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photovoltaics in Australia

time for a rethink

THE CAPACITY OF INSTALLED photovoltaics (PVs) in Australia has expanded from around 50 MW to 4 GW over the past five years, an 80-fold increase. This has been driven by a perfect storm (or perhaps perfect rainbow) of rising retail electricity prices, falling global PV module prices, a strong Australian dollar, and federal and state government support. Indeed, Australian policy makers have widely agreed that PVs have become “too successful,” and almost all state government support was removed several years ago. Still, growing public acceptance of the technology, continuing capital cost subsidies under the Federal Renewable Energy Target, and deployment-driven cost reductions have seen more than 800 MW deployed over the past year, according to the Australian Clean Energy Regulator.

A Household Affair

While per-capita PV capacity in Australia remains well below that of some other countries such as Germany and Italy, Australia's PV market is notable in that almost all of this 4-GW capacity is deployed as residential PV systems typically 1.5–6 kW in size (see Figure 1). This outcome reflects a range of factors, including the targeted nature of PV support policy to date toward households, but also the high retail electricity tariffs they pay, among the highest in the world on an exchange rate basis. Given that household PV systems can now

be purchased at prices below AU\$2/W (US\$1.60/W) installed (indeed as low as AU\$1/W after capital subsidy), they can represent an excellent financial investment, depending on household electricity demand and its match to the PV generation profile. This is because the great majority of residential PV systems in Australia are net metered so that PV generation offsetting that household's electricity demand “earns” the retail tariff (around US\$0.24/kWh). By comparison, with net metering in much of the United States, however, PV exports at times when generation is greater than household demand are typically paid around a quarter of this retail electricity tariff (US\$0.06/kWh).

In the Australian national electricity market (NEM), around one in seven dwellings has a PV system installed. In the sunny states of South Australia and Queensland (representing in total around 27% of Australia's population), the installation rate is around 25% of households. It is estimated that PVs met more than 1.6% of total load (and perhaps 7% of residential load) in the NEM in 2013. PV generation has also approached instantaneous penetrations of 10% of total NEM demand (more than 25% in South Australia) on some sunny afternoons.

Technical Challenges and Revenue Problems for Australian Distribution Network Businesses

The challenge of appropriately integrating all of this household PV falls, first, upon the Australian distribution network service providers (DNSPs). In

the NEM, these are economically regulated monopoly wires businesses, quite separate from the retailers who buy power from the wholesale electricity market to on-sell to energy end-users in the retail market.

Virtually all Australian household PV systems have single-phase inverters connected to the low-voltage (230 V) network. The DNSPs will inevitably have areas of their network with greater than average PV penetrations due to factors including suitable stand-alone housing stock and household demographics. The Australian PV Institute and Centre for Energy and Environmental Markets at the University of New South Wales recently undertook a survey of DNSPs regarding technical issues arising from these emerging high PV penetration areas. The respondents, collectively serving around 70% of Australian electricity customers, identified a range of technical issues associated with high penetrations of PVs that they were experiencing or anticipating. They were also questioned regarding their management responses, present and proposed, toward addressing these impacts. The most prevalent challenges identified were with voltage regulation and phase imbalance. Despite some concerns about PV system islanding, there was no clear evidence of this happening in practice, while periods of minor reverse power flow generally didn't cause any material network operation problems, and the PV system inverters were not producing significant harmonics or causing power factor issues.

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Digital Object Identifier 10.1109/MPE.2014.2380575
Date of publication: 24 February 2015

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in my view *(continued from p. 96)*

The surveyed DNSPs identified that, in most cases, management of PV-related issues to date had involved fairly straightforward responses such as undertaking network studies, making changes to customer phase connection and wider network balancing, adjusting voltage tap settings on distribution transformers, imposing PV capacity limits, and requiring three-phase inverters for larger PV systems. Other options identified included bringing forward timetabled upgrades, for example to low-voltage conductors, or minor augmentations. In some cases, of course, required responses to PV impacts can potentially impose significantly higher costs.

While there is certainly an increase in administrative costs associated with metering and compliance inspections for new PV connections, the recent regulated distribution network pricing proposals, price determination, and regulatory frameworks in the NEM suggest that PV-related increases in network costs are still relatively minor. Indeed, the surveyed DNSPs did report that PV systems were reducing peak demand, albeit modestly, in some areas of the network that might even reduce some longer-term costs.

The most pressing issue, rather than being technical or related to the cost of managing the technical issues, is the revenue implications of PV for the DNSPs.

Network tariffs for households are predominantly consumption based (kWh), and self-consumed PV generation therefore reduces network revenue. Tariff arrangements vary by DNSP, and there are complexities such as fixed charges and time of use pricing. Still, a household reducing its demand by 25% with a PV system will be paying on the order of 25% less to the networks. Interestingly, the DNSPs do receive network payments on net-exported PVs when the exported PV energy is on-sold by the household's retailer to which it is assigned. Generally the retailer is not required to pay households for any exported PV generation that they on-sell to their other customers;

however they typically offer around US\$0.06/kWh, close to the wholesale value of the energy. The network savings including reduced losses don't get factored in here as they have been deemed by regulators to be immaterial and too difficult to measure. While demand-related revenue is being threatened and even peak loads are fairly stable, network tariffs have risen very considerably over the past five years, more than doubling in some cases. A number of government inquiries into these price increases have suggested that network gold plating driven by inappropriate incentives in the regulation of network businesses (particularly an assured return on approved capital expenditure) has been a major driver.

Where Next—Punish PVs or Rethink Network Business Models?

A range of DNSP, regulator, and policy maker proposals have been put forward to address the technical challenges and revenue problems now being experienced by Australian DNSPs. Technically oriented management proposals, some now implemented, include hosting limits that restrict new PVs in parts of the network with significant existing PVs believed to be already causing issues, capping the allowed size of systems, and even banning exports from PV systems. Some PV installers doing larger commercial and industrial PV systems have also argued that there are DNSPs using high and non-transparent fees and long time frames for network studies, along with onerous and excessive technical requirements, to slow the uptake of PVs. There are even some proposed restrictions on dc injection, ramp rates, and protection requirements beyond current inverter standards such as AS4777.

There are, of course, valid reasons for the concerns of DNSPs and regulators over growing distributed PV deployment. However, in our view, some of the changes, existing and proposed, being put forward in response could potentially discriminate against a highly promising and beneficial distributed generation technology and hence slow the clean energy transition that our electricity industry so desperately requires.

First, PV-related technical issues are often difficult to separate from other distribution network issues caused by a range of end-user equipment and behavior. For example, the main voltage challenge for many parts of the Australian distribution network is actually periods of low voltage when highly correlated, high-power, household air conditioners are running. In response, the DNSPs have often set distribution transformer voltages near the upper limit of the permitted voltage range, potentially causing high-voltage problems at times of low load independently of PVs (typically overnight) and leaving little headroom for distributed generation to export into the network. In such cases, is it the PV system or the air conditioners that are most contributing to voltage management problems?

At present, PV inverters are required to switch off when the voltage goes too high; indeed, our DNSP survey suggested that this was one of the most common problems caused by PVs. The inverter disconnecting is in itself not causing a problem for DNSPs but rather helping solve one. However, there is the matter of the power quality investigation triggered by irate owners wondering why their PV system keeps turning off in the middle of the day. By comparison, air conditioners and other loads don't generally monitor the supply voltage and help address low-voltage problems by modifying their own operation. You might ask why PV households have to solve a problem that arguably is caused by the high transformer tap settings required to manage low-voltage problems caused by air conditioners in other houses? In a similar manner, some of

the harmonics and power factor issues commonly associated with PVs are not caused by the unity power factor and very low harmonic output of the PV inverter itself but, instead, the remaining power factor and harmonics from badly behaving loads now seen by the DNSP's network equipment.

With regard to the various revenue solutions being put forward, a number of studies (albeit contested), including one commissioned by the Australian Energy Market Commission, do indicate that network savings from peak load reduction from PVs are generally less than the value of the network tariff avoided by such customers under current net metering. This is largely due, of course, to the relatively poor alignment between PV output and these network peak loads that generally occur in the evening. This does certainly represent an implicit subsidy from households without PV systems to those with the systems. However, PVs are hardly alone in an environment where

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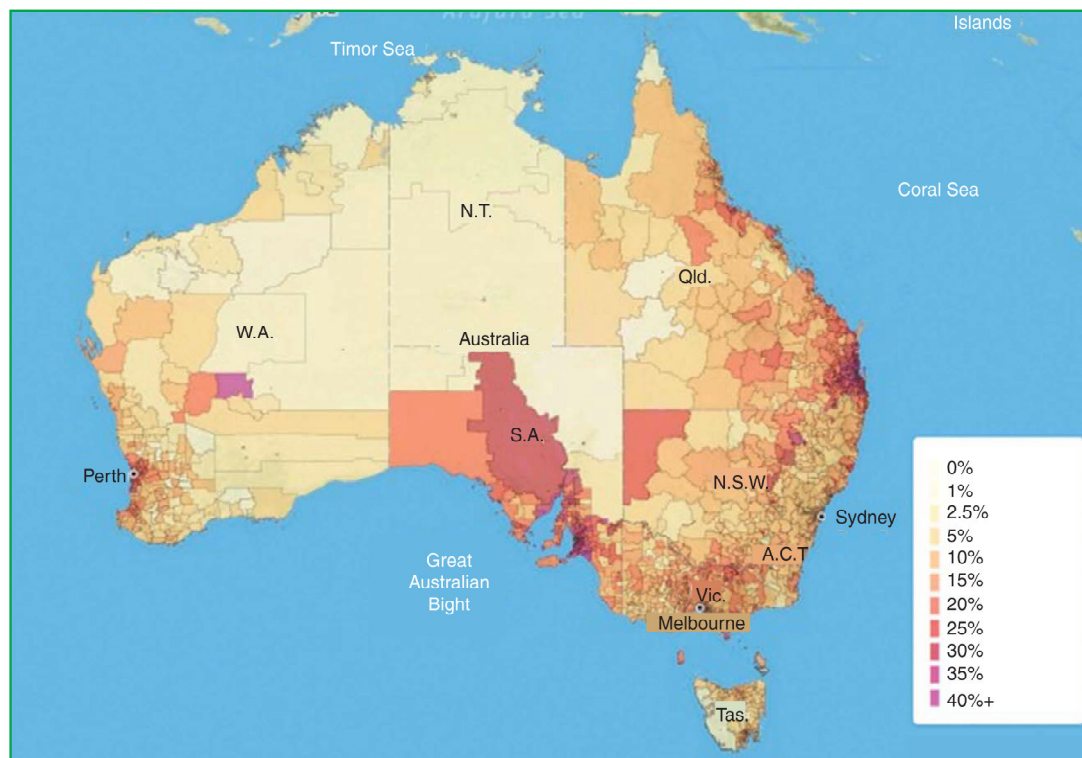


figure 1. The proportion (%) of residential dwellings that have a PV system across Australia by post code (accessed from pv-map.apvi.org.au/historical on 10 December 2014).

underlying network costs and benefits are poorly aligned with tariffs. There are many energy-efficiency measures that also reduce overall household consumption while not necessarily reducing peak demand. Indeed, household demand has fallen markedly over recent years driven by factors that include energy-efficiency programs. And, as noted above, peak demand in many parts of the Australian network is driven by air-conditioning. It has been estimated that the cross subsidy for households with large air conditioners can be an order of magnitude greater than cross subsidies for households with PVs. Meanwhile, the subsidies between city and rural customers likely dwarf even these under current tariff arrangements.

So while the networks certainly face a range of technical and revenue challenges related to PVs, these are just part of a broader suite of challenges and, let it be said, opportunities arising from new distributed technologies including battery

storage, small trigeneration systems, and increasingly smart and remotely controllable smart appliances. These are all now being installed by newly engaged energy users looking to reduce costs while improving their energy services.

While increasing fixed charges (\$/day) might be seen as a way to insulate DNSPs from these distributed technologies and their owners, such charges will certainly reduce incentives to deploy PVs, energy efficiency, and smart loads that can help us save on network expenditure while also delivering wider economic and environmental benefits. There is also the risk of some end-users choosing to add storage to their PVs and depart the grid entirely, an unfortunate and likely economically poor outcome for both such households and the valuable, and publicly funded, asset they are abandoning.

Instead, we need to establish new business models for DNSPs and other key stakeholders that facilitate active support

for and integration of appropriate distributed energy options that will assist in meeting the growing economic, social, and environmental challenges of a clean energy future. Working out what these business models should be, and the policy and regulatory framework within which they will reside, is the work ahead for the industry and other stakeholders. In this regard, there are growing efforts in some jurisdictions and much to learn from the experiences of others. A particularly promising example in Australia is the growing interest of DNSPs serving rural customers to explore distributed energy options rather than continuing the usual, often very expensive, service by the wire. More generally, however, distributed energy challenges and opportunities will invariably vary greatly between electricity industries and are changing rapidly so there will be no “one size fits all always” solution. It’s a difficult journey ahead for the DNSPs and us all, but one we certainly believe is worth taking.

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