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New Forms of Solar PV Provisioning Needed to Advance Energy Justice for Lower Income Households

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Abstract

Australia leads the world with rapid small-scale adoption of solar photovoltaic (PV) encouraged by feed-in-tariffs (FiTs) and rebates. The common business model for small-scale solar PV is designed around individual installation ownership requiring an upfront capital cost from the dwelling owner and rooftop capacity. These conditions are prohibitive for low-income households and renters. The unequal household access to solar PV is occurring as the poorest households experience the most deleterious impact from a sustained period of substantive electricity price increases.

Around 1.8 million Australian households fall within the lowest income quintile. More than one third of the poorest households are renters. Poor households also spend higher proportions of income and expenditure on energy. Thus the poorest households experience greater disadvantage from electricity price increases. The significant scale of Australian household exclusion from the opportunity to reduce energy bills using solar PV raises important principles and practices of energy justice—that the poorest and most vulnerable have equitable access to energy needed for health and well-being that they can afford.

This paper presents the results of a 2018 pilot project which examined the issues influencing a low-income household's decision-making about adopting solar energy to meet its energy needs, the primary information sources for their decision-making, and the advantages and disadvantages of current solar PV business models. Income and demographic data were mapped against solar PV installations by local government area (LGA), focus groups were conducted in the poorest LGA of Australia's largest capital city, and solar PV business models for household uptake were analysed.

Our study provides new insights into older person household attitudes to solar energy, the influence of peers and social norms on meeting household energy needs, and the legal and commercial issues inherent to existing solar PV business models. The results suggest if energy justice is to apply to all—not some—households then low-income household solar PV access needs to be reframed from being a problem to be solved by the individual household to a solution of new access options not dependent on households paying upfront costs or having roof ownership. The results also indicate the current 'shotgun' approach to incentives or business models will exacerbate energy injustice, different household types do not fit the generic assumption of energy policies and business models that consumer/prosumer behaviour will change with price and incentives, and local government could play a key role in improving energy justice.

1. Introduction

The affordability of household energy is a significant political and public concern (ACCC 2018; Australian Government 2017). Increases in electricity prices paid by Australian households—of which nearly 100% use mains electricity—have been well above general price and wage increases since the mid-2000s and have noticeably escalated in recent years (Chester 2015).

Chester (2013) documents the widespread and systemic deleterious impact on the well-being, health and lifestyle of low-income Australian households from the cumulative effects of ever-increasing electricity bills over a sustained period. This study also found that low-income households have reduced their energy use in response to rising energy bills, the scope for further reductions is significantly limited, and substantive improvements in household energy efficiency (such as energy saving appliances, household repairs/improvements) is prohibited by a lack of financial resources as an owner-occupier or being a renter.

Concurrent with rapidly rising energy bills and household energy impoverishment, Australia has been leading the world in small-scale adoption of solar energy with more than 20% of homes estimated to have installations (Australian PV Institute 2016: 5). The installed capacity of solar PV energy in Australia quadrupled from 2011 to 2016. This occurred as public debate intensified about renewable energy sources to reduce Australia's high reliance on carbon-emitting fossil fuels and there has been a prolonged period of energy and climate change policy uncertainty. The pace of small-scale adoption, according to the Clean Energy Regulator (2018), reached in 2017 the equivalent of 9,500 solar panels being installed each day and was more than a 40% increase on the previous year.

The rapid residential uptake of solar PV has been encouraged through State government FiTs and other incentives such as rebates. FiTs provide the opportunity for energy in excess of need to be sold to the household's electricity supplier. Funding subsidies have also contributed to solar PV adoption by schools, hospitals, public buildings, mine sites, and tourist locations as well as industrial, agricultural and recreational applications. New battery storage technologies have provided further impetus to the installation of solar PV. The South Australian, Queensland, Tasmanian and Victorian State governments have announced support for modest solar and battery storage projects to lower the energy bills of, for example, public housing, schools, community buildings and aged care facilities.

Consequently, many Australian households through the adoption of rooftop solar PV are 'prosumers' being both producers and consumers of electricity. However, barely 2% of installed solar PV capacity is independent of the centralised electricity grid (Australia PV Institute 2016: 10). This means that most prosumers using rooftop solar PV 'import' electricity from the grid when their production is insufficient to match their consumption and 'export' electricity to the grid when production exceeds consumption. It also means that most current Australian solar PV prosumer households will—without sufficient additional capacity—not be immune from future electricity price increases although the extent of impact will depend on how much of their consumption is supplied by the centralised electricity grid.

Electricity retailers have developed business models to support small-scale solar PV uptake. The dominant business model to encourage household adoption is structured around individual ownership requiring an upfront cost from the dwelling owner. This model advantages owner-occupiers with adequate financial resources and suitable rooftop capacity. The upfront cost excludes low-income households, and renters are further disadvantaged without rooftop property rights. This unequal access to solar PV, as low-income households experience the most deleterious impact from substantive energy price increases, raises important energy justice principles and practices.

Energy justice:

> is about ensuring that everyone can afford the energy they need for health and well-being. It comprises a range of factors … [including] how government policies affect the way in which household energy is regulated, produced and priced, as well, of course as the way in which individual household reliance on energy and needs comes in play, and ensuring the needs of vulnerable households are met (Saunders 2011, cited by Hall 2013: 423).

This conceptualisation of energy justice focuses on the consumption of energy as a basic need, its affordability and distribution, and the role of policy. Others have conceived energy justice more broadly as encompassing prohibitive and affirmative principles concerning human rights and capabilities that should apply across the spectrum of energy production and distribution to consumption and regulation (e.g. Sovacool, Sidorstov and Jones 2013).

We concur that the concept of energy justice should apply across the energy continuum. Thus we use the concept in this paper to mean that the poorest and most vulnerable in society—those with the lowest income levels—should have equitable access to the energy needed for health and well-being that they can afford. 'Equitable access', in our view, refers to the production, distribution, consumption and regulation of energy both in terms of existing energy systems and transitioning to future low carbon energy systems.

In this paper we present the findings from a recent pilot research project seeking to progress understanding of the 'energy injustice' issues to be addressed for low-income households. Solar PV is envisaged as a possible household energy system to provide the poorest in society with greater control over their energy 'production and consumption' costs.

Section 2 outlines the context for the pilot project—the current energy landscape for low-income Australian households. Section 3 details the research objectives, design and methodology for the pilot project. Section 4 discusses the limitations of the research method of focus groups and the implications for the qualitative data collected. Section 5 highlights the significant findings from the pilot project. Section 6 discusses the insights provided by the findings, the implications of the results and proposes future research directions to improve energy justice—through access to solar PV—for low-income renters.

2. The current energy landscape for low-income Australian households[1]

Around 1.8 million (21%) of Australian households fall within the lowest income quintile, and the main source of income for nearly three quarters of these households is government pensions and allowances (ABS 2017b). More than one third of these are renters with nearly 22% in the private rental market. The number renting has grown as home buying costs have escalated. The number of low-income households in private rental housing has also grown as the availability of public and community housing has not matched demand.

Australian low-income households have higher proportions with five or more persons, multiple families, and no dwelling access to the internet. Poor households spend higher proportions of income and expenditure on energy (Jamasb and Meier 2010). Low-income Australian households spend around 3.5% of average weekly *expenditure* on electricity, more than double the proportion spent by the richest households (ABS 2017a). This average, however, masks the disproportionate impact of energy costs between income groups. The poorest income quintile spends the highest proportion of *disposable income* on electricity costs and more than 3 times that spent by the highest income households (Chester and Morris 2012).

These characteristics mean that the poorest households experience greater disadvantage from electricity price increases and indicate the scale of household exclusion from the

[1] This section draws from Chester, Elliot and Crossley (2018).

opportunity to reduce energy bills using solar PV.[2] The characteristics of low-income households also indicate contracting, billing and technology access issues to overcome if 'energy justice' is to apply to all households.

The feasibility of low-income households accessing solar PV will also depend, amongst other things, on their willingness to shift from their current energy supply arrangements. Russell-Bennett et.al (2017: 6) found that motivation by Australian low-income households to adopt energy efficiency was driven by "awareness, low perceived cost, incentives and rebates, comfort and health/wellness/stress [and] the top five barriers were high perceived costs, knowledge gaps, lack of trust, split incentives and low literacy/cultural barriers".

Other Australian studies of household motivators/ barriers to adopt solar and other microgeneration technologies have found: availability or not of feed-in tariffs influenced satisfaction with adoption by Western Australian households (Simpson and Clifton 2015); and, information through social networks was important for Queensland households (Sommerfeld et. al 2017).

3. Research objectives, design and methodology

3.1 Research objectives and methodology

Existing research has focused on current models for solar PV adoption and does not address the barriers posed for low-income owner-occupier households without the financial capacity or low-income renters without rooftop property access rights. In the first half of 2018 we conducted a small-scale research project as a step towards the development of new options for low-income households to have greater control over their electricity costs through solar PV access. The research objectives of this project were:

1. To examine the advantages/disadvantages of solar PV business models for Australian households;
2. To explore the issues which influence a low-income household's decision-making about the adoption of solar energy to meet its energy needs;
3. To identify the primary information sources which low-income households may use to inform decision-making about switching to solar; and
4. To analyse the legal and commercial issues—for different household types—arising from the different marketing offers to encourage households to install solar PV.

The pilot project used a mixed methods approach of secondary analysis, focus groups and document analysis to collect and analyse quantitative and qualitative data.

3.2 Secondary analysis

Income data from the 2016 ABS Census was used to rank each LGA within each Australian State and Territory, and within each capital city and non-capital city area, to identify those areas with the lowest income households.

Total household weekly income was annualised and classified into four categories, based on the ABS income ranges: $0 to $26,000-$33,999; $0 to $41,600-$51,999; $0 to $52,000-$64,999; and, above $65,000. These categories were chosen because average weekly earnings, in 2016, were the equivalent of $60,600 p.a., the minimum wage was $35,000 p.a. and the ABS estimated the annual mean income for lower income households at $47,580.[3]

[2] Recent claims that 'energy remains affordable' (e.g. Phillips 2018) overlook the reductions in energy use by low-income households and the subsequent impacts on for their standard of living (Chester 2013).
[3] The ABS define 'lower income' as those within the lowest and second income quintiles.

Selected demographic data were similarly ranked for each LGA. These data were: the proportion of households with five plus persons; the proportion of households with multiple families; the proportion of households by housing tenure; the proportion of households which have internet access or not from the dwelling; and, the proportion of households with Aboriginal and/or Torres Strait Islander persons. In addition to household income, these demographic characteristics are indicators of the influences on a household's capacity to manage energy needs and to consider alternative energy sources as well as indicating some of the disadvantages that a household may face.

Income and demographic data by LGA were 'mapped' against Australia PV Institute data on solar energy installations in each LGA. This data shows the proportion of dwellings with installations (density), and the absolute and relative capacities.[4]

The secondary data analysis was also used to identify the most suitable low-income LGA within the Sydney metropolitan area from which to recruit focus group participants.[5] Fairfield LGA was chosen from which to select focus group participants because it has the following household characteristics most suitable for the pilot project:

- the highest proportion (7%) of Sydney households with multiple family households;
- the highest proportion (21%) of Sydney households with 5+ persons usually resident;
- the highest proportion (17%) of Sydney households with no dwelling internet access;
- the highest proportion (19%) of Sydney households with a gross income less than the 2016 minimum wage;
- the highest proportion (34%) of Sydney households with a gross income within the lowest and second income quintiles which are the poorest households;
- the highest proportion (42%) of Sydney households with a gross income less than average weekly earnings of all those employed;
- it is 31st of 33 Sydney LGAs with the highest dwelling capacity to install solar;
- it is 28th of 33 Sydney LGAs with the highest dwelling density (17%) of solar installations; and
- 31% of households within the LGA are renting, 29% own their home outright and 26% are buying their home.

3.3 Focus groups

Face-to-face discussion is the most appropriate method to gain detailed and contextual insights into the issues influencing a low-income household's decision-making about their energy needs and how these may be better met through alternative supply arrangements. Focus groups tap into participants' perceptions, attitudes and opinions. Focus groups were also a cost-effective method for a small-scale pilot project such as this.

The purpose of the focus groups was to determine attitudes to, perceptions of and/or experience of solar energy, the barriers faced in adopting solar energy, willingness to consider new household energy solutions, and capacities to adopt new technologies given the diversity of household energy needs, housing tenure and financial resources.

[4] Subsequent analysis included 2016 ABS Census data on dwelling type given the importance of rooftop capacity to solar PV installations
[5] The research project team is based in Sydney.

Community organisations within the Fairfield LGA—most likely to have contact with low-income households—were asked to distribute a 1-page project information sheet and the Participation Information Statement. Adult household members who self-identified as low-income (i.e. an annual household income less than $50,000) and wished to participate were asked to directly contact the project team (by email or mobile phone) for details of the focus group arrangements.

A sampling frame does not exist for low-income households. Therefore random selection of participants is not an option. Recruitment through snowballing (one subject provides the name of another subject, and so on) has several weaknesses such as representativeness of the participants, and the time/difficulty of finding sufficient participants. It is for these reasons that self-selection of participants was deemed suitable for the qualitative data collection.

Four 1-hour focus groups with six participants each were proposed. Two focus groups were held with a total of 12 participants (see 4.1 below). The focus groups were held at meeting rooms in two Fairfield libraries which were easily accessible from adjoining shopping centres and public transport. The focus group discussions were recorded.

Ethics approval was obtained from the University of Sydney's Human Ethics Committee for focus groups to be held with low-income households within the Fairfield LGA.[6]

3.4 Document analysis

Details were collected of the different types of business models (marketing offers) from electricity companies, and small-scale projects provided by some local councils, commercial and not-for-profit organisations, to encourage households to install a solar PV system. A desktop analysis was conducted to categorise the business models by ownership type, examples of locations at which the installation of each business model had occurred, the organisations (government, private sector/energy company or not-for-profit) involved, and the key features. An analysis was also conducted of the legal and commercial issues for each of the different business models.

4. Limitations using focus groups as one of the pilot project's research methods

Less participants for the focus groups were recruited than intended and representation of different household types was skewed towards older adults post-retirement who were owner-occupiers. We consider, at least three factors, contributed to these recruitment issues.

First, the focus groups were conducted during the day (10:00am to 3:00pm) which precluded the participation of those working and those caring for children or other household members during this time period. Second, focus group participants were asked to self-identify as having an annual income of $50,000 or less. Those in receipt of low incomes are possibly more reluctant to share their income details outside of immediate family and close friends. Third, participants were asked to contact the project team by email or mobile phone. Low-income households have less access to the internet from home, as ABS Census data highlights, and the costs of mobile phone use are limited to necessities (Chester 2013).

These are important factors to be addressed to access a range of different low-income household types. Nevertheless, we consider that the findings from the focus groups provide rich data about the attitudes of older low-income households to using solar PV for their household needs and are very indicative of the issues to overcome some of the energy injustices confronting low-income households more generally.

[6] University of Sydney Human Research Ethics Committee Project No. 2018/289 (1 May 2018).

5. Results

5.1 Household characteristics by LGA

Tables 1 and 2 present summary examples for NSW and Victoria of the findings from the secondary data analysis. These tables show—ranked by income—the bottom two and top two LGAs in Sydney and outside Sydney, and for Melbourne and outside Melbourne.

In the case of Sydney (Table 1), nearly 40% of households in the Fairfield LGA have an annual income of less than $65,000. This is the highest proportion of low-income households across the 33 LGAs comprising the Sydney metropolitan area. Within the Fairfield LGA, 7% are multiple family households with 21% of more than five members, 17% do not access the internet from home and 17% of dwellings have solar PV installations. Notably 31% of households are renters within this LGA with 84% of housing stock being separate or semi-detached dwellings (indicating the potential rooftop space for solar PV). These household characteristics for the Fairfield LGA are all much higher than the average for Sydney and those for the two highest income Sydney LGAs with the exceptions of separate/semi-detached housing and rental housing. The highest income LGAs in Sydney are located in the inner north and eastern LGAs of Sydney which have the highest densities for rental apartments.

For the two lowest and two highest income LGAs outside metropolitan Sydney, the average proportions of low-income households, and those with solar PV installations, separate/semi-detached dwellings and no dwelling internet access are all higher than the Sydney LGA average and higher than the 'poorest' Sydney LGA of Fairfield with respect to solar PV installations and home internet access. On the other hand the proportion of households with multiple families, five plus persons and renting are lower when compared to the Sydney LGA average.

Table 1: Selected household characteristics for NSW LGAs ranked by income

NSW LGAs	% of H'holds with annual income less than $65,000	Solar PV capacity installed (kW)	% of dwellings with solar PV install.	Multiple family household	Five or more persons	Separate or semi-detached house	Rented Housing	Internet not accessed from dwelling
SYDNEY: Bottom 2 and top 2 LGAs ranked by income								
Fairfield	39.5%	31,881	16.8%	6.7%	20.9%	84.0%	31.2%	16.9%
Canterbury-Bankstown	36.8%	31,365	10.9%	3.8%	15.9%	82.1%	31.7%	15.2%
North Sydney	16.1%	2,524	6.4%	0.4%	2.2%	23.6%	41.5%	5.6%
Woollahra	15.3%	2,439	5.1%	0.6%	5.2%	41.4%	29.4%	5.3%
AVERAGE SYDNEY	**26.8%**	**15,205**	**11.4%**	**2.5%**	**10.7%**	**66.9%**	**29.6%**	**9.5%**
OUTSIDE SYDNEY: Bottom 2 and top 2 LGAs ranked by income								
Nambucca *	50.1%	6,601	25.2%	1.3%	6.3%	85.8%	21.3%	20.2%
Kyogle	49.1%	3,986	28.5%	1.0%	6.2%	94.3%	15.7%	20.7%
Yass Valley	25.5%	6,904	22.4	1.2%	9.9%	97.0%	14.1%	11.8%
Queanbeyan-Palerang	24.7%	17,041	17.3	1.5%	8.2%	85.4%	23.6%	11.1%
AVERAGE OUTSIDE SYDNEY	**38.1%**	**12,303**	**21.4**	**1.0%**	**7.3%**	**77.0%**	**20.1%**	**18.5%**

*6.3% of households with Aboriginal or Torres Strait Islander persons

Source: ABS 2016, 2017b; Australia PV Institute 2018.

The same patterns for capital/non-capital city households are evident for Victoria as demonstrated in Table 2.

Table 2: Selected household characteristics for Victorian ranked by income

VICTORIA LGAs	% of H'holds with annual income less than $65,000	Solar PV capacity installed (kW)	% of dwellings with solar PV install.	Multiple family household	Five or more persons	Separate or semi-detached house	Rented Housing	Internet not accessed from dwelling
MELBOURNE: Bottom 2 and top 2 LGAs ranked by income								
Greater Dandenong	40.8%	27,150	13.6%	4.0%	14.2%	88.2%	30.5%	15.0%
Brimbank	37.5%	32,568	15.0%	3.6%	14.0%	95.1%	22.6%	15.5%
Nillumbik	21.6%	11,999	15.5%	1.5%	12.1%	97.1%	8.2%	5.7%
Stonnington	21.4%	6,389	6.6%	0.4%	4.2%	47.9%	37.9%	7.3%
AVERAGE MELBOURNE LGAs	**29.7%**	**22,453**	**12.5%**	**1.6%**	**9.0%**	**84.1%**	**25.4%**	**10.1%**
OUTSIDE MELBOURNE: Bottom 2 and top 2 LGAs ranked by income								
Central Goldfields	52.8%	5,511	23.2%	0.6%	5.2%	96.3%	17.3%	23.4%
Benalla	45.6%	4,894	21.8%	0.6%	5.0%	92.1%	19.2%	18.8%
Queenscliffe	20.1%	10,222	16.6%	0.2%	5.7%	95.7%	7.4%	6.4%
Surf Coast	19.5%	460	15.9%	0.5%	0.7%	97.9%	11.1%	5.9%
AVERAGE OUTSIDE MELBOURNE LGAs	**37.6%**	**10,344**	**20.6%**	**0.6%**	**6.1%**	**87.4%**	**15.8%**	**15.8%**

Source: ABS 2016, 2017b; Australian PV Institute 2018.

These household characteristics indicate:

- areas with higher concentrations of low-income households also have the highest potential capacity for solar PV given the greater availability of rooftop capacity and these areas also have relatively high levels of households in rental housing; and
- internet access from home is much less in areas where low-income households live, and even more so for non-metropolitan areas.

If low-income households are to access distributed household energy systems such as solar PV, the framing of solutions need to ensure that renters are not excluded or marginalised, and need to consider the extent to which use of such an energy system is dependent on household internet access. Other factors that solutions need to consider are the age profile of households, family composition of households/number of children present and the language(s) predominantly spoken at home. These factors influence household energy use and willingness to consider alternatives to existing energy supply arrangements (see Sections 1, 2 and 5.2; Chester 2013; Russell-Bennett et.al 2017).

5.2 Household attitudes to using solar PV to meet energy needs

Focus group participants gave three key reasons for not having, or having minimal, solar uptake:

1. They were managing their energy use and bills well (particularly post-retirement) and it would not be worth their while to install solar (or more capacity).
2. They were too old to recoup any upfront investment in solar.
3. They did not know who to trust for information and wanted an expert authority to help them manage the risks and uncertainties associated with a solar PV installation.

These reasons were intertwined with age being a key factor. For instance, because some participants had the time (post-retirement) to manage their energy use they had manageable

bills. This meant they thought solar PV would not be worth it for them—it might only reduce their electricity bill by a couple of hundred dollars a year. This combined with participants' views about their life stage—that they may not live long enough to recoup the costs—or the uncertainty of housing tenure associated with becoming older and frailer (e.g. potentially having to enter a nursing home).

Participants also expressed a high degree of scepticism about consumer choice for electricity. This was apparent in their concerns about who to trust for information about solar PV, but also more broadly as a lack of trust in the electricity retail sector.

Overall, the focus groups pointed to: the interaction between the life stage of consumers and the business models that will appeal to them financially; and, the problems of consumer choice for complex and technical goods where there is low trust in the market.

The key findings from the focus groups were:

- older low-income households consider that they are managing their electricity bills, and more so when their children are no longer living with them;
- there is a high level of understanding about the common marketing offer for household solar installation with high upfront costs for the dwelling owner and suitable rooftop space;
- older low-income households generally consider that they will not live long enough for a 'return' on the initial capital cost to install a solar energy system;
- there is concern about deciding which are the best solar products and installations, from whom to seek expert advice, and a lack of trust in marketing information;
- family, friends and neighbours are sources of advice although many households consider that government should help them manage the risk by providing clear information when complex technical decisions are needed about installing or using a solar energy system;
- older low-income households perceive little difference between the electricity companies and thus consider they have little control over prices paid and no need to switch companies; and
- decisions about the ways to manage household energy use and responsibility for bill paying differ between household types (e.g. owner, renter, older, with or without children).

5.3 Business models for household solar PV energy systems

Across three types of small-scale solar system ownership—customer, third party and community—we identified a range of business models (Table 3). These models broadly apply to both 'solar PV only' and 'solar PV plus battery'.

Customer ownership may be acquired by self-financing which may be assisted through (Australian Government) rebates and (State Government) FiTs. Alternatively, government or energy companies may provide loans (with interest or interest-free) e.g. Queensland Government's interest-free scheme for low-income homeowners, or AGL's former low interest scheme. Another option for low-income homeowners has been used by the Melbourne Council of Darebin. The council provides financing as a loan, repayments are made through rates over 10 years and a not-for-profit organisation organises installation as well as providing customer advice. Loan schemes generally have a cap (e.g. $4,500 in Queensland) and short-term repayment periods (e.g. 10 years for Darebin Council; 7 years in Queensland; 2 years for the former AGL scheme). Also, NSW regional households—along with businesses and farms—

have been part of community bulk-buys of solar panels at a discount arranged by a not-for-profit organisation (Farming the Sun). Micro-grids are another model for customer ownership. In this case, households form a mini-grid and trade their excess energy with other participants.

Table 3: Types of business models for small-scale solar PV adoption

OWNERSHIP TYPE	BUSINESS MODEL
Customer	1. Fully self-financed 2. Reduced upfront cost (with rebates) and electricity charges (with FiTs) 3. Financed by government or energy company loans (interest or interest-free) 4. Financed by local council and repayments from property rates 5. Community bulk-buy of solar panels at a discount 6. Micro-grid
Third party	1. Power purchase agreement 2. Operating lease 3. Pay-as-you-go 4. Solar hosting 5. Micro-grid
Community	1. Local government, developer, investor, and/or not-for-profit organisation 2. Special purpose entity (energy company or households) 3. Solar garden

Third party ownership of household solar systems is possible through a number of business models. Under a Power Purchase Agreement (PPA) the dwelling owner installs/owns the solar panels and manages the sale of electricity—sometimes through an intermediary— to the resident tenant at less than the retail cost e.g. Ergon Energy Scheme for some Queensland public housing residents. A similar arrangement is an operating lease whereby a third party (or even an energy company) may install panels and the customer makes monthly payments for access to the electricity generated. Pay-as-you-go schemes have also emerged particularly in developing countries. These schemes provide limited amounts of electricity and require regular payments over, for example, a three-year period. Another third party option is solar hosting where a homeowner is paid to install and operate a rooftop solar PV system by, for example, an energy company. In other words, roof space is rented and the electricity generated is dispatched to the grid rather than used by the dwelling owner. The panels used in micro-grids (see above) may also be owned by a third party not the direct (customer/household) participants.

Community ownership of solar PV systems is essentially a variant of customer and/or third party ownership. For example, ‘solar gardens’ are an installation of panels in a public space owned by members of the community. Local government councils, housing developers, individual investors or a not-for-profit organisation may provide the finance for a community solar project until it is repaid by the community organisation e.g. a Sports Centre.

5.4 Legal and commercial issues

The legal and finance structure of each of the business models reviewed all raise a number of issues. These legal and commercial issues, summarised in Table 4, range across consumer protections and rights, the terms of loans and leases, metering, responsibilities for installation property damage, maintenance and the removal of panels, buyout options for leases, the sharing of benefits arising from rebates and incentives between energy companies or third parties with consumers, the criteria used to establish household eligibility for different schemes, the costs and penalties for an early exit from a scheme, and more.

These legal and commercial issues highlight two critical points:

- different household types (e.g. renter, with young children, multiple family, older) need different options to the current common upfront cost scheme to install a solar system which is met by the dwelling owner; and
- options for household (renter and owner-occupier) adoption of solar energy will need to address several issues such as: roofing suitability; responsibility for operation and maintenance; access to consumer data; buyout options; equipment warranty periods; property access issues; consumer protections; and control of the system.

Table 4: Legal and commercial issues with small-scale solar PV business models

BUSINESS MODEL LEGAL-FINANCE STRUCTURE	LEGAL AND COMMERCIAL ISSUES
For all types	Is rooftop capacity in suitable condition for installation of solar panels? Will the conditions of the roof warranty be voided with installation of solar panels? If roofing is unsuitable, are ground-mounted solar panels an option? Who is responsible for potential property damage by installation of solar panels? What approvals or other arrangements are required to install solar panels where multiple households share the same rooftop capacity? If property metering is not by household, can the customer installing panels realise the benefits? Who is responsible for the cost and conduct of any maintenance and/or required repairs? If customer wants to install panels on third party owned property are easements required? What consumer protections and rights exist? Is information from solar panel use securely stored? Is there a risk of misuse by a third party who controls or who has access to the system?
Interest free loans	What are the eligibility criteria for loans? What securities/guarantees are required? What is the loan term? Does the loan term exceed the warranty period of the panels? Who is financing the loan? Do loan repayments coincide with income payments received by the customer? Are there any late repayment penalties?
Reduced upfront capital cost through grants/rebates	Who is financing the grants/rebates? How is eligibility determined for grants/rebates? Are the grants/rebates of limited duration? Do the grants/rebates specify system or installer that needs to be used?
Power purchase agreement (PPA)	What are the criteria for customers to be eligible for a PPA? Does the period of the PPA correlate with housing rental lease periods? Does the lease transfer to the customer at the end of the PPA or are there buyout options? Can the PPA be transferred to a subsequent resident (tenant or owner-occupier)? What are the costs/penalties for early termination of the PPA or if the customer cannot buy out at the end of the PPA term? Is the price paid for electricity generated from the installed solar panels fixed? If not, how is the price calculated and how often may the price change? Are rebates, tax incentives etc the company is eligible for shared with the customer?
Operating lease	What are the criteria for customers to be eligible for an operating lease? Does the period of the operating lease correlate with housing rental lease periods? When are payments due? Do these coincide with income received by the customer? Are there any late payment charges/penalties? What are the costs/penalties of early termination? Are there any buyout options?

BUSINESS MODEL LEGAL-FINANCE STRUCTURE	LEGAL AND COMMERCIAL ISSUES
	What occurs if the customer cannot buyout the lease or cannot transfer the lease to the subsequent resident? If ownership does not transfer to the customer at the end of the lease (or the customer does not wish to lease any longer), who pays for the solar panels to be removed? Are rebates, tax incentives etc the company is eligible for shared with the customer?
Community	How does the customer participate? Does the customer purchase the solar panels or purchase equity in the project? What other eligibility criteria may apply for participation? Does a third party own the solar panels with the benefits flowing to the customers, or are the customers entitled to ownership which reflects their commitment? Who is entitled to rebates, tax incentives or other benefits? If a third party is entitled, are these shared with the customer? Is the electricity generated trade peer-to-peer or sold to an energy retailer? What advice is available to potential customers and how can they access?
Solar hosting	Does the period of the hosting correlate with housing rental lease periods? What are the costs of early termination? Are there any buyout options? What occurs if the customer cannot buy the hosting or cannot transfer the hosting to the subsequent resident? If ownership does not transfer to the customer at the end of the hosting period (or the customer does not wish to host any longer), who pays for the solar panels to be removed? Are rebates, tax incentives etc the company is eligible for shared with the customer?

6. Discussion and conclusion

Australian household energy affordability is a major political and public concern after a sustained period of significant electricity price increases. Solar PV energy provides a key means for greater household control over the cost of electricity bills. Australia has led the world with household adoption of solar PV. Nevertheless this 'energy option' is currently targeted at homeowners with adequate financial resources which creates energy injustice.

The research results reported in this paper suggest that: the accessibility to solar PV by low-income households needs to be reframed from being a problem to be solved by the individual household if energy justice is to apply to all—not some—households; a 'shotgun' approach to uniform incentives or business models will exacerbate not ameliorate energy injustice; policymakers should not ignore the role and influence of peers and social norms on energy consumption decisions by households and particularly older low-income households; different household types do not fit the existing business models that assume consumer and prosumer behaviour will change with price and incentives; and, the motivations, barriers and success factors for solar PV adoption are highly influenced by a household's income level. The feasibility of new business models to open opportunities for low-income household access to reduce their energy bills through solar PV will depend upon the resolution of a number of critical legal and commercial issues as well as the willingness of these households to shift from their current energy supply arrangements.

The research results reported also provide new insights into: the different forms of energy injustice that arise from existing solar PV business models and incentive schemes; older person household attitudes to solar energy which is highly relevant as Australia is experiencing a strong demographic shift to an ageing population; and, the role of family, friends and neighbours as a trusted source of advice about adopting solar PV.

In addition, the results point to the pivotal role that local government can play in improving the energy justice for low-income households—through, for example, the provision of 'trusted' advice on household solar PV systems and installations, or the financing of installations through loan repayments via regular property rates payments, or working with property investors/developers and real estate agents to advance options for low-income renters.

The option for renters to access solar energy has received least attention by policymakers, businesses or researchers. We consider that is primarily because of the range of parties involved (e.g. dwelling owner, real estate agent, housing authority) in addition to the consumer-electricity supplier relationship, and thus the complexity of issues to resolve. The current situation for Australian low-income households, the growth in renting households, and our research findings, demonstrate the need for a national research project that focuses upon low-income *renter* households.[7]

Future research could develop new consumer-focused options—for widespread application to private, public and community rental housing—that overcome barriers to low-income household solar energy use and are supported by electricity retailers, real estate agents, landlords, tenants' unions, public and community housing authorities, affordable housing developers and local councils. This would be assisted by delineation of the different stakeholder issues to be addressed if new consumer options (business models) for low-income households are to be feasible. Such issues may include, for example, lease duration, metering options, responsibility for operation and maintenance, access to consumer data, buyout options, equipment warranty periods, property access, and control of the system. Data could also be collected about the energy needs of low-income renters, their household practices, key energy decision-making issues, and willingness to use solar. Such data could be used to create 'energy profiles' for different low-income renter types and used to inform the design of a set of consumer options (by rental type and household type) to access solar energy which meet the consumer's needs and the legal, commercial and other needs of the multiple stakeholders involved in rental housing.

Solar energy provides a key means for greater household control over the cost of electricity bills. Yet low-income renter households will remain excluded from this step towards energy justice unless there is development and widespread application of new consumer options that are not dependent on upfront capital costs and roof ownership.

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[7] Low-income household characteristics vary across and within Australian States (e.g. multiple family, separate dwelling, languages spoken, energy use mix, housing tenure). There are different State government policy settings supporting solar. A national project can address the implications arising for these differences.

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