Network Tariffs in an Increasingly Distributed, Decentralised, and Decarbonised Power System

BY ALAN RAI

Alan Rai is a Director at Baringa Partners LLP, and a Senior Fellow at the University of Technology, Sydney (UTS). His email is alan.rai@uts.edu.au. Thanks to Garth Crawford, Tim Nelson and Greg Williams for their comments. The views expressed in this article are those of the author and not necessarily those of Baringa Partners or UTS.

See footnotes at end of text.

Australia has seen significant increases in the penetration of variable renewable energy (VRE) driven by the Renewable Energy Target (RET)[1]: Wind (at the utility scale) and rooftop PV (at the small scale). As at end-November 2019, more than 1 in 5 Australian households, around 2.3 million, had rooftop PV, a 27-fold increase over the past decade, or a compound average growth of 40 per cent p.a.[2] Across Australia's National Electricity Market (NEM)[3] combined small-scale (i.e., system sizes of 100kW or less) rooftop PV capacity is around 8½ GW, equivalent to almost 20 per cent of utility-scale generation capacity in the NEM. Uptake has been especially prevalent in Queensland (QLD) and South Australia (S.A.), where over 1-in-3 households have installed rooftop PV.

There has been a significant, albeit less stellar, increase in utility-scale (i.e., system sizes 5MW or more) VRE penetration across the NEM. NEM-wide, VRE penetration was around 15 per cent over calendar year 2019, compared to 1.4 per cent a decade ago. Most of this increase has occurred in S.A., where utility-scale VRE penetration is close to 50 per cent, followed by Victoria (16 per cent penetration rate).

This increase in utility- and small-scale VRE penetration has fundamentally changed the nature of intra- and inter-day electricity demand, with lower demand troughs, faster ramps, yet largely unchanged demand peaks. Intra-day demand increasingly resembles a 'duck' curve (or for Australia, an 'emu' curve), with PV export congestion and export-induced system security concerns increasingly an issue in the middle of the day (Rai et al., 2019).

Efficiency considerations

The Australian Energy Market Commission (AEMC), the rule maker for the NEM and energy policy advisor to governments, made a series of rule changes from late 2014 onward to facilitate the move to more efficient network price signals (AEMC, 2014). In the pre-DER world, efficient network price signals focused on managing peak demand (e.g., 'peak shaving') as a means of maintaining power system reliability and security whilst maintaining affordability. In the same way, efficient network price signals remain important in today's age of decarbonisation and the 'prosumer'.

The difference today is efficient signals are needed for both withdrawals (i.e., consumption and demand) and injections (i.e., supply and production), to manage import and export congestion. The importance of such price signals is growing: rooftop PV capacity is projected to double by 2030, and uptake of other distributed energy resources (DERs), chiefly electric vehicles (EVs) and home batteries, are likely to also accelerate (Rai et al., 2019). In addition, the increasing prevalence of new digital load-control technologies, such as Google Home and Nest, may result in demand that was once thought to be price-inelastic in the short-term becoming price-elastic.

Network congestion – on imports or exports – is often highly localised (i.e., within distribution networks). Hence, efficient price signals must include a spatial and time dimension. However, most time-of-use (ToU) and demand tariffs apply over an entire network, penalising customers in network locations where there is no congestion challenge and providing these customers with no commensurate network benefits (Markham, 2019).

Further, most electricity customers remain on time-invariant, volumetric, network tariffs for both imports and exports: a flat 'average-cost' tariff. While some dynamic (i.e., time-varying) network tariffs exist, chiefly time-of-Use (ToU) tariffs, these relate solely to imports. Moreover, their uptake remains very low due to:

- a low penetration of enabling technologies, chiefly 'smart' meters to enable demand and ToU tariffs, respectively. Outside Victoria, smart meter penetration is around 20 per cent. While penetration rates have risen over time, the growth rate is modest as smart meters are mandatory only for new meter installations or replacing existing accumulation (type-6) meters, and
- the opt-in nature of dynamic tariffs for small electricity consumers, even in Victoria, where residential smart meter penetration rates are close to 100 per cent.

In terms of exports, network tariffs indirectly incentivise self-consumption via-a-vis exports through varying import (i.e., ToU) prices; direct incentives, via feed-in tariffs (FiTs), are provided by retailers, not networks. FiTs are also predominantly time-invariant. And there are no demand charges applied for exports; instead, installed PV capacity is rationed by imposing limits on inverters, a blunt way of dealing with export constraints.[4]

In this article, we use "retail tariff" and "network tariff" somewhat interchangeably, though the two terms are distinct (i.e., the former is offered by the retailer; the latter by the network provider). We do this because, in the NEM's experience, most retail tariffs closely resemble the structure of the corresponding network tariff. This is because retailers are unable or unwilling to hedge any basis (i.e., volume) risk arising from differences between retail and network tariff structures.[5] In contrast, there is a multitude of hedging options in relation to wholesale spot prices (such as vertical integration and financial derivatives), despite spot prices being even more dynamic than network prices.[6] Therefore, if network tariffs were to become more dynamic and cost-reflective, it is possible retailer tariffs could become similarly so at the margin.

A corollary of this is that, were network tariffs to become more dynamic and cost-reflective, it is likely retailer tariffs would become similarly so.

Finally, the focus below is on retail customers, which include residential customers and other 'small' customers (such as small businesses), as larger customers already face dynamic network prices.

Equity considerations

Equity is also an important consideration in network tariff design. An equitable tariff could mean one or both of the following:

- Customers pay a "fair share" of the sunk network costs (i.e., costs unrelated to network utilisation). It is not always clear how these costs should be recovered equitably. For example, these costs could be recovered by charging all customers a uniform fixed charge, consistent with the 'sunk' nature of the costs. However, this can be regressive (i.e., low-income, low-consumption customers are disadvantaged). To offset this, the size of fixed charges can be based on customer demand or socioeconomic status (Burger et al., 2020).
- A tariff that accounts for the extent of financial vulnerability (or ability to pay) of customers; for example, a tariff that is consistent with first-, second- or third-degree price discrimination. Inclining-block tariffs were often considered an example of this (Borenstein, 2012). However, these types of tariffs can be regressive when income/wealth and consumption become negatively correlated due to the increased uptake of rooftop PV predominantly by high-income/high-wealth households (Rai and Nelson, 2019).

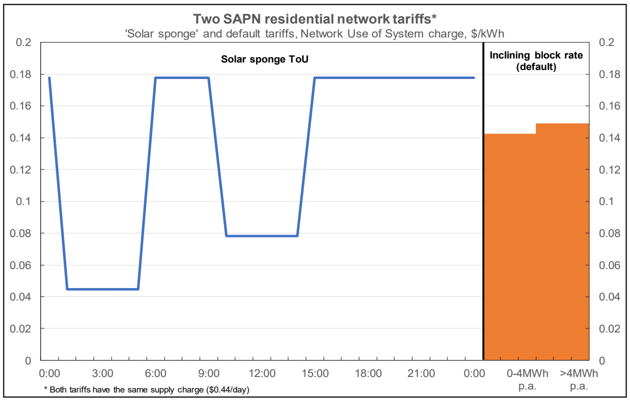
The conventional economist's view is that equity considerations should be best addressed by governments via tax-and-transfer (aka 'redistribution') schemes, rather than by electricity tariff design. However, failures in redistribution schemes, both within the electricity sector (e.g., energy concession schemes) and outside, have undermined this conventional view (Rai and Nelson, 2019).

Furthermore, efficiency and equity can both be enhanced, at least for some tariff designs. Amongst others, Schittekatte et al. (2018), Simshauser (2016), and Simshauser & Downer (2016) find flat-rate volumetric tariffs to be inefficient and inequitable vis-à-vis both ToU tariffs, and ToU tariffs coupled with capacity charges. Schittekatte et al. (2018) argues ToU tariffs on withdrawals and injections are more efficient and equitable than withdrawal-only ToU (even when coupled with demand charges) tariffs under increasing DER uptake. The ability of certain tariff structures to remain efficient and equitable under rising DER penetration (in particular, PV-cum-battery storage systems) is an active area of research, illustrated by the findings of Schittekatte et al. (2018) vis-à-vis Simshauser (2016).

With this in mind, we now discuss the emergence of more dynamic network tariffs in two of the distribution network areas with the highest VRE penetration rates: S.A., and South East Queensland. Our key finding is that network tariffs need to continually evolve towards a more dynamic state – while proposed tariffs are innovative in nature vis-à-vis past tariffs, they are inherently backward-looking and so likely to result in growing inefficiencies and inequities.

South Australia

Electricity distributor SA Power Networks (SAPN) is currently trialling a "solar sponge" residential tariff directly with customers (i.e., not via retailers), to inform its 2020-2025 tariff structure statement. This ToU tariff differs from the default tariff (an inclining-block) as shown in the figure.[7]



Source: SA Power Networks (2019)

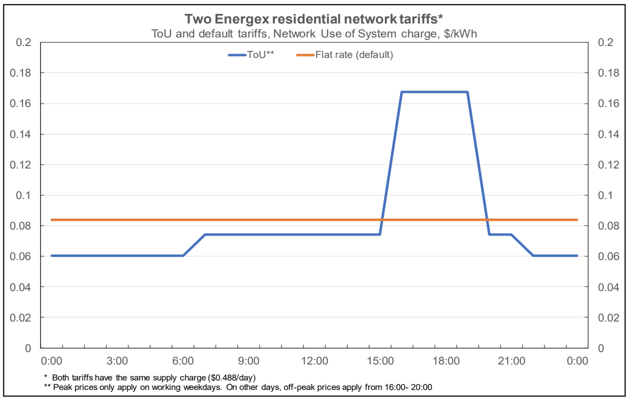
The "solar sponge" component of the ToU tariff is designed to incentivise households to consume electricity at times of high PV generation. Participation in the trial is limited by SAPN to 7,000 customers (SA Power Networks, 2019). This type of ToU tariff is similar to the 'Sunshine tariff' offered by Western Power Distribution to residential customers in the South West of England during 2016, and similar residential tariffs in parts of North America (Faruqui, 2018).

South-east Queensland

Energex, the distribution network provider for South East Queensland, has a two-part tariff as the default, and two optional residential tariffs: (i) a ToU, and (ii) a demand charge coupled with a (two-period) ToU tariff. The ToU and default tariffs are shown in the below figure.[8]

Rooftop PV penetration in some parts of South East Queensland is around 50 per cent, well above the 40 per cent threshold where reverse power flows occur with associated power quality issues (Johnston, 2019). Despite this, Energex does not yet offer a 'solar sponge'-type tariff. Given issues associated with managing the distribution sub-network with such high PV penetration rates, it is likely that some form of control on PV will be needed, via price signals (an incentives-based 'carrot-and-stick' approach) and/or direct network operator control of the devices.

Concluding remarks



Two Energex residential network tariffs*

ToU and default tariffs, Network Use of System charge, $/kWh

* Both tariffs have the same supply charge ($0.488/day)

** Peak prices only apply on working weekdays. On other days, off-peak prices apply from 16:00- 20:00

Source: Energex (2019)

While it can be beneficial to wait for DER uptake to reach levels that necessitate new tariffs or changes to existing tariffs – as is the case with the "solar sponge" tariff – the danger is that uptake occurs faster and earlier than expected, resulting in significant cross-subsidies from ex-DER to cum-DER customers, and in higher network augmentation costs while the wrong price signals remain in place. This reactive approach to tariff design allowed the air-conditioner-induced acceleration in peak demand during the 2000s, and the more recent rooftop PV-induced voltage issues. Unless tariffs are designed somewhat pro-actively, inefficiencies and inequities are likely to also occur in relation to the operation and response of EVs and batteries to the wrong price signals.

Constantly revising or redesigning tariff structures to reflect the impact of greater penetration or utilisation of specific DERs is time- and labour-intensive, and also creates other issues such as:

- claims that networks are trying to "tax the sun" (in the case of solar sponge-type tariffs) or obstructing the movement towards greater decentralisation and democratisation of energy supply, whenever new technology-specific tariffs are proposed. However, the alternative to price signals, such as direct control of devices by networks or specifying PV inverter limits, directly disempower consumers in comparison to providing efficient price signals
- increased complexity under a technology-specific approach to tariff design. Even before finalising the design of its 'solar sponge', there were questions about SAPN expanding its controlled load tariffs to include EVs and batteries. Is this technology-specific approach to tariff design likely to be an efficient response to the emergence and proliferation of new technologies (noting the set of DERs is limited only by our imagination)?, and
- a reactive and technology-specific approach to tariff design is easier said than done: customers, having tuned their usage patterns and investment and operational decisions (the latter especially relevant for batteries) to a particular set of prices and time periods, may be highly averse to changes that undermine these decisions.

So, what is the best way forward? In short, a move to network tariffs that are technology-agnostic and based on dynamic charges for withdrawals and injections that are sufficiently future-proofed. This tariff should be the default (i.e., an opt-out) and have the following form:

- a hosting capacity charge (i.e., $/kVa), based on the nominal limit of net export/import ideally at the connection point, perhaps differentiated by peak and off-peak time periods
- locational ToU charges for withdrawals and injections, to incentivise PV exports at times of high peak demand (and PV self-consumption at other times), which would be especially useful in those sub-network areas where PV hosting capacity is nearing its limits, and
- fixed charges to recover residual sunk costs, taking account of equity considerations (e.g., fixed charges that vary by postcode) as suggested by Burger et al. (2020).

Some degree of network control is likely to be needed even if efficient price signals were in place, reflecting the potential for co-ordination failures and other possible market failures. Such a blend of centralised and decentralised operational decision making is standard practice at the transmission (i.e. wholesale) level, and reflects the inadequacies of relying solely on price signals as a mechanism to co-ordinate and control decision making.

And what about retail tariffs? Retailers can structure their tariffs in line with dynamic network tariffs, as they have predominantly done to date, or provide other structures more suited to customers' preferences. Declining costs of smart meters and other digitally enabled demand response-enabling devices make the latter more viable today, and increasingly going forward, than historically.

While a dynamic, technology-agnostic, tariff would be time-consuming to design and would create winners and losers, the same applies for the existing approach. As tariff (re)design is an intensive process in any event, it seems better to invest the time designing future-proof tariffs. It is also more empowering to let consumers make their own decisions, guided by efficient price signals, combined with an ability for networks to control DER if and when price signals are, on their own, insufficient.

Footnotes

[1] The RET consists of the Large-scale RET (LRET) and the Small-scale Renewable Energy Scheme (SRES). The LRET obligates retailers to buy certificates equal to the annual targets for electricity generated from renewables. It has annual TWh targets, with a target of 33 TWh in 2020, which remains the same through to 2030 when the scheme ends. Like the LRET, the SRES provides a subsidy through to 2030. Unlike the LRET, there is no annual target under the SRES (i.e., it is an uncapped scheme). For more, see http://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target

[2] http://www.cleanenergyregulator.gov.au/RET/Forms-and-resources/Postcode-data-for-small-scale-installations

[3] The NEM is an interconnected electricity market which operates in the five eastern and southern states of Australia, as well as the Australian Capital Territory.

[4] Inverter limits vary by distribution network area and by whether the connection is single- or three-phase. Typically, 5kW is imposed for single-phase connections. . For more details, see https://www.energymatters.com.au/residential-solar/rooftop-solar-power-panels-install-state/

[5] For example, a retailer could offer a volumetric-only tariff as a simpler alternative to a two-part tariff which the retailer faces from the network provider.

[6] This seems to be one of the side-effects of retailer-distributor structural separation. However, technological change – in particular, the declining costs of smart meters and other types of demand response-enabling devices – might improve the ability to hedge basis risk and in turn lead to differing retail and network tariff structures.

[76] SAPN also offers an opt-in demand tariff, with an optional hot water controlled-load component, which can turn on between 10am and 3pm CST when high solar PV output typically occurs.

[8] Energex also offer 'secondary', controlled-load, tariffs with each of these three 'primary' tariffs (Energex, 2019).

References

AEMC, 2014, Distribution network pricing arrangements, Rule Determination, 27 November, https://www.aemc.gov.au/sites/default/files/content/de5cc69f-e850-48e0-9277-b3db79dd25c8/Final-determination.PDF

Borenstein, S., 2012, The redistributional impact of nonlinear electricity pricing, American Economic Journal: Economic Policy, 4, pp. 56-90. https://doi.org/10.1257/pol.4.3.56

Burger, S., Knittel, C., Pérez-Arriaga, I., Schneider, I., and vom Scheidt, F., 2020, The efficiency and distributional effects of alternative residential electricity rate designs, The Energy Journal, 37, pp. 199-239, https://doi.org/10.5547/01956574.41.1.sbur

Energex, 2019, Annual pricing proposal: distribution services for 1 July 2019 to 30 June 2020. Available online at https://www.aer.gov.au/system/files/AER%20APPROVED%20-%20Energex%20Pricing%20Proposal%202019-20%20-%20May%202019.pdf

Faruqui, A., 2018, Modernizing distribution tariffs for households: a presentation to Energy Consumers Australia, The Brattle Group, https://energyconsumersaustralia.com.au/wp-content/uploads/Ahmad-Faruqui-Modernizing-distribution-tariffs-for-households.pdf

Johnston, S., 2019, Solar saturation: sooner than we thought, Energy Networks Australia, https://www.energynetworks.com.au/news/energy-insider/solar-saturation-sooner-than-we-thought/

Markham, D., 2019, Cost reflective pricing: not so simple in practice, Australian Energy Council, https://www.energycouncil.com.au/analysis/cost-reflective-pricing-not-so-simple-in-practice/

Rai, A., Esplin, R., Nunn, O., and Nelson, T., 2019, The times they are a changin': current and future trends in electricity demand and supply, The Electricity Journal, 32(6), 24-32, https://doi.org/10.1016/j.tej.2019.05.017

Rai, A., and Nelson, T., 2019, Australia's National Electricity Market after twenty years, The Australian Economic Review, forthcoming, https://doi.org/10.1111/1467-8462.12359

SA Power Networks, 2019, Pricing proposal 2019/20. Available online at https://www.aer.gov.au/system/files/AER%20APPROVED%20-%20SA%20Power%20Networks%20Pricing%20Proposal%202019-20%20-%20May%202019.pdf

Schittekatte, T., Momber, I., and Meeus, L., 2018, Future-proof tariff design: recovering sunk grid costs in a world where consumers are pushing back, Energy Economics, 70, pp. 484-498, https://doi.org/10.1016/j.eneco.2018.01.028

Simshauser, P., 2016. Distribution network prices and solar PV: resolving rate instability and wealth transfers through demand tariffs, Energy Economics, 54, pp. 108-122, https://doi.org/10.1016/j.eneco.2015.11.011

Simshauser, P., and Downer, D., 2016. On the inequity of flat-rate electricity tariffs, The Energy Journal, 37, pp. 199-229, http://dx.doi.org/10.5547/01956574.37.3.psim

IAEE
INTERNATIONAL
ASSOCIATION for
ENERGY ECONOMICS
WWW.IAEE.ORG

IAEE
WWW.IAEE.ORG
INTERNATIONAL
ASSOCIATION for
ENERGY ECONOMICS