TOTAL ENVIRONMENT CENTRE AND RENEW

CROSS ABOUT SUBSIDIES: THE EQUITY IMPLICATIONS OF ROOFTOP SOLAR IN AUSTRALIA

DISCUSSION PAPER
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Summary

The boom in rooftop solar PV in Australia has created substantial economic and environmental benefits, not only to individual owners but to the energy system and consumers more broadly. While substantially lower electricity bills and great choice and control over household and business energy supply are the main private benefits, the public benefits include lower wholesale market prices, lower network costs in some circumstances, the value of carbon abatement and the health benefits of less coal and gas mining and burning for energy generation.

However, concerns have been raised that (a) there are increasingly substantial costs associated with high bidirectional flows caused by PV exports to the grid; and (b) some of these costs associated are being borne by those who cannot directly benefit from solar, either because they cannot afford to install solar or for practical reasons such as apartment living or shaded roofs. The 'have nots' are said to be cross-subsidising the 'haves', in other words.

In response to both of these concerns, this report attempts to do four things:

- Identify the range of economic costs associated with rooftop PV, especially in high penetrations.
- Quantify the extent of any cross-subsidy, where there is evidence available.
- Suggest a set of principles that could guide attempts to address cross-subsidies.
- Applying these principles, propose appropriate technical, economic and policy responses to cross-subsidies.

This study has identified two main classes of economic cross subsidies: those relating to government subsidies, rebates and other 'green schemes'; and those relating to network costs and revenues. The former are relatively easily remedied—eg, by shifting the cost recovery for green schemes from electricity bills to consolidated revenue (i.e., the tax system), and by targeting rebates and incentives more towards low income households.

Our focus in this paper is therefore on the second class of economic cross subsidies. We find that:

- Network non-solar to solar (NS-S) cross-subsidies are one of a range of cross-subsidies in the energy system, some of which are more substantial (e.g., from non-aircon to aircon owners).
- These network NS-S cross-subsidies relate primarily to the loss of network revenues caused by lower grid consumption by solar owners (in the context of their demand being of a level commensurate with non-solar owners) and potentially the engineering costs associated with managing high levels of export in local parts of the distribution network.

A number of strategies can be implemented to target and address these two cross-subsidies, including tariff reform, technical upgrades and dynamic DER management. There are some challenges involved in implementing these, but they are feasible.

Charging solar owners to export to the grid is sometimes posited as another potential solution.While it could be equitable in the context of a high DER system in which charges are levied for exports that lead to additional network costs and payments made for exports that lead to reduced network costs, it is also the most complex and problematic solution at this point.

We propose a suite of principles that could be utilised to assess the merits of, and potential solutions to, the cross subsidies we have identified and others that may arise in the future. In the current absence of public ownership of most parts of the supply chain, 'causer pays' is probably one of the most important, although it needs to be balanced by consideration of the public good and fairness. Also central are transparency and materiality and fairness: that is, cross subsidies should be addressed where they are evidence-based, substantial and regressive or unfair.

In the medium to long term, regulatory reforms may be required to enable more dynamic trading of DER energy and services (eg, voltage and frequency control); however, these reforms should not be pursued in haste when there are cheaper and easier solutions to deal with current technical and cross-subsidy issues, and when dynamic DER charging carries the risk of unintended consequences.

Finally, we suggest that there is more than one way to skin the cross-subsidy cat, and that welfare and environmental groups should work together to better harness the benefits of solar

and make it available and affordable to the renters, apartment dwellers and other households currently locked out of the solar market.

The Rules

There are two clauses in the NER that directly address DER:

> 6.1.4 (a) A *Distribution Network Service Provider* must not charge a *Distribution Network User distribution use of system* charges for the export of electricity generated by the user into the *distribution network*.
>
> (b) This does not, however, preclude charges for the provision of *connection services*.
>
> 6.18.4(a)(3) however, *retail customers* with micro-generation facilities should be treated no less favourably than *retail customers* without such facilities but with a similar load profile;

The purpose of the first clause is apparently to ensure that networks do not 'double dip' by charging generators as well as consumers for transmission and distribution costs.

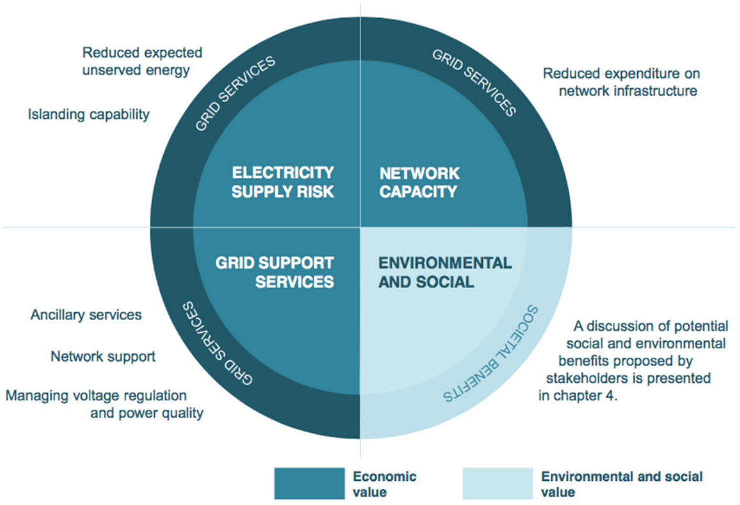
The second clause was the subject of an unsuccessful appeal to the Federal Court by SA Power Networks in 2015 after the AER rejected its application to introduce a network tariff that would have resulted in solar owners paying more for their grid imports.

Introduction

Rooftop solar PV penetration continues to grow strongly in Australia, with 2018 following 2017 as having the highest annual uptake on record. Australia now has the world's largest per capita penetration of rooftop solar, and the residential and commercial sectors are both predicted to continue to grow strongly. The latest forecast by the market operator AEMO predicts a 350 percent increase in the total output from utility and rooftop PV from current levels of 7.4 gigawatts (GW)[i] to 19.7GW by 2036–37.[ii] The 2016 Network Transformation Roadmap (NTR) predicted a 'future where up to 50 percent of all electricity is generated by customers in 2050.'[iii] New spatial analysis by UNSW and the APVI shows there is still a 43GW to 61GW opportunity for new PV installations on Australia's housing stock, including up to 4GW on apartments.[iv]

The boom in rooftop solar PV in Australia has the potential to create substantial economic and environmental benefits, not only to individual owners[v] but to the energy system and consumers more broadly. These benefits (especially putting downward pressure on wholesale prices and in some cases relieving network congestion)[vi] are well known,[vii] even if some (like the value of carbon abatement and the health benefits of less coal and gas mining and burning for energy generation) are difficult to quantify in economic terms. There are other benefits (hereafter referred to as 'social' benefits) that are non-quantifiable, such as the increase in choice, control and autonomy that rooftop solar provides, and the increase in social cohesion provided by community energy projects.

Figure 1 Potential network benefits from distributed generation



Source: Victoria Essential Services Commission, The Network Value of Distributed Generation: Distributed Generation Inquiry Stage 2 Final Report, 2017, xvi

It is generally accepted that the economic, social and environmental benefits of rooftop solar substantially outweigh the costs.[viii] The benefits of a high DER system are only likely to increase over time, thanks primarily to low marginal generation costs and a reduced need for network infrastructure investment with more behind the meter (BTM) generation. For instance, under the NTR scenario described above, 'In 2050, the absolute reduction in average residential electricity bills relative to the counterfactual scenario is $414 per annum (in real terms).'[ix]


Is Australia on the verge of having too much solar energy?

As power prices surge, Victorians are embracing solar — and it's causing problems

Solar power could have to be curtailed to avoid grid disruption

Energy distributors push for a cap on solar power

Australia heading for a 'battle royale' on solar power

Electricity distributors warn excess solar power in network could cause blackouts, damage infrastructure

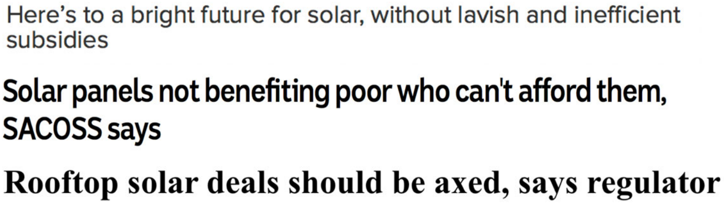
Nevertheless, there are costs associated with the transition to renewable energy generation and to a more decentralised energy system. These costs are incurred directly by all energy consumers to recover the costs of government subsidies and rebates; and indirectly by networks as they upgrade infrastructure to cope with high bidirectional flows.

Concerns have been raised by some regulators,[x] retailers,[xi] distribution network service providers (DNSPs or networks)[xii] and welfare advocates[xiii] that some of the costs associated with subsidising and integrating rooftop PV are being borne disproportionately by those who cannot install them—because they cannot afford to, they are renters, or for practical reasons such as having unsuitable roof space or living in an apartment. For instance, a 2017 report by Australian Council of Social Service, Brotherhood of St Laurence and The Climate Institute noted that

> Put plainly, there are concerns that, without significant policy and regulatory reform, the future energy market will create a two-tiered system that favours those who can access and afford distributive

> energy resources (such as solar panels) and those who cannot, further widening the gap between the haves and the have-nots.[xiv]

This is not only because all electricity customers pay for the costs, but also because solar customers can avoid a share of these and other costs to the system through their generally lower consumption of grid electricity. (However, some of these costs may not be avoided if solar customers pay higher fixed or energy charges than 'non-solars'. This is the case with a minority of retail offers.)[xv]



Here's to a bright future for solar, without lavish and inefficient subsidies

Solar panels not benefiting poor who can't afford them, SACOSS says

Rooftop solar deals should be axed, says regulator

In response to both of these concerns, this report—which is based on the fundamental principle that *there is no implicit conflict between good economic, environmental and social equity outcomes*—attempts to do four things:

1. Identify the range of economic costs associated with rooftop solar, especially in high penetrations.
2. Quantify the extent of rooftop solar-related cross-subsidies, where there is evidence available.
3. Identify a set of principles that could guide attempts to address any cross-subsidies.
4. Applying these principles, propose appropriate technical, economic and policy responses for cross-subsidies.

Not covered in this report are:

- A review of the economic benefits of rooftop solar, which are accepted.[xvi]
- The challenges raised by AEMO relating to how large amounts of rooftop PV impact the way the wholesale market functions, and potentially AEMO's ability to operate the power system securely. These issues, and the various potential models for distribution system operators and DER trading platforms, are being dealt with through the AEMO/ENA Open Energy Networks process.[xvii]
- Any attempt to quantify the higher costs accrued by solar owners on some retail offers or allegations of profiteering by retailers on solar FiTs, since we are not aware of any methodology

that will enable us to quantify the extent of any S-NS cross-subsidy involved. These issues are,

Box 1 What is a cross-subsidy?

In the economic jargon of the national electricity rules (NER), some customers pay substantially more than others for grid services without this be considered a cross-subsidy, as long as the cost to serve is between the 'stand-alone' cost of serving a *single* customer (at the high end) and the marginal (or 'avoidable') cost of serving one *additional* customer (at the low end). In this paper we are using cross-subsidy in the more general understanding of the term—i.e., where costs are fixed, if one group of consumers pays less, then another must pay more. This is sometimes also referred to as wealth transfer.

Two cases in point

The South Australian government is offering significant subsidies to install home batteries. With a total cost of about $100 million, at first glance it would appear that all South Australians will be paying for a program that only homeowners with at least $3000 of disposable income or the ability to repay a loan can take advantage of (although the subsidy is slightly higher for concession card holders). Prima facie, this looks like a cross-subsidy.However, the government claims that 'the installation of these systems will reduce demand on the network (especially during peak periods) and in turn, lower energy prices for all South Australians.' Assuming that the reduction in bills is greater than $100 million over 10 years (the usual warranty period a battery), is this still a cross-subsidy?

Likewise, as part of its 2019 election energy policy platform, the federal ALP has promised subsidies of up to $2000 for up to 100,000 home solar batteries (paid for out of the budget rather then consumer bills). Again, given that the means test cutoff point is $180,000 of household income per year, at first glance it looks like a form of middle class welfare, given that most low income households are unlikely to be able to participate. However, according to analyst David Lietch, the optimum management of these battery systems this likely to reduce evening peak demand by up to 500MW. The downward impact on wholesale market prices could result in the scheme having a payback period of about four years. After that, everyone benefits, whether they have bought the batteries or not. Is this still a cross-subsidy?

In both of these cases, the potential inequity is mitigated by the fact that the costs of these programs will be recovered through government budgets—and thus through the taxation system, which is relatively

however, germane to solar owners in any discussion of costs and benefits.

xviii xix

1 Costs related to rooftop solar PV

There are two main classes of costs and cross-subsidies that have been attributed to rooftop solar PV:

1. Government environmental programs or 'green schemes,' which include:
    - The federal Small-scale Renewable Energy Scheme (SRES).
    - State and territory government premium feed-in tariffs (PFiTs).
    - State and territory energy efficiency programs.
    - State and territory subsidies or rebates for new solar and battery systems.

The costs of some of these initiatives (eg, the SRES and some energy efficiency programs) are recovered through all consumers' electricity bills. Others, particularly subsidies or rebates for new solar and battery systems, are generally paid for through state and territory budgets. Some PFiTs have been funded on-bill, others on-budget.

2. Network impacts, which take two main forms:
    - Infrastructure augmentation required to deal with high bi-directional flows—in particular, to correct voltage spikes caused by high reverse energy flows on particular lines[xx] and to overcome thermal constraints or fault currents on transformers caused by net reverse flows at the substation level.
    - The lower network (network use of service or NUoS) costs recovered from PV customers as a result of reduced grid consumption. While this is not a direct cost, the impact of declining demand in the context of guaranteed network revenues (under a regulated revenue cap regime as currently applies throughout the NEM) and the way network charges are recovered result in an apparent cross-subsidy.

To the extent that each of these costs is either generated by, or equivalent to, a benefit to solar customers, but are paid for as part of energy bills and smeared across the entire customer base, they can be said to involve a cross-subsidy. However, in developing solutions to these issues, it is important to understand exactly what the costs are and the extent to which they are material, which includes assessing the extent to which they may be offset by benefits that are also shared across the customer base (as suggested in Box 1 above).

Government environmental programs

In total, environmental schemes comprised about 6 percent or $106 per annum of an average customer bill in the NEM in 2017-18, although this percentage varies from 4-10 per cent across NEM jurisdictions.[xxi] According to the ACCC, these costs have increased from about 2 per cent of the overall customer bill in 2007-08, driven by a range of factors including the rapid uptake of rooftop solar PV and associated increases in the cost of the SRES. Note that these figures also include the cost of the large-scale renewable energy target (LRET) and state based energy efficiency schemes, so are not reflective of costs related to rooftop solar PV alone.

Small-scale Renewable Energy Scheme

The SRES has been in place since 2011, when the federal Renewable Energy Target (RET) that has been in place since 2001 was split into two streams: the LRET and the SRES. The SRES creates a financial incentive for individuals and small businesses to install eligible small-scale renewable energy systems by creating technology certificates calculated based on the amount of electricity a system produces or replaces (that is, electricity from non-renewable sources). 'Liable entities' (mostly retailers) have an obligation to buy and surrender these certificates to the Clean Energy Regulator. The certificates are provided 'up front' for the system's expected power generation until the scheme ends in 2030. Generally, householders who purchase these systems assign the rights to the certificates to a solar installer in return for a discount off the purchase price.

The cost of the SRES is estimated at $18 per customer per annum across the NEM, or about 1 per cent of an average annual household bill.[xxii] However, because the ACCC estimates that solar owners consume about one-third less grid electricity, this cost is recovered disproportionately from non-solar consumers and therefore appears to constitute a cross-subsidy. That said, if 22 percent of households (the current national uptake of rooftop solar) are effectively paying $12 instead of $18 pa each for the SRES, that amounts to the other 78 percent paying about $20-21 each—a cross-subsidy of $2-3 per year. A cross-subsidy of less than 0.002 percent of the average annual bill is clearly not material.[xxiii]

Nevertheless, in 2014 the Grattan Institute criticised the SRES for being more expensive than other carbon abatement costs, and because all customers were paying for a benefit primarily derived by solar households. More recently, the ACCC recommended scrapping the scheme in 2021, well ahead of the planned 2030 end of the ongoing phase-out. The ACCC argued that the subsidy is no longer justifiable given the fall in the capital cost of installing solar since the scheme's introduction and the relatively short payback time now enjoyed by solar purchasers.[xxiv]

On the other hand, multiple independent economic analyses have concluded that the combined RET schemes (LRET and SRES) effectively lower electricity prices for all consumers:

- A 2014 ACIL Allen report found the RET would save customers between $47 and $65 a year from 2021 onwards, up to $91 per year by 2030.[xxv]
- Modelling conducted by ROAM Consulting in 2014 found that every household would pay over $50 per year extra from 2020 if the RET was abolished.[xxvi]
- In its modelling for the stillborn National Energy Guarantee, the Federal Government found that of the $550 that will be saved on electricity bills between 2020 and 2030, $400 is due to new renewable investment under the RET.[xxvii]

These results are due to the impact of renewable energy, which has marginal generation costs close to zero, on the wholesale electricity price by displacing more expensive marginal cost fossil fuel generation—ie, the 'merit order effect'. Solar PV generation is able to depress electricity prices, particularly in summer peaks and at high price times such as heatwaves, when the generation from solar is high.

There have been several attempts to quantify the merit order effect:

- In 2013, McConnell et al retrospectively modelled the effect of distributed PV generation in the NEM and estimated that for 5 GW of capacity the reduction in wholesale prices would have been worth in excess of $1.8 billion over a 2 year period.[xxviii]
- Modelling by Energy Synapse over 2017 in NSW estimated that small solar PV depressed the volume weighted average price of wholesale electricity in NSW by $29-44 per MWh. This equates to $2.2-3.3 billion over the one-year study period. The study found that the pattern of price reduction followed the pattern of solar generation throughout the day, nonetheless rooftop solar was able to put significant downward pressure on prices in the late afternoon around 4 pm when operating at only 40 percent of capacity.[xxix]
- In 2018 Mark Ogge of The Australia Institute also analysed the impact of solar PV in reducing network peaks across the NEM on the highest demand days.[xxx] He demonstrates that solar reduces both the intensity and length of the peak, and in doing so increases the reliability and resilience of the grid. Peak events are typically driven by heatwaves and with climate change accelerating, these events are increasing in frequency, duration and intensity. While rooftop solar produces best on hot days, gas and coal power stations are less efficient and can break down:

  > Rooftop solar generates best on hot sunny days, exactly the conditions that see gas and coal generation at risk of breakdown. This summer rooftop solar reduced demand peaks in the National Electricity Market by over 2000 MW, while a breakdown at a major coal generator contributed to wholesale electricity prices hitting $12,000 MWh.[xxxi]

Theoretically at least, competition should compel retailers to pass through reduced wholesale prices as well as the added upfront cost of the SRES to all consumers: and if they fail to do so, that cannot be blamed on solar owners. We therefore conclude that there is no reliable evidence of a net cost to non-solar households from the SRES.

State green schemes

Most jurisdictions had or have environmental programs designed to increase the uptake of rooftop solar and batteries and to encourage commercial and residential energy efficiency.

Premium FiTs (PFiTs) were the most significant of the state schemes designed to encourage the uptake of rooftop solar systems. Though the schemes' designs have varied across jurisdictions and over time, they generally involve providing households with payments for the electricity generated from the solar panels, or exported from the property, generally above the wholesale market value of the electricity. While these PFiTs are being phased out across all jurisdictions, a significant number of customers are still receiving legacy tariffs at an average cost to all customers of approximately $53 per year.[xxxii]

With the phasing out of government-sponsored PFiTs, new solar customers access FiTs paid by retailers, which generally reflect the avoided cost to retailers of energy that would otherwise be bought from the wholesale market. These FiTs are in some cases regulated, and may also include a range of other values of PV including reduced line losses and reduction in various NEM fees (where these are based on the volume of purchased wholesale energy). There is much debate about which benefits should be included in FiTs and at what value, which are outside the scope of this paper. However it is worth noting (for reasons discussed later in this report) the 2017 Victorian Essential Services Commission report which has seen for the first time the introduction of a voluntary (for retailers) time-based FiT which reflects the higher energy costs at certain times of the day (and therefore the greater value of avoided energy). For the purposes of this paper we consider current retailer FiTs (as opposed to legacy PFiTs) to be cost neutral for other consumers.

Over the years there have been a number of state schemes subsidising the purchase of solar PV systems. However, as the cost of PV has reduced, these programs have become more limited (with the exception of the new Victorian Solar Panel Rebate, which provides a 50 percent rebate for 650,000 homes over 10 years) and the emphasis has shifted in some states to providing interest-free loans for solar and new subsidies to support battery uptake.[xxxiii] All of these current schemes are paid for from consolidated revenue rather than from customers' electricity bills. They therefore avoid being categorised as energy market cross subsidies. Whether they are fair is another matter, given that the they are largely (with some exceptions)[xxxiv] targeted at homeowners with access to cash for capital upgrades rather than renters, public housing tenants and low income households. However, there are other programs which specifically target these groups, especially in relation to energy efficiency upgrades.

Cui bono (Who benefits)?

Debates about cross subsidies from non-solar to solar owners are sometimes predicated on the assumption that the latter are wealthier than the former. While it is true that, except in relatively rare cases, if you do not own house you cannot currently own a solar system, it is also worth bearing in mind that

- There is only a weak correlation between household income and solar ownership, with asset-rich but income-poor aged pensioners constituting a major cohort of owners.
- There are investment models that would enable tenants to also benefit from rooftop solar, by overcoming the 'split incentive' problem or by fostering the growth of community solar gardens.

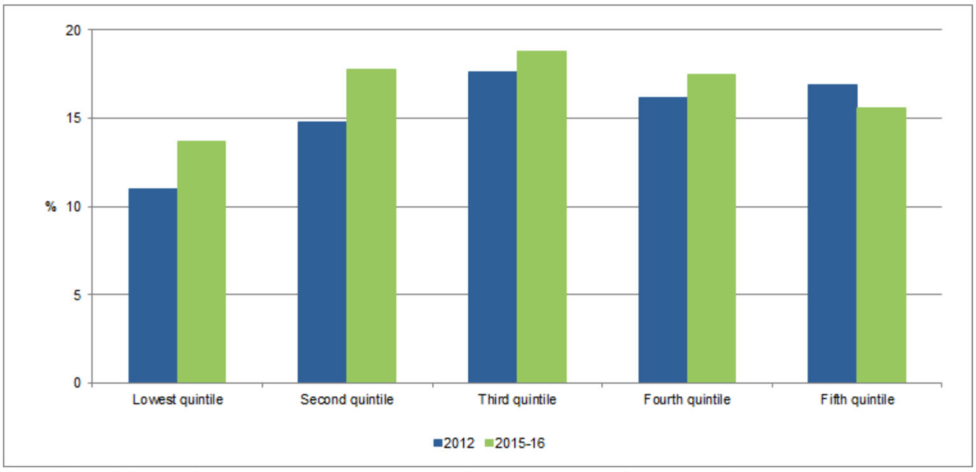


Figure 2 Households with solar panels by income quintile, 2012 and 2015-16

Source: ABS Survey of Income and Housing, 2015–16, ABS Household Energy Consumption Survey, 2012

Network impacts

Infrastructure augmentation costs

Some networks have claimed there are significant augmentation costs associated with large uptakes of rooftop solar PV because the network was not originally designed to cope with high bidirectional flows.

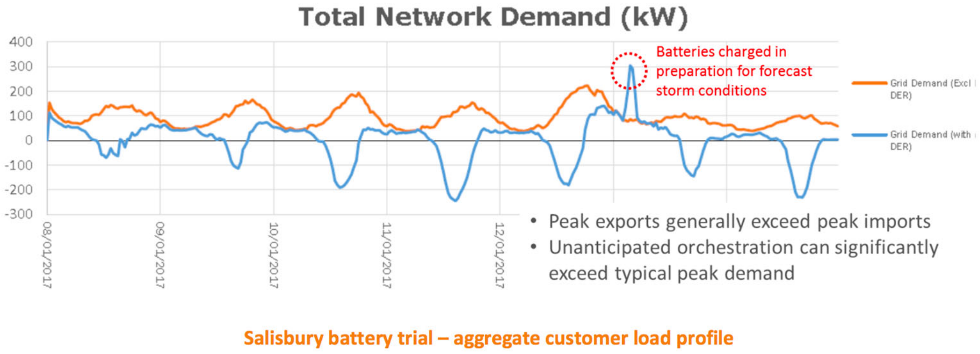
There are two main technical issues caused by large amounts of solar energy being fed back into the grid:

- Voltage spikes on low voltage lines which potentially damage network and consumer equipment and result in networks needing to temporarily shut down solar inverters to restore voltage to normal limits.
- Thermal overloading of substation transformers or fault currents caused by net reverse (upstream) flows.

While the voltage problem exists today—and is not limited to, or caused solely by, high rooftop solar penetrations[xxxv]—the thermal overloading problem is one that is likely to emerge over the medium to long term. The problem will emerge first in South Australia, and may be exacerbated by the uncontrolled aggregation of DER exports in virtual power plants(VPPs). In its Future Network Strategy SAPN observes that

> DER take-up at the levels forecast by CSIRO will have material impacts on networks that were not designed for complex two-way flows of energy. In South Australia, these issues are anticipated to arise in advance in of the rest of the country, with AEMO forecasting that from as early as 2027, the state demand could be met entirely by rooftop PV during low demand periods. Zone substation

reverse flows will be emerging across South Australia by 2020, and by 2050, distributed solar PV load flows on high voltage feeders could potentially exceed asset ratings at times of minimum demand. [xxxvi]



- Peak exports generally exceed peak imports
- Unanticipated orchestration can significantly exceed typical peak demand

Salisbury battery trial – aggregate customer load profile

Figure 3 Illustrating high net reverse flows

Source: SAPN, Future Network Strategy 2017-2030, 4.

The AEMC's 2017 Distribution Market Model (DMM) Draft report included a doomsday list of every technical problem which could conceivably be attributable to DER, including frequency changes, increased harmonic distortion, flicker, and interference with fault protection systems. It also cited problems for AEMO in its load forecasting and management of power security due to limited visibility of how DER are programmed and will respond to specific system disturbances.[xxxvii] Given the predicted continued uptake of solar PV, these technical problems could be expected to grow. On the other hand, the DMM Draft report did not contain a corresponding list of potential network benefits from high bidirectional flows (as in Figure 1 above) and made no attempt to quantify the penetration or export level at which such costs become material for networks or the costs involved to rectify them. Nor did it recognise, in the context of this proposal, the opportunities available through new standards for inverters and batteries to reduce or eliminate these costs and even to allow DER to provide benefits to networks through voltage and frequency control.

To date there appear to be have been limited efforts by networks to quantify the technical issues and the costs of rectifying them. For example, in completing work for the AER on the estimated cost impacts of solar technology on the grid, NERA noted that networks had told them about voltage variation and other costs but as they were not able to quantify these costs they did not include them in their final analysis.

Nevertheless, Ergon Energy estimated in 2015 that 'The requirements for network upgrades alone associated with solar systems are forecast to cost approximately $44 million… out to 2020.'[xxxviii] A similar capex claim by Energex in its 2015-2020 pricing proposal for $38.4 million for monitoring of the low voltage network was reduced by a third by the AER in its final determination. The AER accepted aspects of Energex's claims, including the projected level of PV penetration and the fact that there were power quality issues to be addressed, but did not accept that this supported new investment in network monitoring of voltage levels.[xxxix] It is unclear the extent to which improved monitoring or visibility of LV networks would be advantageous irrespective of high rooftop solar uptake.

The Australian network which is most advanced in forward planning to respond to high solar penetrations is SA Power Networks (SAPN). In its draft plan for 2020-2025 (preliminary to its pricing proposal to the AER), SAPN observes that the total volume of solar flowing back through the grid is at times higher than the capacity of the largest generator in South Australia. In response, SAPN has included $37 million in new capital expenditure and a corresponding $2 million increase in annual operating expenditure to develop systems to monitor and respond to power quality issues arising from bidirectional flows. The measures include developing:

- A Low Voltage (LV) operational model to determine the hosting capacity of the LV network and for structured monitoring in parts of the LV network.

- A DER database to store information on DER connected to the network.
- New systems and interfaces to enable DER export limits to be set dynamically.

In its 2019-24 pricing proposal, Ausgrid likewise proposes to spend around $39 million on a range of measures to 'to adapt the grid to ensure it cost effectively meets customers evolving needs', including but not limited to accommodating higher DER reverse flows.[xl]

The extent of both problems identified above (voltage fluctuations and thermal capacity constraints) varies widely between and within networks depending on a number of factors including the location, intensity, timing and capacity of solar output, the load profile on each part of the grid, and whether there are substation constraints. However, assuming that all projected costs are prudent; that a similar level of expenditure may be required over a full decade (ie, two five year regulatory periods); and that each of the 12 networks in the NEM could incur a similar level of expenditure, this could amount to total DER-related capital expenditure of around $900 million. This constitutes about one per cent of expected network revenues for the next decade.[xli] This would translate into an average impost of about $1 per week per household if the costs were recovered from equally from residential and business customers.

Under current tariff arrangements (ie, with most solar and other customers outside Victoria on flat or nearly flat tariffs), proportionally more of these costs would be recovered from non-solar than from solar households. If solar households consume on average one-third less energy from the grid, assuming that on average over the next decade one quarter of all households will have solar, the average cost of $1 per week becomes roughly 90 cents for solar households and $1.10 for non-solar households.

The hypothetical cross-subsidy here would therefore be a mere 20 cents per week—again, not a material amount. The bigger issue, though, is whether non-solar households should pay *any* of these extra network costs unless there is evidence of commensurate network benefits to all customers. (If not, in this example solar households would instead pay about $4 per week each so that non-solar households could pay nothing.) These wider benefits—which could include frequency and voltage control services, and reduced augmentation costs in constrained parts of the grid under certain circumstances—are as yet largely unrecognised and unquantified.

Finally, it is worth noting that there is also evidence of economic benefits to networks from high reverse flows. For instance, the 2017 ESC report referred to earlier discussed the fact that substation transformer temperatures during evening peaks may be reduced due to high local consumption of DER exports: 'solar PV systems will reduce the amount of zone substation load earlier in the day, which will lower the operating temperature of transformers prior to facing peak loads later in the day.'[xlii] This value does not appear to have been quantified by any network or regulator.

Avoided network charges

This issue relates to the loss of network revenue that is occurring as a result of declining grid consumption from solar owners. The problem arises because networks have 5-yearly guaranteed revenues, so when demand is lower the unit cost of energy and/or the fixed charge per customer must increase in order to recover that revenue. According to AGL's former chief economist Paul Simshauser, these 'volumetric loss induced rate rises add a second layer of tariff increases to already rising network prices'.[xliii] The 'costs' are then recovered from all customers. However, because revenue is typically recovered through a mix of volumetric and fixed charges, solar customers will avoid some of the volumetric charge by generating their own energy behind the meter.

There have been a number of efforts to quantify the value of this cross-subsidy, most of them occurring in 2014/15 in the context of arguments for more cost reflective network pricing. The Grattan Institute estimated that avoided network costs in Australia from 2009 to 2030 will run to $3.7 billion.[xliv] Simshauser, looking only at Queensland, concluded that 'hidden wealth transfers' arising from solar PV amounted to $70.3 million in additional network charges or approximately $72 per household per year.[xlv] Finally, a report by NERA Economic Consulting commissioned by the AEMC concluded that the discount received by solar PV customers under two part flat tariffs outweighed the benefits they provide to the grid and that non-solar customers were paying an extra $120 per year as a result of costs avoided by PV customers.[xlvi]

Each of these estimates was reached by comparing an estimate of the current charges solar customers pay on a flat rate with the rate they might pay if they were on a demand tariff, paying higher charges for their peak use. There are number assumptions that inform the results, not the least of which is that it assumes a 'correct' tariff position as the most cost reflective. Simshauser and Grattan use a demand-based tariff, NERA a 'sharp' time of use. Depending on which tariff scenario is used, the cost estimate will be substantially different. As NERA points out, 'the results are highly dependent on the assumptions underpinning our analysis'. Two other key underpinning assumptions in these arguments are that peak demand is the main driver of network costs, and that solar users make at least an equal contribution to those costs.

In the context of 5-yearly guaranteed network revenues and mostly flat tariffs, solar households appear to be cross subsidised by their non-solar counterparts in respect of total revenue recovery. It is particularly important that this issue is addressed given that solar and non-solar households generally have similar peak demand; that for the time being the economics of batteries mean that they mostly remain dependent on a grid connection; and that the majority of network costs are sunk—ie, independent of the amount of energy actually consumed.

However, there are several important caveats to note here:

- The electricity system is replete with cross-subsidies (eg, between rural and urban, business and residential, and new and are existing customers), some of which are significantly more substantial than that between solar and non-solar households.[xlvii] Simshauser and NERA both found the level of the cross-subsidy related to air-conditioning was significantly—up to five times—higher than the solar cross subsidy. This is unsurprising, since air-conditioning uptake has been the biggest single driver of capex spending to meet actual and/or projected increases in peak demand over the past decade. Yet today air-conditioning customers are so ubiquitous that they are rarely singled out as a specific class. Thus Simshauser discounts the air conditioning cross-subsidy on the basis that 75 percent or customers have air conditioning, and claims at this level it is no longer a wealth transfer. (That will no doubt reassure the 25 percent of mostly low-income households that do not have air-conditioning. It also raises the question of whether, when more than 50 percent of households have solar, the NS-S cross-subsidy issue will magically disappear as well.)
- Lower overall bills do not mean solar owners do not pay low or no network charges. A solar household may have net zero bills because their remaining grid consumption is netted off against the retailer's FiT for their exported solar (which, it is worth noting, is not a subsidy but a market-based payment for the wholesale value of electricity). However, this household still pays network charges on its remaining grid consumption. It is just not obvious because the retailer nets off the FiT against the wholesale, network and other charges. So the average solar household, the grid consumption of which is on average one third less than for non-solar households, is still paying on average two thirds of the network charges, even if that is not obvious in their bills. The difference may be even less than one third where network fixed charges are relatively high and total consumption (ie, solar self-consumption plus grid imports) is relatively low, or where solar households are on time of use or demand tariffs.
- It is not only solar that has reduced demand to date, nor will it be the primary driver of reduced demand in the future. In the latest AEMO demand forecast, energy efficiency savings are projected to total 27GWh over the next 20 years, reducing forecast electricity consumption by 14.8 percent.[xlviii] Most of these gains are in the residential sector. In fact, increases in the energy efficiency of appliances are predicted to reduce demand at a greater annual rate than PV (0.7 percent versus PV 0.5 percent). It would be unusual to single out customers that have reduced their usage or purchased more energy efficient appliances and blame them for rising network costs. Yet the context is similar, with the uptake of energy efficient appliances and retrofits often aided by the availability of government subsidies, and the beneficiaries often being homeowners and those with available capital to invest.
- To regard this revenue disparity as a cross-subsidy assumes that networks should be entitled to fixed revenues even if the usage or load factor decreases thanks to the introduction of new technology like rooftop solar PV and distributed batteries. This is certainly the case under the revenue cap in place throughout the NEM at present; but later on this paper we will challenge this assumption.

- It also assumes that the lower revenue recovery from solar owners is not balanced by the benefits of bidirectional solar flows to networks. In some circumstances rooftop solar helps not only to push out localised or network-wide peak demand to later in the day or evening, but also to reduce the network peak. Given that capex to meet actual or projected increases in peak demand have been one of the two main drivers of higher network charges over the last decade (alongside higher reliability standards in NSW and Queensland), this means that solar households may be helping to constrain future network spending. Nevertheless, the evidence for reductions in network peaks is equivocal; in some cases it does; in others it doesn't. Future network costs are driven mostly by localised demand. For instance, rooftop solar is likely to reduce the network peak in a commercial area, where peak demand is closely correlated with solar output. But in a residential area, north-facing solar panels are unlikely to substantively reduce the evening peak. Conversely, rooftop solar can help to reduce the length of the pm peak, thereby reducing stress the network assets, especially during summer heatwaves.

Quantifying network benefits

A recent attempt to quantify the potential benefit of reduced expenditure on networks was undertaken by Victoria's Essential Services Commission. Their 2017 final report on the network value of distributed generation found that

> Distributed generation can and does provide network value. The value is primarily derived from reductions in network congestion, which can lead to the deferral of network augmentation expenditure and reduce the quantity of expected unserved energy.

However, the ESC found that the extent of this value depends on number of variables including

- Location – the proximity of the output to areas that are congested or nearing congestion.
- Time – the extent to which output coincides with peak demand.
- Asset life cycle – whether or not existing assets are nearing replacement.
- Capacity of generation.
- Optimisation – the extent to which delivery is firm and dispatchable.

While currently solar is mostly of value to networks in areas with capacity constraints and in business-dominated substation areas where the load curve more closely matches solar output, technologies such as energy storage, smart inverters and energy management systems will increasingly optimise PV generation

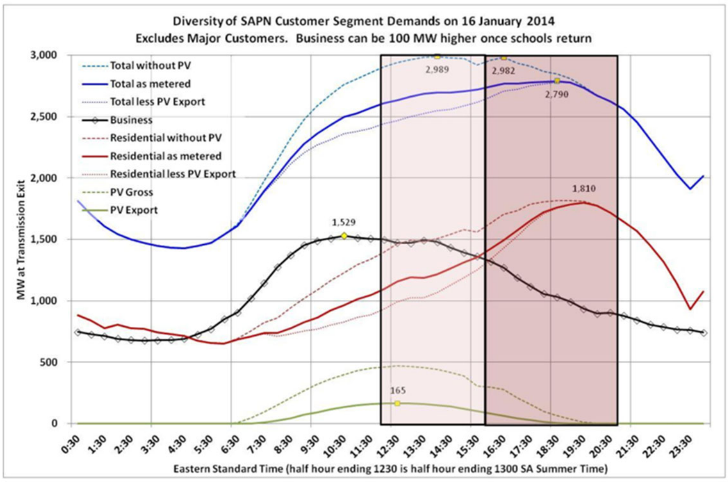


Figure 4: The impact of rooftop solar on network peak demand

SAPN single day summer load profile showing that while rooftop PV reduces and pushes out the total network peak, it has little impact on the timing or height of the peak in residential areas.

2 Principles

To help determine how to respond appropriately to the issues identified above, we suggest that the following principles should apply:

1. **Transparency**: Cross-subsidies are to some extent inevitable where costs are smoothed over time and across the customer base (otherwise every single customer would be charged differently for every minute of every day); but wherever possible they should be made transparent, so that policy makers and consumers can respond appropriately. This principle applies to the whole range of subsidies in the energy system.
2. **Fairness**: Public spending on DER should ensure that the whole community can benefit, while the costs of the DER revolution should be borne primarily by those with the greatest ability to pay for them. Thus, to avoid being regressive, where cross subsidies are material it is preferable they be paid for on budget rather than on electricity bills. Schemes designed to subsidise the cost of solar PV or battery storage should take account of the equity implications of the approach. Public spending on DER should be targeted to maximise not only the economic and environmental benefits but also to reduce inequity between consumer cohorts. In other words, low income and other vulnerable households should be the primary recipients of government spending on DER. Means testing and/or targeted approaches should be in place where appropriate.
3. **Materiality**: When assessing the costs and cross subsidies related to rooftop solar there is a need to determine whether these are material (ie, substantial), taking into account transactional costs, convenience/simplicity, and the extent to which costs are offset by corresponding benefits.
4. **Causer pays**: Wherever feasible, those whose actions create a cost to the system should pay those costs. This principle may be more relevant, in an era of largely private ownership of the energy supply chain, than the principle of the public good. However, a cost benefit analysis should always take a whole-of-system approach, including the hidden costs of externalities such as carbon costs (see #7 below).
5. **Public good:** Nevertheless, government spending on DER incentives and rebates should be targeted to achieve social and environmental as well as economic benefits for whole system rather than for individual households and businesses—especially where private benefits may cause further public spending. This principle also implies that responses should maximise the scope to make a positive contribution to broader public, social and economic policy outcomes. The public good also implies that those social and environmental benefits of rooftop PV which lie outside the current energy market regulatory framework, while often difficult to quantify, are important to acknowledge and, where possible, quantify. (In economic jargon this is referred to as the internalising of externalities.) Consideration of the public good may outweigh that of causer pays in some circumstances— e.g., to achieve rapid decarbonisation at least cost.
6. **Occam's razor**: Where there is a choice available and the differences are otherwise minor, the cheapest and simplest measure to address a cross-subsidy should be chosen.
7. **Complementary measures**: Sometimes the best way to ameliorate the regressive impact of a cross-subsidy is not to unwind it but to introduce other measures that will help the people affected (e.g. energy efficiency programs).
8. **Messaging**: Given the urgency of the climate change problem, we should attempt to find solutions which increase the uptake of renewable energy—e.g. by making solar energy available to more low income households—rather than sending a price or policy signal that renewable energy or DER owners are a problem. Policymakers, regulators and advocates need to be aware that demonising solar owners—or imposing punitive measures against them—could hasten the energy market death spiral, as DER owners increasingly and literally

take the power into their own hands. This would have the effect of imposing further costs on non-DER households and make it harder for them to participate in the DER transition.

What is a cross-subsidy? revisited

Applying these principles to the two case studies in the What is a cross-subsidy? box above, we would argue that, while these battery subsidies may not constitute cross subsidies, it is clear that their owners benefit twice—once from lower grid consumption, and once more from lower wholesale market prices for their remaining grid consumption—while other households only benefit from the latter. To pass the fairness test, it would be better for battery subsidies to be targeted at low income households, so that they—rather than middle income households—get the maximum benefit

3 Potential solutions

Government environmental programs

Whether it is the SRES, PFiTs, energy efficiency programs or solar and battery subsidies, the simplest way to avoid a cross-subsidy is for the upfront costs to be paid for out of government budgets (and thus the taxation system, which is relatively progressive) rather than electricity bills (since low income households tend to spend more of their income on these than do higher income households).

With regard to the ACCC's recommendation to abolish the SRES, its argument about the falling cost of rooftop solar must be balanced against evidence that (apart from the environmental benefits) there is no net cost to any consumer thanks to the merit order effect. While the federal government has recently guaranteed the future of the SRES, it could avoid any equity-related criticism by being funded through the Commonwealth budget instead of recovered through energy bills. Perhaps it could also be better targeted to produce system-wide as well as individual benefits: for instance, by applying a multiplier to solar systems facing east or west, to better match times of system peak demand.

Governments should also find cost-effective and fair ways to end legacy PFiTs without adversely affecting consumers who have made investment decisions on the basis of long-term government policies. This may involve voluntary buyouts; for instance,

> Solar Citizens is proposing that governments offer to voluntarily buyout the PFiT and share the savings between those who forfeit their payments and low-income and vulnerable households. The solar owners who participate get an upfront payout of the majority of their PFiT, to be spent on a battery, and savings are directed to a fund to support low-income and vulnerable households to access solar, storage and energy efficiency upgrades.[xlix]

As above, the targeting principle implies that future solar and battery programs involving public spending should be better targeted to benefit low income and other vulnerable households. As an example, the ARENA-funded project Social Access Solar Gardens concluded that

> If current support programs for rooftop solar were expanded to include Solar Gardens, the model would become viable for all currently excluded consumers: renters, apartment dwellers and low income consumers. In fact, solar gardens may be the only model that can help all locked-out households side step their specific barrier to solar.[l]

Network impacts

Infrastructure augmentation costs

Noting that at present networks are entitled to charge for new connections to recover related costs,[li] there are a number of potential solutions to the voltage and thermal capacity issues identified earlier:

- **Limit installed capacity** when local constraints have been reached. New solar installations (with or without export potential) may be banned when a local or network-wide capacity threshold has been reached. Such limits obviously favour existing solar owners at the expense of new ones, and prevent potential owners even from self-consuming solar energy, so are inherently unfair.

- **Limit maximum exports** as part of the PV connection agreement (e.g., by limiting inverter capacity or export potential to 5kW for single phase systems).[lii] This is slightly fairer, since it gives any household the opportunity to install solar. However, it still assumes that networks have a fixed capacity at the local substation or system-wide level. It may be appropriate in particular circumstances such on long skinny lines with little likelihood of being upgraded.
- **Install 'solar smoothing' devices** or generation management systems (now required in the Horizon Power network in WA)[liii] which 'help to mitigate the effect that a sudden loss of output caused by clouds passing (or similar shading issues) can have on grid stability'.[liv]
- **Adjust the nominal network voltage**: Given that high reverse flows cause voltage spikes, another solution is for networks to set the default voltage towards the lower end of the available range (instead of towards the upper end to cater for high aircon loads). However, there is evidence that this is not the case at present:

  > [V]oltages on our electricity networks are being run at levels far above where they should be, which is 230 volts. University of NSW researchers, using 2,000 devices that monitor voltage in households across the states of SA, Victoria, NSW and Queensland, found that the typical voltage on the network tends to be close to 245 volts whether it's day or night-time. They are only operating close to the standard of 230 volts for less than 1% of the time.[lv]

  In 2017 the Queensland Electricity Regulations were amended to change voltage requirements, effectively removing solar-related voltage problems without the need for further expenditure. The Queensland Government's Regulatory Impact Statement (RIS) proposing the change argued that the regulated 'floor' was too high and it restricted DNSPs ability to operate at a lower voltage in order to manage power flowing from rooftop solar.

Voltage

Voltage issues are not related solely to high penetrations of rooftop PV. While the nominal voltage is 230V, the allowable range for single phase households is 216-253 volts. Research conducted for ABC News in November 2018 involving over 12,000 homes revealed that the average midday voltage was 246V, but it was 242V even at night. Nearly 15 percent of homes were over the upper threshold, with very few under the lower threshold. Generation increases voltage while consumption lowers it. It appears that nominal network voltages are being set at the level that caters to high aircon loads rather than high PV exports.

- **Install equipment to manage voltage fluctuations:** Some networks are installing equipment in local or zone substations that are more responsive to voltage fluctuations. For instance, United Energy's DVM project apparently involves automatically varying the incoming voltage from each zone substation to the supply pole in each street—perhaps by having auto tap changing transformers at the zone substation.[lvi]
- **Smart inverters:** One of the optional features of AS1477.2 compliant solar inverters is volt-VAr capability, which uses reactive power to manage voltage spikes and results in only minor constraining of output on some peak days. This appears to be a cheap and fair solution to the voltage issue. In its Draft Plan for 2020-2025, SA Power Networks (SAPN) stated that

  > In December 2017 we updated our connection standards so that all new solar and battery inverters connected to our network must be configured with the Volt-VAr and (if available) Volt-Watt response modes as defined in Australian Standard 4777.2. Our modelling shows that Volt-VAr, in particular, can reduce local voltage rise issues very effectively if a reasonable proportion of inverters have the mode enabled. The benefits of this new standard will increase over time as new inverters are installed and old ones are replaced.[lvii]

- **Dynamic DER management:** Volt-VAr is dynamic on the customer's side of the meter, but is still invisible and uncontrolled from the network's perspective. SAPN and AusNet Services are two networks which have also canvassed the active or dynamic control of solar/battery inverters as potentially the most efficient solution to voltage and other DER issues. AusNet describes this as an alternative to charging hundreds of dollars in PV connection charges where they cause the need for grid upgrades, while 'customers who are in [other, more isolated] areas where augmentation is not economic will be 'export limited' – meaning that they cannot export solar that they do not consume on-site to the grid – and will therefore not be charged for augmenting the network.'[lviii] ('Dynamic control' in this particular case appears to refer to requests for voltage support or controlled load. It is dynamic in the sense of responding to network signals.) However, there are legitimate economic, consumer protection and control issues around dynamic DER management, including the potential impact on annual solar generation, so we would need to see more detail before endorsing this as a generally appropriate strategy.

Dynamic DER management

As part of its 2020-2025 Draft Plan, SAPN modelled the economic costs and benefits of three potential respons

1. Invest in inc procure demand-side services to s
2. Cap DER at tems to zero export.
3. Dynamic DE

The modelling fou anagement is likely to result in both n alternative outcome of increasing netw

SAPN's proposed which found in 2018 that

> Static export distributed energy resources or
>
> [P]rohibiting new DER systems from exporting where local hosting capacity has been reached or imposing broad restrictions is unlikely to be efficient or to meet customer expectations...
>
> The Commission considers a more sophisticated and dynamic approach such as managing output to meet security, reliability and safety needs of the network would be better suited to managing the

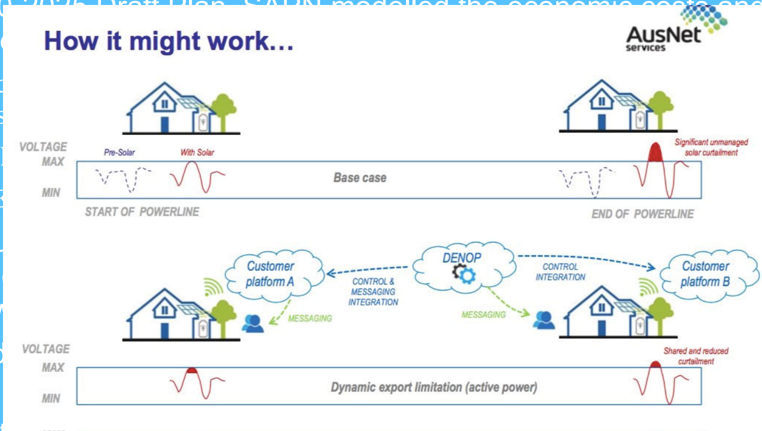


Figure 4: Dynamic DER management

Source: AusNet Services

- **Time-variant FiTs**: Cost reflective network tariffs could be combined with time of export based pricing for solar energy exported to the grid, as recently introduced in Victoria, to signal the ideal times for customers to be exporting their surplus energy. The introduction of time-variant FiTs is likely to encourage more households with rooftop solar PV systems to consider installing west-facing panels (which better meet late afternoon and early evening demand) or battery storage, which allows solar energy to be stored during the day and exported during the evening and early morning peaks. By offering fair value for electricity fed back into the grid during peak periods, households can maximise the benefits of having solar panels installed while reducing the risks associated with high reverse flows in the middle of sunny days. (Conversely, well designed ToU FiTS should also encourage solar owners to shift some discretionary consumption to the middle of the day, so they can still benefit from the value of the exports later in the day, acting as a behind the meter version of a solar sponge.)
- **Solar sponge tariffs:** The stress on network assets resulting from a combination of low daytime demand and high reverse flows can be largely ameliorated by shifting offpeak controlled loads (mostly electric hot water systems, but also pool pumps and slab heating) from overnight to the middle of the day on sunny days. Related tariffs are planned to be introduced in Queensland from 2019 and South Australia from 2020.[lix] Solar sponge tariffs need to be carefully implemented, however, to ensure there are no unintended consequences (eg, a net increase in daytime demand in mixed residential and commercial areas).
- **Charge for solar exports:** This reform is tantamount to introducing a negative FiT for solar exports, and would require a change to the NER.[lx] The AEMC's 2017 DMM Draft report raised the possibility of allowing networks to charge DER users for the export of electricity, on the basis that reverse flows are imposing new costs on networks, while 'all of the capital and operating costs of building and maintaining the network, as well as any difference between connection costs and connection charges, are recovered from all consumers through general network charges'[lxi]—implying a NS-S cross-subsidy.

  The AEMC's proposal to remove Clause 6.1.4 of the NER was supported by some social welfare groups. In a joint submission to the DMM draft report, St Vincent de Paul Society and SACOSS argued that the current rule creates a barrier to appropriate pricing for the use of the distribution network, resulting in increased cross subsidies within customer classes.[lxii] However, after a concerted campaign by solar advocates, in its DMM Final report retreated from recommending the removal of C.6.1.4, noting instead that

> …distributed energy resources can provide benefits, as well as potentially impose costs on a network. Therefore, charging is likely to need to change, and become more specific, so that these benefits and costs are accounted for, and so consumers do not face cross-subsidies…
>
> The Commission therefore considers it may be beneficial to undertake a holistic assessment of access and connection charging arrangements as they relate to distributed energy resources.[lxiii]

As removing C.6.1.4 has also been proposed as a solution to the under-recovery of network revenue from solar households, our main response is in the next section.

Under-recovery of network charges

As with solar-related infrastructure augmentation costs, there are several potential solutions to the problem of networks recovering less revenue from solar than from non-solar households. Let's start with the most obvious:

- **Cost-reflective tariffs**: Because there is not a strong correlation between rooftop solar output and peak residential demand,[lxiv] solar households tend on average or collectively to have similar peak demand to non-solar households. Shifting solar consumers from flat to demand (or other more cost-reflective) tariffs should therefore help to recover a greater proportion of revenue from the charging parameter that reflects both solar and non-solar customers' contributions to the main driver of higher network costs: augmentation to meet increases in peak demand.

  More cost reflective network tariffs should be capable of allocating costs more effectively and reducing cross subsidies where they exist. For instance, a 2018 analysis of 3,663 households in Ausgrid's network by the Alternative Technology Association shows that solar households paid significantly less than everyone else on flat and time-of-use tariffs, but similar to typical low income households on a typical demand tariff, and similar to typical medium income households on a demand tariff with no volumetric component. The results will vary significantly with different tariff rates, but this analysis strongly suggests that demand-based tariffs provide a better opportunity than volume-based tariffs to allocate network costs more fairly according to demand placed on the network by different customers.[lxv]

  Demand tariffs are now being proposed in most jurisdictions with high levels of solar PV, and if designed correctly and passed on transparently enough by retailers, should encourage all customers to shift load out of peak times. Without behavioural change, most solar households would pay more, but this passes the fairness test, especially since load-shifting outside of the peak charging period would allow solar and non-solar households alike to pay less rather than more. In the long term, this reform should put downward pressure on network costs, and thereby on consumer bills. The NTR found that

  > Over $16bn in network savings can be achieved by 2050 through improving existing tariffs, introducing new tariffs and establishing frameworks for networks to buy grid services from customers with distributed energy resources.[lxvi]

- **Higher fixed charges:** Increasing network fixed daily charges for solar households would also allow networks to recover more revenue from them. Most networks are already increasing fixed charges for all customers on the grounds also that their costs are largely sunk and fixed rather than variable according to customers' energy consumption. However, the NER do not allow solar consumers to be charged differently to other consumers, so the increase in fixed charges would need to be universal. This option has the other downside that it is regressive (because vulnerable households—including some solar households—tend to have lower than average consumption) and punishes households with low consumption (some of whom are trying to reduce their carbon footprint).

- **Batteries**: As discussed, battery storage and improvements in the functionalities of inverters will increasingly assist with voltage regulation and other power quality issues and, combined with favourable tariff design, could generate value for networks instead of costs. For example, customers could be incentivised to store rather than export energy in periods of low system demand, significantly lowering the risk of reverse flows. AEMO observed in 2017 that

> When minimum demand is negative in South Australia, the region would act as a net exporter of electricity. This also signals important opportunities for battery storage and to enable more efficient utilisation of energy across the day.[lxvii]

Home batteries become especially useful to networks when aggregated into virtual power plants (VPPs) when the VPP operator can access them to provide network support services in return for payment. Networks can also use larger batteries located in substations to manage frequency and voltage issues as well as reverse flows.[lxviii]

- **Charging for solar exports:** To be clear, there is nothing in the rules to stop networks *paying* (ie, creating positive tariffs) for DER exports. The proposal to remove C.6.1.4 must therefore be aimed at *charging* for DER exports to the grid.

In theory, charging solar owners for their grid exports is another way to recover 'lost' or lower revenue from them (separate to the issue of solar-related infrastructure costs discussed above). However, it has several fundamental flaws. One is that there is no implicit correlation between consumption and export at the individual household level; that is, a solar household may have low grid consumption and low exports, leading (under a charging regime) to a net revenue under-recovery; or high grid consumption and high exports, leading to a net revenue over-recovery.

Secondly, in some circumstances solar exports may be providing services (eg, voltage and frequency control) to networks and the broader system. It would be fundamentally unfair to attempt to recover lost revenue on one hand without also recognising the economic benefits of rooftop solar on the other. This is particularly true where rooftop solar does directly and demonstrably reduce peak demand (eg, in commercial areas). Any charging mechanism would therefore need to be sufficiently granular and sophisticated to enable this cost-benefit analysis, rendering it open to the criticism of overcomplexity: as Victoria's ESC concluded after a lengthy examination of this issue,

> Because of the characteristics of network value, a broad-based feed-in tariff is unlikely to be an appropriate mechanism to support the participation of small-scale distributed generation in a market for grid services. The value of the grid services that distributed generation can provide is too variable – between locations, across times, and between years – to be well suited for remuneration via a broad-based tariff.
>
> If a network value FiT was calculated with sufficient granularity to reflect the underlying network value it would be disproportionately complex and costly to implement. If it were made simple enough to implement, it would be inadequately reflective of value and could lead to payments to distributed generators who were not providing benefits while, at the same time, not sufficiently rewarding those who were.[lxix]

More importantly, the only rational economic argument for charging to export to the grid is to recover costs associated with that export. As discussed above, there may be times and locations in the network where it would be useful to signal that DER export will have a cost impact, and failing to signal this through export tariffs means consumers pay for inefficient investment. However, this is a different argument to using export tariffs to recover lower network revenue from energy (consumption) tariffs.

Also, given that in the NEM all network charges (transmission and distribution) are recovered from consumers rather than generators, this would unfairly favour centralised generation if a similar system were not also implemented for large generators connecting to the transmission and distribution networks. This would constitute a profound structural reform of the NER. This is a reminder that by not directly paying export tariffs, solar homeowners are no more free-riding on other consumers than are the owners of old coal-fired power stations, who likewise do not pay network charges for their energy exports into the transmission network. Changing the NER to recover network charges directly from generators rather than indirectly from consumers would likely produced no net benefit to the latter, because generators large and small would need to increase their prices accordingly to include transmission and distribution charges. Indeed, as rooftop solar becomes increasingly affordable, the more export charging appears to constitute the potential handbrake on greater equity, if low income households also have to pay for their exports.

This is a potentially major regulatory reform that carries its own equity and other risks:

  - Should prosumers on adjacent streets receive potentially radically different price signals purely because they are connected to different substations, while adjoining non-DER consumers continue to be protected by postage stamp or smeared tariffs?
  - If, say, you are a retired couple who has invested in solar to cut the electricity bills in retirement, is it fair that you might as suddenly be faced with substantially higher bills because you are paying the network more for your exports than you're receiving as a FiT from your retailer? Also, is it fair that this couple might be charged to export while solar households in an adjacent so or town are not, thanks to factors such as the age of substation assets or investment decisions made by networks, over which solar householders have no knowledge or control?
  - Once they are allowed to charge for DER exports, there is a risk that networks would become lazy and regard this as a juicy new revenue stream that absolves them of the responsibility to plan strategically and seek least cost solutions to emerging technical issues.
  - If flexible pricing were implemented in the short term, the message many DER owners would get is that their generation is not valued, likely leading to a greater level of behind the meter consumption and potentially grid disconnections. Instead of increasing the equity of network cost recovery, this would leave non-DER consumers to pay even higher network tariffs: the death spiral scenario. DER owners need to have confidence that a shift to flexible pricing is intended to be revenue neutral and will offer them with new opportunities (relating to reducing bills, increasing choice or reducing carbon emissions) rather than simply amount to a discriminatory or revenue-raising measure.
  - It would potentially undermine the ability for solar to be used as a means of assisting the affordability and sustainability of disadvantaged consumers (be they low income, renters, etc). It is the flip side of the argument that these consumers are currently locked out and bare disproportionate costs; that as we find solutions and implement policies and programs to overcome those access barriers, solar and DER more broadly becomes a significant opportunity. Export charging at this point could negate or undermine the potential to realise that opportunity. In a transitioning system with the likelihood of significant cost and disruption, this should be a policy consideration.

  Finally, proponents of this reform have not provided any details to date of how it would work in practice. For instance, would it apply to all DER exports, or only to new connections? What is the relationship between a charging regime and consumer preferences—ie, how do we know it would be the most efficient way to change consumers' behaviour? And so on.

- **Asset writedowns:** Networks only appear to be under-recovering revenue from solar households if it is assumed that revenues should remain more or less fixed in the face of changes in network utilisation. Under the revenue cap model currently in place across the NEM (which is really a revenue guarantee), the value of network assets (the regulated asset base or RAB) is rolled forward every five years and adjusted for inflation, depreciation and the value of new assets.

  Questions are periodically asked about whether the 'roll forward' model, which has only been in place since 2005, is the most appropriate one both to drive efficient network spending, and more particularly in the context of the emerging high DER market. Over the past year both the Grattan Institute and the ACCC have recommended network asset writedowns, principally on the basis that over the past decade the government owned networks in NSW and Queensland in particular have been gold-plated and cannot justify their current valuations.

  In relation to the rooftop solar boom, the situation is unclear. On one hand, some solar owners may argue that they should not have to pay for assets they're using less of. On the other hand, as discussed earlier, their peak demand may be similar, so their impact on future costs may also be similar. And as long as solar owners maintain a grid connection it is fair that they should also pay a share of sunk costs for the capital and operating costs relate to existing infrastructure.

  On balance, there does not appear to be a strong argument at present for low grid consumption or high solar exports to force network asset writedowns—especially bearing in mind the likely impact of high battery and EV updates in the near future. The former is likely to results in an even lower net grid utilisation (ie, the average network load factor), while the latter is likely to substantially increase net grid utilisation (without greatly increasing peak demand, if the tariff signals are right). However, voluntary asset writedowns may be a way for networks to reduce the risk of a death spiral outcome, by encouraging DER owners to maintain their grid connections.

4 The future: flexible DER pricing?

The current system where DER installations are regulated primarily though connection charges and export limiting is relatively crude. Likewise, there is no mechanism requiring networks to pay for DER exports where there is a net network. A high DER future grid is likely to require more dynamic and flexible (temporal and locational) pricing for energy imports and exports to better reflect their value to prosumers, other consumers, networks, the system operator and the wholesale market. Thus the AEMC's preliminary view in 2017 was that

> …one-off connection charges may not be appropriate when there are large amounts of distributed energy resources connected to a network, because the costs caused and benefits created by those resources are variable, depending on where they are connected and when they are being used.[lxx]

In this respect, flexible DER pricing could be considered another tool in the box of regulators and networks, alongside all the others discussed above. That is very different, however, to charging being assumed to be the only or best answer to every DER integration issue.

While they downplay the potential role of cost reflective network tariffs in overcoming the under-recovery issue, we also appreciate the argument put by St Vincent de Paul Society and SACOSS that the rule preventing networks from charging for DER exports potentially undermines a smooth transition to the new transforming energy market, including distributed energy and microgrids.[lxxi] Again, there is nothing in the rules to stop networks offering payments (ie, creating positive tariffs) for DER exports; but such a system may be fairer if they were also allowed to impose negative tariffs to recover any material costs related specifically to overcoming localised DER export issues that could not be more easily or efficiently dealt with by other means.

We recommend against introducing flexible DER pricing, however, while there are simpler and arguably more equitable ways—involving more predictable short-medium term impacts, and/or less risk of unpredictable long term impacts—to overcome the current technical and revenue under-recovery issues. The mass uptake of home batteries and EVs may provide the most appropriate technological and market trigger for a shift to more flexible pricing, since they offer greater opportunities for monetising new grid services, while EVs may create pressures on network capacity without appropriate pricing signals. The other relevant trigger would be the introduction or evolution of a distribution system operator (DSO) model or models capable of optimising orchestrating a DER trading platform or platforms. Indeed, cost reflective and inefficient pricing for DER would be virtually impossible without such a platform.[lxxii]

Meanwhile, there is considerable work underway that will, in time, provide greater clarity around the need for, and practicality of, flexible DER pricing and alternative solutions to DER integration issues, including ARENA's Distributed energy integration program (DEIP)[lxxiii] which includes OakleyGreenwood's project on the development of methodologies for pricing DER services.

5 Recommendations

The following recommendations summarise the solutions proposed above.

1. The cost of existing PFiTs and possibly the SRES should be recovered through government budgets rather than electricity bills.
2. Future government DER incentive and rebate programs should target low income households, renters, apartment residents and other groups experiencing socio-economic disadvantage.
3. Future government DER incentive and rebate programs should also be designed to facilitate public benefits to the energy system as a whole as well as private benefits to individual customers (eg, by favouring potentially more cost-effective larger scale solar gardens and community batteries).
4. Networks should be encouraged to implement low cost, causer pays solutions to voltage variability and thermal capacity/fault current issues caused or exacerbated by high reverse flows.

5. DER and other consumer advocates should support efforts by networks to get greater visibility of DER flows on LV lines.
5. Energy market stakeholders should support the more rapid introduction of cost reflective network tariffs, particularly for DER owners with smart meters, since these more equitably overcome the under-recovery of revenue from solar households than do flat/volumetric/energy-based tariffs.
6. Networks should work with solar and other consumer advocates to address consumer protection and other issues related to dynamic DER management.
7. The AEMC should revisit the issue of flexible DER export pricing once other available solutions have been implemented; when there is more clarity around DSO models and trading platforms; and when there is a greater uptake of home battery systems and EVs.

Notes

All hyperlinks live at 1 October 2018

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[i] 7.4 GW at June 2018. Clean Energy Regulator, 2018: http://www.cleanenergyregulator.gov.au/RET/Forms-and-resources/Postcode-data-for-small-scale-installations#Summary-of-postcode-data

[ii] AEMO, Electricity Forecasting Insights, 2017: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Electricity-Forecasting-Insights/2017-Electricity-Forecasting-Insights/Key-component-consumption-forecasts/PV-and-storage.

[iii] CSIRO and Energy Networks Australia, *Electricity Network Transformation Roadmap: Key Concepts Report*, 2016, 1.

[iv] UNSW and APVI, Solar Trends Report for Solar Citizens, 2018, 2.

[v] The ACCC recently estimated that solar customers save approximately $538 a year in energy costs. ACCC, Restoring Electricity Affordability and Australia's competitive advantage. Retail Electricity Pricing Inquiry Final Report, 2018: https://www.accc.gov.au/system/files/Retail%20Electricity%20Pricing%20Inquiry%E2%80%94Final%20Report%20June%202018_0.pdf.

vi Victoria ESC, xviii.

[vii] See eg 'A fair price for solar in Australia: fact sheet': https://energyconsumersaustralia.worldsecuresystems.com/grants/772/ap772-solar_citizens_fair_price_for_solar_fact_sheet.pdf.

[viii] The only reputable research suggesting that the boom in rooftop solar has come at a net cost to Australian consumers was a 2015 Grattan Institute report which concluded that 'There have been benefits in reduced electricity production from big fossil-fuel power stations and reduced greenhouse gases, but the benefits have been outweighed by the costs to the tune of almost $10bn.' However, that report was roundly criticised by variety of academics and commentators for overestimating the costs and underestimating the benefits of rooftop solar; and in particular, for interpreting the $2-4/MWh average reduction in wholesale market prices as a wealth transfer between generators and retailers rather than a benefit to consumers. Irrespective, the majority of the alleged net cost relates to state government premium feed-in tariffs (PFiTs) which are now being wound down, replaced by retailer FiTs the value of which is based on the wholesale cost of electricity. Also, the Grattan report did not recognise the effect of the SRES in kickstarting the solar industry in Australia, with the economies of scale responsible for a significant decline in the cost of rooftop solar systems over the past decade.

[ix] CSIRO and Energy Networks Australia, *Electricity Network Transformation Roadmap: Key Concepts Report*, 2016, 7.

[x] The ACCC recently estimated that solar customers save approximately $538 a year in energy costs: ACCC (2018) Restoring Electricity Affordability and Australia's competitive advantage. Retail Electricity Pricing Inquiry Final Report: https://www.accc.gov.au/system/files/Retail%20Electricity%20Pricing%20Inquiry%E2%80%94Final%20Report%20June%202018_0.pdf.

[xi] See eg https://www.smh.com.au/business/the-economy/australia-heading-for-a-battle-royale-on-solar-power-20181012-p5099v.html.

[xii] See eg http://www.abc.net.au/news/2018-10-11/electricity-distributors-warn-excess-solar-could-damage-grid/10365622.

[xiii] See eg St Vincent de Paul Victoria and SACOSS, Submission to AEMC Distribution Market Model Draft Report, July 2017.

[xiv] ACOSS, BSL and TCI, Empowering disadvantaged households to access affordable, clean energy, 2017, 7.

[xv] See, eg, the score for each retailer under “Equity of solar products (compared to non-solar)” in the 2018 TEC/Greenpeace Green Electricity Guide.

[xvi] See, e.g., Backroad Connections, Determining a fair value for distributed generation: Research Report and Bibliography, 2017: http://backroad.com.au/?page_id=97.

[xvii] See https://www.energynetworks.com.au/joint-energy-networks-australia-and-australian-energy-market-operator-aemo-project.

[xviii] See eg http://theconversation.com/are-solar-panels-a-middle-class-purchase-this-survey-says-yes-97614; https://onestepoffthegrid.com.au/busting-solar-ceiling-fight-millions-australians-locked-rooftop-solar/

[xix] Noting that these are back of the envelope calculations only, but that the principle remains relevant, see: https://reneweconomy.com.au/alp-battery-subsidy-could-save-100m-a-year-and-reverse-auctions-will-also-deliver-cheaper-energy-74109.

[xx] See, e.g., https://renew.org.au/our-news/high-grid-voltage-and-solar.

[xxi] ACCC, 2018, op cit.

[xxii] ACCC, 2018, op cit, Figure E, x.

[xxiii] The Australian Energy Market Commission 2017 Electricity Price Trends Report states that the average annual electricity bill across Australia for the current year is up $100 from the previous year to $1576, with an average charge of 34.41 cents per kilowatt-hour – an average increase of 4 cents from the previous year.

[xxiv] ACCC, 2018, 216-218.

[xxv] Referred to in https://theconversation.com/how-does-the-renewable-energy-target-affect-your-power-bills-29694.

[xxvi] ROAM Consulting, RET policy analysis, report to Clean Energy Council, 2014.

[xxvii] https://www.cleanenergycouncil.org.au/policy-advocacy/renewable-energy-target.html.

[xxviii] D. McConnell et al., Retrospective modelling of the merit-order effect on wholesale electricity prices from distributed photovoltaic generation in the Australian National Electricity Market, *Energy Policy* 58, 2013, 17–27.

[xxix] Energy Synapse, Impact of small solar PV on the NSW wholesale electricity market, 2017.

[xxx] Mark Ogge, Watt on a hot tin roof: how solar increases reliability and reduces electricity prices, The Australia Institute, 2018: http://www.tai.org.au/sites/default/files/P527%20Watt%20on%20a%20hot%20tin%20roof%20%5BWEB%5D.pdf.

[xxxi] Ogge, 1.

[xxxii] ACCC, 2018, op. cit. The NSW scheme has now fully ended, however in Victoria, South Australia, Queensland and the ACT schemes have only been closed to new entrants. The cost of premium FiTs varies considerably across the NEM from $73 per annum per customer in South Australia (where there has been a large uptake in PV) to $0 in Queensland where the government has recently removed the cost from electricity bills and will pay the costs from taxation revenue.

[xxxiii] Subsidy schemes exist for solar in the ACT (targeted to pensioners and including an interest free loan component) and Victoria, while Queensland has an interest free loan arrangement available for households eligible for the Family Tax benefit B and with high electricity consumption. Queensland has also announced a new scheme involving both loans and grants will be available for solar and batteries later in the year, however full eligibility details are yet to be announced. South Australia and the ACT are already offering subsidies for batteries.

[xxxiv] See e.g., https://static1.squarespace.com/static/5b46af5a55b02cea2a648e93/t/5be38577352f53b275e555b0/1541637500920/181108+-+Renters+To+Benefit+From+Labor's+Solar+Panels+Plan.pdf?.

[xxxv] See, eg, https://www.abc.net.au/news/2018-11-08/high-voltage-fuelling-increased-electricity-consumption/10460212.

[xxxvi] SAPN, Future network strategy 2017-2030, 4.

[xxxvii] AEMC, Distribution Market Model Final report, 2017,13-15: https://www.aemc.gov.au/sites/default/files/content/fcde7ff0-bf70-4d3f-bb09-610ecb59556b/Final-distribution-market-model-report-v2.PDF.

[xxxviii] Ergon Energy, Submission to Queensland Productivity Commission on the Issues Paper on Solar Feed-in Pricing in Queensland, November 2015, 11.

[xxxix] The AER noted that the proposal reflected quality monitoring above the levels of other network operators and had not been subjected to a sufficient cost benefit analysis. They also noted that Energex had recently introduced a new standard for the connection of small-scale rooftop solar PV systems on its network (in conjunction with Ergon Energy). Under this connection standard, a particular solar PV system must cut its electricity output to the distribution network if voltage exceeds 255 volts. The AER believed that if these connection standards were enforced it would remove over-voltage issues. In addition they noted the potential for a market led role out of smart meters to deliver the functionality that Energex required to monitor voltage levels across its low voltage network.

[xl] Ausgrid, Network Innovation Capex Program Cost Benefit Analysis Summary, 2018.

[xli] According to data from The Australia Institute, total NEM network revenues were around $10 billion annually in 2016: see https://reneweconomy.com.au/consumers-got-burned-electricity-prices-started-networks-48000, Figure 7.

xlii Victoria Essential Services Commission, The Network Value of Distributed Generation: Distributed Generation Inquiry Stage 2 Final Report, 2017, 54, fn. 47.

[xliii] Paul Simshauser, Network tariffs: resolving rate instability and hidden subsidies. Working Paper No.45. AGL Applied Economic and Policy Research, 2014.

[xliv] Woods, T and Blowers, D., 2015, Op.Cit.

[xlv] Simshauser, 2014, Op. Cit.

[xlvi] NERA Economics, 2014, Op. Cit.

[xlvii] In the case of Queensland's uniform tariff policy, the cross-subsidy from largely urban customers in the southeast to Ergon's customers in the rest of the state amounted to $491 million, or $701 per year, in 2017-18. This cross-subsidy is managed by the Queensland Government through the state budget rather than being recovered directly from energy consumers.

[xlviii] AEMO, 2017, Op. Cit.

[xlix] Solar Citizens, Sharing the Savings: A voluntary buyout of Premium Feed-in Tariff schemes that can help vulnerable households, 2018, 4.

[l] Rutovitz, J et al, Social Access Solar Gardens for Australia. Institute for Sustainable Futures, University of Technology Sydney, 2018, 7.

[li] See NER, Chapter 5A, Part E, Connection charges; also C.6.1.4(b).

[lii] See eg https://www.solarchoice.net.au/blog/solar-system-size-limits-by-network.

[liii] See https://horizonpower.com.au/solar/apply-to-connect-solar-to-our-network/generation-management/ It is not clear what Horizon's "generation management " requirements entail beyond AS4777.2 compliance.

[liv] https://www.solarchoice.net.au/blog/solar-system-size-limits-by-network

[lv] Tristan Edis, Is Australia on the verge of having too much solar energy? https://www.theguardian.com/commentisfree/2018/oct/30/is-australia-on-the-verge-of-having-too-much-solar-energy referring to Stringer, Naomi & Bruce, Anna & Macgill, Iain, Data driven exploration of voltage conditions in the Low Voltage network for sites with distributed solar PV. Conference: Asia Pacific Solar Research Conference 2017, Melbourne: https://www.researchgate.net/publication/322419305_Data_driven_exploration_of_voltage_conditions_in_the_Low_Voltage_network_for_sites_with_distributed_solar_PV.

lvi NEM Watch FaceBook page; post by John G. Hooper on November 10 at 11:46 AM, quoting from a letter from United Energy.

[lvii] SA Power Networks 2020 –2025 Draft Plan, 2018, 32.

[lviii] https://onestepoffthegrid.com.au/ausnet-flags-hefty-connection-fees-rooftop-solar-victoria.

[lix] SA Power Networks 2020 –2025 Draft Plan, 2018, 71.

[lx] It would require a change to Clause 6.1.4 of the NER, which prohibits networks from charging distributed generators for their use of the grid. (Transmission and distribution network charges are recovered from consumers rather than generators at present.)

[lxi] AEMC, Distribution Market Model Draft report, 2017, 58.

[lxii] St Vincent De Paul Society and SACOSS, Submission to AEMC DMM Draft report, 2017.

[lxiii] AEMC, Distribution Market Model, Final report, 2017, 62.

[lxiv] This problem does not arise in relation to commercial solar, wherein there is a strong correlation between maximum solar output and peak consumption.

[lxv] Dean Lombard, Sharing the load: Understanding consumer outcomes of network tariff reform, Alternative Technology Association, 2018: https://1drv.ms/b/s!Al08m3BYjwYOm1R9oQDZ_QaD-VZx.

[lxvi] NTN, 40.

[lxvii] AEMO, 2017 Electricity Forecasting Insights: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Electricity-Forecasting-Insights/2017-Electricity-Forecasting-Insights/Key-component-consumption-forecasts/PV-and-storage. AEMO also predicted that battery storage is forecast to reduce peak demand by 1.5 percent by the end of the 20-year forecast period.

[lxviii] See eg http://www.endeavourenergy.com.au - media - media releases - 2017 - NSW'S LARGEST GRID SUPPORT BATTERY TO BE INSTALLED AT WEST DAPTO.

lxix Victoria Essential Services Commission, The Network Value of Distributed Generation: Distributed Generation Inquiry Stage 2 Final Report, 2017, xxii.

[lxx] AEMC, Distribution Market Model Final report, 2017, 61-62.

[lxxi] St Vincent De Paul Society and SACOSS, Submission to AEMC DMM Draft report, 2017.

[lxxii] See eg http://www.energynetworks.org/electricity/futures/open-networks-project.

[lxxiii] See https://arena.gov.au/where-we-invest/distributed-energy-integration-program.