How trial network tariffs impact the potential benefits of Neighbourhood Batteries

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We acknowledge, respect and celebrate the Ngunnawal and Ngambri people, on whose land this research was conducted, and pay our respects to Elders, past, present and emerging.

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Image: Yarra Energy Foundation battery

Executive summary

Neighbourhood batteries are being trialled across Australia with the goal of supporting the increasing penetration of customer energy resources, such as rooftop solar and electric vehicles, in the electricity grid.

One focus of the government-funded rollout is the design of network tariffs that will be paid by neighbourhood batteries. Network tariffs are regulated fees charged by Distribution Network Service Providers (DNSPs) and should reflect how network usage impacts future infrastructure costs. As batteries can both consume and export power, their operations can lead to both network costs and savings. For example, charging during high solar output and discharging during peak demand can result in network savings, while charging during peak periods or exporting during low demand can increase costs. By aligning tariffs with the long-term costs incurred by the network, DNSPs can encourage efficient network use and ensure fair cost allocation.

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For the neighbourhood batteries rolling out under government-funded trials, at least five DNSPs across the National Energy Market (NEM) have introduced trial network tariffs with varied features, such as energy charges with flat or time-of-use rates, demand charges with time-varying or seasonal rates, and capacity charges. This study used simulations to analyse these trial tariffs, assessing their impact on peak demand reduction and financial outcomes for stakeholders.

Key findings from the simulations include:

1. Two-way time-of-use tariffs resulted in a significant reduction in network peak demand (kW), by 7% in one example scenario, and an overall payment to the battery owner.
2. Adding a two-way demand charge further reduced network peak demand (kW), by 2% in the example scenario, and increased the payment to the battery owner.
3. The tariffs did not impact local solar utilisation, i.e., the proportion of total household electricity requirements met by locally generated rooftop solar.

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The results suggest that a combination of two-way time-of-use network tariffs with two-way demand charges leads to the best outcomes for the network in terms of peak demand reduction. This network benefit comes with a net payment to the battery operator through the two-way tariff structure. While this complex tariff would likely be unsuitable for households to navigate directly, we propose that battery software systems can absorb complex tariffs, potentially enabling households to benefit from simpler, more straightforward tariff structures.

For next steps, we recommend:

1. verifying our simulation results with real-life data from ongoing trials under government programs, and
2. conducting further research to determine whether network payments to battery owners arising from these tariffs are consistent with the network savings resulting from battery operation.

This is an important step to ensure battery payments are not unfairly subsidised by other network users. Based on these further results, our goal is to generate a recommendation for a single NEM-wide neighbourhood battery network tariff that maximises network benefits and ensures the best outcomes for consumers, both of which are key targets for the ongoing implementation of neighbourhood batteries in Australia.

Background

Neighbourhood batteries (NBs) are more than just a technological advancement; they have the potential to be a community-focused solution that resonates with the public's growing preference for fair, shared and sustainable energy practices. The concept of 'keeping energy local' is particularly appealing as it aligns with the broader societal movement towards giving people more visibility and control over their energy and the desire to retain the benefits of renewable energy generation within communities (Ransan-Cooper, Shaw et al. 2022).

Our previous work has provided an in-depth examination of the potential role of neighbourhood batteries in Australian energy markets, highlighting the benefits of improved grid stability and increased local consumption of solar energy (He, Bardwell et al. 2023). Work in Europe also identified technical and economic benefits of community storage over household batteries, including a reduction in the levelised cost of battery storage by 27% (Parra, Norman et al. 2017).

In addition, new opportunities for citizen participation within communities and increased awareness of energy consumption and environmental impacts were highlighted (Parra, Swierczynski et al. 2017). However, despite potential technical, economic and social benefits of neighbourhood batteries, knowledge gaps still exist around how to implement neighbourhood batteries in the way that delivers on their promised benefits. For example, Muller and Welpe investigated eight demonstration projects in Germany and Western Australia with respect to potential business models and barriers, and found that in-front-of-meter models face significant barriers largely relating to tariffs (Müller and Welpe 2018).

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In Australia, innovative distribution network tariffs are being trailed and neighbourhood battery trial tariffs fit into these wider changes. The primary purpose of network tariffs is to accurately allocate the future network costs or savings that arise as a result of network use. In the case of batteries, their ability to both consume and export power means that their operations can have either positive or negative impacts on network utilisation and costs. Battery actions that help to balance supply and demand, such as charging during periods of high solar output and discharging during peak demand periods, can lead to network savings. Conversely, battery actions that exacerbate network constraints, such as charging during peak periods or exporting during times of low demand, can result in higher network costs.

The challenge for policymakers and utilities is to design tariffs that fairly apportion these costs and savings to battery owners, following basic tariff design principles e.g. providing clear and predictable price signals, ensuring equity and avoiding cross-subsidisation, and maintaining compatibility with existing tariff structures. For equity reasons, location-specific tariffs are not allowed in Australia even though network costs vary substantially by location, for example with rural networks typically being more expensive.

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Network tariffs being proposed in Australia increasingly have more complex structures including time-of-use, two-way and demand charges. Two-way charges can either charge or disburse payments to the battery operators. Time-of-use (TOU) charges vary across the day and demand charges reflect the users maximum demand rather than total usage.

However, implementing these tariffs is not straightforward. Recent media coverage in Australia has highlighted the stress faced by many householders when exposed to complex tariff structures, such as time-of-day and demand charges. Further, although the goal of demand charges is to lead to more efficient use of network infrastructure and reduce peak demand pressures, recent work has suggested that demand tariffs can be counterproductive because the user peaks targeted by these charges often do not overlap with system peaks (El Gohary, Stikvoort et al. 2023). Finally, the inability to use location-specific tariffs interferes with the targeting of resources for specific parts of the network that would benefit from them.

However, implementing these tariffs is not straightforward. Recent media coverage in Australia has highlighted the stress faced by many householders when exposed to complex tariff structures, such as time-of-day and demand charges.

Neighbourhood batteries may help address some of these challenges. First, batteries can operate under complex tariff structures without the need for them to be easily understandable to consumers. By shifting the complexity of tariff management onto battery energy management systems, households may be able to benefit from optimised network usage and cost savings without the burden of understanding and responding to complicated pricing structures themselves. Second, neighbourhood batteries may be able to respond to demand charges in a more productive way that targets system peaks. Finally, although location-specific tariffs are not allowed, location-specific charges or payments could still be achieved via network support agreements directly between the DNSP and the battery storage operator (see Citipower 2024 for recent discussion).

While the methodologies and regulatory environments differ, the move towards more sophisticated tariff structures is a common theme globally. The current study contributes to this effort by attempting to quantify, through simulations, whether these tariff structures, as adopted by neighbourhood battery trial tariffs, contribute to desired outcomes for all stakeholders. The Australian experience, with its significant deployment of solar PV and government-funded neighbourhood battery trials, can provide valuable insights into the efficacy and stakeholder impacts of distribution network tariff reforms.

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Methodology

This report is based on simulations of a neighbourhood battery operating under realistic conditions and under a range of scenarios including a range of battery capacities (100–300 kWh) and a range of PV penetration levels (50–100%).

For the results presented in this report, the battery was located in a distribution network with 100 households, 75% of which had rooftop solar. The battery was operated to maximise profit according to real-time NEM prices (with perfect foresight) and the network tariff. We compared trial network tariffs for five Australian DNSPs – Ausgrid, CitiPower/PowerCor/United Energy, Essential Energy, EvoEnergy, and Jemena.

Each tariff was classified according to their main features, which included one-way flat rate (Ausgrid), two-way time-of-use (TOU) with seasonal demand charge (Jemena), two-way TOU with no demand charge (Citipower), two-way TOU with two-way demand charge (Essential), two-way flat rate with one-way demand charge (Evoenergy).

Note that critical or peak event charges are also common across tariffs but were not included in our modelling since critical time periods are hard to predict and can determined differently by each DNSP based on their unique network conditions. A full description of the network tariff structures as well as details on the simulation scenarios are given in the accompanying methodology and full results report, here. We analysed the impact of the trial network tariffs on peak demand, financial outcomes and local utilisation of rooftop solar.

Results

Results are presented for operating a 200 kWh/100 kW battery for 100 households where 75 of the houses had rooftop solar. Results for other scenarios studied are included in the accompanying methodology and full results report, here.

There were three main findings:

1. Two-way time-of-use network tariffs resulted in a significant reduction in network peak demand (kW). In our example scenario, there was a 7% reduction in peak demand. This network tariff also resulted in an overall payment to the battery owner of $1,026/year, compared to the $3,408/year charge corresponding to the one-way flat rate tariff.
2. Adding a two-way demand charge further reduced network peak demand (kW). In our example scenario, the further decrease was 2%. This tariff also resulted in a substantial increase in payment to the battery owner ($5,477/year) compared to $1,026/year payment for the two-way time-of-use tariff with no demand charge.
3. Tariffs did not impact how much locally generated rooftop solar provided the total electricity requirements of households (local solar utilisation).

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MAX. DAILY PEAK LV POWER (KW) VS TARIFF

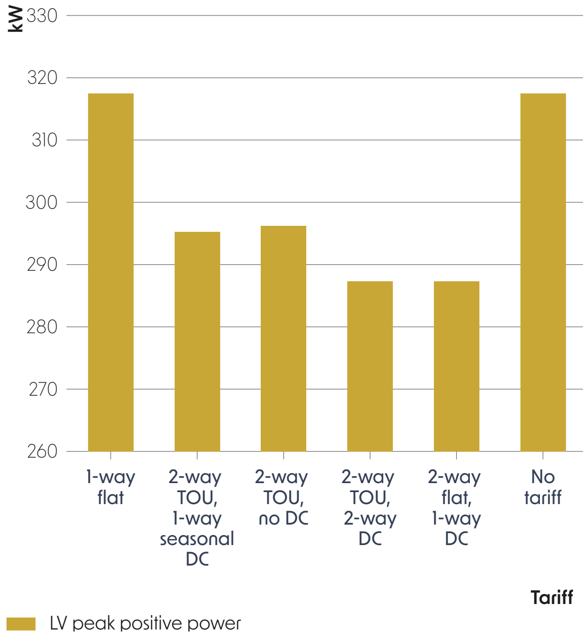

Figure 1 Maximum daily demand (peak positive power in kW) on the low voltage (LV) network section as a function of the five trial neighbourhood battery network tariffs tested, as well as with no network tariff. Decreased maximum daily peak is desirable because it unlocks network capacity for more customer energy resources. Across the scenarios tested, two-way time-of-use (TOU) network tariffs resulted in decreased maximum daily peak power compared to no network tariff and the one-way flat network tariff tested. In the scenario shown in this figure, the decrease was 7%. Demand charges (DC) further reduced peak positive power by around 2%.

MAX. DAILY PEAK LV POWER (KW) VS TARIFF

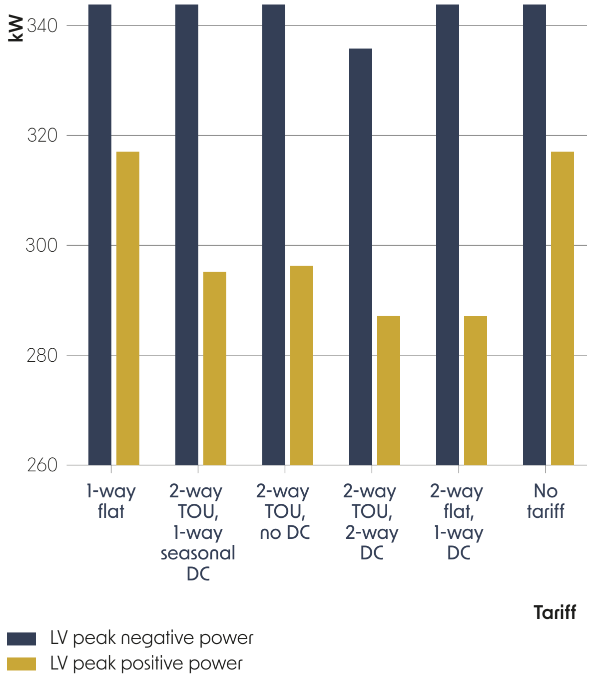

Figure 2 Maximum daily demand (peak positive power in kW) and maximum exports (negative power in kW) on a section of low voltage (LV) network as a function of the five trial neighbourhood battery network tariffs tested, as well as with no network tariff. Note that trial network tariffs did not impact negative peak power (exports) with the exception of the two-way time-of-use (TOU) plus two-way demand charge tariff from Essential.

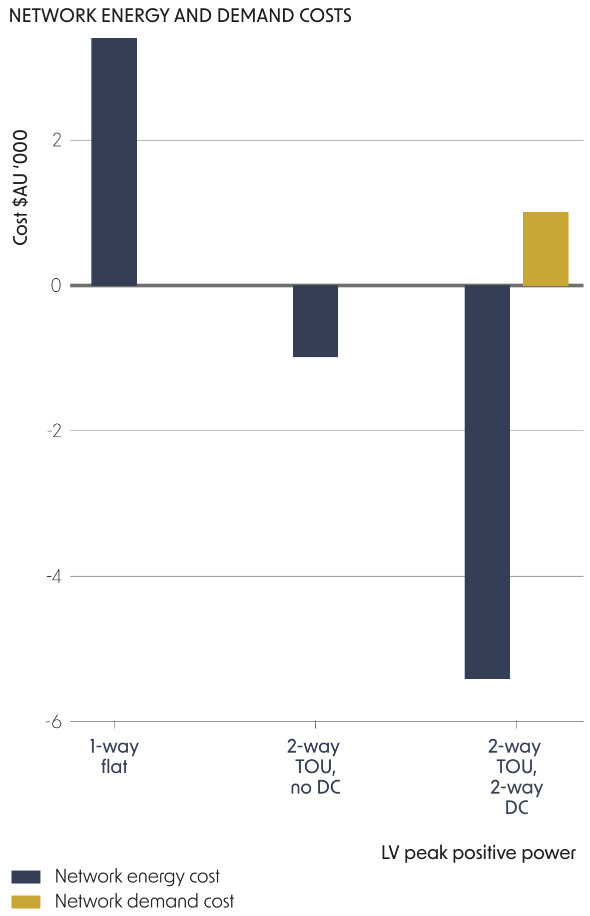

Figure 3 Annual network tariff charges (positive) and payments (negative) to the battery operator. The two-way TOU network tariff with two-way demand charges resulted in a larger payment to the battery operator, compared to the two-way TOU network tariff with no demand charge and the one-way flat rate network tariff. The demand charge was clearly offset by the two-way energy payment for the Essential tariff.

We also tested the impact of the trial network tariffs on solar self-consumption (SSC) which is a measure of the amount of local solar generation that is consumed by all households and the battery in the local network instead of being exported to the grid. Under the condition of operating the battery at maximum one cycle per day, the average SSC was 64% and only varied by 2% between tariffs.

Summary, next steps and recommendations

The goal of our analysis was to test whether the current neighbourhood battery trial network tariffs are likely to achieve their intended objectives i.e. to incentivise batteries to optimise network utilisation and reduce peak demand, while avoiding cross-subsidisation.

Our results show that some of the trial network tariffs are effective in reducing peak system demand. In particular, two-way time-of-use (TOU) tariffs had the biggest impact on reducing peak demand, with two-way demand charges further reducing demand. In practice, this would increase network capacity for more rooftop solar and electric vehicle charging i.e. directly benefiting consumers.

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Two-way network tariffs, which can either charge or disburse payments to the battery operators, returned revenue to the battery owner in our simulations. Further work should investigate whether network payments to battery owners arising from these tariffs are consistent with the network savings resulting from battery operation. This is an important step to ensure battery payments are not unfairly subsidised by other network users. It will also be important to investigate whether these network tariff payments make neighbourhood battery business models more financially feasible.

Currently, many neighbourhood battery projects face challenges in achieving financial viability due to high upfront costs and limited revenue streams. If network tariff payments can significantly improve the economics of these projects, they could play a crucial role in accelerating the deployment of neighbourhood batteries and unlocking their potential benefits for the electricity grid and consumers.

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Further investigation is needed to determine whether these findings hold for real-life data and across different scenarios, particularly when the battery operates with real-world imperfect forecasts and in networks where DNSPs are using dynamic operating envelopes (DOEs). Imperfect forecasts are expected to reduce the impact of network tariffs on battery behaviour.

DOEs are used by network operators to manage the import and export limits of distributed energy resources, like neighbourhood batteries, in real-time and based on available network capacity.

While both DOEs and neighbourhood batteries aim to optimise network utilisation and reduce peak demand, they may have different implications for battery operators and consumers. DOEs, for example, may limit batteries' ability to respond to price signals from network tariffs, potentially reducing the tariffs' effectiveness in incentivising desired battery behaviour. Therefore, further research is needed to investigate the benefits of neighbourhood battery trial tariffs in network scenarios that also utilise DOEs. Based on these further results, our goal is to generate a recommendation for a single NEMwide neighbourhood battery network tariff that maximises network benefits and ensures the best outcomes for consumers.

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