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PV in Australian Apartment Buildings – Opportunities and Barriers

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Abstract

This paper outlines opportunities for, and barriers to, increasing PV deployment on apartment buildings in Australia. With PV penetration reaching 40% of residential dwellings in some parts of the country, access to renewable energy for the 14% of Australians who live in apartments has lagged behind. Installation of PV on apartment buildings can help relieve network congestion as well as reduce household energy bills, and with multi-unit dwellings accounting for 25% of new residential building, the opportunities are significant.

Most apartment buildings in Australia operate under strata title which enables individuals or businesses to own a section of a property, while sharing ownership of the common property (CP) of the building. Despite some major advantages of this framework compared with other approaches, issues around strata organisation have led to a perception that PV on apartments is 'too hard.' However, new models are emerging, including those from developers and from community energy organisations, to overcome these barriers to PV deployment.

The huge variety amongst existing building stock precludes standardised retrofitting solutions for PV, while financial viability of such systems is highly dependent on specific load profiles and network tariffs. PV can potentially be installed to supply electricity to CP, to serve individual apartments, or as a resource shared between multiple apartments through embedded networks or virtual net metering. Each approach has particular technical, legal, regulatory and financial issues. The paper explores these issues, and suggests some possible paths forward to facilitate the deployment of PV in multi-unit strata-titled buildings.

1. Introduction

Increasing population pressures have driven the development of 'compact city' planning strategies across Australia's cities, and although the success of these strategies is mixed (Bunker, 2014), 1.3 million Australians (14% of the population) (ABS, 2011) currently live in "flats, units or apartments" (referred to as "apartments" in this paper) and growth in high-density housing continues, with 32% of new dwelling building approvals in August 2015 being apartments (ABS, 2015). Such developments are, of course, unevenly distributed spatially, with over 70% of the population living in multi-unit dwellings in some urban local government areas, such as the City of Sydney, North Sydney and City of Melbourne (ABS, 2011).

Despite Australia's world leading domestic PV uptake, reaching 40% of residential dwellings in some parts of the country(APVI, 2015a) deployment of PV on apartments is much lower. Significantly, 72% of Australian apartment dwellers live in low-rise buildings of 3 storeys or less (ABS, 2011), and a Canadian study (Hachem, Athienitis et al., 2014) found that apartment blocks of 3 floors or less (with good passive solar and energy efficient design) have the potential to generate 96% of their energy usage from rooftop PV. Because apartments house a relatively high proportion of overseas born Australians, young, single people

(Randolph and Easthope, 2007), and households with low gross income (ABS, 2012), lower access to the benefits of reduced electricity bills from PV for these households represents an equity issue.

Because many apartments are located far from utility scale generation, rooftop PV has the potential to reduce network congestion, particularly when located close to commercial loads. Despite representing a valuable market opportunity for the PV industry, and - like community renewable energy (CRE) - having the potential to populate the "scale gap" between utility and household renewable energy (C4CE, 2015), deployment of PV on Australian apartments has been slow. Sections 2 and 3 explore the opportunities and barriers to deploying PV on apartments, both generally and with respect to specific implementation models, through a review of the available literature and with reference to some preliminary data from case studies of apartment blocks in NSW and Victoria. Section 4 examines some alternative governance models, and Section 5 suggests some questions for further research that could help facilitate the deployment of PV in multi-unit strata-titled buildings.

2. General Barriers to Deployment of PV on Apartments

The City of Melbourne's Higher Density Residential Efficiency Solutions (HI-RES) project (City of Melbourne, 2012) identified 4 categories of barriers to sustainable improvements in multi-unit residential buildings: governance, physical limitations of existing building stock, lack of finance and lack of knowledge. What follows is an exploration of the barriers to PV deployment on apartment buildings, using these categories as a starting point, with the addition of a category relating to regulatory and network issues.

2.1. Governance Issues

The ownership of apartment buildings in Australia is largely governed under Strata Title legislation which varies from state to state in its detail and terminology, but is based on common principles (Sherry, 2009). The shared spaces and structure of a strata building are called Common Property (CP), which is either owned collectively by the apartment owners, or by the Owners Corporation (OC) – called Body Corporate in some states – acting as an agent or trustee for the owners. In practice, an elected Executive Committee takes on a lot of the decision making around the upkeep, maintenance and day-to-day management of the building, with some tasks delegated to a strata manager – either an individual employee or an external management company. Decisions involving changes to the by-laws that govern the property or large financial expenditure must be taken by a quorate General Meeting or Annual General Meeting of the Owners Corporation.

The issue of 'split incentive' (or 'principal-agent') issues between property owners and their tenants has been much discussed with reference to energy efficiency investments (Brechling and Smith (1994),Jaffe and Stavins (1994),Schleich and Gruber (2008),Gillingham, Harding et al. (2012)). Owners of rental properties are less likely to invest in energy efficiency measures than owner-occupiers, as the benefits (reduced energy costs) are enjoyed by their tenants. Conversely, renters are less likely to invest, particularly in "immobile" technologies such as PV (Ameli and Brandt, 2015a,p13), as they cannot recoup the full value of their investment, even if they were permitted to install the infrastructure. As only a third of occupied private apartments are owned or part-owned by their occupants, compared to 77% of detached houses (ABS, 2011), the split incentive issue is particularly relevant to this housing type.

High turnover in apartment ownership, compared to standalone houses, is also an issue as property owners are less likely to install PV if they envisage selling the property in the near future (Ma, Polyakov et al., 2015). 38% of apartment owner-occupiers surveyed by the ABS in 2011 had bought the apartment in the previous 3 years (ABS, 2012). Coupled with high levels of investment ownership, this is likely to support a short-term approach to building improvements generally and sustainability retrofits in particular.

2.2. Physical Limitations of Building Stock

There are a number of physical issues around retrofitting PV to apartment buildings that can apply regardless of the implementation or ownership models adopted. Shortage of roof space relative to total energy demand is likely to be most problematic in high-rise buildings, but competition for roof space (e.g. as shared open space) can be an issue in all building types. Within the small sample of case studies, a wide range of roof fixtures - Solar Hot Water, air conditioning units, aerials, phone masts (a common income stream for OCs), housings for lift motors, safety harness fixing points - were found to reduce available space and in some cases create shading issues.

The installation of PV on flat roofs found commonly on apartment buildings may penetrate waterproof coatings and can make access difficult for scheduled resurfacing, although non-penetrating, ballast mounting systems are now available. In addition, cabling may compromise fire separation barriers.

The height of many apartment buildings often necessitates a crane for installation, and may require extra provisions to ensure safe working access, thereby increasing capital costs for PV. As zoning arrangements mean that apartment blocks tend to be clustered, solar access issues can arise, with potential shading caused by existing or future buildings.

2.3. Financial Issues

Regardless of the profitability of PV investment, capital constraints can make it unfeasible to install PV. Like any major common property development, PV installation in a strata block can be funded either by using the existing sinking fund, imposing a special levy, or by borrowing. Arkcoll, Guilding et al. (2013) suggest that using a sinking fund is a preferable option in terms of greater cost efficiency, equity between past, present and future owners, minimisation of financial distress and promotion of community harmony. However, OCs may either have inadequate sinking funds or prefer to reserve them for more urgent repairs (City of Melbourne, 2012). Because OCs do not own the CP but manage it on behalf of the owners, any borrowing by the OC is unsecured and therefore comes at a higher cost than it would for a property owner.

Environmental Update Agreements (EUAs) - specific loans to cover capital costs of sustainability improvements to residential and commercial buildings, repaid through local councils as increased rates charges – are designed to reduce the cost of borrowing, and to help overcome the split-incentive issue. However, there are issues with the legal requirements on strata OCs that means they may require approval by 100% of the owners (and in Victoria, 100% of tenants) (Everett and Bateman., 2010), making EUAs in their existing form hard to utilise for residential strata property.

Whether PV is funded from a loan, sinking fund or special levy, an economic argument is usually needed to gain OC approval for the investment. Typically, PV installations involve payback periods of 7 or 8 years, but this can be considerably longer. Because other sustainability retrofits have considerably shorter paybacks (e.g. 2-3 years for upgrading to LED lighting for one of the case studies in this paper), PV may be seen as low priority, to be considered only after other improvements have been completed. Even then, because of the high turnover of ownership in apartments, the payback period may be too long. Altmann (2013) notes that the costs of environmental improvements retrofitted to properties must be recouped within a few years to be financially viable for owners if there is a high turnover of ownership.

Gillingham, Newell et al. (2009) identify artificially low energy prices that exclude externalities such as the environmental costs of burning fossil fuels as a market failure. Further diluting any energy price signal, for many apartment buildings the CP energy demand is sufficient to trigger high-usage commercial tariff structures with a high ratio of capacity to volumetric charges, which is a significant factor in the slow take-up of PV on apartment buildings. Although a demand tariff structure can be a step towards more cost reflective pricing, the measurement of customers' peak demand (rather than demand at the time of network peak) means that many of these tariffs do not reflect the actual cost of network usage (APVI, 2015b) and may represent a further market failure which disincentives PV deployment. Certainly, it is more difficult to make an economic case for PV if total (network plus usage) peak volumetric tariffs are 12c - 15c/kWh (as for some of the case studies included in this paper), with high demand charges based on evening peaks; compared to stand-alone residential Time of Use tariffs, with typically much higher volumetric charges.

An additional financial obstacle to the early take-up of PV by Owners' Corporations is the tax complexity of dealing with Feed in Tariff (FiT) income. Taxation ruling IT 2505 (due to be replaced by Draft TR 2015) treats OCs as businesses and (except in South Australia, Tasmania and Northern territory), treats income to the OC from the export of PV energy as 'assessable income', meaning that it should be divided amongst the individual owners and declared on each individual's tax return. With most FiTs now reduced to a few cents per kilowatt, the taxable amounts may be small, but the administrative complexity can still be a disincentive for apartment owners. However, as the low FiTs are likely to drive PV system design towards smaller systems with 100% self-consumption, this becomes less significant.

Recent initiatives by some local councils (City of Melbourne Smart Blocks Rebates,City of Sydney Environmental Grants (2015)) provide grant subsidies to OCs for installation of PV (as well as for energy assessments and other retrofitted sustainability improvements), and disseminate information. These have been instrumental in overcoming some of the barriers discussed here and assisting some of the case studies to deploy PV.

2.4. Knowledge Issues

Ameli and Brandt (2015b) discuss in some detail the literature on the so-called "energy-efficiency gap", whereby the uptake of energy efficiency measures is less than it would be if consumers acted entirely according to their rational economic interests, although Nadel and Keating (1991) argue that this gap may be less than suggested by many studies, which overestimate the potential energy savings or underestimate costs. A number of the case studies for this research had been given quotes for PV installation that appeared to overestimate potential savings (by ignoring potential shading, or modelling PV generation with panel tilt or orientation angles that would be impracticable on the sites) or excluded a range of installation costs (e.g. plant hire for roof access, moving existing roof fixings, roof x-rays / structural engineering assessment, inverter protection or ventilation, or waterproofing roof fixing points).

Modelling the financial costs and benefits of deploying PV on a building is subject to a number of unknown variables - particularly interest rates, inflation rates and changes to energy tariffs - which can create great uncertainty for owners over the lifetime of the project, although the effect of this uncertainty on behaviour varies. For one of the case studies, the risk of uncertain returns meant a very high 'hurdle rate' was used in the financial forecasts. This supports the theory of Hassett and Metcalf (1993) that 'rational' consumer risk aversion drives high discount rates and so slows roll out of energy-saving technologies. However, the OC in another case study cited uncertainty in energy costs coupled to price increases in recent years, as reason to invest in PV despite pessimistic financial modelling. The uncertainty also means that solar companies can plausibly use high figures for future energy costs thus predicting short payback periods for PV installation.

There is anecdotal evidence from the case studies that some PV installation companies have little experience with the physical complications (see 2.2) that can affect installations on apartment buildings and so are not able to provide realistic quotes. However, recent initiatives such as Smart Blocks have improved access to information about PV for OCs and provide advice on how to deploy it on apartment buildings.

2.5. Network & Regulatory Limitations

In addition to the barriers that affect energy efficiency improvements, PV is also subject to some specific issues related to network and planning regulations. In many local government areas, a PV system below 10kW can be installed as complying development, without the requirement for a Development Application (DA). However, unlike most standalone residential systems, optimally sized PV systems for apartment blocks will often exceed this threshold and so necessitate the additional expense and time of a DA. To ensure the safety of these relatively large systems network operators may impose additional protection requirements which increase the technical complexity and costs of installation (e.g. requirements for inverters above 30kW are described in Ausgrid (2013)).

Despite the wide range of barriers to deploying PV on Australian apartment buildings, the opportunities are significant, and the next section of this paper will focus on potential implementation approaches that can assist in addressing some of the key challenges.

3. Implementation Models

The energy demand in apartment buildings is split between the energy used in individual apartments, and the energy demand of centralised services and common areas of the property. Where there is potential to install rooftop PV on apartment buildings, it can be used to supply CP and/or individual apartment load, with a variety of possible implementation arrangements as shown in Table 1. These models and their specific barriers are discussed below.

Table 1. Implementation Models for PV in Apartments

		Governance of PV	
		Individual	**Shared**
Demand Met	**Individual Units**	Individual PV for Apartments **(3.1)**	Shared PV distributed via Embedded Network or VNM **(3.2) & (3.3)**
	Common Property		Shared PV to supply CP **(3.4)**

3.1. Individual PV for Apartments

Because the roof space in most apartment buildings is part of the CP, there are a number of specific issues around the installation of PV systems to serve the demand of individual units. In a strata building, a bylaw (requiring a special resolution of the owners' corporation) is needed to give an individual the right to install equipment on CP. Because there are risks that must be borne by the Owners' Corporation (e.g. potential damage to roof structure, disruption of common areas for cabling, etc.) with no direct benefit to other owners, it can be hard to secure the necessary majority vote (opposition of only 25% of a quorate meeting is needed to block a special resolution) (Sherry, 2008).

Although there is a valid issue of equitable use of CP roofspace, it can be seen as an example of the how the "tragedy of the anticommons" (Heller, 1998) prevents appropriate utilisation of CP (Hastings, Wong et al., 2006,Easthope and Randolph, 2009). In Queensland, the so-called "ban the banners" legislation (2009) sought to reduce the ability of Owners' Corporations to prevent sustainable improvements (including PV installation) to strata buildings by amending the Building Act (1975) to prevent prohibition of PV or SHW installation on the grounds of preserving the external appearance of a building. However, the revised act does still allow prohibition of PV or SHW installation if it "interferes with a person's use … of any part of the building" (Building Act (1975), Section 246T).

Because of these issues and the dependence of costs on apartment-specific factors (e.g. installation is simpler and cheaper for top floor apartments), take-up of retrofitted PV for individual apartment use is likely to continue to be sporadic. However, a number of new residential developments are installing or facilitating individual apartment PV systems. Examples include the Riverdale "Flo" Project (Psaros, 2014), with 2kW of arrays installed for each of the 86 apartments (Vorrath, 2015), and Square One Apartments (Colgan Industries, 2015) built with rails, cabling, meters and conduit pre-installed to allow each apartment to install a 1.08kW system with minimum cost and disruption.

3.2. Shared PV distributed to Apartments via Embedded network

An alternative implementation model involves a shared PV system on the shared roof space, which can be owned and operated by the Owners Corporation, the building developer or owner, or by another commercial entity or community organisation. Energy from the grid and from the PV is distributed to individual apartments through an embedded network, and - with the network configured with a 'parent and child' smart-metering arrangement - only a single grid connection is necessary. Although the costs of retrofitting the network can be large and there is an administrative burden associated with retailing energy to residents, the removal of multiple grid connections and fixed charges may generate significant cost savings for households.

In this scenario, the OC (or other organisation) acts as an Embedded Network Operator (ENO) and is therefore subject to regulatory obligations (AEMC, 2015). These are less onerous if the ENO applies to the AER and is granted exemption from registration as a Network Service provider (NSP). However, under a proposed rule change from AEMO (AEMC, 2015), if the embedded network has 10 or more customers, the ENO will be required to appoint an embedded network Manager (ENM) with responsibility for maintaining residents' access to a choice of alternative retailer within the National Energy Market, and for other data gathering tasks. This proposal is still out for consultation but may result in increased costs for small ENO's such as Owners' Corporations.

The ENO also acts as the energy retailer and must apply for a retail exemption under the Energy Retail Law. As the law stands, *registrable* (or *deemed* for very small networks) Class R2 exemptions are available for new embedded networks, but for retrofitted networks individual exemptions must be applied for (AER, 2015a). However, the AER is proposing to amend the law so that a registrable or deemed exemption (with standard conditions (AER, no date)) will be available if a retrofitting proposal has the explicit informed consent of all affected residents; if some residents withhold consent, an individual application is needed and exemption conditions are likely to include "offer-matching and measures to facilitate access to competition to the extent possible" (AER, 2015b)

3.3. Shared PV distributed to Apartments via Virtual Net Metering

An alternative to using an embedded 'behind the meter' network to distribute PV energy from the roof of an apartment building to individual units is to use Virtual Net Metering (VNM). VNM involves the use of a local network to move energy between distributed generators and consumers, subject to a fee paid to compensate the Distributed Network Service Provider (DNSP) for the use of the network. Where the generator and consumer are geographically close, the fee (or 'wheeling charge') is a small portion of the total Transmission Use of System (TUoS) and Distribution Use of System (DUoS) charges (Langham, 2013).

Apartment buildings present a great opportunity for VNM, with a large number of potential energy consumers in very close proximity to the rooftop generation, so using only a small part of the network (within the building) to distribute energy. In California, the California Solar Initiative mandated energy companies to offer VNM tariffs to builders of multi-occupancy residential buildings. These were initially targeted at low-income households through the MASH scheme, coupled with capacity-based incentives for PV installation which preferentially incentivised schemes which supplied apartments as well as CP loads (CCSE, 2011), but have now been extended to all multi-occupancy buildings resulting in 4.1MW of installed PV outside the MASH program (Bichkoff, Curran et al., 2015).

In Australia, alternative methodologies for calculating VNM tariffs have been explored by Langham, Rutovitz et al. (2014), but implementation of VNM has so far been restricted to single-entity examples (a generator transferring energy to another site belonging to the same company) or third-party arrangements involving a single generator and single consumer, in both cases paying full network tariffs (Langham, 2013).

3.4. Shared PV for Common Property

Using a shared generation resource on shared roofspace to supply shared CP demand is the most straightforward model for apartment PV, and is the model adopted by several of the case studies. Installation is relatively straightforward as CP demand is connected via a small number of meters (often just one), so cabling through the building is minimised. Because the benefit of reduced energy bills flows to the OC (and can be passed on to apartment owners as reduced strata fees), split incentive issues are less significant than when dealing with apartment demand.

CP demand may include lighting for common areas, stairwells and carparks; lifts; water heating and pumping for centralised hot water and/or pools; heating, air conditioning and ventilation for common areas and sometimes for all apartments. Although CP energy demand can be relatively low in low-rise walk-up apartments, it can account for a large proportion of the total building energy usage in high and medium rise buildings (Myors, O'Leary et al., 2005). As for other residential building loads, CP demand is likely to peak in the evening, but many buildings have continuous CP load that result in relatively flat demand profiles.

However, buildings with high annual CP loads often have tariffs with low volumetric charges and high fixed or capacity charges. If PV generation does not impact on peak demand, energy savings may be relatively low per kW installed, and payback periods can be substantially longer than for standalone residential buildings, or for PV serving apartment loads.

4. Governance Models

Because the OC manages the CP (including the roof) in an apartment building, and typically purchases CP electricity on the owners' behalf, it is the obvious vehicle for investment in and management of the PV system. Such a project requires a functional, engaged and forward-looking OC and a motivated executive committee to overcome resistance to long payback and uncertainty, particularly as 25% opposition can block the project.

An alternative model, which is being explored by one of the case studies, is ownership through a Community Renewable Energy organisation (CREO). Here, the OC agrees to allow use of the roof by the CREO, and enters into an agreement either to buy CP energy from the CREO for the lifetime of the project (a Power Purchase Agreement – PPA) or to lease the PV system from the CREO. Crucially, because it does not need to commit the capital investment, OC agreement may be easier to secure. Capital is raised through a share offer available to owners and tenants (and to the wider community if necessary), and repaid with a return over the life of the project. This helps to overcome the split incentive issue by allowing all building occupants to benefit from the installation if they wish. If an owner or tenant leaves the strata, they can keep their shares or sell them, so this approach also helps counter short-termism and can make longer payback periods more acceptable. This approach goes some way towards 'closing the loop' between community investors and energy users, which is an aspiration of CRE policy (Ison, Byrne et al., 2014). It can also bring other benefits of CRE: community engagement & motivation, local sustainability & self-reliance, energy efficiency & RE education. This model of CRE PV on apartment buildings has been used successfully in other countries, including the UK (Repowering London) and Germany (Behrendt, 2014).

Commercial models of governance are also possible, where a commercial organisation installs PV on apartments and sells energy either to the OC to meet CP demand or (via an embedded network or VNM) to residents. The commercial organisation might be the building developer, an energy retailer, a solar installer or a third party. Overseas examples include Toshiba in Germany (Meza, 2013), Pietra Apartments in New York (PR Newswire, 2011).

5. Conclusion and Future Work

There is a significant and under-utilised opportunity for deployment of PV on apartment buildings in Australia. Despite the barriers, implementation models exist that are technically and financially viable in the right circumstances. A number of areas for potentially fruitful research have been identified as follows. Council data and mapping tools could be used to make an assessment of the extent of the PV opportunity on apartment buildings. Interval demand data for apartments and common property load could be used to model embedded network scenarios with PV systems and with storage. The impacts of these scenarios could be analysed in terms of household economies, network benefits and carbon reduction. Examining the sensitivities of these models to tariff structures and external financial variables would aid an understanding of the implications of different implementation models and governance arrangements.

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