditioned in the warmer months.	4.22	1.690	3.53	1.836	.001	4.626	.393
I have trouble falling asleep at night without an air-conditioner on.	3.96	1.826	3.01	1.818	.001	6.035	.517
While others might turn off their air-conditioners in the cooler months, my own need for being cool is high.	3.96	1.709	3.11	1.721	.001	5.767	.494

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree.

3.5 The Solar Rebound

Do households feel that they use more electricity after installing rooftop solar?

The solar rebound effect can aggravate the problem of inefficient energy use. A direct rebound is explained by price effects, and it refers to the situation where an efficiency improvement in a resource leads to more consumption of that resource (Adua et al., 2021). For example, since solar households benefit from free electricity (at least when the sun is shining), they are likely to be less motivated than non-solar households to curtail their use of electricity. Furthermore, there may be an indirect rebound effect due to a psychological mechanism known as the 'moral licensing' effect, which means that past moral behavior makes people more likely to do potentially immoral things without feeling guilty, and moral licensing often lowers the gains of environmentally responsible behaviour (Merritt, Effron, & Monin, 2010).

Findings

Table 17 reports the results. Respondents perceive a weak rebound effect. For the direct rebound, the mean value ranges from 2.90 to 3.53, indicating that respondents "somewhat agree" with statements related to using more electricity after installing rooftop solar. In relation to the indirect rebound, most respondents select the "somewhat agree" and "neutral" response categories.

T-tests were conducted to determine differences in mean responses between groups. No significant differences were found between people who were living comfortably/very comfortably on current income and those who were finding it difficult, or just coping, on current income. Significant differences were found between the younger and the older generations. Table 17b reports the means, standard deviations, p values, the t-statistic and the effect size (Cohen's d). In contrast to younger generations, older generations scored lower (disagree or neutral) on all statements relating to the solar rebound effect.

TABLE 17: SOLAR REBOUND PERCEPTIONS

Direct rebound (n=303)	Mean	Std.Dev
With solar panels, I use more electricity than I did previously without the panels	2.90	1.50
With solar panels, I undertake more electricity-intensive activities than I did previously with the panels	3.18	1.51
Compared to before the solar panels were installed, I now turn on the air conditioners more often when I am warm.	3.53	1.79

Prior to the installation of solar panels, I turned on the fans when I was warm. Now, I turn on the air conditioner instead	3.49	1.74
Indirect rebound / moral licensing		
Because I save with solar panels, I may allow myself some other things.	3.94	1.58
I am already doing my part with the solar panels; therefore, it is not that important to restrict myself (more) in other areas	3.38	1.66
It does not matter how much energy you use if you have solar panels.	2.77	1.66

disagree, 5=somewhat agree, 6=agree, and 7=strongly agree.

TABLE 17B: SOLAR REBOUND PERCEPTIONS BY AGE GROUP

	Younger (18-55) (n=108)		Older (56 plus) (n=157)				
Rebound	Mean	Std Dev	Mean	Std Dev	p	t	Cohen's d
With solar panels, I use more electricity than I did previously without the panels	3.53	1.525	2.50	1.323	.001	5.666	.727
With solar panels, I undertake more electricity-intensive activities than I did previously with the panels	3.72	1.433	2.85	1.454	001	4.821	.601
Compared to before the solar panels were installed, I now turn on the air conditioners more often when I am warm.	4.12	1.610	3.08	1.741	001	5.015	.618
Prior to the installation of solar panels, I turned on the fans when I was warm. Now, I turn on the air conditioner instead	4.12	1.616	3.09	1.696	001	5.002	.620
Because I save with solar panels, I may allow myself some other things.	4.45	1.443	3.55	1.579	001	4.832	.594
I am already doing my part with the solar panels; therefore, it is not that important to restrict myself (more) in other areas	3.80	1.706	3.11	1.579	001	3.324	.422
It does not matter how much energy you use if you have solar panels.	3.48	1.721	2.35	1.476	001	5.566	.716

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree.

3.6 Engagement with Electricity-Saving and Interest in Energy-Efficient Appliances

To what extent do consumers engage in electricity-saving practices? Is electricity-saving a form of habitual behaviour? Do consumers have positive attitudes towards saving electricity? Are they interested in energy labels? Do they intend saving electricity in the future?

Examining electricity-saving practices by households is important for several reasons. Since 2010, rising demand for energy services in households – particularly for cooling, appliances and connected devices – has been outpacing energy efficiency and decarbonisation gains (IEA, 2021b). Addressing the behaviour of the household's occupant, promoting voluntary curtailment or sufficiency (reducing demand for energy services) is challenging (Sorrell, 2015), but it can bring major and lasting gains (Samadi et al., 2017; Millward-Hopkins, Steinberger, Rao, & Oswald, 2020). In order to save energy, people can invest in more efficient technologies (efficiency behaviour) and/or use the existing technologies less (curtailment behaviour) (Umit et al., 2019). Curtailment behaviours are generally habitual and need to be repeated continuously over time to achieve their optimal effect. Examples include adjusting the thermostat, using warm water economically and using a clothes' line rather than a dryer (Gardner & Stern, 2008). Habits are defined as a learned, automatic response that is maintained in certain situations (Wood et al., 2014).

This research explored electricity-saving behaviour in several ways. Firstly, consumers' attitudes towards electricity saving in the home were examined. Ajzen (1991, p. 188) defines attitude as "the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour in question". Scholars who apply the Theory of Planned Behaviour (Ajzen, 1985) report that favourable attitudes influence pro-environmental behaviour in general (Cook *et al.,* 2002). The theory of planned behaviour (TPB) (Ajzen, 1985) has a significant following in the social sciences and is one of the most influential theories used to understand human behaviour. Secondly, the propensity for an individual to perform electricity-related behaviours automatically, without awareness, was examined. Thirdly, intentions to save electricity in the future were surveyed. Finally, consumer interest in the purchase of appliances with the energy star label was explored. In Australia, the *Energy Rating Label* is part of the Australian Government's *Equipment Energy Efficiency* (E3) Program, where minimum energy performance standards (MEPS) have been set for appliances. The Energy Star label has been around for over 30 years and allows consumers to compare the energy efficiency and running costs of appliances (Energy Rating, 2020a) The international Energy Agency (IEA) sees gains in energy efficiency as a highly effective policy instrument, one that bring benefits to consumers as well as lower emissions and lower energy demand (IEA, 2021). For instance, dishwashers are 25% more efficient compared to those of 10 years ago (Energy Rating, 2020b). Efficiency-boosting actions are purchase-related and are taken only once or infrequently and have lasting effects.

Findings

The results show that people are motivated to save electricity, with most actions being performed “about half of the time” or “most of the time”, although unplugging devices when not in use received the lowest score (see Table 18).

Electricity use is not seen as a habitual form of behaviour, with most people reporting that they “somewhat disagree” or “neither agree nor disagree” with the statements related to using electricity without conscious thought (see Table 19).

Attitudes towards electricity-saving are mixed. Most people agree that saving electricity is a beneficial and a good thing to do. However most people do not view electricity-saving as enjoyable, with people reporting that they “somewhat disagreed” with the related statement. Statements about the importance and utility of saving electricity received a neutral score (see Table 20).

Table 21 shows that there is interest in buying energy-efficient appliances, with most respondents agreeing that they seek out the energy star label when buying appliances. Table 22 shows that most respondents agree that they have intentions to save electricity in the future. T tests reveal significant differences between younger and older generations, with older people scoring higher than younger generations (see Table 22b).

TABLE 18: ELECTRICITY SAVING PRACTICES

Electricity Saving Practices (n=609)	Mean	Std.Dev
Turn off lights when going out, even for a short time	4.19	1.11
Shorten the duration that the fridge door is kept open	3.84	1.24
Use the washing machine when I don’t have a full load of laundry (reverse coded)	3.81	1.29
Reduce the use of the air conditioner by opening the windows, using fans, etc.	3.79	1.19
Leave items plugged in even after I have finished charging (reverse coded)	3.76	1.20
Unplug, or switch off, the main power of an electrical device when not using it	3.09	1.42

Note: a 5-point scale was used, where 1=(Almost) Never, 2=Sometimes, 3=About half the time, 4=Most of the time, and 5=(Almost) Always. Two items were reverse coded.

TABLE 19: HABITUAL BEHAVIOUR

Habitual behaviour (n=609)	Mean	Std.Dev
In my daily actions, I use electricity without conscious thinking	3.77	1.82
In my everyday life, I do not give much thought to the way I use electricity.	3.51	1.76

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree

TABLE 20: ATTITUDES TOWARDS ELECTRICITY-SAVING

Attitudes towards electricity-saving (n=609)	Mean	Std.Dev
Saving electricity is (not) enjoyable*	3.20	1.58
Saving electricity is (not) important*	3.94	1.22
Saving electricity is (not) useless*	3.92	1.19
Saving electricity is beneficial	5.88	1.14
Saving electricity is good.	5.99	1.05

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree Certain items were reverse coded.

TABLE 21: INTEREST IN THE ENERGY STAR LABEL

Energy labels and purchase behaviour (n =609)	Mean	Std.Dev
The energy label is important in the decision to buy an appliance.	5.60	1.18
When I buy an appliance, I pay attention to the energy label.	5.71	1.21
I am more willing to buy an appliance with an efficient energy class.	5.77	1.18
I have purchased energy efficient electrical appliances in the past few years.	5.64	1.25

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree

TABLE 22: INTENTIONS TO CONSERVE ELECTRICITY

Intentions (n=607)	Mean	Std. Dev
I intend to conserve electricity in the future	5.63	1.12
I will conserve electricity in the future	5.67	1.10
I am ready to conserve electricity	5.67	1.09

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree

TABLE 22B: INTENTIONS TO CONSERVE ELECTRICITY BY AGE GROUPS

	Younger (n=247)		Older (n=304)				
Statement	Mean	Std Dev	Mean	Std Dev	p	t	Cohen's d
I intend to conserve electricity in the future	5.49	1.192	5.70	1.046	.027	-2.221	-.193
I will conserve electricity in the future	5.53	1.161	5.73	1.046	.030	-2.178	-.189

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree

3.7 Psychological factors influencing decision making

To what extent do psychological constructs such environmental self-identity, frugality and anticipated guilt characterise energy consumers? Is bill-consciousness characteristic of consumers?

Self-identity is generally interpreted "as the label that people use to describe themselves" (Cook *et al.,* 2002, p. 559). An environmental self-identity forms a robust and stable motivational basis for climate action (Bouman *et al.,* 2021). It is widely known that self-identity predicts pro-environmental behaviours (Whitmarsh & O'Neill, 2010).

Frugality is associated with sustainable consumption and has a significant, positive effect on the purchase intentions of electric vehicles (Chen *et al.,* 2019) and intentions to save energy (Chen *et al.,* 2017). Frugality reflects careful spending of money, and both restraint and discipline in acquisition (Lastovicka et al., 1999). Rooftop solar and battery storage buyers get the following benefits: (1) they enjoy subsidies from governments, which reduces the purchase cost of the system, and (2) they pay less for their electricity. Hence, adopters or potential adopters of solar and battery storage systems may be frugal by nature.

Studies show that emotions can trigger pro-environmental behaviour. Guilt is generally defined as an unpleasant emotional state that occurs when one's behaviour fails to follow personal or social standards (Lewis, 1993). Research finds that anticipated guilt is associated with low carbon consuming behaviour (Jiang et al., 2020) and has a direct influence on recycling, and furthermore, guilt appeals are seen as a relevant tactic in communications strategy to promote pro-environmental behaviour (Elgaaied, 2012).

Research has shown that bill consciousness positively predicts energy conservation intentions (Chen, Xu, & Day, 2017). Rising electricity prices have been a feature of the Australian marketplace (Orton & Nelson, 2015) and COVID-19 has resulted in higher bills and higher electricity use (ACCC, 2021). Electricity-saving behaviour is motivated by financial pressure (Sweeney et al., 2013). Therefore, it is important to assess the degree to which Australian consumers are bill conscious as it has an impact on energy-related decisions.

Findings

The results showed that the respondents did not have a strong environmental self-identity, with most respondents indicating that they "somewhat agreed" with the related statements (see Table 23). Table 24 shows that the mean values for frugality norms ranged from 4.6 to 5.4, indicating that most respondents "somewhat agreed" with related statements. Feelings of anticipated guilt over wasting electricity were not salient in this study. Survey respondents indicated that they "somewhat agreed" that they would feel guilty about not saving electricity (see Table 25). Bill consciousness is evident with people agreeing that they keep track of their electricity bills and feel motivated to keep electricity costs under a reasonable amount (see Table 26).

Older generations are more bill conscious than younger generations and score higher on intentions to save electricity. However they are mostly similar in terms of frugality norms, although older people are less likely to "resist buying things today so that they can save for tomorrow" (see Table 26B).

TABLE 23: ENVIRONMENTAL SELF-IDENTITY

Self-identity (n =609)	Mean	Std.Dev
I think of myself as someone who is concerned about environmental issues	5.19	1.45
I see myself as being an environmentally friendly consumer	5.13	1.42
I would be embarrassed not to be seen as having an environmentally friendly lifestyle	4.40	1.64
Buying energy efficient appliances makes me feel that I am an environmentally friendly consumer	5.20	1.39

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree.

TABLE 24: FRUGALITY NORMS

Frugality (n=607)	Mean	Std. Dev
I lead a simple and modest life although I could afford a higher standard of living	4.67	1.46
There are things I resist buying today so I can save for tomorrow	4.98	1.37
When shopping, I discipline myself to get the most from my money	5.43	1.23

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree.

TABLE 25: ANTICIPATED GUILT

Guilt (n=607)	Mean	Std. Dev
I would feel guilty if I did not save electricity on a daily basis	4.98	1.43
My conscious would bother me if I did not save electricity on a regular basis	4.72	1.51
I would have a bad conscience towards the environment if I did not save electricity on a daily basis	4.65	1.51

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree.

TABLE 26: BILL CONSCIOUSNESS

Bill consciousness (n=607)	Mean	Std. Dev
I pay attention to energy-saving tips to reduce my electricity bills	5.13	1.36
I keep track of my electricity bills	5.63	1.25
I am motivated to keep my electricity costs under a reasonable amount	5.60	1.21

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree

TABLE 26B COGNITIONS AND AGE GROUPS

	Younger (n=247)		Older (n=304)				
Statement	Mean	Std Dev	Mean	Std Dev	p	t	Cohen's d
Bill conscious							
I keep track of my electricity bills	5.41	1.291	5.79	1.217	.001	-3.462	-.298
Frugality							
There are things I resist buying today, so that I can save for tomorrow	5.19	1.257	4.77	1.432	.001	3.675	.311

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree

3.8 Perceived Behavioural Control

Do consumers feel capable of saving electricity in the home?

In the context of the theory of planned behaviour, Ajzen (1991, p. 188) describes perceived behavioural control as the individual's perceived ability or power to perform that certain behaviour in question, and whether performing the behaviour is seen as easy or difficult. Studies on energy consumption report that perceived behavioural control (or self-efficacy) is significantly and positively related to an individual's intention to save energy (Ru, Wang, & Tan, 2018). Feelings of competence in pursuing electricity-saving and having a sense that it is easy to perform that action (such as switching off appliances that are not being used) is likely to enhance electricity conservation.

Findings

Most consumers report a moderate sense of self-efficacy, and the mean response lies between "somewhat agree" and "agree" (see Table 27).

TABLE 27: PERCEIVED BEHAVIOURAL CONTROL

Perceived Behavioural Control (n =609)	Mean	Std. Dev
I believe that I am capable of saving electricity in my home	5.51	1.15
I have the knowledge and skills to save electricity in my home	5.47	1.10
If I wanted to, it would be easy for me to save electricity	5.29	1.20

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree

3.9 Subjective Norms

Do consumers feel that others would approve of their electricity saving efforts?

Based on the theory of planned behaviour, Ajzen (1991, p. 188) defines subjective norms as "the perceived social pressure to perform or not to perform the behaviour", showing that people's intentions are generally influenced by the societal norms or expectations. The extent to which an action is considered legitimate in society can encourage individuals to embrace the action. For instance, prior research shows that the acceptance of recycling significantly explains intentions to recycle (Ecjegarau & Hansstein, 2017). Social norms have been theorized as major forces to curbing undesirable behaviours and fostering responsible practices (Schultz et al., 2007). Furthermore, norm-based messaging is pertinent to residential energy usage, particularly for household that have high consumption levels (Andor, Gerster, Peters, & Schmidt, 2020). For example, marketing that appeals to social norms could highlight how a particular household's electricity consumption deviates from the average in the neighbourhood, or it could rely on testimonials or word-of-mouth from other energy consumers.

Findings

The findings suggest that social pressure is weak, with most respondents indicating that they "somewhat agree" with the statements related to social norms (see Table 28).

TABLE 28: SUBJECTIVE NORMS

Subjective norms (n =609)	Mean	Std. Dev
Most people who are important to me would be happy if I saved electricity.	5.16	1.26
People who are important to me think that I should save electricity	4.90	1.38

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree

3.10 Adopters of battery storage and rooftop solar versus non-adopters

Do households with battery storage and rooftop solar differ from non-adopters in terms of cognitions and behaviours? Do households with battery storage and rooftop solar differ from non-adopters in terms of socio-demographics?

Researchers tend to focus on the economic motivations for both rooftop solar and battery storage, highlighting price and acceptable pay-back periods (van Groenou, Lovell, & Franklin, 2018), as well as concern over rising electricity prices (Couture, Barbose, Jacobs, Parkingson, & Belden, 2014). Studies have found that potential adopters of storage are characterised by high electricity consumption and so may derive greater benefits than others from a battery system (Klingler, 2017). Scholars emphasise the role of financial constraints and the importance of feed-in tariffs in motivating uptake of battery storage (Best, Li, Truck, Trück,& Truong, 2021). Studies report that socio-demographics, notably high income and education, play a key role in the adoption of batteries (Grimm et al., 2018), and the desire for energy self-sufficiency and grid independence drives renewable energy decisions (Agnew & Dargusch, 2017). This study seeks to differentiate between adopters and non-adopters of renewable energy by using demographic and cognitive variables.

Findings

T-tests were performed to compare two groups, the battery storage and non-storage households. The results showed that there were significant differences in cognitions between the two groups. Table 29 reports the means, standard deviations, p values, the t-statistic and the effect size (Cohen's d).

Compared to non-storage households, battery storage respondents show stronger agreement with the statement that "saving electricity is enjoyable". In terms of environmental self-identity, battery storage households show a higher level of agreement with the statement that they would be "embarrassed not to be seen as having an environmentally friendly lifestyle". Battery storage households show a slighly higher level of agreement with the statement about leading "a simple and modest life". Battery storage households have a higher perceived need for thermal comfort. Battery storage households differ significantly from non-storage households in terms of automatic load-shifting behaviour.

TABLE 29: BATTERY STORAGE AND NON-STORAGE HOUSEHOLDS, COGNITIONS AND BEHAVIOURS

	Battery Storage (n= 52)		Non-Battery Storage (n=557)				
Statement	Mean	Std Dev	Mean	Std Dev	p	t	Cohen's d
Attitudes							
Saving electricity is enjoyable (reverse coded)	3.79	1.882	3.14	1.543	.019	2.410	.412
Self-identity							
I would be embarrassed not to be seen as having an environmentally friendly lifestyle	4.88	1.555	4.36	1640.	.026	2.227	.104
Thermal comfort							
I find I cannot relax or work well unless the house is air-conditioned (in the Summer)	4.38	1.611	3.78	1.808	.013	2.556	.633
I have trouble falling asleep at night without an air conditioner on (in the Summer)	4.31	1.687	3.34	1.872	.001	3.577	.519
While others might turn off their air conditioners, my own need for comfort is high	4.48	1.639	3.39	1.736	.001	4.369	.633
Frugality norms							
I lead a simple and modest life although I could afford a higher standard of living	5.15	1.304	4.62	1.462	.012	2.525	.366
Load-shifting (automatic)							
I use a time or delayed start function to operate appliances	2.72	1.512	1.58	1.440	.001	5.082	.785
I use remote-controlled devices to operate appliances	3.12	1.493	1.51	1.358	.001	7.545	1.166

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree

The estimated electricity bill of solar, non-solar and battery storage households was compared (see Table 30). Not surprisingly, solar and battery storage households were paying much less than the non-solar households. Nearly half of all solar households(47.2%) were paying less that $200 and close to a third of battery storage homes (30.8%) were paying less than $200.

Chi-square analysis was performed on socio-demographics (categorical data), rooftop solar adoption, and battery storage (binary coded). For ease of analysis, the response categories were recoded. The results show that respondents with battery storage differ significantly to those who do not have storage (see Table 31).

Not surprisingly, households with rooftop solar are more likely to have battery storage (χ^2 [1, 609] = 47.589, $p < .001$, Cramer's v = .280.). In the table, the value of 1 represents solar households and the value of 2 denotes non-solar.

In terms of socio-demographics, the age variable was collapsed into three main categories, young (1) aged 18-36, middle-aged (2) aged 36-55, and older (3) aged 56 plus. There is an association between age and battery storage (χ2 [2, 609] = 45.073, $p < .001$, Cramer's v = .272.), with younger age groups more likely to have battery storage.

There is a significant association between employment and battery storage. The employment variable was collapsed into four main categories, student (0); employed and self-employed (1); unemployed (2); and retired or looking after home or family (3). There is an association between employment status and battery storage (χ2 [3, 609] = 36.475, $p < .001$, Cramer's v = .245.), with employed persons being more likely to have battery storage.

Education is assocated with battery storage. This variable was collapsed into three main categories, primary or high school certificate (1); trade and diploma (2), degree or post-graduate degree (3). There is an association between high levels of education and battery storage (χ^2 [2, 609] = 11.290, $p < .004$, Cramer's v = .136).

Income was recategorised into three groups, difficult or very difficult to live on current income (1), coping (2) or living comfortably or very comfortably (3). There is an association between subjective income status and battery storage (χ^2 [2, 609] = 9.511, $p < .009$, Cramer's v = .125), with the comfortable respondents being more likely to have battery storage.

Income was recategoried into four groups, less than $30,000 (0), $30,000 to $64,000 (1), $65,000 to $99,999 (2) and above $100,000 (3). There is an association between objective income status and battery storage (χ^2 [3, 570] = 18.783, $p < .001$, Cramer's v = .182), with higher income respondents, those earning above $100,000, being more likely to have battery storage.

Household size was recoded into four groups, single-person (1), two-person (2), three person (3) and 4 persons and more (4). There is an association between household size and battery storage (χ^2 [3, 609] = 17.606, $p < .001$, Cramer's v = .170), with larger households, those with 4 persons or more, being more likely to have battery storage.

TABLE 30: ESTIMATED ELECTRICITY BILL

	Solar (n=307)	Non-Solar (n=302)	Battery Storage (n=52)
Estimated electricity bill	Percent	Percent	Percent
Under $200	47.2	13.9	30.8
Over $200	52.8	86.1	69.2

TABLE 31: BATTERY STORAGE AND SOCIO DEMOGRAPHICS

Category	**Storage – Yes**				**Storage – No**				**P value**
	0	**1**	**2**	**3**	**0**	**1**	**2**	**3**	
Rooftop solar		96.2	3.8			46.1	53.9		.001
Age		38.5	48.1	13.5		14.5	24.6	60.9	.001
Employment	3.8	80.8	1.9	13.5	0.4	44.5	5	50.1	.001
Education		19.2	23.1	57.7		31.2	34.5	34.3	.004
Income - subjective		19.2	21.2	59.5		15.6	42.9	41.5	.009
Income - objective	6	22	14	58	15.4	31.7	24.2	28.7	.001
Household size	19.2	21.2	28.8	30.8	16.7	49.7	17.4	16.2	.001

Note: 0 cells have expected count less than 5.

Solar households are very similar to non-solar households in terms of cognitions (i.e., environmental self-identity, frugality norms, thermal comfort needs, etc). However, t-tests reveal significant differences in relation to the grid independence motive, perceived behavioural control, electricity-saving and acceptance of battery storage (see Table 32). Solar respondents have a stronger desire to be independent from their energy provider, feel they have the knowledge and skills to save electricity in their home, and show greater acceptance of battery storage. They are less likely to save electricity by reducing the use of air conditioners. No significant differences in relation to socio-demographics were observed.

TABLE 32: SOLAR VERSUS NON-SOLAR HOUSEHOLDS - COGNITIONS

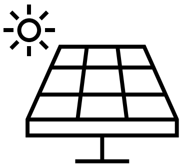
	Solar (n=307)		Non-Solar (n=302)				
Statement	Mean	Std Dev	Mean	Std Dev	p	t	Cohen's d
Motives							
I would like to be more independent from my energy provider	5.18	1.396	4.80	1.335	.001	3.261	.279
Perceived Behavioural Control							
I have the knowledge and skills to save electricity in my home	5.56	1.093	5.36	1.124	.036	2.103	.179
Electricity-Saving Practices							
Reduce the use of air conditioner, by opening the windows, using fans, etc.	3.68	1.214	3.90	1.162	.037	-2.091	-.179
Acceptance of battery storage							
I would like to use a PV battery storage system.	4.93	1.440	4.35	1.655	.001	4.412	.374
I consider PV battery storage systems to be sensible and sustainable.	5.16	1.378	4.38	1.708	.001	5.926	.501
I can imagine using a PV battery storage system.	4.78	1.418	4.42	1.563	.005	2.850	.242
Investing in a PV battery storage system has more advantages than disadvantages.	4.97	1.372	4.54	1.591	.001	3.386	.287
I can imagine investing (or have already invested) in a PV battery storage system.	4.74	1.473	4.27	1.647	.001	3.541	.301

Note: a 7-point scale was used, with 1=strongly disagree, 2=disagree, 3=somewhat agree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, and 7=strongly agree

4. Discussion and Recommendations

The focus of this report is on the purchase-related behaviours of consumers and their electricity-saving practices in the home. The following section discusses the main findings and presents the recommendations.

4.1 Rooftop solar adoption



Rooftop solar

The survey data shows that respondent's decision to install rooftop solar is motivated by both private and public benefits. The reasons for the adoption of rooftop solar include environmental values (lowering carbon footprint) and economic benefits (savings on bills, earning money from exporting to the grid, decreasing cost of solar systems). In addition, when a householder decides to install technologies such as rooftop solar, they must determine what size and type of system will meet their needs and to research products and installers. A high priority was given to product and service-related attributes, and this places high expectations on installers and operators with good track records will be rewarded as the expansion of rooftop solar continues at pace.

Recommendation: for solar retailers, the success of companies' marketing strategies will depend upon selling a high-quality product, offering a wide choice and gaining the trust of the consumer through offering a high level of service. Energy policy and marketing communications should emphasise the private and public benefits of installing rooftop solar.

4.2 Battery storage technology

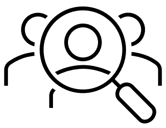
Battery storage

Battery storage was installed by a small percentage (16%) of the sample. However, one fifth of the solar household segment (22%) report that they are "definitely" likely to get batteries in the future. Grid independence does not appear to be a motive for installing batteries. Barriers to installing barriers are primarily economic, such as the cost, long payback periods and lack of government subsidies, and there are slight concerns about safety, technological change and the risk of not picking the best storage option. Research shows that the market has shifted towards lithium-ion technology and the reasons for the success of lithium-ion batteries include the decreasing specific system prices, higher energy efficiencies and longer lifetimes compared to those of lead-acid in cyclic applications, and prices have been falling rapidly (Figgener et al., 2020). Recent estimates are that 50% of generation, assisted by battery storage, may take place outside of the electricity grid by 2030 (Parkinson 2015). However, problems emerge when electricity self-sufficiency becomes a popular alternative and could give rise to the problem of the 'death spiral', where those remaining on the grid are required to pay the increasingly higher network charges.

Recommendations

Marketing communications could target current or potential battery storage homes and encourage them to remain on the grid, outlining the private and public benefits. Householders need reassurance that lithium-ion batteries are the safe and technologically advanced option.

4.3 Prosumers and business models



Prosumers

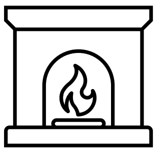
Although consumers are driving the clean energy transition through the adoption of rooftop solar, electricity networks and governments are grappling with issues of peak and minimum demand, voltage control, and other technical issues. Policy makers are interested in enhancing demand response, which in turn, can support the security and reliability of the grid, as it responds to the challenges of a high penetration of distributed energy resources (Finkel, 2017). Currently there are significant policy conversations about tariffs and smart meters. For instance, penalties could be applied to solar injections or exports during peak periods.

There is a dualism in the discourse of energy. One strand of thought tends to focus on delegating as many tasks as possible to the technology, thereby bypassing the user. A competing view focuses on active user participation and behavioural change (Skjolsvold et al., 2015). The emphasis is on the responsible individual, the prosumer, a person who is responsible for the supply of electricity, who is competent and disciplined, and who can monitor their behaviour, and make decisions about how much electricity to use and when to use it. However, this demands increased knowledge, time and emotional investment, and such resources are often unavailable (Haines and McConnell, 2016).

Several survey questions were designed to understand consumer attitudes towards the prosumer vision, such as trading and sharing electricity under new business models, load-shifting, smart meters and time-varying tariffs. The survey showed that respondents are “slightly likely” to install battery storage under a feed-in tariff regime. Business models such as leasing are popular with some segments. The survey responses show that consumers are willing to manually shift electricity use from the evening to the daytime when the sun is shining, and they do this “about half the time”. Time-varying tariffs can help prosumers determine whether they should inject or store their power, and whether they should increase or decrease their onsite load. Respondents “somewhat agree” that they want a time-varying tariff and a smart meter to easily monitor their electricity usage. Older generations are less likely to want a smart meter than younger generations. The findings suggest that the vision of the prosumer in policy documents is overly optimistic.

Recommendations: New business models such as leasing offer a pathway to increasing battery storage adoption. There is a small segment of solar homes that is willing to lease batteries and engage in energy sharing, which should reduce the spill of excess solar into the grid. Although some electricity users might become more active and engaged than they currently are, the view that passive electricity consumers can be transformed into active energy system participants is overly optimistic. Energy policy should accommodate prosumer householders who install rooftop solar and battery storage to benefit themselves.

4.4 Thermal comfort



Thermal comfort

The results show that consumers do not perceive a high need for thermal comfort, with most respondents indicating that they “somewhat agree” or “neither agree nor disagree” with the statements capturing high thermal comfort needs. There are significant differences between younger and older generations, and older generations are more inclined to “somewhat agree” with statements related to thermal comfort, such as having trouble falling asleep at night without an air conditioner.

Given that climate change will lead to increasing summer temperatures and extreme weather, the use of air conditioning is likely to rise, along with energy costs (International Energy Agency, 2021b). Making people’s homes comfortable with new energy technologies, while lowering their energy bills, will continue to be important. There are many strategies for comfortable living at higher (or lower) room temperatures. To add to traditional methods such as the use of air conditioners, fans and light clothing, there are now innovative appliances to fend off the heat. Personal cooling devices (i.e. misting fans, neck cooling fans) have become popular, which cool the person rather than the ambient air and are more efficient that cooling rooms or the entire house.

Recommendations: helping householders, particularly older age groups, maintain thermal comfort is important and new energy technologies have a role to play in meeting people's need for personal comfort.

4.5 The solar rebound effect

Solar Rebound

As the transition to clean energy unfolds, there is concern that the adoption of rooftop solar could mean a solar rebound effect. Respondents perceive a weak rebound effect and respondents "somewhat agree" with statements related to using more electricity after installing rooftop solar. In relation to the indirect rebound, most respondents select "somewhat agree" or "neutral" and the moral licensing effect appears to be muted. There are significant differences between younger and older generations, and older generations are less likely to report that they succumb to the solar rebound effect. Prior research has found that energy consumption by older generations is more restrained when compared to younger generations. For example, a recent study reported that as the ratio of people aged 60 or over within a city rises by 1%, the urban household average energy consumption decreases by 61 kilowatt hours (Bakó, et al., 2021).

Recommendations: marketing communications that are designed to curb the solar rebound could target younger generations, those aged 18 to 55, and remind energy consumers that restraint in electricity consumption during peak periods is needed and this action helps cut electricity bills.

4.6 Engagement in electricity saving and purchase of energy efficient (energy star) appliances

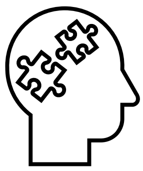
Energy label and electricity saving

A good deal of behaviour in the home depends on electricity, such as heating, cooling, lighting, cooking, working and relaxing. Generally, these behaviours are simple and are conducted routinely or repetitively (e.g. turning off the lights when leaving a room). However, the survey showed that respondents do not view electricity saving as habitual. The results show that people are motivated to save electricity, even though electricity saving is not viewed as enjoyable. Most actions are performed "about half of the time" or "most of the time", although unplugging devices when not in use received the lowest score. Research shows that technology, such as smart plugs, can be effective in encouraging behavioural change (Oh, 2020). Most respondents agree that they have intentions to save electricity in the future. Given the forecasted rise in residential electricity consumption in Australia from 204.2 in 2020 to 297.5 in 2040 (Energy Rating, 2021), prudent use of electricity is warranted.

This study found that the energy star label is used for evaluating products and moderately influences the purchase decision. This result is promising since energy efficiency is a key strategy to achieving climate goals, and helps households save money on electricity bills.

Recommendations: marketing communications should emphasise the need to unplug devices when not in use. Subsidies for the use of smart plugs may be warranted. Since the energy star label guides decision making, marketing communications should remind energy consumers to seek out the energy label and buy the highly efficient appliances.

4.7 Psychological factors influencing decision making



Psychological factors

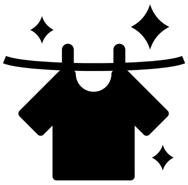
The survey results show that, on average, respondents do not have a strong environmental self-identity and do not have strong frugality norms. Feelings of anticipated guilt over wasting electricity are not salient in this study.

Bill consciousness is evident with people agreeing that they keep track of their electricity bills and feel motivated to keep electricity costs under a reasonable amount. Older generations are more likely to keep track of their bills than younger generations.

As the transition to clean energy unfolds, there is concern that the decarbonisation of the electricity sector will mean higher prices. While the introduction of low-cost renewable supply over the last decade has moderated wholesale and retail electricity prices, electricity pricing is complex; low wholesale prices encourage the early exit of aging coal plants, which needs to be managed to avoid price shocks (Chandrashekeran et al., 2022). Market authorities in Australia are, however, forecasting a decline in wholesale prices, as well as prices for a typical customer over the next three years (Australian Energy Market Commission 2021).

Recommendations: Marketing campaigns that appeal to the bill conscious consumers, particularly older generations, should be effective. Money-saving appeals may encourage both efficiency (purchase-related) and curtailment behaviour. It is recommended that retailers continue to provide information and feedback on energy consumption, for example reference prices on bills, energy-saving tips and information on how installing renewable energy technology can lead to bill reductions.

4.8 Perceived behavioural control

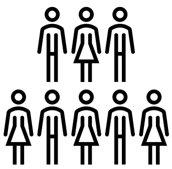


Perceived behavioural control

Perceived behavioural control is a key factor in the theory of planned behaviour and it is theorized that having a sense of control over electricity-saving helps drive more responsible use of electricity. The survey results are aligned with this theory and most respondents perceive that they have a moderate sense of self-efficacy.

Recommendation: Behavioural modification campaigns based on the re-enforcement of existing attitudes and the affirmation of a sense of self-efficacy should be effective.

4.9 Subjective norms



Subjective norms

Although the theory of planned behaviour posits that social norms help foster responsible practices, this study suggest that social pressure is weak, with most respondents indicating that they “somewhat agree” with the statements related to social norms. This may be due to the private or ‘invisible’ nature of electricity consumption.

Recommendation: social marketing communications that seek to appeal to social norms may not be effective in bringing about behavioural change and use of other appeals may be warranted.

4.10 Adopters of battery storage and rooftop solar versus non-adopters

Adopters versus non-adopters

Comparison of battery storage and non-storage households show that battery storage is a technology for the middle class; adopters are employed, well-educated, live within comfortable means and can afford to buy high-priced energy technologies. Battery storage households differ from non-storage households in terms of cognitions; respondents believe that saving electricity is enjoyable and they differ in their responses to statements related to frugality, thermal comfort and environmental self-identity. Given that battery storage adoption is not economical at present, non-economic factors appear to explain adoption.

Although battery storage households save money on their electricity bills, they are far from being self-sufficient. Their reliance on grid-supplied electricity could be explained by household size (which is larger than non-storage households) or perhaps by the size of the battery installed (not addressed in the survey). It has been observed that winters create a renewable energy deficit, which is covered mostly by grid imported electricity. Overall, it is difficult to generalize about why battery storage homes incur high bills. The literature shows that the size of a customer's bill will vary markedly, depending on the multiple factors, such as the size of the dwelling, household size, age of the appliances, and heating or cooling mode (Đurišić et al., 2020). Furthermore, network charges are an important component of retail electricity prices, representing about 45% of the overall Australian bill (Chandrashekeran et al., 2022).

Solar households are very similar to non-solar households. However, solar respondents have a stronger desire to be independent from their energy provider, feel they have the knowledge and skills to save electricity in their home, and show greater acceptance of battery storage. They are less likely to save electricity by reducing the use of air conditioners. No significant differences in relation to socio-demographics were observed.

Recommendations

For state governments that wish to accelerate the uptake of solar coupled with battery storage, initiatives could be developed to address financial barriers. These may include, for example, interest-free loans, tax deductions, subsidies and grants. On the grounds of energy justice, such incentives could be targeted at low-income households. For solar retailers, marketing campaigns that seek to promote rooftop solar should target homeowners and appeal to the independence motive. Rooftop solar could be positioned as way of reducing motivational conflict, such as the desire to use the air-conditioner and save electricity at the same time. Battery storage campaigns should be targeted at higher socio-economic groups, and advertising appeals should reflect self-interest (thermal comfort) and self-identity (the environmentally conscious and frugal person).

List of References

Abreu, J., Wingartz, N., & Hardy, N. (2019). New trends in solar: A comparative study assessing the attitudes towards the adoption of rooftop PV. *Energy Policy*, *128*, 347-363.

Adua, L., Zhang, K. X., & Clark, B. (2021). Seeking a handle on climate change: Examining the comparative effectiveness of energy efficiency improvement and renewable energy production in the United States. *Global Environmental Change*, *70*, 102351.

AECOM (2015). *Energy Storage Study*. https://arena.gov.au/knowledge-bank/energy-storage-study/

AER (2021) *State of the energy market 2021*. https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2021

AER (2022). *Smart Meters.* https://www.aer.gov.au/consumers/my-energy-service/smart-meters

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

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In *Action control* (pp. 11-39). Springer, Berlin, Heidelberg.

Ajzen, I. (1991). The theory of planned behavior. *Organisational Behavior Human Decision Process*, *50*, 179–211.

Alipour, M., Irannezhad, E., Stewart, R. A., & Sahin, O. (2022). Exploring residential solar PV and battery energy storage adoption motivations and barriers in a mature PV market. *Renewable Energy*, *190*, 684-698.

Andor, M. A., Gerster, A., Peters, J., & Schmidt, C. M. (2020). Social norms and energy conservation beyond the US. *Journal of Environmental Economics and Management*, *103*, 102351.

Australian Consumer and Competition Council (ACCC) (2021) *Inquiry into the National Electricity Market – May 2021 Report.* https://www.accc.gov.au/publications/serial-publications/inquiry-into-the-national-electricity-market-2018-2025/inquiry-into-the-national-electricity-market-may-2021-report

Australian Energy Market Commission (2021): Residential Electricity Price Trends 2021, Final Report, 2021. Online available at https://www.aemc.gov.au/sites/default/files/2021-11/2021_residential_electricity_price_trends_report.pdf

Australian Renewable Energy Agency (ARENA) (2018). *What are distributed energy resources and how do they work?* https://arena.gov.au/blog/what-are-distributed-energy-resources/

Australian Renewable Energy Agency (ARENA) (2022). *What are batteries?* https://arena.gov.au/renewable-energy/battery-storage/

Australian Government Department of Industry, Science, Energy and Resources. (2022). *Climate Change.* Department of Climate Change and Energy Efficiency. https://www.climatechange.gov.au

Bakó, F., Berkes, J., & Szigeti, C. (2021). Households' Electricity Consumption in Hungarian Urban Areas. *Energies*, *14*(10), 2899.

Best, R., Burke, P. J., & Nishitateno, S. (2019). Evaluating the effectiveness of Australia's Small-scale Renewable Energy Scheme for rooftop solar. *Energy Economics*, *84*, 104475.

Best, R., Li, H., Trück, S., & Truong, C. (2021). Actual uptake of home batteries: The key roles of capital and policy. *Energy Policy*, *151*, 112186.

Bouman, T., van der Werff, E., Perlaviciute, G., & Steg, L. (2021). Environmental values and identities at the personal and group level. *Current Opinion in Behavioral Sciences*, *42*, 47-53.

Chandrashekeran, S., Cludius, J. McConnell, D., Noka, V., and Ritter, D. (2022). *Energy Affordability: Sharing Lessons from the EU and Australia's Low Carbon Transitions*. Climate College, University of Melbourne https://www.climatecollege.unimelb.edu.au/

Chapman, A. J., McLellan, B., & Tezuka, T. (2016). Residential solar PV policy: An analysis of impacts, successes and failures in the Australian case. *Renewable Energy*, *86*, 1265-1279.

Chen, C. F., Xu, X., & Day, J. K. (2017). Thermal comfort or money saving? Exploring intentions to conserve energy among low-income households in the United States. *Energy Research & Social Science*, *26*, 61–71.

Chen, K., Ren, C., Gu, R., & Zhang, P. (2019). Exploring purchase intentions of new energy vehicles: From the perspective of frugality and the concept of 'mianzi.' *Journal of Cleaner Production*, *230*, 700–708.

Cook, A. J., Kerr, G. N., & Moore, K. (2002). Attitudes and intentions towards purchasing GM food. *Journal of Economic Psychology*, *23*(5), 557-572.

Couture, T., Barbose, G., Jacobs, D., Parkinson, G., Chessin, E., Belden, A., & Rickerson, W. (2014). *Residential prosumers: drivers and policy options (re-prosumers)* (No. LBNL-6661E). Meister Consultants Group; Lawrence Berkeley National Lab.(LBNL), Berkeley, CA (United States).

CSIRO (2013). *Change and Choice. The Future Grid Forum's Analysis of Australia's Potential Electricity Pathways to 2050.* https://publications.csiro.au/rpr/download?pid=csiro:EP1312486&dsid=DS13

Djongyang, N., Tchinda, R., & Njomo, D. (2010). Thermal comfort: A review paper. *Renewable and Sustainable Energy Reviews*, *14*(9), 2626–2640.

Echegaray, F., & Hansstein, F. V. (2017). Assessing the intention-behavior gap in electronic waste recycling: the case of Brazil. *Journal of Cleaner Production*, *142*, 180–190.

Elgaaied, L. (2012). Exploring the role of anticipated guilt on pro-environmental behavior–a suggested typology of residents in France based on their recycling patterns. *Journal of Consumer Marketing*, 29/5, 369-377.

Energy Rating (2020a) *The energy rating label.* https://www.energyrating.gov.au/label

Energy Rating (2020b) *About the e3 program*. https://www.energyrating.gov.au/about-e3-program

Energy Rating (2021). *2021 Residential Energy Baseline Study: Australia and New Zealand,* 18 May 2022 https://www.energyrating.gov.au/news/2021-residential-energy-baseline-study-australia-and-new-zealand

Esplin, R., & Nelson, T. (2022). Redirecting solar feed in tariffs to residential battery storage: Would it be worth it? *Economic Analysis and Policy*, *73*, 373-389.

Đurišić, V., Rogić, S., Smolović, J. C., & Radonjić, M. (2020). Determinants of household electrical energy consumption: Evidences and suggestions with application to Montenegro. *Energy Reports*, *6*, 209-217.

Figgener, J., Stenzel, P., Kairies, K. P., Linßen, J., Haberschusz, D., Wessels, O., ... & Sauer, D. U. (2020). The development of stationary battery storage systems in Germany–A market review. *Journal of energy storage*, *29*, 101153.

Finkel, A. (2017). *Independent Review into the Future Security of the National Electricity Grid: Blueprint for the Future*, June 2017, Commonwealth of Australia https://www.energy.gov.au/sites/default/files/independent-review-future-nem-blueprint-for-the-future-2017.pdf

Fu, W., Zhou, Y., Li, L., & Yang, R. (2021). Understanding household electricity-saving behavior: Exploring the effects of perception and cognition factors. *Sustainable Production and Consumption*, *28*, 116–128.

Gardner, G. T., & Stern, P. C. (2008). The short list: The most effective actions US households can take to curb climate change. Environment: science and policy for sustainable. *Development*, *50*(5), 12–25.

Grimm, V., Kretschmer, S., & Mehl, S. (2018). Diffusion of green innovations: The role of consumer characteristics for domestic energy storage adoption. *Available at SSRN 3122235*.

Haines, F., & McConnell, D. (2016). Environmental norms and electricity supply: an analysis of normative change and household solar PV in Australia. *Environmental Sociology*, *2*(2), 155-165.

Huebner, G., Cooper, J., & Jones, K. (2013). Domestic energy consumption – what role do comfort, habit and knowledge about the heating system play? *Energy and Buildings*, *66*, 626–636.

International Energy Agency (IEA) (2021a) *Net zero by 2050: A Roadmap for the Global Energy Sector.* https://www.iea.org/topics/net-zero-emissions

International Energy Agency (IEA) (2021b) *Tracking Buildings 2021.* https://www.iea.org/reports/tracking-buildings-2021

Jiang, X., Ding, Z., Li, X., Sun, J., Jiang, Y., Liu, R., ... & Sun, W. (2020). How cultural values and anticipated guilt matter in Chinese residents' intention of low carbon consuming behavior. *Journal of Cleaner Production*, *246*, 119069.

Judge, M., Warren-Myers, G., & Paladino, A. (2019). Using the theory of planned behaviour to predict intentions to purchase sustainable housing. *Journal of Cleaner Production*, *215*, 259–267.

Kallies A., Chandrashekeran S., Keele S. and Godden L. (2019) *The Smart Meter Promise: A Review of Smart Meter Deployment Challenges in Australia and Germany,* Report for the Australian-German Energy Transition Hub, University of Melbourne: Victoria.https://www.energy-transition-hub.org/resource/smart-meter-promise-review-smart-meter-deployment-challenges-australia-and-germany

Karjalainen, S. (2007). Gender differences in thermal comfort and use of thermostats in everyday thermal environments. *Building and environment*, *42*(4), 1594-1603.

Klingler, A. L. (2017). Self-consumption with PV+ Battery systems: A market diffusion model considering individual consumer behaviour and preferences. *Applied Energy*, *205*, 1560-1570.

Lastovicka, J. L., Bettencourt, L. A., Hughner, R. S., & Kuntze, R. J. (1999). Lifestyle of the tight and frugal: Theory and measurement. *Journal of consumer research*, *26*(1), 85-98.

Lewis, M. (2008). Self-conscious emotions: Embarrassment, pride, shame, and guilt. In M. Lewis, J. M. Haviland-Jones, & L. F. Barrett (Eds.), *Handbook of emotions* (pp. 742–756). The Guilford Press.

Li, H.X., Edwards, D.J., Hosseini, M.R., Costin, G.P., (2020). A review on renewable energy transition in Australia: An updated depiction. *Journal of Cleaner Production* 242, 118475.

Ludlow, M. (June 3, 2022). *Perfect storm: How Australia's energy crisis ignited.* Australian Financial Review (AFR). https://www.afr.com/companies/energy/perfect-storm-inside-australia-s-energy-crisis-20220602-p5aqk2

Merritt, A. C., Effron, D. A., & Monin, B. (2010). Moral self-licensing: When being good frees us to be bad. *Social and Personality Psychology Compass*, *4*(5), 344–357.

Millward-Hopkins, J., Steinberger, J. K., Rao, N. D., & Oswald, Y. (2020). Providing decent living with minimum energy: A global scenario. *Global Environmental Change*, *65*, 102168.

Neves, C., & Oliveira, T. (2021). Drivers of consumers' change to an energy-efficient heating appliance (EEHA) in households: Evidence from five European countries. *Applied Energy*, *298*, 117165.

Nykvist, B., & Nilsson, M. (2015). Rapidly falling costs of battery packs for electric vehicles. *Nature climate change*, *5*(4), 329-332.

Oh, J. (2020). IoT-based smart plug for residential energy conservation: An empirical study based on 15 months' monitoring. *Energies*, *13*(15), 4035.

Orton, F., & Nelson, T. (2015). Relief in sight: Why residential electricity costs in Eastern Australia may fall between 2015 and 2020. *Economic Analysis and Policy*, *48*, 57–70.

Parag, Y., & Sovacool, B. K. (2016). Electricity market design for the prosumer era. *Nature Energy*, *1*(4), 1-6.

Queensland Competition Authority (2013). *Final Report. Estimating a Fair and Reasonable Solar Feed-in Tariff for Queensland.* https://www.qca.org.au/wp-content/uploads/2019/05/31514_ER-QCA-FinalReport ReviewofSolarFeedinTariffQLD-0313-3.pdf

Queensland Government (2022). *Energy.* https://www.des.qld.gov.au/climateaction/sector-action/energy#:~:text=The%20Queensland%20Government's%20commitment%20to,support%20our%20emissions%20reduction%20targets.

Rai, A. (2020). *Network tariffs in an increasingly distributed, decentralized, and decarbonized power system.* IAEE Energy Forum/Third Quarter. file:///C:/Users/jc203156/Downloads/203rai.pdf

Ren, Z., & Chen, D. (2018). Modelling study of the impact of thermal comfort criteria on housing energy use in Australia. *Applied Energy*, *210*, 152–166.

Ru, X., Wang, S., & Yan, S. (2018). Exploring the effects of normative factors and perceived behavioral control on individual's energy-saving intention: An empirical study in eastern China. *Resources, Conservation and Recycling, 134*, 91–99.

Samadi, S., Gröne, M. C., Schneidewind, U., Luhmann, H. J., Venjakob, J., & Best, B. (2017). Sufficiency in energy scenario studies: Taking the potential benefits of lifestyle changes into account. *Technological Forecasting and Social Change*, *124*, 126–134.

Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2007). The constructive, destructive, and reconstructive power of social norms. *Psychological Science*, *18*, 429–434.

Seebauer, S. (2018). The psychology of rebound effects: Explaining energy efficiency rebound behaviours with electric vehicles and building insulation in Austria. *Energy Research & Social Science*, *46*, 311–320. https://doi.org/10.1016/j.erss.2018.08.006

Simshauser, P. (2016). Distribution network prices and solar PV: Resolving rate instability and wealth transfers through demand tariffs. *Energy Economics*, *54*, 108-122.

Skjølsvold, T. M., & Lindkvist, C. (2015). Ambivalence, designing users and user imaginaries in the European smart grid: insights from an interdisciplinary demonstration project. *Energy research & social science*, *9*, 43-50.

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*, *67*, 315–323.

Sorrell, S. (2015). Reducing energy demand: A review of issues, challenges and approaches. *Renewable and Sustainable Energy Reviews*, *47*, 74-82.

Stephenson, J., Barton, B., Carrington, G., Doering, A., Ford, R., Hopkins, D., ... & Wooliscroft, B. (2015). The energy cultures framework: Exploring the role of norms, practices and material culture in shaping energy behaviour in New Zealand. *Energy Research & Social Science*, *7*, 117-123

Sweeney, J. C., Kresling, J., Webb, D., Soutar, G. N., & Mazzarol, T. (2013). Energy saving behaviours: Development of a practice-based model. *Energy Policy*, *61*, 371–381.

Umit, R., Poortinga, W., Jokinen, P., & Pohjolainen, P. (2019). The role of income in energy efficiency and curtailment behaviours: Findings from 22 European countries. *Energy Research & Social Science*, *53*, 206–214.

van Groenou, A. B., Lovell, H., & Franklin, E. (2018, December). *Household Decision-Making for Home Batteries.* Asia Pacific Solar Research Conference, 4-6 December 2018, Sydney, Australia.

Victoria, M., Haegel, N., Peters, I. M., Sinton, R., Jäger-Waldau, A., del Cañizo, C., ... & Smets, A. (2021). Solar photovoltaics is ready to power a sustainable future. *Joule*, *5*(5), 1041-1056.

Vorath, S (2016). *Bitcoin-inspired peer-to-peer solar trading trial kicks off in Perth.* http://reneweconomy.com.au/bitcoin-inspired-peer-to-peer-solar-trading-trial-kicks-off-in-perth-29362

Wang, B., Wang, X., Guo, D., Zhang, B., & Wang, Z. (2018). Analysis of factors influencing residents' habitual energy-saving behaviour based on NAM and TPB models: Egoism or altruism? *Energy Policy*, *116*, 68–77.

Whitmarsh, L., & O'Neill, S. (2010). Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours. *Journal of environmental psychology*, *30*(3), 305-314.

Wittenberg, I., & Matthies, E. (2016). Solar policy and practice in Germany: How do residential households with solar panels use electricity?. *Energy Research & Social Science*, 21, 199-211.

Wittenberg, I., Blöbaum, A., & Matthies, E. (2018). Environmental motivations for energy use in PV households: Proposal of a modified norm activation model for the specific context of PV households. *Journal of Environmental Psychology*, *55*, 110-120.

Wood, W., Labrecque, J. S., Lin, P. Y., & Rünger, D. (2014). Habits in dual process models. *Dual process theories of the social mind,* 371-385.

Yang, L., Yan, H., & Lam, J. C. (2014). Thermal comfort and building energy consumption implications–a review. *Applied Energy*, *115*, 164–173.

Appendix A Profile of Households (n= 609)

	Demographics	No.	Percent
Gender	Male	238	39.1
	Female	371	60.9
Age	18-25	30	4.9
	26-35	71	11.7
	36-45	82	13.5
	46-55	80	13.1
	56-65	114	18.7
	66-75	161	26.4
	76+ years	71	11.7
Employment	A student	4	.7
	Employed	252	41.4
	Self-employed	38	6.2
	Unemployed	29	4.8
	Looking after home or family	49	8.0
	Retired	237	38.9
Education	Primary school, or no formal qualification	34	5.6
	High school certificate	150	24.6
	Trade or vocational qualification	105	17.2
	Diploma or advanced diploma	99	16.3
	Undergraduate degree (Bachelor's)	166	27.3
	Postgraduate degree (Masters, PhD)	55	9.0
Income (subjective)	Finding it very difficult to live on current income	29	4.8
	Finding it difficult to live on current income	68	11.2
	Coping on current income	250	41.1
	Living comfortably on current income	206	33.8
	Living very comfortably on current income	56	9.2
Income (objective)	Less than $30,000	83	13.6
	$30,000 to $64,999	176	28.9
	$65,000 to $99,999	133	21.8
	$100,000 to $149,000	94	15.4
	$150,000 to $199,000	50	8.2
	$200,000 to $249,000	22	3.6
	$250,000 to $299,999	7	1.1
	More than $300,000	5	.8
	Do not know/prefer not to say	39	6.4
Area	Regional Queensland	38	6.2
	South-East Queensland	124	20.4
	Other part of Queensland	447	73.4
Household size	1 person	103	16.9
	2 persons	288	47.3
	3 persons	112	18.4
	4 persons	70	11.5
	5 persons or more	36	5.9

Appendix B: Survey

The aim of this research is to gain an insight into the attitudes of homeowners towards rooftop solar photovoltaic (PV), battery storage and electricity usage in the home. This survey will take approximately 10 to 15 minutes to complete. Your responses will be anonymous. You are free to discontinue at any stage. However, if a person decides to withdraw from the study after having submitted the completed survey online, then the data cannot be deleted on request, as it is anonymous. The data from the study will be used in research publications and conference presentations.

The study is being conducted by Dr Breda McCarthy, Senior Lecturer in Marketing. The research has been approved by the James Cook University's ethics committee. If you have any concerns regarding the ethical conduct of the study, please contact: Human Ethics, Research Office James Cook University, Townsville, Qld, 4811 Phone: (07) 4781 5011 (ethics@jcu.edu.au). If you wish to be provided with information on the project's findings or outcomes, please contact the principal investigator by email. Email: breda.mccarthy@jcu.edu.au.

We are recruiting homeowners, people who own their own home (owned with a mortgage or owned outright). Are you a homeowner?

Yes ○ No ○

Before continuing, please give your informed consent. **I agree to participate in the survey:**

Yes ○ No ○

Q1 Please read the following statements and give us your answer. If you already have solar or energy storage, select 'not applicable'

	Definitely yes	Probably yes	Might or might not	Probably not	Definitely Not	Not applicable
I am likely to install rooftop solar (photovoltaic) at home in the future	⑤	④	③	②	①	⓪
I am likely to get a battery/energy storage system at home in the future.	⑤	④	③	②	①	⓪

Q2 Do you have rooftop solar at home?

Yes ○ No ○

Q3 What was the size of the solar system that was installed?

- ○ A small solar system (5 kW or under).
- ○ A medium solar system (6 to 9 kW).
- ○ A large solar system (10 kW or over).

Q4 When was the rooftop solar system installed?

- ◯ 2007 or before
- ◯ Between 2008 and 2012-13 (when a premium feed-in tariff of 44c was available)
- ◯ Between 2013 and 2014 (when a lower feed-in tariff was available)
- ◯ Between 2015 and 2019
- ◯ After 2020

Q5 We are interested in your attitudes towards electricity use after installing solar. Please indicate below how strongly you agree or disagree with the following statements

	Strongly agree	Agree	Somewhat Agree	Neither agree nor disagree	Somewhat Disagree	Disagree	Strongly disagree
With solar panels, I use more electricity than I did previously without the panels.	⑦	⑥	⑤	④	③	②	①
With solar panels, I undertake more electricity-intensive activities than I did previously with the panels.	⑦	⑥	⑤	④	③	②	①
Compared to before the solar panels were installed, I now turn on the air conditioners more often when I am warm	⑦	⑥	⑤	④	③	②	①
Prior to the installation of solar panels, I turned on the fans when I was warm. Now, I turn on the air conditioner instead.	⑦	⑥	⑤	④	③	②	①
Because I save with solar panels, I may allow myself some other things	⑦	⑥	⑤	④	③	②	①
I am already doing my part with the solar panels; therefore, it is not that important to restrict myself (more) in other areas.	⑦	⑥	⑤	④	③	②	①
It does not matter how much energy you use if you have solar panels	⑦	⑥	⑤	④	③	②	①

Q6 To what extent do you perform electricity-consuming activities to match electricity production from your rooftop solar system?

	(Almost) Always	Most of the time	About half of the time	Sometimes	(Almost) Never	Do not know/does not apply
I turn on appliances during the day when solar PV production is high.	⑤	④	③	②	①	⓪

I use a timer or delayed start function (if available) to operate appliances.	⑤	④	③	②	①	⓪
I use remote-controlled devices to operate appliances.	⑤	④	③	②	①	⓪

Q7 How important were the following factors in influencing the decision to install a solar system?

	Extremely important	Very Important	Moderately important	Slightly important	Not at all important
Concern about rising electricity prices.	⑤	④	③	②	①
Earn money from selling electricity back to the grid.	⑤	④	③	②	①
Increase the value of my home.	⑤	④	③	②	①
Use an innovative/high-tech system.	⑤	④	③	②	①
Save money (due to lower electricity bills).	⑤	④	③	②	①
Make the household more self-sufficient.	⑤	④	③	②	①
Reducing impact of the environment by using a renewable energy source.	⑤	④	③	②	①
Reliable installers / electricians.	⑤	④	③	②	①
Service warranty.	⑤	④	③	②	①
Wide choice of brands/suppliers to choose from.	⑤	④	③	②	①
High quality system	⑤	④	③	②	①
Knowing the equipment is recyclable	⑤	④	③	②	①
Decreasing cost of solar systems	⑤	④	③	②	①

Q8 To what extent do you accept battery storage systems?

	Strongly agree	Agree	Somewhat Agree	Neither agree nor disagree	Somewhat Disagree	Disagree	Strongly disagree
I can imagine using a PV battery storage system.	⑦	⑥	⑤	④	③	②	①
I would like to use a PV battery storage system.	⑦	⑥	⑤	④	③	②	①
Investing in a PV battery storage system has more advantages than disadvantages.	⑦	⑥	⑤	④	③	②	①
I consider PV battery storage systems to be sensible and sustainable.	⑦	⑥	⑤	④	③	②	①
I can imagine investing, or have already invested, in a PV battery storage system.	⑦	⑥	⑤	④	③	②	①

Q9 Do you have battery storage at home?

Yes ◯ No ◯

Q10 If you **do not** have battery storage, please indicate your opinion of the following potential barriers, or concerns, associated with installing batteries.

	Clearly describes my concerns	Mostly describes my concerns	Moderately describes my concerns	Slightly describes my concerns	Does not describe my concerns
I am not sure how much longer I will stay in this house.	⑤	④	③	②	①
I don't think the investment will pay off / payback period is too long	⑤	④	③	②	①
I/we are lacking the financial resources.	⑤	④	③	②	①
My/our house is already energy-optimised.	⑤	④	③	②	①
I am concerned about safety.	⑤	④	③	②	①
I am apprehensive of technological change and the risk of not picking the best storage option.	⑤	④	③	②	①
I am getting a premium feed-in tariff of 44c for my electricity and have no incentive to store it.	⑤	④	③	②	①
Adequate government subsidies are not available	⑤	④	③	②	①
Battery storage is not necessary	⑤	④	③	②	①

Q11 Please read the following. "*Batteries can be charged by solar panels on the roof. Since they store electricity, they make solar energy less dependent on the weather and could meet a home's daily energy needs. Surplus electricity could be sent to the national grid earning money for homeowners. A feed-in tariff is a credit people can receive when excess energy is sent back to the grid. Batteries also support the grid, making it more secure and reliable. A new policy incentive, a generous feed-in tariff rate, has been introduced to promote battery storage and reward people for sharing and trading electricity*". How likely would you be to install battery storage under this scenario?

	Extremely likely	Moderately likely	Slightly likely	Neither likely nor unlikely	Slightly likely	Moderately unlikely	Extremely unlikely
Likelihood	⑦	⑥	⑤	④	③	②	①

Q12 Please read the following future scenario: "*You are considering the purchase of a battery storage system. The batteries can be installed onto an existing rooftop solar system or with new rooftop solar systems*". Which option would you choose? Rank the product options in order of preference, from 1 (most preferred) to 3 (least preferred). If you would not choose any of these options, select 'none of the above' by typing in 0.

______ Owned outright. Purchase price $12,000. Government subsidy of up to $2,000. Option to export solar to the grid at times of high demand in return for a credit on the electricity bill.

______ Owned outright. Purchase price $8,000. No government subsidy. Limited option to export solar to the grid since the system is used for the home's energy needs only (i.e. evening time, when the sun is not shining).

______ Leased (five year contract). Discounted purchase price of $5,000. No government subsidy. Third party maintains the battery and exports solar to the grid at times of high demand in return for a credit on the electricity bill.

______ None of the above (0)

Q13 We are interested in your daily habits (related to electricity use). To what extent do you agree with the following statements?

	Strongly agree	Agree	Somewhat Agree	Neither agree nor disagree	Somewhat Disagree	Disagree	Strongly disagree
In my daily actions, I use electricity without conscious thinking.	⑦	⑥	⑤	④	③	②	①
In my everyday life, I do not give much thought to the way I use electricity	⑦	⑥	⑤	④	③	②	①

Q14 To what extent do you perform the following electricity-related practices?

	(Almost) Always	Most of the time	About half of the time	Some-times	(Almost) Never	Do not know/does not apply
Leave items plugged in even after they have finished charging.	⑤	④	③	②	①	⓪
Turn off the lights when going out even, for a short time.	⑤	④	③	②	①	⓪
Reduce the use of the air conditioner, by opening the windows, using fans, etc.	⑤	④	③	②	①	⓪
Unplug, or switch off, the main power of an electrical device when not using it.	⑤	④	③	②	①	⓪
Shorten the duration that the fridge door is kept open.	⑤	④	③	②	①	⓪
Use the washing machine when I don't have a full load of laundry.	⑤	④	③	②	①	⓪

Q15 To what extent do you feel you are able to save electricity? Please indicate your level of agreement or disagreement with the following statements.

	Strongly agree	Agree	Somewhat Agree	Neither agree nor disagree	Somewhat Disagree	Disagree	Strongly disagree
I believe that I am capable of saving electricity in my home.	⑦	⑥	⑤	④	③	②	①
I have the knowledge and skills to save electricity in my home.	⑦	⑥	⑤	④	③	②	①
If I wanted to, it would be easy for me to save electricity.	⑦	⑥	⑤	④	③	②	①

Q16 What are your attitudes towards saving electricity in the home?

	Strongly agree	Agree	Somewhat Agree	Neither agree nor disagree	Somewhat Disagree	Disagree	Strongly disagree
Saving electricity is not enjoyable.	⑦	⑥	⑤	④	③	②	①
Saving electricity is not important.	⑦	⑥	⑤	④	③	②	①
Saving electricity is useless.	⑦	⑥	⑤	④	③	②	①
Saving electricity is beneficial.	⑦	⑥	⑤	④	③	②	①
Saving electricity is good.	⑦	⑥	⑤	④	③	②	①

Q17 Please indicate your level of agreement or disagreement with the following statements.

	Strongly agree	Agree	Somewhat Agree	Neither agree nor disagree	Somewhat Disagree	Disagree	Strongly disagree
Most people who are important to me would be happy if I saved electricity.	⑦	⑥	⑤	④	③	②	①
People who are important to me think that I should save electricity.	⑦	⑥	⑤	④	③	②	①

Q18 Please read the following statements about energy labels and indicate your level of agreement or disagreement.

	Strongly agree	Agree	Somewhat Agree	Neither agree nor disagree	Somewhat Disagree	Disagree	Strongly disagree
The energy label is important in the decision to buy an appliance.	⑦	⑥	⑤	④	③	②	①
When I buy an appliance, I pay attention to the energy label.	⑦	⑥	⑤	④	③	②	①
I am more willing to buy an appliance with an efficient energy class.	⑦	⑥	⑤	④	③	②	①
I have purchased energy efficient electrical appliances in the past few years.	⑦	⑥	⑤	④	③	②	①

Q19 We would like to find out more about your level of environmental concern and how you see yourself.

	Strongly agree	Agree	Somewhat Agree	Neither agree nor disagree	Somewhat Disagree	Disagree	Strongly disagree
I think of myself as someone who is concerned about environmental issues.	⑦	⑥	⑤	④	③	②	①
I see myself as being an environmentally friendly consumer.	⑦	⑥	⑤	④	③	②	①
I would be embarrassed not to be seen as having an environmentally friendly lifestyle.	⑦	⑥	⑤	④	③	②	①
Buying energy efficient appliances makes me feel that I am an environmentally friendly consumer.	⑦	⑥	⑤	④	③	②	①

Q20 We are interested in your attitudes towards personal comfort and cooling your home. To what extent do you agree or disagree with the following statements

	Strongly agree	Agree	Somewhat Agree	Neither agree nor disagree	Somewhat Disagree	Disagree	Strongly disagree
I find I cannot relax or work well unless the house is air-conditioned (in the Summer).	⑦	⑥	⑤	④	③	②	①
I have trouble falling asleep at night without an air-conditioner on (in the Summer).	⑦	⑥	⑤	④	③	②	①
While others might turn off their air-conditioners, my own need for comfort is high.	⑦	⑥	⑤	④	③	②	①

Q21 We are interested in your general attitudes towards electricity. To what extent do you agree or disagree with the following statements?

	Strongly agree	Agree	Somewhat Agree	Neither agree nor disagree	Somewhat Disagree	Disagree	Strongly disagree
I would like to be more independent from my energy provider.	⑦	⑥	⑤	④	③	②	①
I want to have a smart meter. Then I could easily monitor electricity usage.	⑦	⑥	⑤	④	③	②	①
I want to have a time-dependent electricity tariff. Then I could at least partially transfer my	⑦	⑥	⑤	④	③	②	①

consumption to the cheapest time (e.g. washing at night).							
I pay attention to energy-saving tips to reduce my electricity bills.	⑦	⑥	⑤	④	③	②	①
I keep track of my electricity bills.	⑦	⑥	⑤	④	③	②	①
I am motivated to keep my electricity costs under a reasonable amount.	⑦	⑥	⑤	④	③	②	①
I would feel guilty if I did not save electricity on a daily basis.	⑦	⑥	⑤	④	③	②	①
My conscience would bother me if I did not save electricity on a daily basis.	⑦	⑥	⑤	④	③	②	①
I would have a bad conscience toward the environment if I did not save electricity on a daily basis.	⑦	⑥	⑤	④	③	②	①
I lead a simple and modest life although I could afford a higher standard of living.	⑦	⑥	⑤	④	③	②	①
There are things I resist buying today so that I can save for tomorrow.	⑦	⑥	⑤	④	③	②	①
When shopping, I discipline myself to get the most from my money	⑦	⑥	⑤	④	③	②	①

Q22 Please evaluate the following statements about saving electricity and indicate your level of agreement or disagreement.

	Strongly agree	Agree	Somewhat Agree	Neither agree nor disagree	Somewhat Disagree	Disagree	Strongly disagree
I intend to conserve electricity in the future.	⑦	⑥	⑤	④	③	②	①
I will conserve electricity in the future.	⑦	⑥	⑤	④	③	②	①
I am ready to conserve electricity.	⑦	⑥	⑤	④	③	②	①

Q23 What was your electricity bill (estimated) for the last quarter?
- Under $200
- $200 to $299
- $300 to $399
- $400 to $499
- $500 to $599
- $600 to $699
- $700 to $799
- Over $800

Part B: For our comparisons, please tell us a little about yourself.

Q1. What is your gender?
- Male
- Female
- Other/prefer not to say

Q2. In what age group are you?
- 18-25 years
- 26-35 years
- 36-45 years
- 46-55 years
- 56-65 years
- 66-75 years
- 76+ years

Q3. What is your employment status?
- Employed
- Student
- Unemployed
- Retired
- Self-employed
- Looking after home or family

Q4 What is your highest level of education?
- Primary school, or no formal qualification
- High school certificate
- Trade or vocational qualification
- Diploma or advanced diploma
- Undergraduate degree (Bachelor's)
- Postgraduate degree (Masters, PhD)

Q5 How would you describe your household's current income?
- Finding it very difficult to live on current income
- Finding it difficult to live on current income
- Coping on current income
- Living comfortably on current income
- Living very comfortably on current income

Q6 What is your total household income from all sources?

- ❍ Less than $30,000
- ❍ $30,000 to $64,999
- ❍ $65,000 to $99,999
- ❍ $100,000 to $149,000
- ❍ $150,000 to $199,000
- ❍ $200,000 to $249,000
- ❍ $250,000 to $299,999
- ❍ More than $300,000
- ❍ Do not know/prefer not to say

Q7 Where do you normally live?

- ❍ Regional Queensland - served by Ergon (such as Cairns, Townsville, Roma, etc.)
- ❍ South-East Queensland - with a choice of electricity retailers (such as Brisbane, Ipswich, the Gold Coast, the Sunshine Coast, etc.)
- ❍ Other

Q8 How many people are there in your household (including yourself)? ___________

Appendix C: Measurement items

Construct and definition	Measurement Items[1]	Source
Attitudes: the extent to which electricity saving is valued by households, and whether positive (or negative) attitudes are held.	Saving electricity is not enjoyable.* Saving electricity is not important. * Saving electricity is useless* Saving electricity is beneficial. Saving electricity is good*.	Ajzen (1985; 1991); Judge et al, (2019)
Subjective norms: the extent to which households are influenced by the perceived expectations of important others or perceived societal norms of electricity-saving.	Most people who are important to me would be happy if I saved electricity. People who are important to me think that I should save electricity.	Ajzen (1985; 1991) Judge et al., (2019)
Perceived behavioral control: a person's perceptions of how easy or difficult it is to perform the behaviour; the degree to which a person believes that saving electricity is possible and under his or her control.	I believe that I am capable of saving electricity in my home. I have the knowledge and skills to save electricity in my home. If I wanted to, it would be easy for me to save electricity.	Ajzen (1985; 1991) Fu et al., (2021)
Intentions: the likelihood that households will hold intentions to save electricity.	I intend to conserve electricity in the future. I will conserve electricity in the future. I am ready to conserve electricity.	Ajzen (1985; 1991) Neves & Oliveira (2021)
Behaviour: the extent to which a person will perform a specific behaviour	Specific behaviour outlined below.	Ajzen (1985; 1991)
Behaviour: - Electricity curtailment: the degree to which a person continuously performs electricity-saving behaviours or strives to save electricity on a regular basis.	Leave items plugged in even after they have finished charging*. Turn off the lights when going out, even for short time. Reduce the use of the air conditioner, by opening the windows, using fans, etc. Unplug, or switch off, the main power of an electrical device, when not using it. Shorten the duration that the fridge door is kept open. Use the washing machine when I don't have a full load of laundry*.	Wittenberg, Blöbaum, & Matthies (2018).
Energy label consciousness in the purchase process: the degree to which buying appliances with an energy-efficient label (i.e., the energy star rating) is important to the consumer during the purchase process.	The energy label is important in the decision to buy an appliance. When I buy an appliance, I pay attention to the energy label. I am more willing to buy an appliance with an efficient energy class. I have purchased energy efficient electrical appliances in the past few years.	Wang, Lin, & Li, (2018).
Frugality norms: the degree of interest in avoiding waste, living a disciplined life, saving money	There are things I resist buying today so that I can save for tomorrow. When shopping, I discipline myself to get the most from my money.	Seebauer (2018).

Bill consciousness: the degree to which a person pays attention to the electricity bill.	I pay attention to energy-saving tips to reduce my electricity bills. I keep track of my electricity bills. I am motivated to keep my electricity costs under a reasonable amount.	Chen, Xu, & Day (2017)
Habits: the degree to which a person uses electricity in an unconscious and habitual manner	In my daily actions, I use electricity without conscious thinking. In my everyday life, I do not give much thought to the way I use electricity.	Seebauer (2018).
Anticipated guilt: the degree to which a person feels that wasting electricity would arouse negative emotions such as guilt in the future.	I would feel guilty if I did not save electricity on a daily basis. My conscience would bother me if I did not save electricity on a daily basis. I would have a bad conscience toward the environment if I did not save electricity on a daily basis.	Elgaaied (2012).
Environmental identity: the extent to which a person identifies as being an environmentally friendly person.	I think of myself as someone who is concerned about environmental issues. I see myself as being an environmentally friendly consumer. I would be embarrassed not to be seen as having an environmentally friendly lifestyle.* Buying energy efficient appliances makes me feel that I am an environmentally friendly consumer.	Whitmarsh & O'Neill, (2010)
Thermal comfort: a feeling of being hot or cold; the degree to which a person relies on electricity services to provide a desired level of comfort;	I find I cannot relax or work well unless the house is air-conditioned in the warmer months. I have trouble falling asleep at night without an air-conditioner on. While others might turn off their air-conditioners in the cooler months, my own need for being cool is high.	Chen, Xu, & Day (2017)
Solar rebound: consumer demand increases when improving efficiency makes the provision of a service cheaper. Indirect rebound occurs if income freed up by efficiency gains is expended on other products and services	With solar panels, I use more electricity than I did previously without the panels. With solar panels, I undertake more electricity-intensive activities than I did previously with the panels. Compared to before the solar panels were installed, I now turn on the air conditioners more often when I am warm Prior to the installation of solar panels, I turned on the fans when I was warm. Now, I turn on the air conditioner instead. Because I save with solar panels, I may allow myself some other things I am already doing my part with the solar panels; therefore, it is not that important to restrict myself (more) in other areas. It does not matter how much energy you use if you have solar panels	Seebauer (2018)

Note 1: * items were reverse coded for analysis

Appendix D: List of outputs

The following outputs are based on pilot study data and the data from the project funded by Energy Consumers Australia (ECA).

Presentations

Conference presentation
McCarthy, B. (2022). The solar rebound and renewable energy adoption in the 'Sunshine State', *International Conference on Business, Economics, Management, and Sustainability* (BEMAS), July 1st to 3rd, 2022, Centre for International Trade and Business in Asia (CITBA), James Cook University, Australia.

Keynote and panel speaker
Organiser: The Australian Competition & Consumer Commission (ACCC) National Consumer Congress, Doltone House, Darling Island, Pyrmont, Sydney, New South Wales.
Date: Thursday, 16th June 2022.
Keynote topic: Consumer behaviour, sustainability and greenwashing. Findings on consumer response to the energy star label were outlined during the keynote speech.
Panel discussion: the panel discussion covered environmental claims and greenwashing, consumer behaviour and opinions and helping consumers be sustainable.

Journal Publication

McCarthy, B. (2022). Renewable energy householders in the Sunshine State: do they perceive a rebound effect? *Journal of Resilient Economics*
https://journals.jcu.edu.au/jre/issue/view/204

Conference Paper

McCarthy, B. (2022). Residential battery storage – disruptive technology, disjuncture between policy and reality. *The Australia New Zealand Academy of Marketing Conference (ANZMAC), Reconnect and Reimagine*, Perth, Western Australia, 5th to 7th December, 2022.
https://www.anzmac2022.com/

The Solar Rebound and Renewable Energy Adoption in the Sunshine State

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