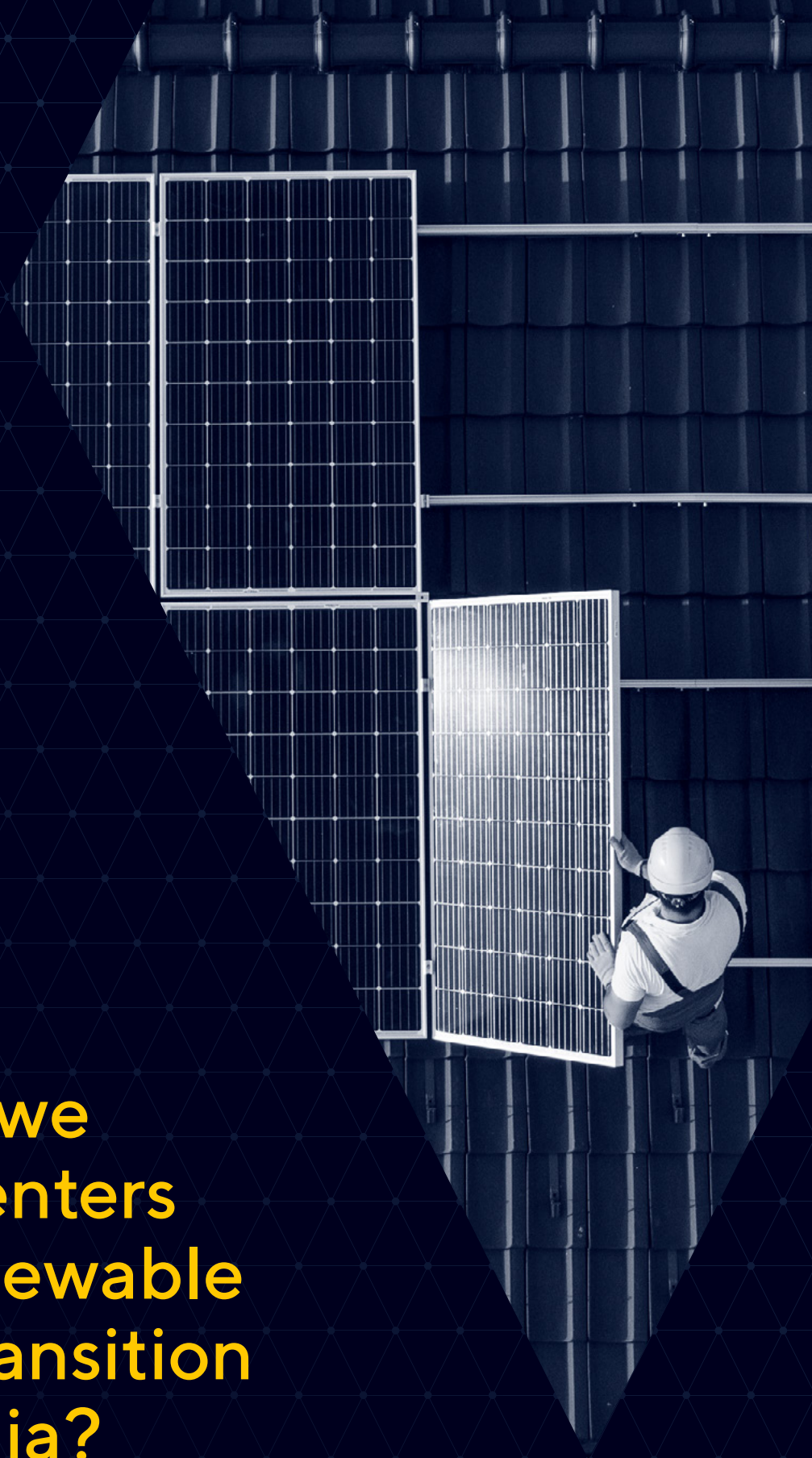
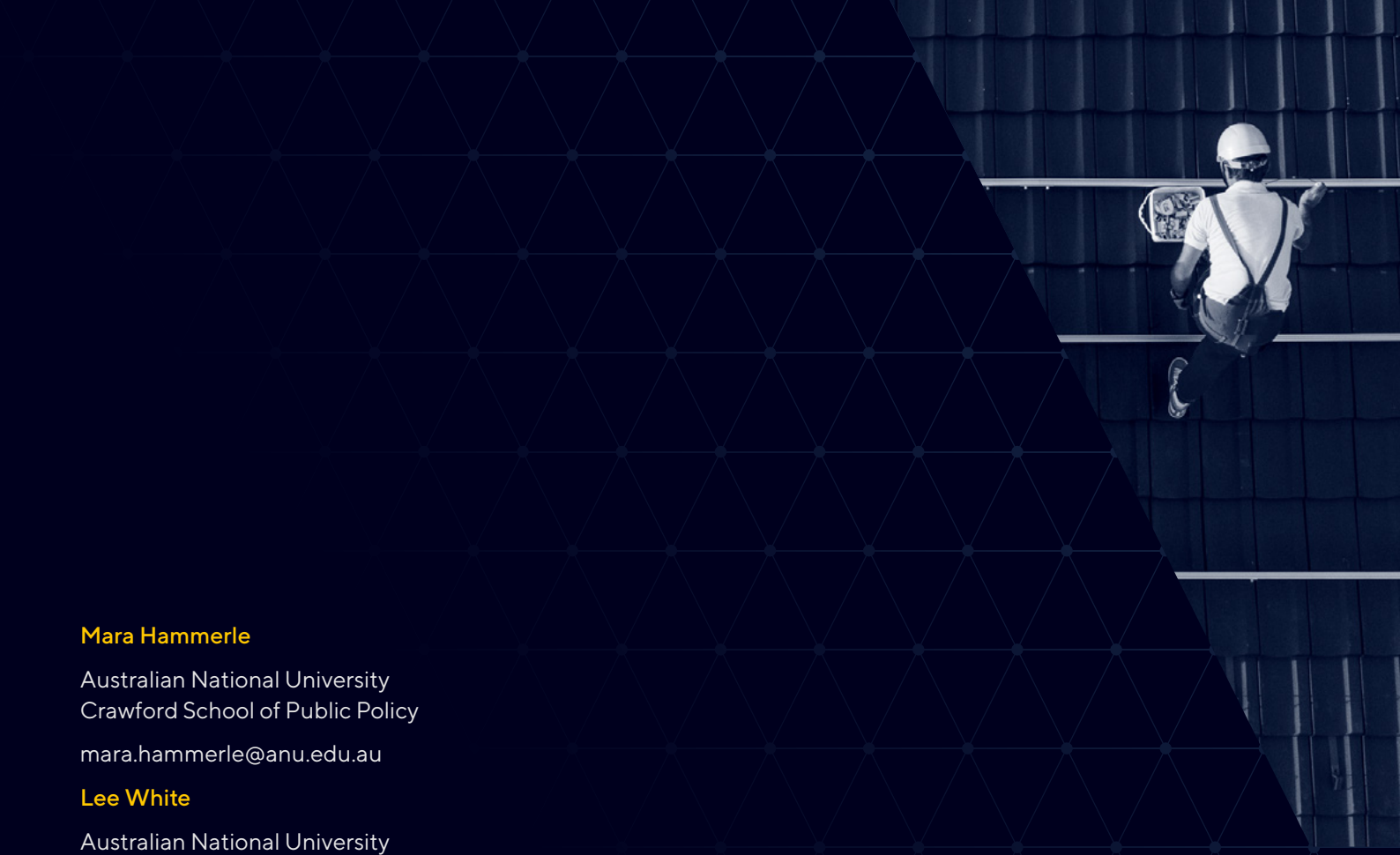


How can we involve renters in the renewable energy transition in Australia?



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Executive Summary

This project received funding from Energy Consumers Australia to examine policies that can support investment in rooftop solar PV for rental properties by property investors.

The project took a three-stage approach, combining interviews and surveys, to understand the perspectives of property investors, property managers, and policymakers involved in designing and implementing solar PV and energy efficiency policies. Best-worst scaling (BWS) was used to assess property investor perceptions of barriers to installing solar PV, then a discrete choice experiment (DCE) was used to examine property investor interest in potential policy designs to remove these barriers.

Overall, we find that property investors do not currently see sufficient value in investing in solar PV, brought about by both high upfront capital costs and a perception that renters are unwilling to pay higher rents for properties with the technology. The results stress the need to focus on making the potential financial benefits of investment in solar PV for rentals as visible as possible, such as by introducing information campaigns to ensure that property investors, renters and property managers can properly value the benefits of solar PV on factors including energy costs and thermal comfort.

The results indicate that while barriers to uptake are clear – including fears of being unable to recoup the costs of the investment through higher housing rents, and high upfront capital costs – identifying the necessary policies to address these is complex. While an independent not-for-profit operator could feasibly help address split incentive issues by directing feed-in tariffs to property investors, similar to third-party management options proposed in earlier research to better distribute costs and benefits of solar (Dodd and Nelson, 2022), property investors tended to vote against this option. Moreover, reducing the upfront capital costs could be feasible through providing interest-free loans to investors. However, more than two-thirds of the property investors we surveyed prefer policy options where costs are paid upfront. That is, interest free loans are not necessarily removing a barrier for many investors.

The concerns about return on investment indicated by survey findings highlight the need for policies that can facilitate better understanding of solar as a feature whose value the rental market can appraise, as is already the case with air conditioners and similarly tangible upgrades. In implementing policies to support solar for renters, policymakers should consider the following features:

- **Improve the benefit-cost trade-off for property investors**, particularly through an increased appreciation of the value of solar in the rental market and an accompanying confidence for all stakeholders in the appropriateness of higher rents for solar properties.
- **Make different options available for repayment of system costs**, for example by offering both the option to repay the system costs upfront as well as an option to spread the costs out over time.
- **Implement an education campaign to highlight existing and new knowledge about willingness-to-pay by renters for properties with solar PV**. A major barrier to investment in solar PV is a belief by property investors and property managers that renters would be unwilling to pay higher housing rents.
- **Consider active monitoring and disclosure** of the performance of solar PV systems to the rental market (to provide the market with assurance that a system is operating well).
- **Targeted actions such as state supported trials** to build investor confidence in returns on investment and familiarity amongst property managers may be another measure to increase the visibility of the value of solar.
- **Further consider opportunities for co-creation** between stakeholders in designing policies to promote solar PV on rental properties.

The study further examined barriers towards investing in energy efficiency measures by property investors. The main barriers are financial, including measures being expensive to install. These are similar to barriers facing property investors when considering solar PV installations. However, unlike with solar PV, property investors also indicated that difficulties of seeing some types of energy efficiency measures prevent higher levels of investment.

Overview

The project investigated the research question: how can we involve renters in the energy transition? At present, renters are very unlikely to either find a home to rent that has solar PV, or to be able to add solar PV to a home once they have rented it. As of 2017-18, around 4 percent of renters had solar PV, compared to 25 percent of homeowners (Australian Bureau of Statistics, 2019). To change this situation, it is necessary to first understand the barriers that property investors perceive regarding installation of rooftop solar on rental properties. Second, it is necessary to develop policies that could remove these barriers. This project sought to inform understanding of these barriers and to explore hypothetical policy options, incorporating the perspectives of property investors, property managers, policymakers, and advocacy groups.

Aims and scope

This research focused on the design of policies to increase the availability of solar PV for rental properties. Through interviews with property investors, property managers, and policymakers, as well as two large-scale surveys of property investors, we investigated: (1) which barriers prevent property investors from investing in solar PV for their rental properties; and (2) which policy features would be most important to increase the uptake of solar PV for rental properties. Our aim was to identify barriers to remove so that property investors are more likely to install solar PV, and so that in turn renters can more fully participate in the energy transition. We additionally examined the potential for several hypothetical policy designs to remove barriers.

The study focused primarily on the perspectives of property investors. As the aim of the project is to support renter participation in the transition to renewable energy, it is key to understand the incentives and barriers faced by property investors, on whom renters are dependent for energy upgrades such as installation of solar PV and energy efficiency improvements.

With the aim of achieving changes to policy to increase options for renters, we also engaged with advocacy and non-profit groups in the renter and energy spaces. Throughout the project, our aim was to use principles of co-creation to design policies that could potentially promote solar for renters. Co-creation involves bringing together those affected by policies (in our case, property investors and renters) and those who make the policies (in our case, governments and community organisations) to tackle social issues. Through careful use of co-creation, policies can be designed that have higher likelihoods of being adopted, are more socially legitimate, and are more effective at reaching policy objectives (Itten et al., 2021).

In analyses, we assess four key questions:

1. Are upfront costs a key barrier to PV installations by property investors?
2. Is distribution of benefits of solar between property investors and renters a key factor influencing investor willingness to install solar?
3. Are policies that more evenly distribute benefits preferred by property investors?
4. Does aversion towards system costs depend on whether property investors believe renters are willing to pay more for properties with solar PV?

Background

Property investors face several constraints when considering energy efficiency improvements to rental properties (Best et al., 2021; Cellini, 2021; Charlier, 2015; Melvin, 2018). A split incentive issue arises because property investors cover the costs of any improvements, while renters enjoy the lower electricity bills and/or higher levels of energy services such as heating (Best et al., 2021). As the renter does not know for how long they will live at their current address, their own investment in costly improvements would be risky (Bird and Hernández, 2012). Property investors may also feel they are unable to afford the high upfront costs of improving energy efficiency or installing solar PV on their rental properties (Hope and Booth, 2014; Lang et al., 2021; Phillips, 2012). Other barriers include a lack of information about the types of retrofits that are possible and their benefits (Heffernan et al., 2021), a lack of trusted government initiatives to encourage improvements (Hope and Booth, 2014; Lang et al., 2021), and that property investors do not believe renters desire increased energy efficiency (Ambrose, 2015; Hope and Booth, 2014).

While these barriers apply for energy efficiency improvements for rental properties, the issue of solar PV specifically remains under examined (Dodd and Nelson, 2022; Heller, 2019). The installation of solar PV shares many characteristics with the installation of energy efficiency features. Both technologies pose a challenge for the rental market because it is very difficult for prospective renters and property managers to ascertain the value that these features will deliver for them (i.e., the impact on their electricity bills and wellbeing). A key difference between the energy-saving measures is that unlike some energy efficiency features, including wall and roof insulation, the presence of solar PV is observable to renters. However, there may still be challenges in valuing the ability of solar to contribute to electricity bills reductions without detailed information about the systems.

Prior research finds that renters are willing to pay higher rental prices for properties with higher energy efficiency including in Australia (Bian and Fabra, 2020; Cajias et al., 2016; Fuerst et al., 2020; Fuerst and Warren-Myers, 2018). This extends to preferences for energy-efficient appliances in the United States (Hopkins et al., 2020), as well as solar PV in Australia (Best et al., 2021; Fuerst and Warren-Myers, 2018). Improvements to the energy features of a rental property may also mean that it spends less time-on-market between leases (Cajias et al., 2016; Fuerst et al., 2020), although evidence for this is mixed (Fuerst and Warren-Myers, 2018).

Prior work has investigated policy designs to increase property investor action to improve energy efficiency in rental properties (Heffernan et al., 2021; Wrigley and Crawford, 2017), and has proposed hypothetical designs for policies to support solar PV on rental properties (Dodd and Nelson, 2022; Heller, 2019). This work adds to prior discussions by empirically examining how policies can be designed to encourage property investor installation of solar PV on rental properties. Specifically, the report identifies barriers to installing solar PV on rental properties and tests property investor preferences for characteristics of policies to promote this solar PV uptake.

Data collection

Using a three-stage data collection approach, we conducted semi-structured interviews to inform design of a best-worst scaling survey which in turn informed design of a discrete choice experiment survey. Through the BWS, we identified the most important barriers for property investors when deciding whether to invest in solar PV for their rental properties. The DCE then enabled us to examine the quantitative trade-offs property investors make between different policy characteristics, namely between system costs, management of electricity bills, and whether the system costs are paid upfront or via instalments over time.

Semi-structured interviews

In September–October 2021, we interviewed a total of six property managers in New South Wales, Victoria, Queensland, South Australia, and the Australian Capital Territory; three property investors in Queensland, Victoria, and the Australian Capital Territory; and four state and local government policymakers in New South Wales, Queensland, and the Australian Capital Territory. We sought policymakers with experience working on designing and/or implementing policies to support increased energy efficiency or uptake of solar PV for rental properties. Appendix A provides a list of the main sub-national energy policies in Australia for the residential rental sector.

Interviews were forty-five minutes to one hour in duration. Property managers and policymakers were recruited using contact emails found on real estate and government department websites, respectively. Two property investors were recruited by asking property managers for leads while another contacted us after seeing a media article about the project.

The aim was to understand the barriers that property investors face in deciding to install solar PV on their rental properties. Interviews followed a semi-structured approach, with questions on broad categories of barriers and motivations for installing solar PV and improving energy efficiency in rental properties and awareness of relevant government policies.

Surveys

We conducted two surveys through the market research company PureProfile in December 2021 – January 2022 (survey 1) and March 2022 (survey 2). The first, which included the BWS questions, targeted 1,000 property investors across Australia with no more than 10 percent combined across Western Australia and the Northern Territory. Respondents were required to be 18 years of age or older and own at least one residential investment property. As the focus of the first survey was on the barriers to installing solar PV, we did not retain respondents who had already installed the technology on their nominated rental property (n=75). We also removed respondents who gave internally inconsistent answers, i.e., those who indicated in one part of the survey that they did not have solar but indicated in a later part that they did (n=6). We did not exclude respondents based on the time taken to complete the surveys; comparisons of preliminary analyses showed little difference based on this exclusion criteria. Our final sample for analysis contained 931 people.

For the second survey, which included the DCE questions, we targeted 150 property investors across Australia with no more than 10 percent combined across Western Australia and the Northern Territory. We excluded respondents who had already installed solar PV on their nominated investment property. Respondents to the survey were required to be 18 years of age or older and own at least one standalone house as an investment property. Those who own apartments are likely to face hard constraints on ability to install solar PV such as lack of roof space or building management prohibitions. Further, respondents were required to lease their properties to renters who are not known personally to them, and to expect to hold their selected investment property for at least another six months. Three respondents gave internally inconsistent answers and were dropped from the sample. The final sample size for this survey was 147 property investors.

Table 1 shows the percentage of surveyed property investors located in each Australian state and territory, alongside the percentage of Australian renters in each state and territory. About one-quarter of Australia's renters live in New South Wales and about another quarter in Victoria, consistent with these states being the largest in terms of population. Less than one percent of renters live in the sparsely populated Northern Territory. Overall, the proportions of investment properties captured in our surveys are similar to the proportions of Australian renters in each state and territory. To answer the BWS or DCE questions in the surveys, respondents were asked to focus on a nominated rental property of their choosing. In the BWS, we requested that they focus on (one of) their fully-detached house(s) if they have one and either a townhouse or apartment building if they do not. For the DCE, respondents were asked to select (one of) their fully-detached house(s). 77 and 78 percent of their nominated properties were managed by a real estate agent/ professional manager in the first and second surveys, respectively.

Descriptive statistics for explanatory variables included in the statistical models are also provided in Table 1. The surveys assessed several questions related to the demographics of the respondent and their property investment activities. These included environmental self-identity, willingness to pay for measures to benefit the environment, and the states and territories in which respondents live.

Table 1: Locations of nominated investment properties by surveyed property investors and Australia's renters

	Investment properties		Renters	
	Survey 1 (BWS)	Survey 2 (DCE)	All (HILDA)	Private (HILDA)
New South Wales	27.39	28.57	28.79	28.22
Victoria	31.15	29.93	23.94	24.81
Queensland	22.99	26.53	24.96	25.87
South Australia	8.38	7.48	7.72	6.88
Tasmania	1.83	4.08	3.38	3.00
Australian Capital Territory	0.86	0.68	2.18	2.28
Western Australia	6.66	2.72	8.20	8.15
Northern Territory	0.75	0.00	0.84	0.78

Notes: Values provided are percentages. A private renter is a renter who rents from a private property investor or real estate agent. Renters are households. HILDA values are from the Household, Income and Labour Dynamics in Australia (HILDA) (2020) survey.

We compare our sample to respondents in the Household, Income and Labour Dynamics in Australia (HILDA) survey who report investing in property (undefined as to whether residential or commercial) in Table 2 . Our respondents are largely comparable in age and education to investors responding to HILDA. Like the property investors in HILDA, the property investors that we surveyed were also more likely to hold a bachelor's degree or higher compared to the general population. However, our surveys collected data from more females than might be expected in the broader population of Australian residential property investors, and the median income of the respondents to survey 2 was lower than that for the HILDA investors.

Table 2: Descriptive statistics

	Our surveys (2021–2022)		HILDA (2020)	
	Survey 1 (BWS)	Survey 2 (DCE)	Property investors	General population
Gross annual income (A$)	65,000 – 103,948[a]	100,000 – 124,999[b]	150,000 – 199,999[b]	100,000 – 124,999[b]
Age (years)	45-54	45-54	51	35
Female (%)	58.32	61.22	49.10	51.49
Year 12 or below (%)	14.39	19.05	18.21	28.82
Cert III or IV, or adv diploma, diploma (%)	20.73	18.37	34.43	24.45
Bachelor's degree or higher (%)	64.88	62.59	47.36	21.12
Full-time employed (%)	–	57.82	–	–
Have lived in property[g] (%)	30.40	24.49	–	–
Property over A$500 weekly rent[cg] (%)	27.71	42.18	–	–
Personal weekly income A$2,000 or more[d] (%)	22.02	–	–	–
Household yearly income A$150,000 or more[d] (%)	–	27.21	–	–
Long investment[eg] (%)	64.23	57.14	–	–
Important for living costs (%)	39.85	53.06	–	–
Rent price agree[f] (%)	–	30.61	–	–
No. observations	931	147	2,065	22,932

Notes: Values for gross income and age are based on medians. [a] Refers to personal income; [b] Refers to household income. [c] As of September 2021, the median rent paid in Australian capital cities was $488 for houses and $438 for units (Domain, 2021). [d] Captures around one-quarter of each study sample. [e] Based on a question asking respondents how long they expected to hold the investment property for (BWS study) or how much longer (DCE study) – long-term is classified as five years or more. Equals one if respondent answered "agree" or "strongly agree" to a question asking whether they believe properties with solar PV can be rented out at higher prices. [g] Refers to the respondent's nominated rental property that they focused on during the survey.

Best-worst scaling

BWS is a type of choice modelling exercise in which respondents are asked to select their most and least preferred option from multiple lists with the same number of options in each. Repeated selections by respondents of different combinations of the items reveal the relative attractiveness of each item in the set. We used this method to examine the barriers that property investors identify as most and least important in their decisions to not yet install solar PV.

Following the semi-structured interviews, we compiled a list of all the barriers to installing solar PV that the interviewees had discussed. We then considered the areas where barriers overlapped or were not mutually exclusive and condensed these into eleven barriers to be used in the BWS task (Table 3). These are grouped into sets of barriers associated with (1) finance; (2) lack of benefit for the property investor (distributional factors); (3) information; and (4) other.

Following common convention, we constructed choice sets for the BWS using a balanced incomplete block design (BIBD), which ensures that each of the items appears the same number of times in total across the choice sets and appears the same number of times with each other item. Choice sets are used to group the items: in our case, respondents were shown 5 items drawn from the list of 11 barriers in Table 3. Each respondent viewed eleven lists of five items and selected the most and least important barrier from each list, with an example of a BWS survey question provided in Figure 1.

Table 3: Barriers to installing solar panels on rented rooftops as shown to respondents in the best-worst scaling survey

Category	Barrier
Financial	I can't afford to make such expensive financial investments.
Financial	The payback periods for installing solar PV panels are too long. The numbers don't stack up.
Financial	My margins on the rental property are already quite low/negative. I don't want to spend even more money on it.
Distributional	Installing solar PV panels won't reduce the vacancy period between tenancies.
Distributional	I don't receive the savings in electricity bills.
Distributional	Tenants won't pay more rent for solar PV panels.
Distributional	I'm not confident that solar PV panels will increase the resale value of my property.
Informational	I don't think I can install solar PV panels on my property.
Informational	I don't have enough time to evaluate the information and make an educated decision.
Other	I've just never really considered installing solar PV panels.
Other	There's no appropriate government support for me to install solar PV panels.

Figure 1: Example of a BWS survey question

When you think about reasons that you haven't installed solar PV panels on your rental property, which is the MOST and LEAST important reason from the list below? (Please select one most important reason and one least important reason from the list.)

Most important		Least important
○	I can't afford to make such expensive financial investments.	○
○	Installing solar PV panels won't reduce the vacancy period between tenancies.	○
○	I don't think I can install sloar PV panels on my property.	○
○	I don't have enough time to evaluate the information and make an educated decision.	○
○	I've just never really considered installing sloar PV panels.	○

Due to key stakeholder requests to include consideration of energy efficiency, the survey additionally included a Likert scale question asking respondents to consider their nominated rental property and indicate the extent to which they agree or disagree with the following statements (from 1 = Strongly Disagree to 7 = Strongly Agree). These statements were developed based on key barriers identified in interviews regarding energy efficiency upgrades in rental properties, and thus represent a summary of interview insights into energy efficiency barriers:

- Some energy efficiency measures are very difficult to see so renters don't know if they're there.
- Installing energy efficiency measures tends to be extremely expensive.
- I don't have enough time to evaluate the information about energy efficiency measures and make an educated decision about which to install.
- I've never really considered installing energy efficiency measures.
- There aren't enough government policies that encourage property investors to invest in energy efficiency measures.
- My property is already energy efficient.
- It will be hard to get body corporate approval to implement energy efficiency measures (for owners of townhouses and apartments).

Discrete Choice Experiment

In a DCE question, respondents are asked to select their most preferred option from a set of options, typically including an opt-out (none of the above) option. The options are characterised by different attributes, which vary across the options and questions. Doing this multiple times reveals to the researcher how respondents value the different characteristics. In our case, the DCE enables us to understand the value that property investors place on selected policy characteristics. To do this, we construct hypothetical policies that vary according to their policy characteristics.

Since the results of the BWS task revealed that respondents are mainly concerned about the financial aspects of installing solar PV on their rental properties, we focused on attributes related to financial concerns in the DCE. Table 4 displays these attributes and their levels. Attributes are characteristics of the policies, whereas levels are the different realisations of these attributes.

Table 4: Attributes and levels in the discrete choice experiment

Attributes	Levels (and descriptions shown to property investors)
Payment timing	**Upfront** (You pay the full cost (taking into account any available rebates) up-front.) **Monthly payments** (You access a loan at zero interest (with no deposit) that is provided by an agency such as the state government for a policy to support solar. You pay for the system in equal monthly instalments over five years. *You pay any remaining amount upfront if you sell the property.*) **Monthly payments tied to property** (You access a loan at zero interest (with no deposit) that is provided by an agency such as the state government for a policy to support solar. You pay for the system in equal monthly instalments over five years. *The loan is linked to the property. If you sell it, the remaining loan transfers to the next owner who then continues paying it off.*)
Management of electricity bills	**Electricity bills in property investor's name** (The property's electricity bills are in your name, and you directly bill the renter for the electricity they consume from the grid. You get any feed-in tariffs (payments for electricity produced by the system and exported to the grid). Renter can consume electricity free-of-charge from solar system.) **Electricity bills in renter's name** (The electricity bills are in the renter's name and they pay directly for energy consumed from the grid. They collect the feed-in tariffs. Renter can consume electricity free-of-charge from solar system.) **Third party management** (A third party (an independent not-for-profit) manages the bills on your behalf. They send you any feed-in tariffs and charge the renter for the electricity they consume from the grid. Renter can consume electricity free-of-charge from solar system.)
System cost (AUD)	**$1,000** **$2,000** **$3,000** **$4,000** **$5,000** (This is the cost of the solar system after any government subsidies have been applied. The cost is given in AUD.)

The "payment up-front" attribute had three levels. The first, "upfront payment", represents one of the key ways homeowners finance their solar PV systems in Australia. The second, "monthly payments", is analogous with policy offerings of interest free loans for solar on residential dwellings such as that trialled by the Victorian Government (Solar Victoria, 2022). The final level, "monthly payments tied to property", is similar to the interest-free loan level but the payments are linked to the property, meaning that owners transfer the payments if they sell the property before five years. This approach has been trialled in the City of Adelaide (City of Adelaide, 2022). This attribute was included to capture the extent to which policies that reduce initial capital outlay could increase solar installations on rental properties.

We considered three ways for the electricity bills to be managed. During interviews, property investors indicated that they would be more likely to install solar PV if they could receive the feed-in tariffs (FiTs) but that they would not want to have to bill their renters for electricity. We thus designed three options – one where the renter manages bills and receives FiTs (billing to "renter"); a second where the owner receives the FiTs but manages bills (billing to "property investor"); and a third option where a third party manages the bills on behalf of the property investor and distributes FiTs to the property investors (billing to "third party"). Under current arrangements, renters would typically manage the bills and receive FiTs. In addition to incorporating insights from the interviews, the third-party design is similar to that suggested by Dodd and Nelson (2022). We told respondents that the third party is an independent not-for-profit. Interviews with property managers revealed that managing the electricity bills associated with solar PV would not be feasible for them as the monetary value of the bills was perceived to be less than the cost of chasing renters for payment. In all cases, we assumed that the renter consumes electricity free-of-charge from the solar system, consistent with a net metering payment system as currently used by most Australian households with solar PV.

The system cost attribute represents the cost of the solar system after any government subsidies have been applied. Currently, the cost of a 5 kW solar system is around A$5,000 after taking into account the benefits received under the Australian Government's Small-Scale Renewable Energy Scheme (Solar Calculator, 2022).

Figure 2 provides an example of a DCE survey question. The selection of the specific combinations of policy features was based on a D-efficient design. D-efficient designs are commonly used when the sample size is small, which was the case here as PureProfile was able to provide a maximum of 150 respondents (Rose and Bliemer, 2013). They apply an iterative process: first, a pilot study is conducted to gain some understanding of preferences for the attributes and the minimum number of respondents for statistical inference; then, the final design of the questions is programmed. We conducted a pilot survey of 20 respondents from the same group targeted in the full DCE survey. The results of the pilot survey revealed that we needed a minimum of 25 respondents to be able to estimate trends in preferred policy options.

Figure 2: Example of a DCE survey question

Which policy for supporting investment in solar PV panels for rental properties would you choose to participate in? Assume that the panels, involved agencies, and installation steps are identical between options apart from the variation described below.

(Please click here for descriptions of the policy characteristics.)

	Option 1	Option 2	Option 3
Payment upfront	Monthly payments	Monthly payments tied to property	Upfront
Management of electricity bills	Tenant	Property investor	Third-party
System cost (after any subsidies applied)	$2,000	$1,000	$5,000

- ○ Option 1
- ○ Option 2
- ○ Option 3
- ○ None of these (no solar PV)

Before respondents commenced the DCE survey questions, they viewed an introduction and example DCE question. The introduction informed the respondents that the solar PV system is 5 kW, the panels are fully standards complaint and approved for use in Australia, the manufacturer's warranty is ten years, the expected lifespan of the system is 25 years, the panels are installed at the best angle to maximise the amount of electricity produced, and the system is tax deductible as a capital improvement. The values of these characteristics are based on the Australian context: for example, the mode for solar PV system sizes in Australia is 5 kW (Canstar Blue, 2022). They next read a statement that requested they keep their financial and other circumstances in mind when making the choices.

As part of the survey design and testing for the DCE survey, we interviewed nine property investors. This time, we used cognitive interviews instead of semi-structured interviews. Cognitive interviews are a tool commonly used in rigorous survey design to test whether newly developed questions are working as intended. The interviewer verbally goes through draft survey items with the interviewee to understand the thought processes that each respondent might potentially go through and how they might understand different phrases in the survey questions. Based on the cognitive interviews, in the final survey we provided clarity around the meaning of a 5kW system, stated that the system is tax deductible, and explained that the "third party" in the "management of electricity bills" attribute is an independent not-for-profit. The cognitive interviews also revealed confusion about whether to answer the income question for an individual or household and the types of income categories to consider. Consequently, we changed the focus of the income question from an individual in the first survey to a household in the second survey and provided information about the types of income to include.

Limitations

The study has various limitations. First, while we explored three policy characteristics, there is scope for more research on preferences for other features, including how to create an attractive taxation environment that encourages installation of energy technologies on rental properties. Moreover, while DCEs can reduce hypothetical bias compared to other stated preference methods (Hoyos, 2010), property investors were not required to commit financial capital to their choices and so might have chosen differently than they would have if making real-life decisions. For example, more property investors may have chosen the "no solar" option in reality than in the survey. Future real-world pilots of policies to support solar PV in the private rental sector would be useful, accompanied by rigorous research of both existing and new policies.

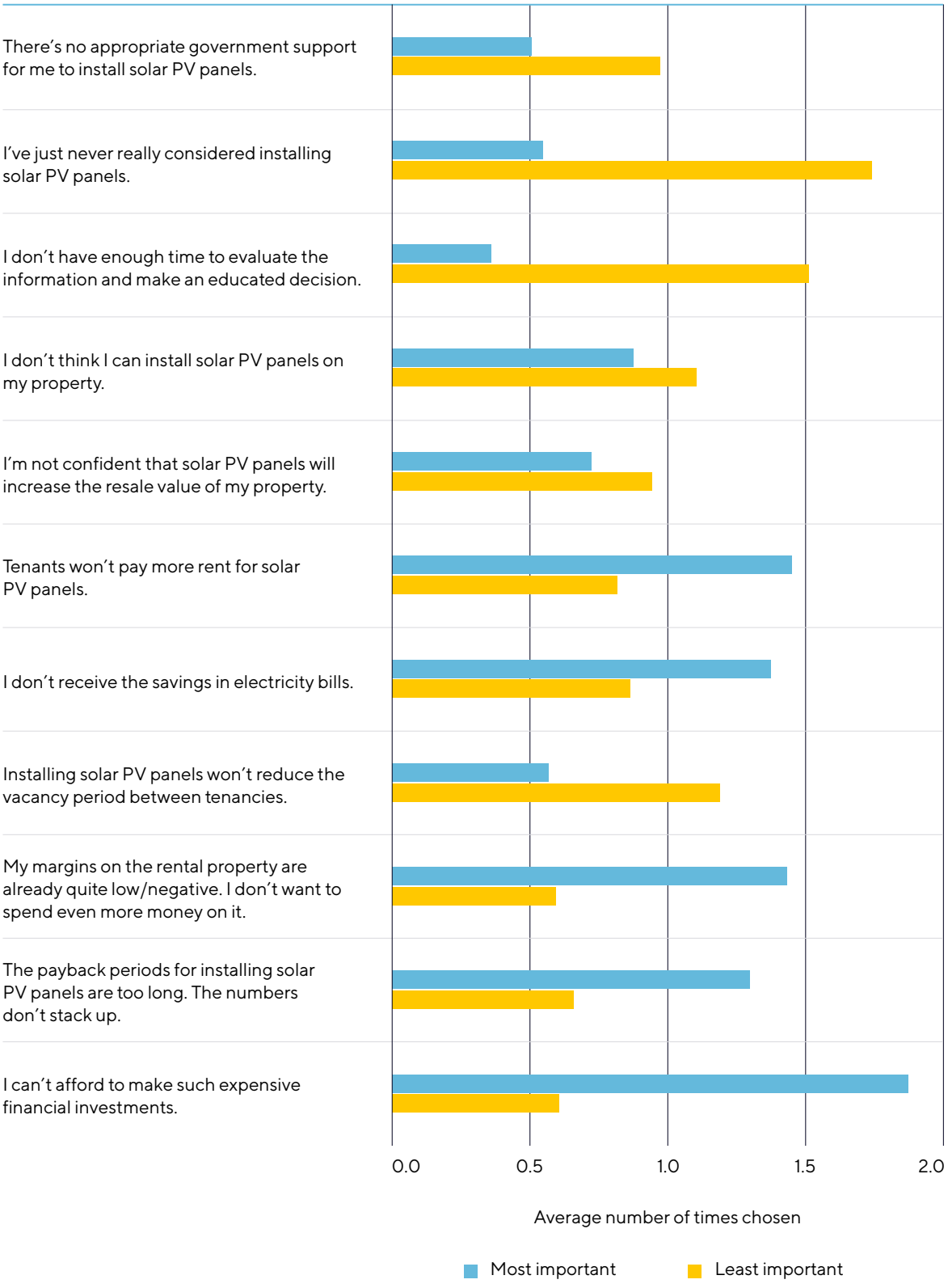
Findings

Barriers to solar

Overall, we find that property investors consider financial and distributional factors to be the most important barriers to proceeding with solar PV installations on rental properties. This was indicated by analyses with BWS, both through simple analysis of the options most frequently chosen as best and worst, and through more nuanced analysis including models accounting for respondent characteristics. Interviews also highlighted these concerns, for example, "it's a costly exercise and landlords really don't want to be putting out lots of money on stuff that they're not going to get a return on," (property manager 1) and "because we're not living in the property, there's no financial benefit to us as an investor to invest that kind of money in the solar panels if it's not going to be reflected in rent" (property investor 1).

Figure 3 summarises the average number of times that each respondent chose an option as the "most important" or "least important" barrier. Feeling unable to afford the upfront capital costs was the barrier chosen the greatest number of times on average, and financial barriers overall appear to be particularly pertinent for property investors who may not have sufficient liquid capital or may deem other types of spending as higher priority. The belief that renters would be unwilling to pay higher rents for solar PV panels was chosen as the "most important" barrier the second greatest number of times on average, highlighting distributional concerns. Informational barriers such as not having time to assess the options or simply not having considered solar PV frequently rated as the least important reasons that property investors had not installed the technology. A lack of government support to install solar PV panels was also deemed to be less important in preventing installations, with this option not chosen frequently as either the most or least important.

Figure 3: Average number of times that respondents chose each barrier as most and least important (n = 931 respondents making 11 selections each)



Notes: For example, a value of 1 for most important means that this barrier was chosen as most important an average of once per respondent over the five BWS questions that included this barrier.

We explored the data in greater detail using two types of models for statistical analysis of the barriers. The first identifies the overall preferences for the average property investor in the sample. The findings of this analysis indicate that the financial barriers as well as a perception by property investors that renters are unwilling to pay higher housing rents for properties with solar PV are overall the most pertinent barriers. The second type of model (latent class analysis) enables analysis of variability in the levels of importance placed by different groups of respondents on the barriers. Rather than researchers manually selecting the groups, this type of modelling automatically identifies different groups (classes) of respondents by identifying preferences that are similar within each group. As part of this analysis, the model identifies whether the observed characteristics that the researcher controls for distinguish the classes from each other. We summarise results of this model below and include the full model in Appendix B.

For the latent class analysis, we controlled for several variables related to respondents and their investment properties. Respondent characteristics included whether they are female, whether they earned $2,000 or more in gross income in the 2020-2021 financial year, and whether they consider the income from their investment properties to be important in supporting their living costs. We also included variables for whether the investment property the respondent focused on during the survey is a fully-detached house, whether they have ever lived in it, whether the rent paid on it is $500 or more per week, and whether the respondent believes they will own it for more than five years. Additionally, we controlled for the place in which the barriers appeared in each list shown to respondents, which was not randomised across respondents. For example, respondents may be more likely to choose an option at the top of a list, if they view it as the easiest for them to select.

The final analytical model only includes the variables that impacted the ability of the model to predict property investor preferences. Initial models also trialled variables including whether the rental property was located in a major city, the environmental preferences of the respondent, and whether the respondent is aged 65 years or older, as we expected these variables to be of interest. Variables that did not impact model fit were subsequently excluded from the analysis. Thus, the included variables are those that emerged as defining class features in the model optimisation.

Our analysis identifies three classes. BWS class 1 is particularly concerned about the potential for renters not being willing to pay more housing rents for solar PV and that the savings from solar panels accrue to renters rather than to them personally. They are also concerned about such factors as a long payback period associated with installing solar PV, low margins, and that the resale value of the property will not be higher with the addition of solar panels. Compared to BWS class 3, respondents in BWS class 1 are more likely to have a fully-detached dwelling that is rented out at less than A$500 per week, and to consider the property as a long-term investment. They are less likely to have lived in the property themselves.

BWS class 2 perceives all the other barriers as more important than not considering installing solar PV. They are particularly concerned about the upfront capital costs. Compared to BWS class 3, respondents in BWS class 2 are more likely to have a fully-detached dwelling that is rented out at less than A$500 per week, and to be female. They are relatively less likely to have more than A$2000 in weekly income and more likely to find the income from their property investment important for their living costs.

Investment in solar PV by BWS class 3 appears to be stifled because they have not considered it, with this group perceiving that they are unable to install the technology. The respondents in this group are less likely to have a fully-detached dwelling but it is more likely for the rent on their selected dwelling to be over A$500 per week. That is, property investors who own townhouses and apartments perceive a different set of barriers to installing solar when compared with those who own stand-alone investment properties. Barriers for this class of investors are less financially based.

Table 5: Summary table of BWS property investor classes

	BWS Class 1	BWS Class 2	BWS Class 3
Main concerns	The potential for renters not being willing to pay more housing rents for solar PV. The savings from solar panels accruing to renters rather than to them personally. Long payback periods associated with installing solar PV. Low rental property margins. The resale value of the property not being higher with solar panels.	Upfront capital costs. They think all other barriers are more important than not considering installing solar PV.	Being unable to install solar PV panels. A main barrier is that they have not considered installing the technology.
Characteristics	More likely to have a fully-detached dwelling that is rented out at less than A$500 per week. More likely to consider the property as a long-term investment. Less likely to have lived in the property themselves.	More likely to have a fully-detached dwelling that is rented out at less than A$500 per week. More likely to be female. Less likely to have more than A$2000 in weekly income. More likely to find the income from their property investment important for their living costs.	Less likely to have a fully-detached dwelling. More likely for the dwelling to be rented out at over A$500 per week.
Potential policies to target this class	Financial support, such as subsidies to increase financial attractiveness of installing solar PV Information campaigns, supported by existing and future research, about the impact of solar PV on housing markets, including rents and resale values Greater focus on benefits, both financial and non-financial of installing solar PV for the property investors themselves	Particular emphasis on financial support to reduce upfront costs, such as subsidies and low/zero-interest rate loans	Broader policies that support uptake of solar PV on apartments and other Strata-managed properties Analysis of different types of existing schemes and their respective benefits
Percent of respondents in this class	45%	32%	24%

Notes: Characteristics are described relative to the reference class (Class 3). Characteristics describing class 3 are therefore the opposite of the characteristics describing both of the other classes in the same way.

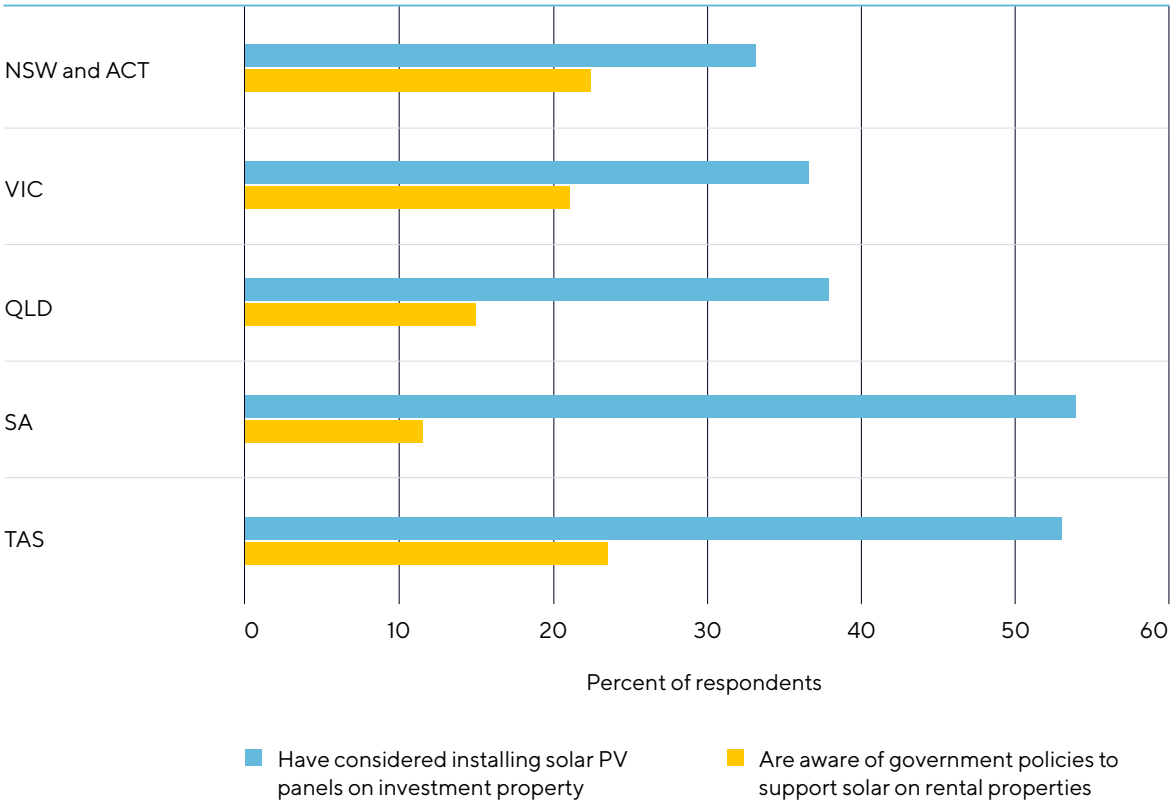
Considering responses across states and territories

In this section we include summary statistics dividing responses by the property investor's location. 85 percent of property investors nominated an investment property in the same state or territory in which they live. We focus on respondents living in states and territories covered by the National Electricity Market (NEM).

Policy awareness may form a particularly relevant mechanism by which other barriers, such as the high upfront costs of installing the technology, may be addressed. Victoria had a policy active to support installation of solar on rental properties during the study period, and Queensland had a similar policy active slightly before the study (see Appendix A). However, respondents in Victoria and Queensland did not generally report greater awareness of government policies that support solar PV for rentals than respondents in other states (Figure 4). Property investors would have also been able to access national subsidies for solar installation. Respondents in NSW and the ACT as well as Tasmania were most likely on average to indicate they were aware of relevant existing policies to support solar installation. The generally low awareness indicated in survey responses (Figure 4) indicates room for information programs that focus on exploring the benefits of solar PV for renters, from both the property investor and renter perspectives.

The percent of respondents who indicated that they had considered installing solar PV on their nominated rental property also differs by state, with the highest percent in South Australia (Figure 4). It is notable that Adelaide ran a Solar Savers program, but this ended in 2018 (Appendix A). The percent of Tasmanian property investors who have considered installing solar is also high, but is only based on 17 respondents, so may not be representative. Respondents in NSW and the ACT are less likely to have considered installing solar PV for their nominated rental properties.

Figure 4: Percent of respondents who have considered installing solar PV for their nominated rental property and percent of respondents who are aware of existing government policies supporting solar PV for rentals, by respondent's state of residence (n = 862, NEM states only; NSW and ACT n = 263, VIC n = 290, QLD n = 214, SA n = 78, TAS n = 17)

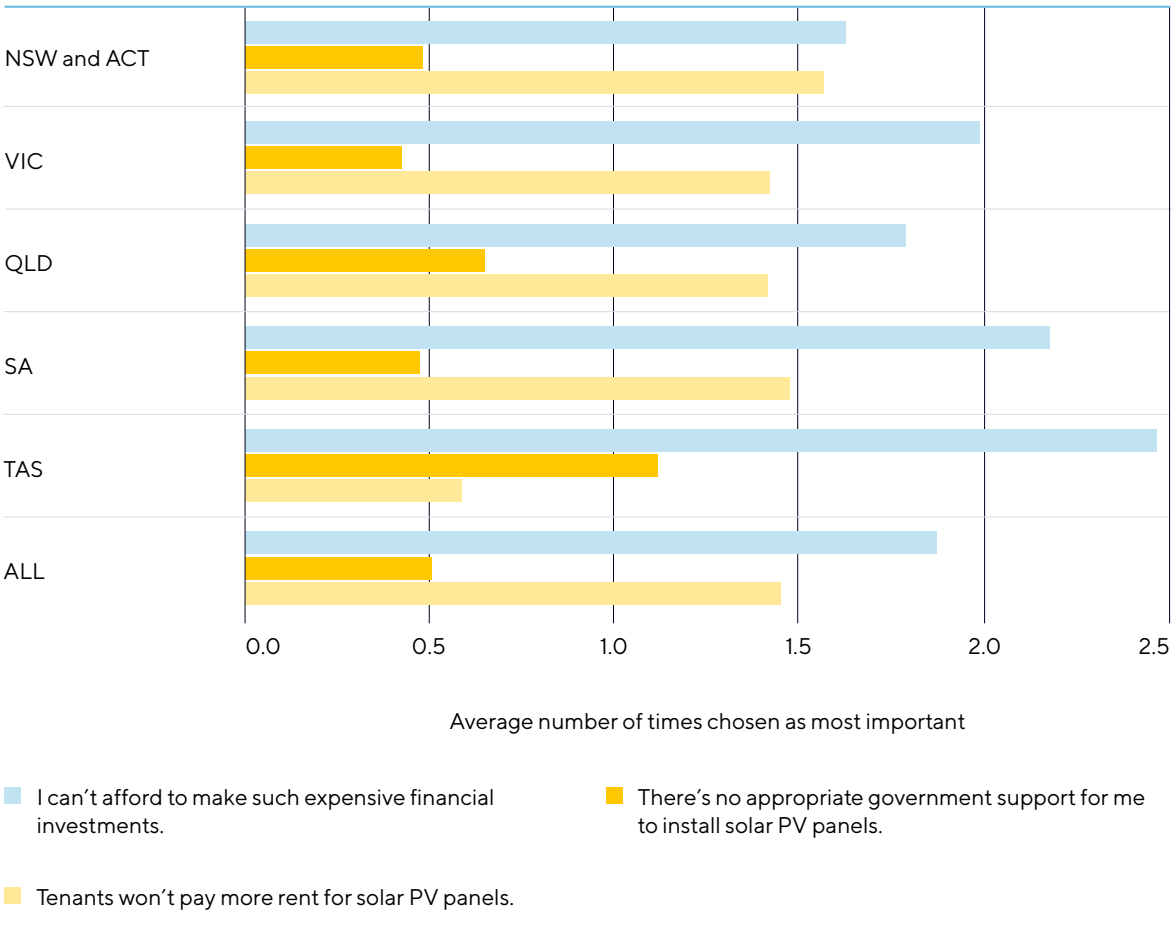


Existing policies for supporting the uptake of solar PV on rental properties in Australia typically focus on subsidies (see Appendix A), coupled with either zero-interest loans (such as in Victoria) or rates charged to the land and paid off in instalments over time (as for the Solar Savers Adelaide program). The results of the BWS analysis indicate that many property investors are dissuaded from investing in solar PV because of the high upfront costs involved, and these policies focus on overcoming these types of barriers. Considering this across states and territories, it appears that policies focusing on financial incentives may be particularly effective for those in South Australia and Tasmania, who most frequently report an inability to afford the upfront costs of the investment as the most important barrier (Figure 5). Compared to financial and distributional barriers, lack of policy support was less often chosen as the most important barrier across all states (Figure 5).

The importance of income from property investment in supporting living costs of respondents also varies by state (in NSW and ACT, 36.88 percent considered this very or extremely important; in VIC, 42.07 percent; in QLD 37.85 percent; in SA 46.15 percent; and in TAS, 52.94 percent). Respondents in Tasmania and South Australia, followed by those in Victoria, are the most likely to report that income from their rental properties is important for supporting their living costs. Therefore, policies in these states may wish to ensure a strong focus on the financial barriers associated with installing solar PV by property investors.

For those in BWS class 1, split incentives and a perceived lack of benefits for the property investor from installing solar PV are particularly important. The belief that renters are unwilling to pay more rent for properties with solar PV is pertinent for all states and territories with the possible exception of Tasmania (Figure 5). In Tasmania, respondents selected this barrier more frequently as the least important than the most important, though we note again that there was only a small sample from Tasmania.

Figure 5: Average number of times select barriers were chosen as most important, by respondent's state of residence (862 respondents making 11 selections each, NEM states only, select barriers; NSW and ACT n = 263, VIC n = 290, QLD n = 214, SA n = 78, TAS n = 17)



Preferences for hypothetical policies

Following our analyses with BWS, we used a DCE to examine preferences for hypothetical policies. As in the BWS, we used two types of models as described above, first considering the average property investor, and second using latent class analysis to consider "classes" of property investors. Our analysis identified substantial heterogeneity in preferences for the policy features. For the latent class analysis, we first ran several trial models to identify the variables that help predict preferences for the policy characteristics. We kept those variables, which included the position in which the barriers appeared in each question shown to respondents (left, centre, or right), whether the respondent is employed full-time, and whether the respondent believes that properties with solar PV attract higher housing rents. The latter variable was based on responses to a 7-point Likert-scale statement, coded one for respondents who selected "agree" or "strongly agree" to the statement "a property with solar PV panels can be rented out at a higher price" and zero otherwise. Other variables, including the perceived importance of rental income in supporting the respondent's living costs and whether respondents live or have lived in a home that they own with solar PV panels for electricity, did not improve model fit. For the findings shown in Table 6 and Appendix C, we focus on those variables that improve model fit and allowed the model to select the classes that best fit the sets of preferences.

The DCE tests one way to address distributional barriers by having either the property investor themselves or a third party on their behalf manage the electricity bills and direct any feed-in tariffs to the property investor. Compared to property investor management of electricity bills, we find that DCE Classes 2 and 3 prefer that renters manage the bills, thereby receiving the FiTs. Respondents in these classes may be more likely to believe that the costs in terms of time and other factors of managing the bills themselves would outweigh the benefits of any income from FiTs, that it is easier to raise rents slightly than change bill management, and/or that renters should receive the full benefits of the solar system. None of the classes prefer the "third party management" option compared to the "renter" option, potentially suggesting that the former option is viewed as infeasible by the property investors.

One way to reduce the upfront capital costs of installing solar PV is to offer property investors some form of interest-free or low-interest loan. However, the results of the analysis in Appendix C indicate that loans would not be broadly expected to increase the uptake of solar PV for rental properties. From the DCE analysis in Table 6, this is because some property investors view them positively (DCE Class 2) while others view them negatively (in particular DCE Class 3). Existing research also finds that loans may be unattractive for supporting property investors to invest in energy upgrades to rental properties (Ambrose, 2015; Miu and Hawkes, 2020). There may be scope for policies to provide options to pay the full cost upfront or to spread costs out over time. The Solar Savers Adelaide program, for example, only provided the option to repay costs over time while the Solar for Rentals program in Victoria offers a rebate with an interest-free loan being optional.

Table 6: Summary table of DCE property investor classes

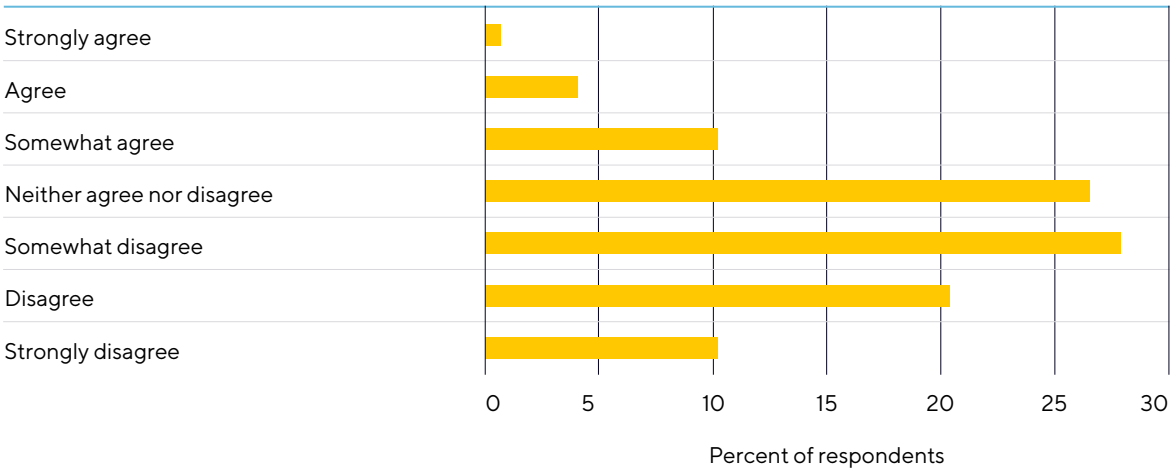
	DCE Class 1	DCE Class 2	DCE Class 3
Main concerns	Prefers paying full system costs upfront (but mostly indifferent between the options). Prefers property investor management of electricity bills. Does not like high system costs.	Prefers repaying system costs over time either through monthly repayments or monthly repayments tied to property. Prefers renter management of electricity bills over property investor management; indifferent between renter management and third-party management. Does not like high system costs.	Prefers paying full system costs upfront. Prefers renter management of electricity bills. Does not like high system costs.
Characteristics	More likely to believe renters would be willing to pay higher housing rents for solar PV. More likely to be full-time workers.	More likely to believe renters would be willing to pay higher housing rents for solar PV.	Reference group.
Percent of respondents in this class	31%	31%	38%

The potential future role of information

We also investigated whether aversion towards system costs depends on whether property investors believe that renters are willing to pay more for properties with solar PV. This investigation relates to our finding in the BWS that a major barrier to investment in solar PV by property investors is their perception that renters would be unwilling to pay higher housing rents for properties with the technology. Property investors may be less negatively affected by the presence of high system costs if they are aware of the benefits.

As shown in Figure 6, around 31 percent of respondents agreed or strongly agreed with the statement that "a property with solar PV panels can be rented out at a higher price". Only one respondent strongly disagreed with this statement.

Figure 6: Percent of respondents who agree that properties with solar PV attract higher housing rents (n = 147)



We first examine the findings of the latent class analysis (described in the above section and presented in Appendix C). We found that both DCE Classes 2 and 3 contain more respondents who believe properties with solar PV attract higher housing rents compared to the reference class and are less averse towards high system costs (using the delta method (Daly et al., 2012)).

However, overall, our analysis does not reveal a clear answer to our question of whether property investors who believe that renters will pay more for properties with solar are less averse to high solar PV system costs. As a robustness check, we additionally examined a mixed multinomial logit model, which does not separate respondents into classes (this model is presented in Appendix D). This model indicates that perception of renter willingness to pay higher rent has no impact on property investor utility for solar (evidenced from the interaction term between these variables being statistically insignificant). This may be a fruitful topic for future research to understand whether addressing the information gap can support investment in solar PV by property investors.

An education campaign around the impacts of solar PV on housing rents may be useful to reduce any impacts on investment arising from the belief by property investors that renters are unwilling to pay higher housing rents for properties with solar PV. While we tested one mechanism by which this belief may impact property investor preferences for policy characteristics, we are unable to use our DCE format to test whether property investors who believe renters would be willing to pay higher housing rents would be more likely to install solar. Our BWS analysis also indicates that this belief is a primary barrier to preventing higher uptake of solar PV for rental properties. An information campaign could use information from existing research on this topic (see, for example, Best et al. (2021) and Fuerst and Warren-Myers (2018)). It could also offer property investors insights into which types of renters might be likely to seek properties with solar PV, with recent research indicating that this would include higher-wealth renters (Best, 2022).

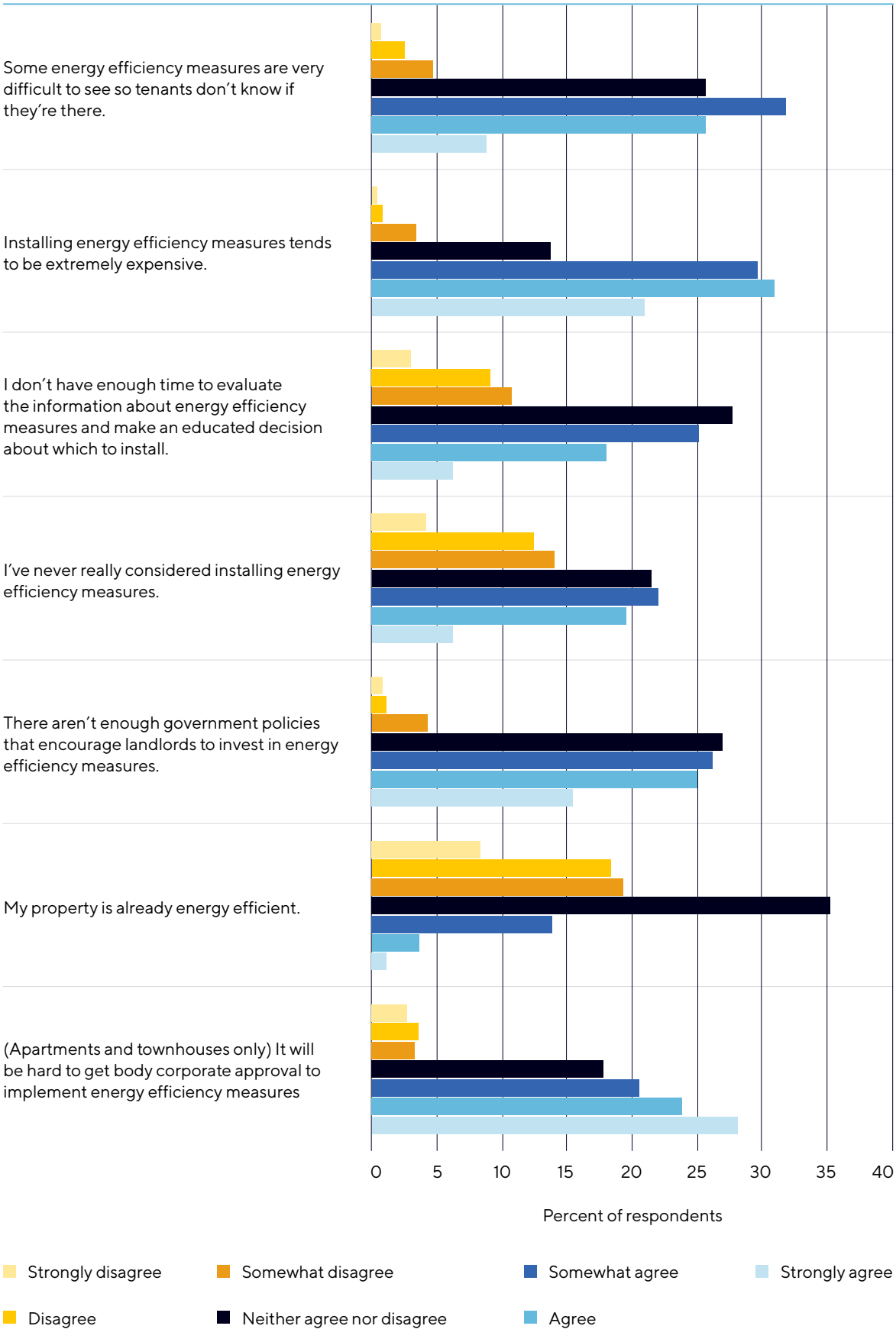
Exploring beyond solar: Future directions for energy efficiency

We also collected information on barriers preventing property investor investment in energy efficiency improvements in the semi-structured interviews and the first (BWS) survey. In interviews, respondents indicated that property investors are unlikely to exceed legally binding requirements set by state and national governments, "with the construction, it's always whatever the requirements are at that time. I've never gone above and beyond the standards. Just no benefit to me" (property investor 2). A lack of benefits for the property investor were identified as a key reason for this: "the owners aren't overly bothered about energy efficiency, I don't think, just because they're not in the property utilising it" (property manager 2). For renters, "anything that's energy efficient … it doesn't really factor into a tenant decision" (property manager 2). One reason for the lack of focus on energy efficiency by renters may relate to the lack of visibility of some energy efficiency features: "it's something that new tenants can't see; they don't know it. They don't know that the owner has put insulation in the roof. I can tell them, but a lot of people don't know what that means in terms of comfort" (property manager 3).

Based on the interviews, the key barriers to property investors installing energy efficiency measures in rental properties are:

- Long payback periods
- No benefit to the property investor
- No change in rental prices
- No impact on time-on-market for rental properties
- High costs
- Not knowing that low energy efficiency is an issue
- Potential for over-capitalisation
- Belief that renters don't care about energy efficiency
- Belief that having a low energy efficiency rating doesn't really matter to a renter, as long as they have somewhere to live (in areas with highly competitive rental markets)
- Difficulties in renters being able to directly observe many energy efficiency measures

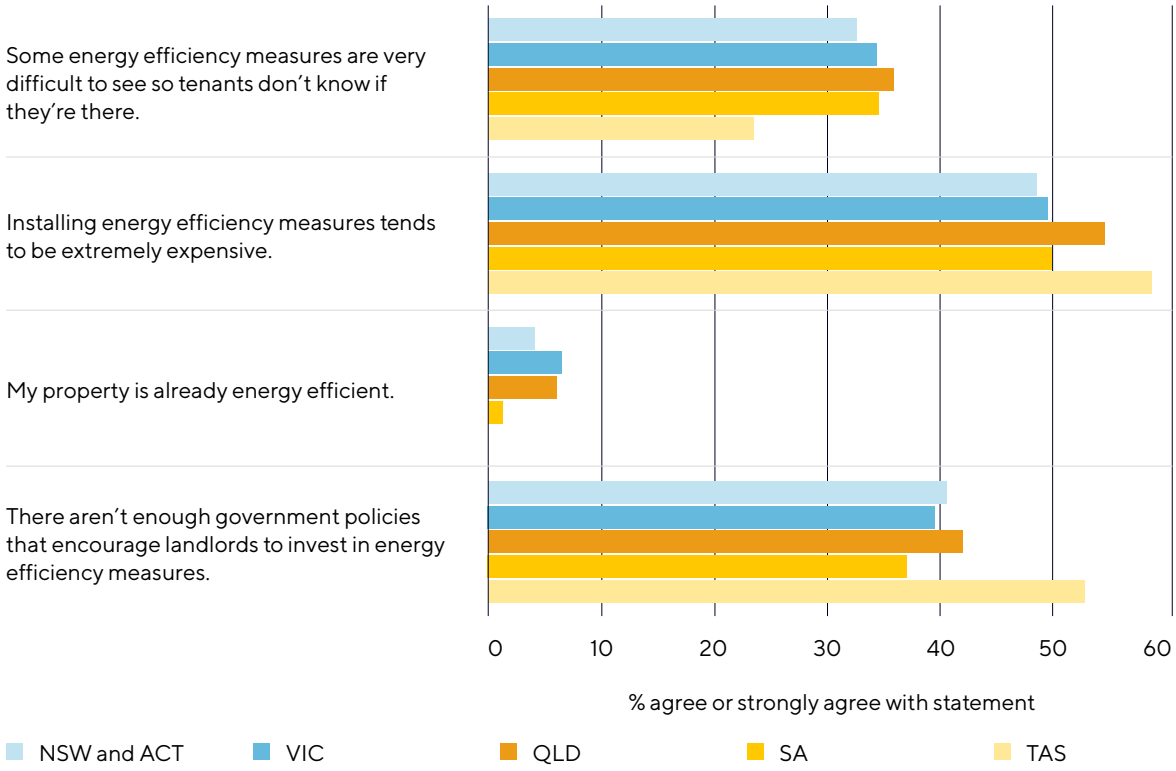
Figure 7: Strength of respondent agreement with statements about energy efficiency measures



Notes: The number of observations is 931; except for the "apartments and townhouses only" question where the number of observations is 331.

In the first survey, we focused on asking property investors about their agreement or disagreement with seven statements about energy efficiency, with the results presented in Figure 7. We find that, as with solar PV, property investors are generally focused on financial concerns for installing energy efficiency measures. Property investors rated the strongest agreement with statements regarding barriers of energy efficiency being expensive to install. Around half the respondents in all NEM states indicated that they agreed or strongly agreed that energy efficiency measures are extremely expensive to install. According to Figure 8, the percentages are higher in Tasmania (59 percent) and Queensland (55 percent).

Figure 8: Percent of respondents who agreed or strongly agreed with selected statements about energy efficiency, by respondent's state of residence (n = 862, NEM states only; NSW and ACT n = 263, VIC n = 290, QLD n = 214, SA n = 78, TAS n = 17)



Many property investors also agreed with statements about energy efficiency measures being difficult to see, which impacts the ability of property investors to attract more desirable renters or higher rental payments by installing energy efficiency measures. Based on Figure 8, respondents who live in Queensland (36 percent) were the most likely on average to indicate that energy efficiency measures are difficult to see for renters. A low proportion of property investors in each state agreed that their property was already energy efficient.

In contrast to the BWS results, which find that property investors do not view limited government policies or lack of information as barriers to installing PV, property investors frequently agreed with statements that there are not enough incentives to install energy efficiency and that they do not have enough information to make informed decisions. However, we note that the BWS and Likert scale results are not directly comparable; BWS forces respondents to choose only the best and worst options in each choice set, whereas in the Likert exercise it was possible for respondents to strongly agree with as many stated barriers as they wished.

The findings on energy efficiency suggest that future work looking at improving energy efficiency in rental properties should focus on the financial and regulatory aspects, as opposed to the informational aspects, of energy efficiency programs. Further, if future work were to consider a BWS survey similar to that used in our examination of solar PV, there is a clear need to differentiate technologies on aspects such as visibility and upfront cost. The perceived barriers surrounding visibility and cost would likely be ranked very differently for

technologies such as reverse cycle air conditioners versus ceiling insulation versus draught proofing. We also note that fewer than 10% of respondents in each state agreed with the statement that their property was already energy efficient, suggesting that there is a strong need for improvement for rental properties.

Insights from prior literature

To date, there has been very little analysis of which policies may support the uptake of solar PV for rental properties. Some researchers have explored theoretical possibilities for policies seeking to support solar for renters, including:

- A renter's power purchasing agreement under which property investors install solar PV and require renters to purchase the energy produced by the systems (Heller, 2019).
- New market structures that create independent not-for-profit companies who lease rooftops from property investors and install solar systems on them (Dodd and Nelson, 2022).

In the broader context of promoting installations of energy efficiency measures in rentals, the following policies have been highlighted (Burfurd et al., 2012; Gabriel and Watson, 2012; Heffernan et al., 2021; Miu and Hawkes, 2020; Wrigley and Crawford, 2017):

- Grants and subsidies
- Enabling energy efficiency improvements to be tax deductible for property investors
- Zero-interest loans
- Minimum environmental performance and/or energy efficiency standards for rental properties (forms of which have been legislated in Victoria and the ACT)
- Environmental performance disclosure of rental properties, preferably mandatory (there is mandatory disclosure of a rental property's energy efficiency star rating in the ACT but only for properties with existing ratings)
- Making changes to legislation to enable property investors to increase housing rents based on a property's energy efficiency

These policies may also be suitable for promoting the uptake of solar PV on rental properties, given the similarities between solar PV and energy efficiency features in reducing energy bills and improving access to energy services such as thermal comfort.

One policy option that has not yet been widely discussed in the literature on how to support property investors to install energy technologies is that of informational strategies. Such strategies would aim to increase property investor knowledge and perceptions of such investment, with the aim of promoting sustainable behaviour (Steg and Vlek, 2009; Van der Werff et al., 2019). However, informational strategies often have small and ambiguous impacts on behaviour change (Osberghaus and Hinrichs, 2021; Van der Werff et al., 2019; Varotto and Spagnolli, 2017) and previous research may be affected by data limitations (Osberghaus and Hinrichs, 2021).

Based on existing literature, information campaigns targeting property investors could be made more effective by incorporating knowledge about the property investor communities they attempt to reach (Nixon and Saphores, 2009), including information about the outcomes of increasing access to solar PV (Casado et al., 2017; Van der Werff et al., 2019), and drawing upon the experiences and leadership of property investors who have already installed solar PV (Nixon and Saphores, 2009; Varotto and Spagnolli, 2017). Engaging property investors over an ongoing time period (Van der Werff et al., 2019) and through multiple sources of information (Nixon and Saphores, 2009) is also likely to be effective. Overall, information campaigns may prove effective if a lack of awareness is a primary driver of low uptake of solar PV for rental properties (Varotto and Spagnolli, 2017). In both semi-structured interviews and the BWS survey, respondents demonstrated a lack of awareness about how housing markets would react to solar PV on rental properties and about relevant government policies. The findings suggest that the former is particularly important for low uptake of solar PV for rental properties.

Summary of findings

Policy interventions that seek to redress the exclusion of rental properties from solar PV face a delicate balance in both perceptions and impacts: creating benefits for renters, who are worried about having to pay higher rents (Zander, 2020), without overly benefiting property investors, who are seen as financially well to do. Striking such a balance with effective and equitable policies requires a sound understanding of stakeholders' perceived barriers and desired interventions. Our study contributes to this by elucidating the perspective of property investors, through two Australia-wide surveys.

We briefly summarize our core questions and research findings:

1. **Are upfront costs a key barrier to PV installations by property investors?** Our survey findings indicate that yes, upfront costs remain a key barrier to PV installation. This is particularly the case for respondents in BWS Class 2, i.e., female property investors with fully-detached dwellings rented out at less than $500 per week, who earn less than $2,000 per week and find the income from their property investment important for their living costs. However, over two-thirds of respondents to the DCE prefer policies that require upfront payment of system costs. Outside property investors whose preferences align with those in DCE Class 2, loans are unlikely to achieve widespread increases in solar installations by property investors.
2. **Is distribution of benefits of solar between property investors and renters a key factor influencing investor willingness to install solar?** Yes, there is a general trend of property investors perceiving that they will not gain value from installing solar (in the form of increased rents or otherwise). That is, our research identified the belief that renters are unwilling to pay higher rents for properties with solar PV as one of the key barriers to investment in the technology by property investors. The distribution of benefits from installing solar PV on rental properties is a key form of split incentives in the renter-property investor relationship and the best way to address this remains an open area of research. However, we suggest that increasing the visibility of the value of solar could be one way to address this barrier and improve the cost-benefit trade-off for property investors. We provide relevant policy recommendations in the following section.
3. **Are policies that more evenly distribute benefits preferred by property investors?** Semi-structured interviews in the first round of data collection suggested that property investors would be more likely to install the technology if they received the feed-in tariffs from the solar system. We therefore tested a policy design that would use management by a third-party not-for-profit organization to distribute feed-in tariffs to property investors, but this option was not preferred by any of the investor groups. Although the distribution of benefits is a barrier, other mechanisms are needed to address this concern. An avenue for future research could be to understand whether it would be possible to encourage utilities to redirect FiT revenues to property investors.
4. **Does disutility for system costs depend on whether property investors believe renters are willing to pay more for properties with solar PV?** Findings for all other questions indicated that the belief that renters would pay more for properties with solar should be a key mechanism for increasing property investor interest in installing solar on rental properties. We find tentative indications that system cost preferences of some groups of property investors are influenced by perceptions that renters will pay higher rents for solar, but these findings are not robust across model specifications and cannot be considered conclusive. This is, however, the most promising area for future policy design and future research.

Recommendations for policy

The core policy implication of our study is that there remains significant work to do in building a widespread and robust understanding of the value that solar PV can bring to both property investors and renters. Below we outline several areas that could be pursued in future policy design and research to further this goal. These recommendations are developed based on analysis findings, prior academic literature, and drawing on the perspectives of property investors, property managers, and state and local government policymakers that we spoke to in interviews and follow-up conversations:

- **Improve the benefit-cost trade-off for property investors**, particularly through an increased appreciation of the value of solar in the rental market and an accompanying confidence for all stakeholders in the appropriateness of higher rents for solar properties. Future work could explore other mechanisms to increase perceived value of solar, including informational approaches.
- **Make different options available for repayment of system costs,** for example by offering both the option to repay the system costs upfront as well as an option to spread the costs out over time. Different options are preferred by different property investors.
- **Implement an education campaign to highlight existing and new knowledge about willingness-to-pay by renters for properties with solar PV.** A major barrier to investment in solar PV is a belief by property investors and property managers that renters would be unwilling to pay higher housing rents. While we considered the impact of this belief on preferences for system costs in the DCE, the evidence was mixed. Future research could investigate this issue further. However, it is likely that visibility of this value would reduce the perceived spilt of incentives. This could be informed by recent findings on renter valuation of solar (Best et al. (2021) and Fuerst and Warren-Myers (2018)).
- **Consider active monitoring and disclosure** of the performance of solar PV systems to the rental market (to provide the market with assurance that a system is operating well). This measure could also increase visibility of the value of solar; it could provide a way to assure potential renters that a system is operating well, increasing tangibility of the property feature's benefits. Monitoring information would likely be most effective when presented in tangible financial (dollar) terms. The Queensland Government's solar for rentals trial was a good demonstration of how solar monitoring and data reporting can be incorporated into a government incentive scheme. Over time, the public disclosure of this value could help to build awareness within both the rental market and broader society.
- **Targeted actions such as state supported trials** to build investor confidence in returns on investment and familiarity amongst property managers may be another measure to increase the visibility of the value of solar. Targeted actions such as state supported trials have the advantages of enabling bespoke messaging for the quite distinct stakeholders (property investors, property managers, renters), and building capacity within each stakeholder group, most critically with property managers who advise clients on setting appropriate rental prices.

- **Further consider opportunities for co-creation** between stakeholders in designing policies to promote solar PV on rental properties. This study uses a three-stage approach, combining perspectives from property investors, property managers, and policymakers, as well as expert insight on renters from the team at Better Renting. This process highlighted the diversity of pressures and incentives faced by different groups, including different groups of property investors. Engaging diverse stakeholders in local policy design is likely to improve ability of policies to promote change.

Transferability to other energy upgrades

While our findings primarily speak to property investor installation of solar, some insights could be extended to other energy-related property features. The core findings of our study appear transferable: if there is no financial benefit perceived, action is unlikely to be taken even if it is low cost. This may limit the value of subsidies – if no return on investment is expected in the form of increased rents or other benefits, then even a half-price solar system may remain unappealing. This is likely to also be the case for other less tangible property upgrades such as energy efficiency.

Our survey also indicated barriers to energy efficiency upgrades include the lack of visibility of energy efficiency upgrades, and associated perceptions that a more energy efficient property would not be more highly valued. Disclosures of energy efficiency ratings can partially address energy efficiency visibility issues, and renters tend to value more efficient properties more highly (Bian and Fabra, 2020; Cajias et al., 2016; Fuerst et al., 2020; Fuerst and Warren-Myers, 2018).

References

Abrahamse, W., Steg, L., Vlek, C., Rothengatter, T., 2005. A review of intervention studies aimed at household energy conservation. J. Environ. Psychol. 25, 273–291. https://doi.org/10.1016/j.jenvp.2005.08.002

Ambrose, A.R., 2015. Improving energy efficiency in private rented housing: Why don't property investors act? Indoor Built Environ. 24, 913–924. https://doi.org/10.1177/1420326X15598821

Australian Bureau of Statistics, 2019. 6553.0 - Survey of Income and Housing, User Guide, Australia, 2017-18 [WWW Document]. URL https://www.abs.gov.au/ausstats/abs@.nsf/mf/6553.0 (accessed 3.7.22).

Best, R., 2022. Household wealth of renters promotes their solar panel access. Econ. Model. 106, 105704. https://doi.org/10.1016/j.econmod.2021.105704

Best, R., Esplin, R., Hammerle, M., Nepal, R., Reynolds, Z., 2021. Do solar panels increase housing rents in Australia? Hous. Stud. 0, 1–18. https://doi.org/10.1080/02673037.2021.2004094

Bian, X., Fabra, N., 2020. Incentives for information provision: Energy efficiency in the Spanish rental market. Energy Econ. 90, 104813. https://doi.org/10.1016/j.eneco.2020.104813

Bird, S., Hernández, D., 2012. Policy options for the split incentive: Increasing energy efficiency for low-income renters. Energy Policy, Special Section: Frontiers of Sustainability 48, 506–514. https://doi.org/10.1016/j.enpol.2012.05.053

Burfurd, I., Gangadharan, L., Nemes, V., 2012. Stars and standards: Energy efficiency in rental markets. J. Environ. Econ. Manag. 64, 153–168. https://doi.org/10.1016/j.jeem.2012.05.002

Cajias, M., Fuerst, F., Bienert, S., 2016. Are Energy Efficiency Ratings Ignored in the German Housing Market? – Evidence from a Large-Sample Hedonic Study (SSRN Scholarly Paper No. ID 2799206). Social Science Research Network, Rochester, NY. https://doi.org/10.2139/ssrn.2799206

Canstar Blue, 2022. Average Solar System Size & Costs [WWW Document]. Canstar Blue. URL https://www.canstarblue.com.au/solar/average-solar-system-size-and-cost/ (accessed 3.7.22).

Casado, F., Hidalgo, M.C., García-Leiva, P., 2017. Energy efficiency in households: The effectiveness of different types of messages in advertising campaigns. J. Environ. Psychol. 53, 198–205. https://doi.org/10.1016/j.jenvp.2017.08.003

Cellini, S., 2021. Split incentives and endogenous inattention in home retrofits uptake: a story of selection on unobservables? Energy Econ. 104, 105656. https://doi.org/10.1016/j.eneco.2021.105656

Charlier, D., 2015. Energy efficiency investments in the context of split incentives among French households. Energy Policy 87, 465–479. https://doi.org/10.1016/j.enpol.2015.09.005

Daly, A., Hess, S., de Jong, G., 2012. Calculating errors for measures derived from choice modelling estimates. Transp. Res. Part B Methodol., Emerging and Innovative Directions in Choice Modeling 46, 333–341. https://doi.org/10.1016/j.trb.2011.10.008

Dodd, T., Nelson, T., 2022. Australian household adoption of solar photovoltaics: A comparative study of hardship and non-hardship customers. Energy Policy 160, 112674. https://doi.org/10.1016/j.enpol.2021.112674

Domain, 2021. Domain Rental Report - September 2021 [WWW Document]. Domain. URL https://www.domain.com.au/research/rental-report/september-2021/ (accessed 3.25.22).

Fuerst, F., Haddad, M.F.C., Adan, H., 2020. Is there an economic case for energy-efficient dwellings in the UK private rental market? J. Clean. Prod. 245, 118642. https://doi.org/10.1016/j.jclepro.2019.118642

Fuerst, F., Warren-Myers, G., 2018. Does voluntary disclosure create a green lemon problem? Energy-efficiency ratings and house prices. Energy Econ. 74, 1–12. https://doi.org/10.1016/j.eneco.2018.04.041

Gabriel, M., Watson, P., 2012. Supporting Sustainable Home Improvement in the Private Rental Sector: The View of Investors. Urban Policy Res. 30, 309–325. https://doi.org/10.1080/08111146.2012.673484

Heffernan, Troy William, Daly, M., Heffernan, E.E., Reynolds, N., 2021. The carrot and the stick: Policy pathways to an environmentally sustainable rental housing sector. Energy Policy 148, 111939. https://doi.org/10.1016/j.enpol.2020.111939

Heffernan, Troy W., Heffernan, E.E., Reynolds, N., Lee, W.J. (Thomas), Cooper, P., 2021. Towards an environmentally sustainable rental housing sector. Hous. Stud. 36, 397–420. https://doi.org/10.1080/02673037.2019.1709626

Heller, R., 2019. Financing Solar PV for Single-Family Rental Properties, in: Walker, T., Krosinsky, C., Hasan, L.N., Kibsey, S.D. (Eds.), Sustainable Real Estate: Multidisciplinary Approaches to an Evolving System, Palgrave Studies in Sustainable Business In Association with Future Earth. Springer International Publishing, Cham, pp. 313–327. https://doi.org/10.1007/978-3-319-94565-1_12

Hope, A.J., Booth, A., 2014. Attitudes and behaviours of private sector property investors towards the energy efficiency of rentered homes. Energy Policy 75, 369–378. https://doi.org/10.1016/j.enpol.2014.09.018

Hopkins, E.A., Carswell, A.T., Love, K.R., 2020. Impacts of ENERGY STAR Appliances on U.S. Multifamily Rents. Fam. Consum. Sci. Res. J. 49, 37–51. https://doi.org/10.1111/fcsr.12372

Hoyos, D., 2010. The state of the art of environmental valuation with discrete choice experiments. Ecol. Econ. 69, 1595–1603. https://doi.org/10.1016/j.ecolecon.2010.04.011

Itten, A., Sherry-Brennan, F., Hoppe, T., Sundaram, A., Devine-Wright, P., 2021. Co-creation as a social process for unlocking sustainable heating transitions in Europe. Energy Res. Soc. Sci. 74, 101956. https://doi.org/10.1016/j.erss.2021.101956

Lang, M., Lane, R., Zhao, K., Tham, S., Woolfe, K., Raven, R., 2021. Systematic review: Property investors' willingness to retrofit energy efficiency improvements. J. Clean. Prod. 303, 127041. https://doi.org/10.1016/j.jclepro.2021.127041

März, S., 2018. Beyond economics—understanding the decision-making of German small private property investors in terms of energy efficiency investment. Energy Effic. 11, 1721–1743. https://doi.org/10.1007/s12053-017-9567-7

Melvin, J., 2018. The split incentives energy efficiency problem: Evidence of underinvestment by property investors. Energy Policy 115, 342–352. https://doi.org/10.1016/j.enpol.2017.11.069

Miu, L., Hawkes, A.D., 2020. Private property investors and energy efficiency: Evidence for policymakers from a large-scale study in the United Kingdom. Energy Policy 142, 111446. https://doi.org/10.1016/j.enpol.2020.111446

Nixon, H., Saphores, J.-D.M., 2009. Information and the decision to recycle: results from a survey of US households. J. Environ. Plan. Manag. 52, 257–277. https://doi.org/10.1080/09640560802666610

Osberghaus, D., Hinrichs, H., 2021. The Effectiveness of a Large-Scale Flood Risk Awareness Campaign: Evidence from Two Panel Data Sets. Risk Anal. 41, 944–957. https://doi.org/10.1111/risa.13601

Phillips, Y., 2012. Property investors versus renters: Information asymmetry and mismatched preferences for home energy efficiency. Energy Policy 45, 112–121. https://doi.org/10.1016/j.enpol.2012.01.067

Rose, J.M., Bliemer, M.C.J., 2013. Sample size requirements for stated choice experiments. Transportation 40, 1021–1041. https://doi.org/10.1007/s11116-013-9451-z

Steg, L., Vlek, C., 2009. Encouraging pro-environmental behaviour: An integrative review and research agenda. J. Environ. Psychol., Environmental Psychology on the Move 29, 309–317. https://doi.org/10.1016/j.jenvp.2008.10.004

Van der Werff, E., Vrieling, L., Van Zuijlen, B., Worrell, E., 2019. Waste minimization by households – A unique informational strategy in the Netherlands. Resour. Conserv. Recycl. 144, 256–266. https://doi.org/10.1016/j.resconrec.2019.01.032

Varotto, A., Spagnolli, A., 2017. Psychological strategies to promote household recycling. A systematic review with meta-analysis of validated field interventions. J. Environ. Psychol. 51, 168–188. https://doi.org/10.1016/j.jenvp.2017.03.011

Wrigley, K., Crawford, R.H., 2017. Identifying policy solutions for improving the energy efficiency of rental properties. Energy Policy 108, 369–378. https://doi.org/10.1016/j.enpol.2017.06.009

Zander, K.K., 2020. Unrealised opportunities for residential solar panels in Australia. Energy Policy 142, 111508. https://doi.org/10.1016/j.enpol.2020.111508

Appendix A

Table A1: Australian policies for solar PV in rental properties

Scheme	Description
Queensland Solar for Rentals trial	The Queensland Government offered 1,000 rebates of up to $3,500 for landlords to install solar PV on their rental properties. The program ended in mid 2020.
Victoria Solar for Rentals program	Offers eligible landlords a rebate of up to $1,850 for the installation of solar PV on their property plus the option of an interest-free loan up to the same amount of the rebate as $1,850 for a duration of 4 years or 48 months until 30 June 2021. The program is still active.
Moreland pilot program	Worked with three properties to install solar.
Collaboration between Z-Net Uralla (community group in regional NSW) and CORENA (Citizens Own Renewable Energy Network Australia) fund	Program to give landlords interest-free loans to install solar on their rental properties.
"Solar savers" scheme, Darebin City Council in Melbourne	Initiative to offer landlords interest-free loans that can be paid off via rate instalments. Landlords can transfer their loan to the new owner when the property is sold
Solar Savers Adelaide program, Adelaide City Council	Solar Savers Adelaide was a scheme from the City of Adelaide to install solar PV systems on low-income owner-occupied and rental dwellings. The costs of systems were covered by the council and repaid through an additional council rates charge. The program ended in early 2018.

Table A2: Australian policies for energy efficiency in rental properties

Scheme	Description
Minimum Energy Efficiency Standards for Rental Homes (ACT)	The ACT Government has committed to the goal of introducing minimum energy efficiency standards for rental homes.
ACT's home energy efficiency star rating	The ACT is the only state or territory in Australia where a home's energy efficiency star rating must be disclosed to the renter before they move in (but poorly enforced and doesn't apply to properties without energy efficiency ratings).
Victorian Budget 2020/2021: Minimum efficiency standards for rental properties	Rental homes must have a fixed heater (not portable) in good working order in the main living area by 29 March 2021. If a fixed heater has not been installed in the main living area by that date, the rental provider must install an energy efficient heater. From 29 March 2023, heaters must also meet energy efficiency standards subject to some exceptions.
Victorian Government announcement	In November 2020, the Victorian Government announced that it would introduce minimum standards for insulation, draught sealing and hot water systems in rental properties.
ACT Government Renters' Home Energy Assessments program	This program provides Australian Capital Territory residents who rent their home with free energy assessments.
COAG Energy Council meeting, November 2019	All jurisdictions signed up to an addendum committing them to establishing a framework for energy-efficiency standards for renters by the end of 2022, to be implemented in law by 2025.

Appendix B

Table B1: Best-worst scaling results: latent class analysis

	BWS Class 1	BWS Class 2	BWS Class 3
Can't afford	1.101 (1.115)	3.200*** (0.544)	-1.207*** (0.177)
Payback periods too long	1.987*** (0.730)	1.647*** (0.239)	-0.757 (0.498)
Rental margins are low	1.798*** (0.695)	2.175*** (0.271)	-0.606* (0.348)
Won't reduce time on rental market	0.765 (0.600)	0.406** (0.205)	-0.899*** (0.294)
I don't receive the savings	3.011** (1.434)	0.930*** (0.275)	-0.571* (0.340)
No higher rents	3.086** (1.328)	1.149*** (0.272)	-0.124 (0.352)
Won't increase resale value	1.537* (0.829)	0.821*** (0.204)	-0.395* (0.228)
Can't install	0.275 (0.677)	0.570*** (0.182)	0.802** (0.396)
Not enough time	-0.063 (0.221)	0.361** (0.164)	-0.929** (0.390)
Insufficient government support	1.492 (1.063)	1.086*** (0.250)	-0.594*** (0.205)
Fully-detached	1.710** (0.782)	1.585** (0.669)	N/A
Female	0.054 (0.224)	0.379* (0.198)	N/A

	BWS Class 1	BWS Class 2	BWS Class 3
Have lived in property	-0.404* (0.238)	-0.146 (0.205)	N/A
Over 500 rent	-0.425* (0.250)	-0.632*** (0.212)	N/A
Income 2000 plus	0.131 (0.251)	-0.489* (0.252)	N/A
Long investment	0.428* (0.225)	0.108 (0.217)	N/A
Important for living costs	0.074 (0.225)	0.361* (0.206)	N/A
Class share	0.447	0.318	0.236
Log likelihood		-27,546.73	
AIC/N		5.390	
Observations		10,241	

*Notes: Robust standard errors. Standard errors are in parentheses. Models control for ASCs. *** p < 0.01, ** p < 0.05, * p < 0.1. Parameters are estimated for each class and can be interpreted as the net marginal importance of one barrier compared to the reference "Not considered" barrier, within the same class. The estimates of the socio-demographic and sentiment variables for the other classes are interpreted relative to the third class.*

Appendix C

Table C1: Discrete choice experiment results: latent class analysis

	DCE Class 1	DCE Class 2	DCE Class 3
Monthly payments	-0.237* (0.140)	0.651*** (0.227)	-1.114*** (0.366)
Monthly payments tied to property	-0.128 (0.125)	0.935*** (0.247)	-1.524*** (0.439)
Property investor	0.444** (0.194)	-0.688** (0.283)	-2.515*** (0.783)
Third party	-0.531*** (0.178)	-0.493 (0.338)	-2.874*** (0.587)
System cost	-0.000* (0.000)	-0.001*** (0.000)	-0.001*** (0.000)
Rent price agree	1.586*** (0.609)	1.100* (0.657)	N/A
Full-time employed	1.367*** (0.498)	0.361 (0.542)	N/A
Class share	0.310	0.310	0.381
Log likelihood		-1752.490	
AIC/N		2.014	
Observations		1,764	

*Notes: Robust standard errors. Standard errors are in parentheses. Model controls for ASCs. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The estimated parameters for the categorical attributes can be understood as the marginal utility as one moves from one level of an attribute to another.*

Appendix D

Table D1: Discrete Choice Experiment results: MMNL

Attributes		
Monthly payments	-0.076 (0.094)	
Monthly payments tied to property	-0.066 (0.099)	
Property investor	-0.049 (0.144)	
Third party	-0.343*** (0.119)	
System cost	-7.903*** (0.162)	
Dist. of RP: System cost	-1.252*** (0.158)	
Interactions	Rent price agree	Full-time employed
Monthly payments	0.160 (0.237)	0.025 (0.232)
Monthly payments tied to property	0.212 (0.229)	-0.003 (0.240)
Property investor	0.067 (0.313)	0.143 (0.329)
Third party	-0.247 (0.274)	0.350 (0.289)
System cost	0.000 (0.000)	0.000** (0.000)
Log likelihood	-1,811.51	
AIC/N	2.075	
Observations	1,764	

*Notes: Robust standard errors. Standard errors are in parentheses. Models control for ASCs. The random parameter (RP) for "system cost" has a log-normal distribution. The model uses Halton draws with 500 replications to simulate the maximum likelihood. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*