NETWORK VALUE OF LOCAL SOLAR

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TEC has been asked to provide a short overview of the value to distribution networks of distributed – ie, rooftop – solar.[1] It is more general than the excellent work done for the Victorian Essential Services Commission as part of its inquiry into the "true value of distributed generation"[2] and the methodological work done for the Clean Energy Council as part of its Future Proofing in Australia's Electricity Distribution Industry project.[3] It does, however, draw on lessons learnt from three years' involvement with the Institute for Sustainable Futures on what became the Local Generation Network Credit (LGNC) rule change process as well as ISF's ARENA-funded Local Network Credit/Local Electricity Trading project.[4]

Any form of energy is likely to have a different value from different perspectives, or to different actors or segments of the supply chain, so there are several ways of approaching this question. We have therefore approached the question of the value of solar to networks from a variety of perspectives:

1. As perceived by owners.
2. To current distribution networks.
3. To microgrids.
4. To future distribution networks.

1. **For owners**, the idea that they export energy to the grid for a maximum of 10 cents per kilowatt hour while they import grid energy – or their next door neighbour imports their exported solar – for an average of 27 cents might imply that either the network or the retailer is ripping them off. The difference of 17 cents is composed of network charges, the RET and state-based "green schemes" and the retailer's margin. That price differential is why solar owners should try to maximize their onsite or behind the meter consumption, because it is effectively worth as much to them as grid electricity costs to import. And as we will see, it is certainly worth more to them than to the network under current arrangements.
2. The second way to approach the issue is **the value of solar to current distribution networks**, which is what this note is mainly concerned with. The fact that distributed solar does not have to travel far should mean that it is more valuable than centralised energy, since it does not require extensive upstream infrastructure – the high voltage, sub-transmission and transmission networks and

[1] Hereafter, "solar" refers to distributed or rooftop PV.
[2] Essential Services Commission, The Network Value of Distributed Generation, Distributed Generation Inquiry Stage 2 Discussion Paper, June 2016.
[3] Ernst & Young, Evaluation Methodology of the Value of Small Scale Embedded Generation and Storage to Networks: Task FPDI TA-2C for the Clean Energy Council July 2015.
[4] See https://www.uts.edu.au/research-and-teaching/our-research/institute-sustainable-futures/our-research/energy-and-climate-2.

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associated zone substations – to transport it to consumers. With network charges constituting around half of retail bills across the NEM, to put it crudely, simply by avoiding the transmission network at least, in theory solar should be worth at least as much as the transmission system costs consumers (around 8% of retail bills).

But that is not how distribution businesses work. As regulated monopolies, their revenue (under revenue caps, now the norm in the NEM) is primarily a function of the rate of return they earn on capital invested in existing or sunk assets plus new spending for network augmentation or replacement, as well as operating expenditure and incentive schemes. This model is inherently conflicted, because the more spending they can justify on new capex, the more revenue networks earn; while the optimal outcome for consumers is less spending and lower prices.

Given this business model, networks should be antagonistic to distributed solar, since it effectively bypasses much of the existing grid, and may even cause them to incur additional costs to augment the grid to cater for issues relating to feeder peaking and voltage and frequency fluctuations associated with high upstream or bidirectional flows. For instance, Ergon Energy estimated in 2015 that "The requirements for network upgrades alone associated with solar systems are forecast to cost approximately $44m… out to 2020."[5] It has even floated the idea of "buying back" the 44 cent FiT in some locations and putting those customers on the 6.5 cents net FiT to encourage load-shifting.[6] On the other hand, solutions may not be expensive: Ergon estimates that lowering the grid-wide voltage to 230V and installing LV static compensators would cost only one-quarter of traditional augmentation options.[7]

This is partly why some networks have displayed a range of anti-solar behaviours such as limiting exports to the grid and in some areas banning new connections altogether; in SA Power Networks' case by attempting to introduce a higher solar tariff; and generally reacting to lower grid utilisation by solar households by increasing fixed charges. On the other hand, the effective average $700 annual cross-subsidy from other consumers to the owners of air conditioners has not been a great cause for concern for networks because it has created the incentive to build more infrastructure over the past decade to meet this principal driver of peak demand.

Nevertheless, to counter the urge to overbuild or "gold plate", through incentive schemes networks are also theoretically incentivised to seek alternatives to capex. And they must always balance their ability to earn a regulated return on assets for up to 50 years with the financial risks (which have been very low in practice) associated with "lumpy" capex investments. Also, to be fair some networks have been proactive in seeking to reduce peak demand – such as Energex's highly successful PowerSmart rebates for energy efficient air conditioners with direct load control capability.

In this context, on the very generous assumption that the current regulatory framework is now working effectively to counter the historical preference for capex spending, the main value of distributed solar to networks should be in avoiding the need for new poles, wires and substations to meet higher peak demand. Solar may also be useful in reducing replacement capex (repex) where lower asset utilisation results in less expensive kit being required on replacement.

There is evidence that high solar penetration pushes out the system-wide peak from late afternoon to early evening, and that in some cases it reduces this peak by up to 20 per cent.[8] But these estimates vary widely depending on the location, season and data source. In 2012 AEMO estimated that

> In the mainland regions, summer maximum demand typically occurs in the late afternoon, when rooftop PV generation is declining from its midday peak and is operating at an estimated 28%– 38% of

[5] Ergon Energy, Submission to Queensland Productivity Commission on the Issues Paper on Solar Feed-in Pricing in Queensland, November 2015, 11.
[6] See http://reneweconomy.com.au/2014/ergon-may-buy-back-solar-feed-in-tariffs-to-avoid-costly-upgrades-88424.
[7] Ergon Energy, Submission to Queensland Productivity Commission on the Issues Paper on Solar Feed-in Pricing in Queensland, November 2015, 10-11.
[8] See, eg, the load profile enclosed (from SA Power Networks, Tariff Structure Statement, December 2015, 18), which shows the network peak demand to be 7% lower with PV than without it. It also shows that PV is operating at close to full capacity around 2 pm, when the network-wide peak occurred.

capacity. Maximum demand in Tasmania typically occurs on a winter evening, when rooftop PV generation is negligible.[9]

(However, even a 25 per cent local penetration of solar effectively results in a reduction in peak demand of only one-quarter of this 28-38 per cent figure, or less than 10 per cent in total.)

In theory, especially as solar installations grow, where solar does reduce peak demand it should also reduce the need for future capex spending to meet future peak demand. In practice it depends on the network load profile and where the solar is situated. Being mostly on residential rooftops at present, solar may not contribute much to lower system-wide demand, since business constitutes the majority of load on most networks. Also, because of weather fluctuations it is not regarded as firm capacity; that is, overcast weather or storms on the afternoon of the 10 or so hottest or coldest days of the year for which infrastructure is built to meet, it may not always be available. And for networks with winter evening peaks, there is little solar can do directly to meet this demand.

These are issued which have arisen, inter alia, in LGNC rule change process. The LGNC was intended to introduce a mechanism into the NER to require networks to provide "a price signal for exported energy where and to the extent that the exported energy serves to defer or avoid augmentation, reduce the cost of replacement assets, or reduce load at risk."[10] In effect, it would primarily pay a credit to local generators providing a network benefit such as peak demand reduction or network support. (The only such credit in the NEM to date has been AusNet's 4 c/kWh summer generation credit for solar owners, the rationale for which was unclear; and it has recently been terminated.)

Calculating the value of distributed generation as a function of its contribution to reducing peak demand is not very helpful to solar. Early work by ISF for the rule change process arrived at a value of 3.3c/kWh during peak periods, 0.3c/kWh during shoulders and 0c during offpeak periods.[11] More recent work by ISF based on long run marginal cost (LRMC) values found that there would be no overall financial benefit in 2020 to consumers with PV systems from introducing a local network credit, and only a potential saving of $13 in 2050,[12] due primarily to the fact that maximum output does not closely match system load and is not firm. (These values are "smeared" or network-wide, and would be higher where the grid is constrained, and in view of transaction costs ISF recommended that they not apply to PV systems under 10 kW, although the role of aggregators is unclear. And ISF also recommended the credit not be paid to existing distributed generators, as they are not as helpful in reducing future peak demand as new generation.) By contrast, large benefits accrue to large commercial customers with cogeneration plants exporting to the grid during peak periods.

However, this smeared approach does not take into account the fact that some feeders and substations are primarily residential (with late afternoon and/or evening peaks) while some are primarily business (with early afternoon peaks). Where residential or commercial distributed solar can contribute to reducing the peak on a primarily business area, it could have a higher value – especially where the network is already constrained or close to it in that area. And in primarily residential areas, to reduce the late afternoon/evening peak networks could take more advantage of the peak-shaving potential of distributed solar by means such as offering rebates for consumers installing west-facing panels. They could also incentivise consumers to reduce the need for air conditioning on hot summer afternoons and evenings by paying them to installing ceiling insulation or awnings.

In other words, under current arrangements solar is mostly of value to networks in areas with capacity constraints and in business-dominated substation areas. It is the rule change proponents' view that this value is not adequately recompensed through existing mechanisms such as avoided transmission use of service (TUoS) payments and incentives such as (underutilised) network support

[9] AEMO, Rooftop PV Information Paper, 2012, iii.

[10] OakleyGreenwood, Local Generation Network Credit Rule Change Proposal, 2015, 2.

[11] Langham, E., et al, *Calculating the network value of local generation and consumption*. Report prepared for Total Environment Centre and the City of Sydney, 2014, 29.

[12] Kelly, S., et al, An *Economic Impact Analysis of Local Generation Network Credits for New South Wales*. Institute for Sustainable Futures, UTS, 2016, iv.

payments. The rule change sought to remedy this undervaluation by requiring networks to offer a credit or negative load tariff for distributed generation based on the network's LRMC.

Solar is of greater value to networks even in residential areas under several scenarios:

- Where panels face west and can meet late afternoon and early evening demand.
- With the addition of batteries, which allow solar energy to be stored during the day and exported during the evening and early morning peaks.
- To heat water in the middle of the day, when it can replace the overnight heating of electric storage hot water (ESHW) systems.[13]
- Where tariffs encourage load shifting away from the evening peak into the peak solar output period.[14]
- Where LRMC values are calculated over a time horizon greater than 10 years, so more grid constraints become evident.
- Where the output from small generators can be aggregated and automated to reduce administrative and transaction costs.

Finally, there are other services that networks value, such as voltage and frequency control, but in practice it appears that (as discussed above) solar is more likely to be a cause of these issues than a solution. However, recent changes to AS4777 have reduced the likelihood of these problems arising from PV owners' inverters.

3. **The value of solar to embedded networks or microgrids** rather than to distribution networks. Whether they are completely offgrid/islanded or connected to the distribution network via a "skinny" or low capacity connection, microgrids have more options around how they use and value solar. Some have centralised solar arrays and batteries, while others rely on individual or group systems, but effectively in these cases solar plus batteries and/or cogen, diesel or petrol gensets, plays the role of centralised generation.

   The economics will vary widely depending, for instance, on whether the grid is existing and can be bought back from the network or must be built from scratch, the size of the solar array, local weather conditions, consumers' choices around reliability and fossil fuelled backup supply (from gensets), etc. But as an example, the developer of a new housing estate may decide between solar and batteries for every house and centralised units, and in so doing may decide to offer an export price for solar during evening peaks that is greater than the 10c maximum available from retailers but less than the (up to) 50c/kWh charged during peak periods under time of use tariffs or 50c/kW under demand tariffs.[15]

4. **The value of solar to future distribution networks.** As networks shift towards becoming service platforms for a range of energy services rather than purely energy transporters as at present, solar could be more valuable as it is integrated into the sale of locally generated energy. Although the widespread takeup of batteries will result in more energy being used onsite rather than exported to the grid (the latter constituting about half of all solar generated at present, depending on the system size and load profile), networks will need to incentivise solar owners to install larger systems, face them west and export surplus generation into the grid because the alternative is much lower gird utilisation, followed by either lower network revenue or higher prices for legacy grid-dependent consumers.

   In the emerging decentralised energy system, instead of "What is solar worth to networks?", the question could instead be framed as "How valuable are networks to solar consumers?" and vice versa.

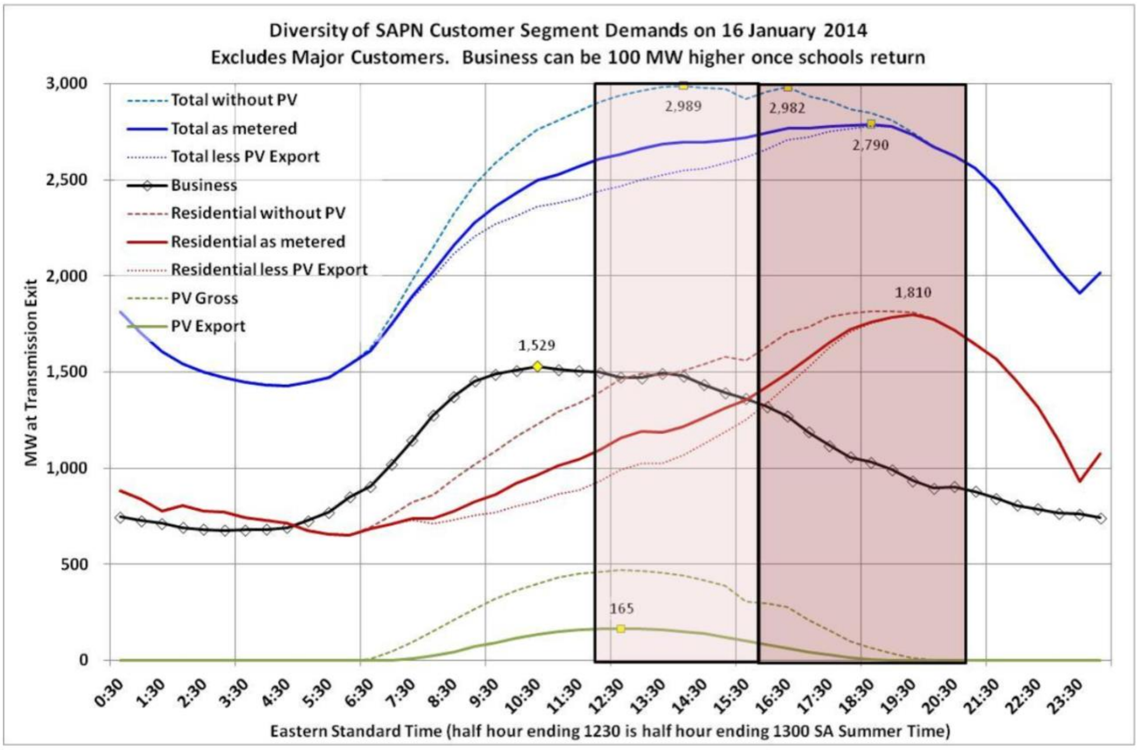
[13] Some networks are taking advantage of this option by offering "solar sponge" tariffs between 10 am and 2 pm, reducing the artificial peak that happens at, say, midnight when all the controlled load ESHW begin to heat.
[14] This value is arguably more to consumers than to networks, which recover a fixed amount of revenue from all customers.
[15] For maximum demand on the highest consumption day of the month in summer; see SA Power Networks, Tariff Structure Statement, December 2015, Appendix A.

In other words, what is it worth to networks to keep solar customers tied to the grid instead of disconnecting? The main economic equation here is that the cost of going offgrid with solar, batteries and an energy management system should be less than the cost of remaining grid-connected with a retail contract over a 10 year horizon (the usual warranty period for batteries).

In practice, within a decade this will be a live question for many households, especially as fixed charges and retail bills increase, the cost of batteries decreases, and demand tariffs and smart meters become almost universally adopted across the NEM. The offgrid option will be particularly attractive for low consumption, energy efficient households with a relatively flat load profile who correctly match their consumption pattern with their PV and battery systems.[16] For such consumers, networks may need to change their business model or come up with new options such as feed-in tariffs for solar energy stored and exported during peak periods in order to retain these customers.

Conclusion

Without internalising the social and environmental benefits of solar, under most current scenarios it has a low value for networks under given their current business model and regulatory arrangements. The value is higher for solar that can be exported when and where it is of most use to networks. In the future, though, the decentralised energy system will put more power in the hands of solar owners, and they will be able to benefit financially to the extent that they are willing to become energy literate, to store their solar energy or to allow other market participants to control their energy system on their behalf.



[16] See, eg, ATA, Life After FiTs, May 2016, 4.3.