Battery Storage and Grid Integration Program
An initiative of The Australian National University

How trial network tariffs impact the potential benefits of Neighbourhood Batteries – methodology and further results

Methodology

This report is based on simulations of a neighbourhood battery operating in realistic Australian low-voltage networks under a range of scenarios. The scenarios included: how the battery was operated, the network charges applied to the battery, the battery size and the number of houses with rooftop PV.

The three battery operation modes were (1) profit maximisation, (2) solar soaking and (3) balanced. Profit maximisation meant that the battery only operated according to price signals. Solar soaking meant that the battery only operated to charge during solar hours and discharge during the evening peak. Balanced mode meant that the battery operated to generate revenue according to price signals but within the bounds of still soaking up solar generation.

Our assessment reviewed five trial network tariffs designed specifically for neighbourhood batteries across Australia. We categorised these different tariffs 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).

We analysed the impact of the trial tariffs on peak demand, financial outcomes for stakeholders, and grid support. The simulation was carried out according to the plan outlined in Figure 1.

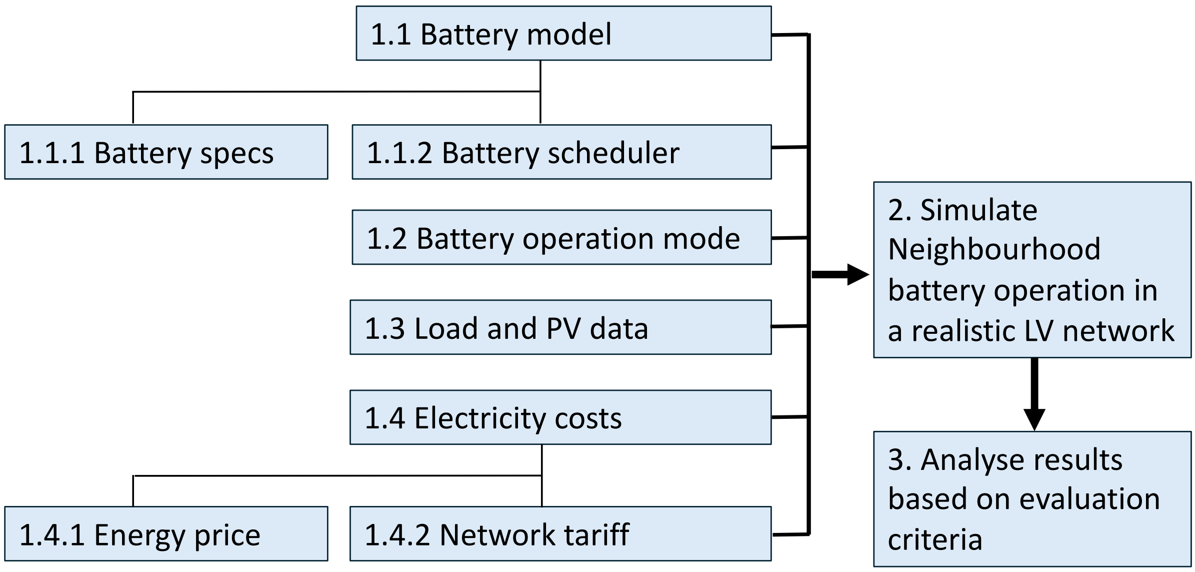


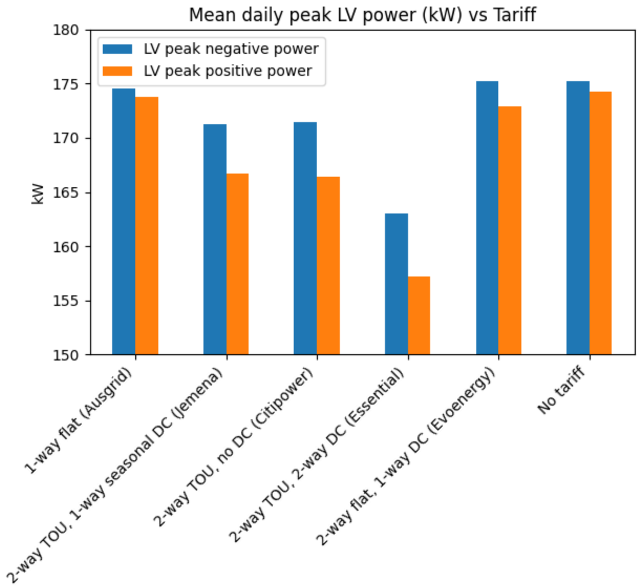
Figure 1: Battery, load and cost data was fed into a simulation of a neighbourhood battery in a realistic low-voltage (LV) network. The results were evaluation based on evaluation criteria as outlined in Table A. 1 in the Appendix.

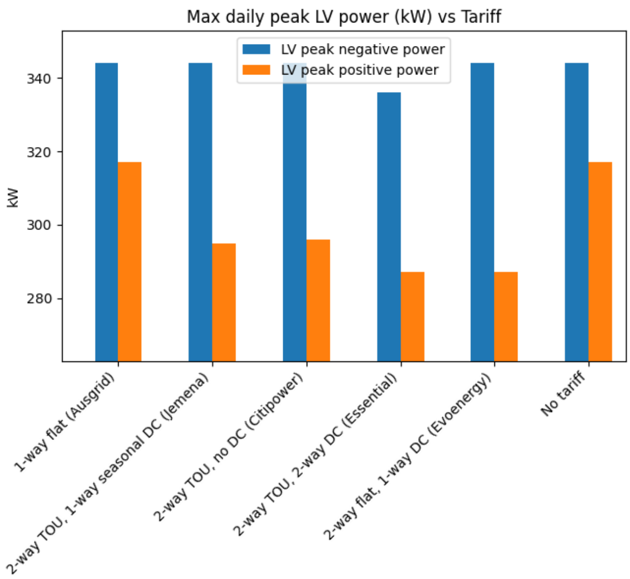
Full details of methodology, with numbering corresponding to Figure 1	
1. Battery specs	Capacity = 100 – 300 kWh, Power = 50 – 150 kW, round-trip efficiency = 0.85, depth of discharge = 90%, maximum daily cycle = 1 Note that the power is also the maximum charge/discharge rate of the battery
2. Battery scheduler	Based on our in-house battery optimisation software (Python, Pyomo) and the Gurobi solver, the best charge and discharge times and demand profile for the battery are found. The number of households (with loads only as well as both loads and PVs), the wholesale prices, the network tariffs, and the operation objectives were all given.
3. Battery operation mode	Given the wholesale spot prices and the battery network tariffs, the battery is optimally charged and discharged to achieve the following objectives in each of the three different battery operation modes (strategies): 1) solar soaking: generally charging during solar hours and discharging during the evening peak, to minimise the import and export power of the LV network (including all households and the battery) for each day. 2) profit maximisation: to maximise the revenues or minimise the costs for the battery owner for each day. 3) balanced: to maximise the balance between the needs for solar soaking and profit maximisation.
4. Load and PV data	Using historical loads and PV output measurements from the 2018 NextGen dataset for Canberra (Shaw, Sturmberg et al. 2019). Whilst data is available from 2016 onwards, the simulation inputs were taken from a cleaned 2018 subset. Positive load convention was followed such that any negative loads or positive solar PV data were removed from the dataset. Additionally, where data was

	sparse or discontinuous these days were also removed (Shaw, Sturmberg et al. 2019). Load profiles at 5-minute intervals as well as PV outputs were then assigned to each household on the network.
5. Energy prices	Historical NSW spot prices from 2022 were used
6. Network tariffs	Trial network tariffs for community batteries from the five DNSPs, Ausgrid, CitiPower/PowerCor/United Energy, Essential Energy, EvoEnergy, and Jemena, were used in simulations. 1) The descriptions found in the tariff notifications published in 2024 by each DNSP at the AER website informed modelling. 2) The trial tariffs were categorised based on their components. Four categories were identified. These were (i) Flat/Fixed rate only (ii) Two-way TOU rates only (iii) Two-way flat rate with demand charges (import only, vary with season) and capacity charge and (iv) Two-way TOU rates with demand charges (for both import and export, vary the time of the day) The rates for these tariff components were taken from the five DNSPs, as published in the associated tariff notifications (see further information below in the 'Neighbourhood battery trial network tariffs' section).
7. Analyse results based on evaluation criteria	Design criteria for evaluating the impact of network tariffs on local energy management and cost outcomes for the battery owner were: 1) Local energy management: the maximum 5-min import and export power of the LV network (including all households and the battery) over the yearly horizon. 2) Solar utilisation: self-solar consumption (SSC) and self-sufficiency (SS) a. SSC measures 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. b. SS measures the amount of local demand that are satisfied by the local generation in the LV network, instead of being met by the imported energy from the grid. 3) Cost and benefits: total cost or revenue for the battery owner (including the wholesale energy cost and the network costs). The results of different types of tariffs were compared against these criteria. • The battery network tariff that only includes a flat rate was used as the base case, • All other tariffs were then compared to the base case, and each compared to the analysis criteria., • Finally, the results of scheduling the battery against the wholesale spot prices without any battery network tariffs was compared to the different tariff results
8. Simulation time horizon	Simulations were run for a full year, using 2022 spot price data. The battery optimised its scheduling based on a rolling horizon. This meant that the optimisation was conducted for each individual day, until all days in 2022 had been simulated. The optimisation was based on perfect forecasting. Realistically, imperfect forecasts will result in worse outcomes for battery performance.

Table A. 1 Details of the simulation methods

Results





Tariff	Mean daily LV peak negative power (kW)	Mean daily LV peak positive power (kW)
1	174.6	173.8
2	171.3	166.7
3	171.5	166.4
4	163.0	157.2
5	175.2	172.9
6	175.2	174.3

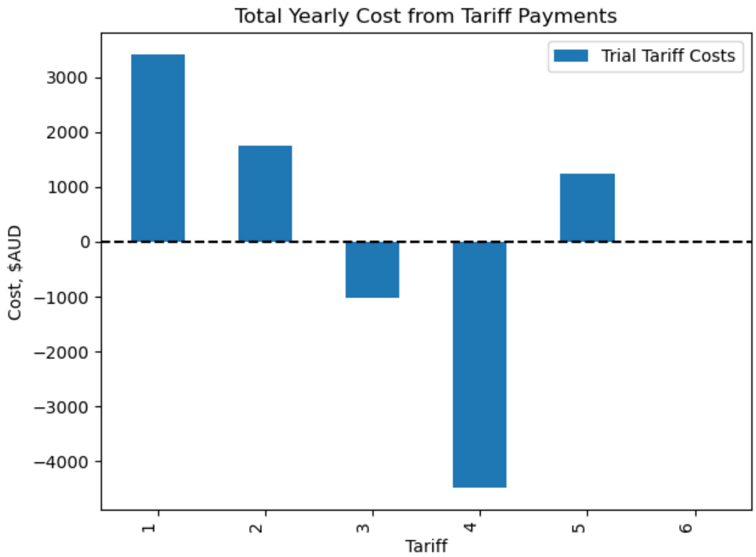
Tariff	Max daily LV peak negative power (kW)	Max daily LV peak positive power (kW)
1	344.0	317.0
2	344.0	295.0
3	344.0	296.0
4	336.0	287.0
5	344.0	287.0
6	344.0	317.0

Tariffs:
1 = one-way flat (Ausgrid)
2 = two-way TOU, seasonal demand (Jemena)
3 = two-way TOU no demand (Citipower)
4 = two-way TOU and two-way DC (Essential)
5 = two-way flat and one-way DC (Eveoenergy)
6 = no tariff

Results above show the results for a 200kWh/100kW neighbourhood battery operating in a section of LV network with 100 households where 75 of those households had rooftop solar PV. The five trial network tariffs tested had an impact on both the mean (left) and the maximum (right) positive (orange) and negative (blue) daily peak aggregate LV power (kW). The two-way time-of-use (TOU) network tariff with two-way demand charge (DC) from Essential Energy resulted in the lowest mean and maximum (positive and negative) daily peak power, with a reduction of 9% compared to no network tariff or the one-way flat rate from Ausgrid.

The difference in maximum daily peak power (kW) between the tariffs was tested for statistical significance. Based on a student t-test, we found that the decrease from the one-way flat tariff to the two-way TOU tariff was around 7% and was significant (p=0.017). The decrease from the two-way TOU and the two way TOU with two-way demand charges, which was around 2%, was also statistically significant (T-test, p=0.006).

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.



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For the financial results shown above, the two-way time-of-use (TOU) network tariff with two-way demand charge (DC) returned around $4000 annual revenue to the battery owner, based on a $5000 payment through the two-way energy tariff and a $1000 charge through the two-way demand charge. This was substantially more revenue than the $1,026 annual payment to the battery owner with the two-way time-of-use tariff with no demand charge and the $3,408 charge to the battery owner with the one-way flat rate network tariff.

Neighbourhood battery trial network tariffs

A network tariff is a cost charged by Distribution Network Service Providers (DNSPs) to users of the electricity network which should reflect how their current use of the network will impact future network infrastructure costs. This cost is used for building, operating, and maintaining network elements.

Recently, the Australian Energy Regulator has initiated network tariff reform with a focus of allowing distributed energy resources (DER) such as solar PV, batteries and electric vehicles to be integrated onto the grid as efficiently as possible. As a result, five DNSPs have proposed different trial tariffs specifically for neighbourhood batteries. These DNSPs include Ausgrid, CitiPower/PowerCor/United Energy, Jemena, EvoEnergy and Essential Energy. Despite the differences in these trail tariffs, there are four common components:

1) *Fixed charges*: a fixed daily cost that consumers pay regardless of their electricity usage.
2) *Energy charges*: a cost that is proportional to the total electricity usage of the consumer (measure in kWh).
3) *Demand charges*: a cost that is proportional to the maximum power required by the consumer at certain time periods of a day (e.g. during the high-demand hours from 5pm to 8pm)
4) *Capacity charges*: a cost that is proportional to the maximum power required by the consumer at any time of a day.

The capacity charge is similar to the demand charge; however, it is based on the maximum demand at any time, which determines the minimum capacity for the electricity generation and transportation of a power system. Note that another common component among these tariffs is a critical or peak event charge, which is a cost associated with the energy consumption during critical times, such as in an extreme hot or cold day. These critical time periods are hard to predict and can be determined differently by each DNSP based on their unique network conditions. Therefore, we do not include this component in our study.

The design for each of these components varies with DNSPs. For example:

- An energy charge can be designed as a one-way or two-way flat rate (see Figure A. 1) and a two-way time-of-use (TOU) rates (see Figure A. 2).
- A demand charge (DC) can be a rate that varies with seasons (see Figure A. 3) or with the time of the day (see Figure A. 4). A DC can also be applied to one direction (such as to import power only) or two directions (such as to both import and export power). Furthermore, a DC can be a single rate or a block rate that increased with the maximum power (see Figure A. 5).
- A capacity charge is often a flat rate that is based on the maximum power over a rolling time window, such as the current week, the current month, or the previous 13 months.

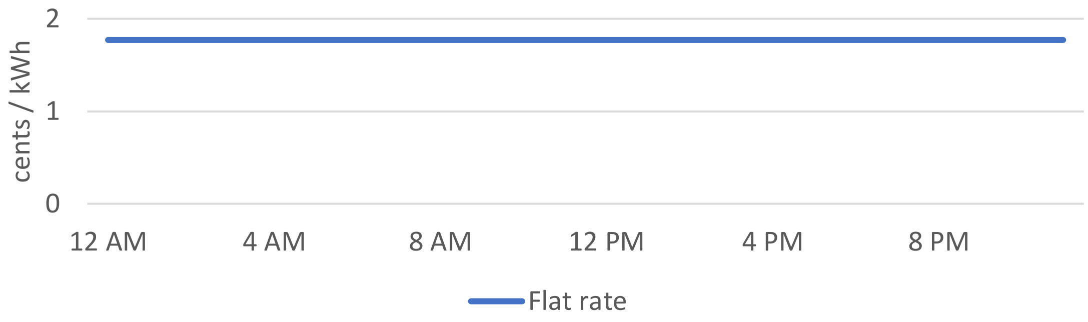

Figure A. 1 Flat energy charge rate which can be applied to import and/or export energy.

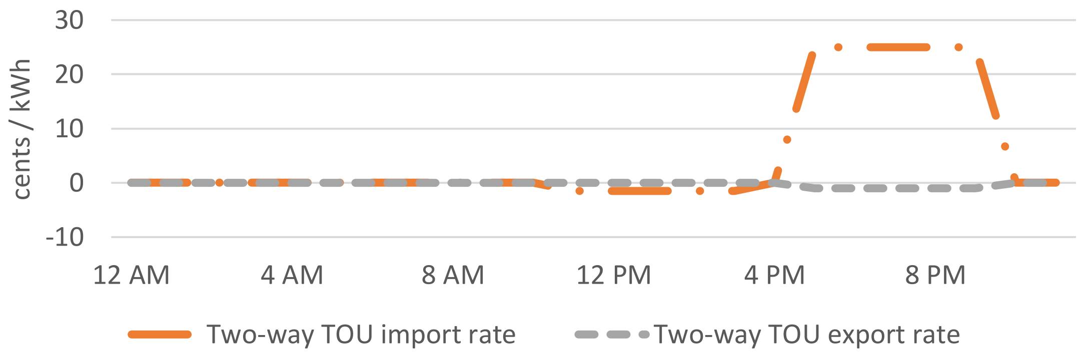

Figure A. 2 Two-way TOU energy charge rates.

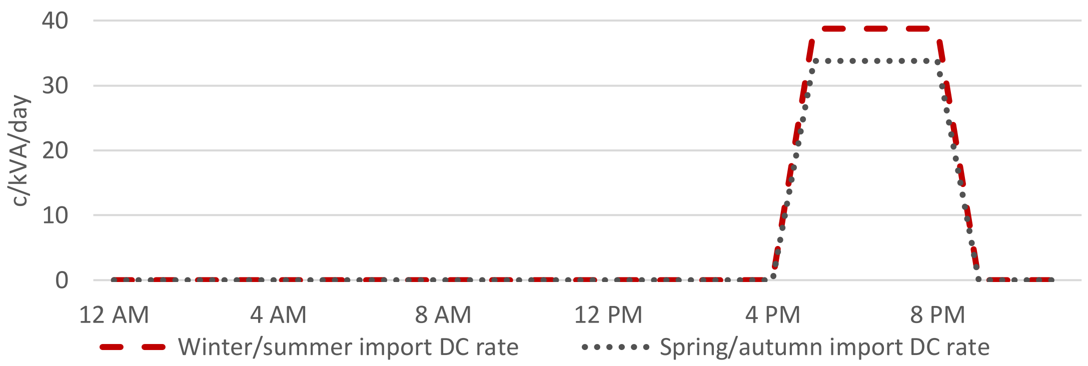

Figure A. 3 Import demand charge rate that varies with seasons.

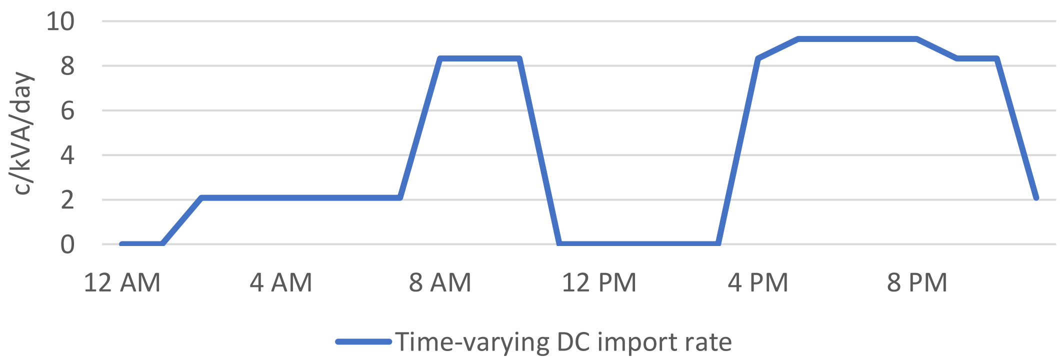

Figure A. 4 Import demand charge rate that varies with the time of the day.

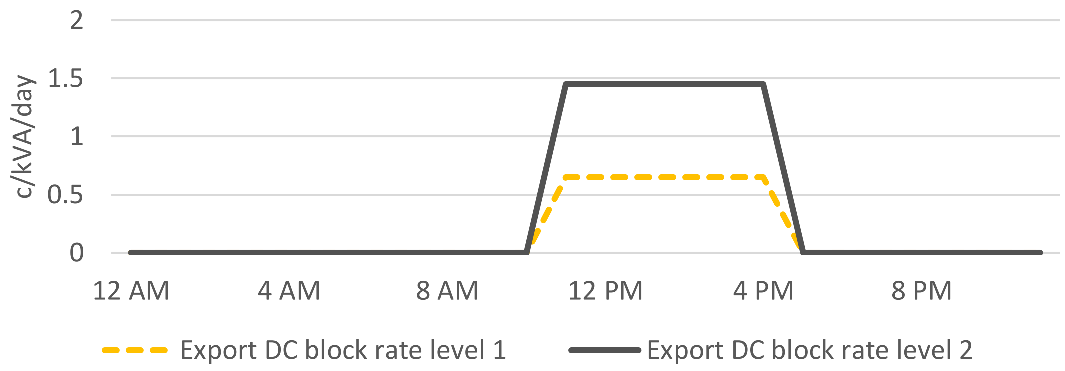

Figure A. 5 Export demand charge block rates. The level 1 rate is applied to export power less than 3kW, and the level 2 rate is applied to any export power above 3kW.

For comparison, we summarised the component design of the battery trial tariffs proposed by the five different DNSPs as Table A. 2. Hyperlinks link to the information and rates that were used in this study.

DNSP	Import energy charge	Export energy charge	Import demand charge	Export demand charge	Capacity charge
Ausgrid	Flat	-	-	-	-
CitiPower/ PowerCor/ United Energy	TOU	TOU	-	-	-
Jemena	TOU	TOU	4-7pm in summer only	-	-
EvoEnergy	Flat	Flat	Seasonal	-	Based on the previous 13 months
Essential Energy	TOU	TOU	Time-varying	Time-varying block rates	-

Table A. 2 Component design of the battery trial tariffs from the five different DNSPs (exluding the critical or peak even charges).

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