An Economic analysis of Local Use of System charges for neighbourhood batteries

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Abstract

Should neighbourhood batteries pay discounted "Local Use of System" (LUoS) charges for their use of the electricity grid? This article presents economic arguments. It concludes that a rationale exists for such discounted charges, for the same reason that network charge discounts are justified to avoid network by-pass. Eligibility needs to be carefully defined to maximise the prospect that neighbourhood batteries are charged from distributed (local) solar. We also conclude that if LUoS is applied to neighbourhood batteries, fairness arguments suggest solar sponge tariffs should be offered to residential consumers.

Keywords: neighbourhood batteries, network by-pass, solar sponge tariffs, local use of system charges

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Introduction

This working paper explores the rationale, in economics, for a discounted "local" use of system" (LUoS) tariff for neighbourhood batteries. In this document, the terms LUoS and "LUoS discount" are used frequently. The latter is an expression of the discount that is offered in an LUoS tariff relative to the Distribution Use of System (DUoS) tariff. Neighbourhood batteries" (N-B) (also known as "community batteries") can be distinguished from "Behind the Meter Batteries" (BTM-B) and "Big Batteries" (B-B).

A consumer in this paper, typically refers to a small electricity user, but not necessarily a household. A "prosumer" is a small electricity that also produces electricity. "Battery" is a device that stores electricity drawn from the grid and is able to later discharge it from the grid. A battery is not necessarily chemical although it can almost invariably be expected to be chemical.

What is a neighbourhood battery?

A "neighbourhood battery" is not uniquely defined. The definition we have used in this study is a storage device that:

1. Is located in a front of customers' meters and either on the low voltage (LV) feeders or on the MV network. Such batteries are rarely likely to be bigger than a few hundred kilowatts/kilowatt-hours.
2. Is located in parts of the network that are electrically proximate to lots of customers with rooftop solar who are injecting relatively large amounts of electricity into the grid.
3. Is not restricted to charge and discharge as specific times.
4. Is not restricted in who it provides a storage service to or who it buys electricity from or sells electricity to.
5. May be owned by communities, retailers, third parties or the unregulated arms of network service providers.
6. May operate for-profit or not-for-profit.

We do not have in mind any specific commercial model for the N-B. It may enter into contracts with prosumers to provide a storage service (which could be charged for in a variety of ways), or to buy their injected electricity. It may sell that electricity back to prosumers or consumers and could conceivably also provide ancillary services to AEMO.

Layout

The next section provides relevant background, covering institutional arrangements for network pricing, agencies' perspectives on LUoS for batteries, the network charges in Britain for storage facilities, and finally neighbourhood battery feasibility studies and trials. The third section presents our analysis. It starts with a brief review of relevant theoretical aspects and then proceeds to set out the arguments for and against LUoS for N-B. This is followed by a discussion, and then consideration of applying LUoS in practice. A concluding section summarises the main points.

1 Background

1.1 Institutional arrangements for network tariffs

In the National Electricity Market (NEM), transmission and distribution network service providers are required to develop "Tariff Structure Statements" that set out how they intend to structure their charges. These statements are then subject to the Australian Energy Regulator's (AER) approval. The guiding principles for such statements are set out in the National Electricity Rules (NER). They mean (broadly) that in setting prices network services, transmission and distribution network service providers should respect the following:

- the upper bound of prices (the stand-alone cost of providing the service to retail customers) and the lower bound of prices (the avoidable cost of not serving the demand);
- prices should be cost-reflective and location-specific, based on a long-run marginal cost (LRMC) methodology; and
- revenue recovery should reflect the total efficient costs of providing the service to retail customers.

These principles can be interpreted quite differently: "cost reflective", "stand-alone cost", "avoidable cost", "long-run marginal cost" and "total efficient cost" can plausibly mean quite different things in practice even if, in principle, the definition of some are reasonably accepted. In reality, the only two tightly binding constraints on tariffs are i) that the aggregate revenue recovered should not exceed the regulator's determination of the maximum allowed revenue, and ii) injections to the grid should not incur TUoS/DUoS charges (although there is currently pressure to change this).

1.2 Agencies' perspectives on LUoS for storage providers

1.2.1 Australian Energy Market Operator (AEMO)

AEMO's perspectives on network charges for batteries have evolved. In 2017, AEMO released interim arrangements for utility scale batteries in order to expedite the entry of utility scale battery projects to the NEM (Australian Energy Market Operator, 2017). These arrangements covered many aspects of battery connection and market integration. With respect to TUoS/DUoS charges, AEMO suggested that this was a matter for network service providers and batteries to resolve. However, batteries smaller than 5 MW are exempt and treated in the same way as "auxiliary load" [1] to generators, which are not charged TUoS/DUoS (Australian Energy Market Operator, 2021).[2]

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[1] Auxiliary load refers to "components of a generating system that consumes electricity to provide operational assistance to generating units, especially where this may support maintenance activities or assisting the generating system to come online" (Australian Energy Market Operator, 2017).

[2] AEMO grant a standing exemption for: "any person who engages in the activity of owning, controlling, or operating a generating system with a total nameplate rating of less than 5MW will be automatically exempt from the requirement to register as a Generator in relation to that

In 2019, however, AEMO proposed rule changes to better accommodate batteries by establishing a new registered participant category "Bi-directional Resource Provider" (BDRP) to describe a battery (5 MW or larger) operator (Australian Energy Market Operator, 2019). AEMO proposes "Bi-directional Resource Providers" should not be charged Transmission Use of Service (TUoS) tariffs when they withdraw from the grid because they do not have firm access, but they should be charged DUoS when they withdraw from the grid (AEMO says that this is consistent with current policy).

1.2.2 Australian Energy Markets Commission (AEMC)

In July 2021, the AEMC released an updated draft rule determination on AEMO's proposed rule changes (Australian Energy Market Commission, 2021). AEMC decided not to define storage or hybrid facilities in the NER, as per AEMO's recommendations. AEMC seem to support the proposal by AEMO that DUoS but not TUoS should apply to energy withdrawn from the grid and stored in a battery 5 MW or larger. However, AEMC is currently considering charging DUoS for exports (Australian Energy Market Commission, 2021, p.vii), and the 5 MW threshold for exemption in separate policy processes (see, for instance, *Generator registration thresholds* rule change request (Australian Energy Market Commission, 2020a)) (Australian Energy Market Commission, 2020, p.38).

1.2.3 Australian Energy Regulator (AER)

The AER has developed its views on network charges for grid-connected batteries in the process of approving the Victorian distributors 2021-2026 *"Tariff Structure Statement"*[3] (Australian Energy Regulator, 2021). The AER agreed with the distributors' proposal that DUoS would not be charged on batteries that were included in distributors' regulated asset bases. With respect to unregulated storage (i.e. not included in the regulated asset base), the AER suggested that these should be exposed to DUoS charges in the same way as all other demand.

1.3 British network charging arrangements for storage facilities

The Office of Gas and Electricity Markets decided that the network charge for batteries should be the same as for generators, in other words that storage facilities should not pay the distribution 'demand residual' element of network charges, when storage takes electricity from the network" (Ofgem, 2019).

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activity, where both of conditions (a) and (b) apply: either: (i) the generating system is not capable of exporting to a transmission system or distribution system in excess of 5MW; or (ii) the generating system has no capability to synchronise to a distribution system or transmission system; and where there is any potential for the generating system to export energy, either: (i) the sent out generation is purchased in its entirety by a Market Participant who is financially responsible for all electricity generated or consumed at the same connection point; or (ii) each of the generating units comprising the generating system is classified as a market generating unit by a Market Small Generation Aggregator" (Australian Energy Market Operator, 2021).

[3] Tariff Structure Statements are available at: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements?f%5B0%5D=field_accc_aer_sector%3A4

1.4 Australian neighbourhood battery feasibility studies

Ausgrid engaged KPMG and AECOM to undertake a feasibility study into the drivers that would make a Community Battery Initiative (CBI) a cost-effective alternative to traditional network investment (KPMG, 2020). The economic and regulatory assessment was designed to recommend how Ausgrid could install financially viable community batteries, and what regulatory implications would arise. KPMG recommends firstly flows to the battery not pay DUoS. Second, energy consumed by households (notionally supplied by batteries) pay LUoS. The rational is that BTM-B don't pay DUoS when they charge or discharge, and N-B largely involve local flows on the low voltage network. KPMG assume any electricity exported via the retailer (net of energy stored in the battery) is subject to standard DUoS tariffs.

The Australian National University (ANU) undertook a Cost-Benefit Analysis (CBA) of installing a community battery, considering four different types of ownership and profitability models[4] as part of the *ANU Battery Storage and Grid Integration Program* (partly funded by ARENA's Advancing Renewables Program) (Australian National University, 2020a).[5] The CBA was based on a trial in Jacka ACT (discussed below).[6] The CBA examined whether a community battery would be financially viable and under what conditions (including size, scope, household participation and DUoS/LUoS tariffs). ANU recommend a LUoS apply when a battery is withdrawing from the grid, as well as when customers consume electricity stored in the battery but released back to the grid (Australian National University, 2020b). The rationales are firstly that the flows are local and so should only be charged for local network usage, and secondly without discounted network tariffs, community batteries would not be viable. Shaw (2020) undertook a cost-benefit analysis (CBA) of installing a community battery, considering four different types of ownership and profitability models.[7] The CBA was based on a trial in Jacka ACT (discussed below). The CBA examined whether a community battery would be financially viable and under what conditions (including size, scope, household participation and DUoS/LUoS tariffs). Shaw et al. recommends a LUoS apply when a battery is withdrawing from the grid, as well as when customers consume electricity that was previously stored in the battery. The rationales are firstly that the flows are local and so should only be charged for local network usage, and secondly without discounted network tariffs, community batteries would not be viable.

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[4] These four models are: NFP community owned battery, FP community owned battery, NFP DNSP owned battery, and FP DNSP owned battery.

[5] Further information on the program can be found at: https://arena.gov.au/projects/community-models-for-deploying-and-operating-distributed-energy-resources/

[6] These assumptions include: Customers are paid the spot price for excess solar PV generated; Reduced energy transport fees (LUOS tariff) apply; All households (with or without solar PV) can purchase electricity from the battery; All customers have 5 kWh soar PV installed in the new suburb of Jacka; Batter operates on a low voltage network.

[7] These four models are: NFP community owned battery, FP community owned battery, NFP DNSP owned battery, and FP DNSP owned battery.

1.5 Neighbourhood battery trials in Australia

Victoria

In January 2021, the Yarra Energy Foundation (YEF) and CitiPower agreed to develop community–scale battery storage in the Melbourne CBD and inner-city suburbs by late 2021.[8] CitiPower/Powercor representatives told us that they envisage no use of system charges will apply when the battery is being charged, and they envisage discounted use of system charges for electricity supplied by the battery to the prosumers that nominally store their electricity in it (we understand the discount is that off-peak use of system charges will apply for battery-supplied electricity in peak periods).

In May 2021, Powercor also announced plans to install up to 20 big batteries totalling over 1.1 GW at key network centres (also referred to as "renewable energy zones"). We understand that these are not however intended to be "community" batteries.

Following a two-year planning process, the Yackandandah community battery became operational in April 2021.[9] The trial is led by Indigo Power (an energy company established by the local community members), in partnership with Totally Renewable Yackandandah and support from philanthropic funders, and the Victorian Government. The Yackandandah community battery is relatively small (274 kWh), servicing a small community town of around 1,800 people. In the Yackandandah trial, solar panels have been installed on the roof of an old sawmill (the "Agency of Sculpture workshop"), and the battery is located within the building below. The battery is a large BTM battery and so the issues of LUoS are not relevant when it charges (because a BTM battery is not paying DUoS when it charges from the solar on the roof). There may nonetheless be an argument for LUoS of some form for the electricity supplied by the battery. No such LUoS currently applies.

New South Wales

The Beehive Project, announced in December 2020, is a joint project led by Enova Community Energy in partnership with Ausgrid, and funded by the NSW Regional Community Energy Fund.[10] The trial will include up to 500 households (with and without rooftop solar) in the Kurri Kurri area sharing a 1MW Tesla community battery. The battery will be paired with an online platform (Powertracer) that enables trading and sharing for participating solar and non-solar households situated anywhere in NSW. Battery deployment is anticipated late 2021. We do not know if there has been any consideration of LUoS.

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[8] https://www.powercor.com.au/news/citipower-and-yarra-energy-foundation-pursue-victorian-first-solar-sponge-community-battery-network

[9] https://indigopower.com.au/yackandandah-battery-update/

[10] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjV4e_iu-LxAhUj73MBHft9DQoQFnoECCMQAA&url=https%3A%2F%2Flp.enovaenergy.com.au%2Fhubfs%2FThe%2520Beehive%2520Project%2520Site%2520Announcement%25208%2520December.pdf%3FhsLang%3Den-au&usg=AOvVaw1Y7v2xkb7QtQN9ixHbMm3a

In February 2021, Ausgrid launched a two year trial of a community battery (150 kW / 267 kWh) in Beacon Hill.[11] All residents with rooftop solar living in the Northern Beaches trial area can participate and store up to 10 kWh each day at no cost. The excess energy is credited against the households' electricity use per day, and households receive quarterly payments for these excess energy credits. Ausgrid plans to install two additional community batteries in Canterbury/Bankstown and Lake Macquarie areas.

In April 2021, Ausgrid unveiled another community battery in Bankstown.[12] The trial allows up to 250 households (who either have solar or are about to install solar) access to receive credits for each unit of excess solar electricity stored in the community battery, to an upper limit of 10kWh per day. Ausgrid is trialling two different battery systems as part of the trial, including two Tesla PowerPack 2 batteries (each delivering up to 130kW power and 232kWh of storage) and an MTU Energy Pack QS (providing around 320kW/550kWh of storage capacity).

Queensland

In late 2019, Energy Queensland (through a subsidiary, Yurika) installed a 4MW battery (Tesla Power Pack) at Bohle Plains on the northern outskirts of Townsville.[13] The battery is justified on the basis of network benefits and participation in wholesale markets. Although this is a small battery, it is not a "community" battery as we use the term.

Australian Capital Territory

The ACT Government and Evoenergy are partnering with the Australian National University to examine the feasibility of a large community battery for a new 700-home development of the suburb of Jacka (ACT) where solar panels will be installed on every house (Australian National University, 2020a, 2020b; Shaw et al., 2020).[14]

Western Australia

Commencing in April 2016, the Alkimos Beach community battery is a joint project between Synergy, Alkimos Beach development partners Development WA and Lendlease, and supported by the Australian Renewable Energy Agency (Cornwell, Warren, Wheatley, & DevelopmentWA, 2019).[15] All households in the new Alkimos Beach development have solar PV installed, access to a 1.1MWh community battery and are charged the Peak Demand Saver tariff (PDST). Customers that generate excess energy from rooftop solar PV during the day are granted a credit for net energy created that can be drawn down later in the day.

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[11] https://www.ausgrid.com.au/About-Us/News/community-battery-trial

[12] https://reneweconomy.com.au/ausgrid-unveils-new-community-battery-project-in-sydneys-bankstown/

[13] https://www.yurika.com.au/news/2019/yurika-to-deliver-community-scale-battery-in-townsville

[14] https://www.abc.net.au/news/2020-06-05/community-battery-may-be-built-in-new-canberra-suburb/12266938

[15] https://arena.gov.au/projects/solar-and-storage-trial-at-alkimos-beach-residential-development/

The Alkimos Beach community battery does not receive a discount on network tariffs. However, Synergy and Western Power are currently discussing a possible discount for use of system charges when the battery draws electricity from the grid. Synergy anticipates discounted network tariffs may involve changing some of the battery operating parameters, or occasionally using the battery for network purposes.

PowerBank (a joint venture between WA retailer Synergy and WA network service provider, Western Power) have rolled out several N-B trials in established suburbs across WA. The batteries are owned by Western Power. The initial PowerBank trial commenced in November 2018 with 52 households in Meadow Springs, generating solar electricity and sharing access to a 420kWh Tesla battery.[16] The Meadow Springs suburb comprises more than 12,000 small scale solar power systems with a collective capacity approaching 36MW. Each household is allocated 8kWh of virtual storage, accessible after 3pm each day, and households are charged between $1 and $2 a day to store 6-8 kW. Since the initial trial, additional PowerBank batteries have been installed as part of the Western Australian Government's Distributed Energy Resources (DER) Roadmap, at Canning Vale, Dunsborough, Ellenbrook, Falcon (Mandurah), Kalgoorlie, Leda, Parmelia, Port Kennedy, Singleton, Two Rocks and Wanneroo.[17] From our interactions with Synergy representatives, we understand that DUoS tariffs have not been explicitly considered and by implication through Western Power's ownership of the batteries, they are not be charged DUoS currently.

2 Economic analysis

This section sets out our economic analysis. It important to be clear on the question we are seeking to answer and on the bounds of this analysis.

Our question is whether LUoS has a rationale in economics. By this we mean whether LUoS will increase aggregate "Marshallian" welfare (i.e. the sum of the producer and consumer surplus).[18] This could happen, for example, if the LUoS discount resulted in cheaper storage services (when measured across the industry) that are not offset by higher charges for network services to other customers to fund the discounts.

Our analysis does not consider wider costs and benefits of storage – such as by helping to reduce greenhouse gas emissions by supporting greater renewable electricity production, or the creation of local jobs and the support of local communities. We assume that policy objectives that consider these would be expressed in mechanisms other the arrangements for the use of electricity distribution networks.

[16] https://www.pv-magazine-australia.com/2018/11/05/community-tesla-battery-trial-kicks-off-ahead-of-schedule-amid-overwhelming-interest/

[17] https://www.mediastatements.wa.gov.au/Pages/McGowan/2021/04/Major-milestones-for-Distributed-Energy-Resources-Roadmap.aspx
https://www.synergy.net.au/About-us/News-and-announcements/Media-releases/Latest-battery-storage-trial-to-benefit-hundreds-of-WA-homes

[18] The producers' surplus is benefit that producers get when they are able to sell their produce for a higher price than the minimum they would be willing to accept. The consumers' surplus is the benefit that consumers get if they pay a price that is lower than they are willing to pay.

The section firstly summarises, very briefly, the key theoretical constructs that have a bearing on our question. This leads to a layout of the arguments for and against LUoS. The final sub-section asks and answers the question of "if LUoS, how?".

2.1 Theory

Neoclassical economics orthodoxy says that welfare is maximised when prices are equal to marginal costs. However electricity networks are characterised by lumpy capacity increments (transformers and electrical conductors come in discreet sizes) and scale economies (cost and voltage is linearly related but cost and capacity is quadratic in voltage). In addition, network investments are justified not just on the basis of transfer capacity but also reliability (i.e. redundancy). For these reasons, in electricity networks average costs are almost always higher than marginal costs (and marginal cost are often but not always very small). As a result, a central problem in electricity pricing is the method for the recovery of the gap between average and marginal costs. In the extensive literature on this, arguments have been made that these should be recovered mainly from tax payers rather than electricity consumers (Hotelling, 1938). But since the value of electricity to consumers is typically much higher than its price, in practice electricity costs are almost always recovered from network users rather tax payers. A common approach in the recovery of network costs is to recover them disproportionately from those users with the least elastic demand. This is typically electricity consumers rather than producers.

How is this relevant to the economic analysis of LUoS for N-B? If a N-B is able to provide a storage service for consumers that can compete effectively with conventionally supplied electricity, there is the potential to increase welfare by discounting network cost recovery from N-B, as long as N-B do not impose additional costs on the network. This is, essentially, the same rationale that applies in the case of the network by-pass discounts that are justified on the basis of avoiding wasteful network duplication.

A second important theoretical foundation in the economic rationale for LUoS is Kirchoff's Current and Voltage Laws.[19] The implication of these laws is that an electrons source of origin is impossible to know with certainty on a shared electricity network. In the context of N-B, once electrons have left my roof and flowed into the network it is impossible to objectively determine if my electrons have been stored in a neighbourhood battery, or whether they have found their way into my neighbour's house or further up into the network to be consumed elsewhere.

How is this relevant to the economic analysis of LUoS for N-B? The point is that commercial agreements between N-B and consumers or prosumers are necessarily "financial" (they reflect agreements on prices for volumes whose origin is anonymous) rather than "physical" (agreements on prices for volume whose source can be specifically identified – for instance, on a co-located N-B). This means that the electrical current stored in N-B in any realistic situation cannot be specifically identified as originating in the surplus electrons produced on my or your roof. Likewise when the N-B discharges, the electrons cannot be directed through the network to any specific consumer. This renders the assessment of the power flows into and out of N-B necessarily *probabilistic* rather than *deterministic*: at best we can say that, under various conditions, is it *likely* that

[19] https://en.wikipedia.org/wiki/Kirchhoff%27s_circuit_laws

the surplus solar from specific customers is being stored in the N-B, or that when the N-B discharges to the grid, that that electricity finds its way to local rather than distant consumers.

2.2 Arguments for and against LUoS

Argument for LUoS	Counter-argument
1. **Transaction costs:** N-B may reduce network losses, improve local voltages, improve network strength and increase network capacity. But establishing prices for these benefits may be difficult. In this case, a LUoS discount may be a practical alternative to reflect benefits that are difficult to explicitly transact.	Network benefits associated with N-B are difficult to price because they are difficult to measure, are uncertain and/or stochastic. But explicitly pricing them and transacting for them brings expenditure efficiency benefits that will be lost if the benefits are compensated through a LUoS discount.
2. **Local grid usage:** N-B that charge locally and discharge for local consumption do not rely on the upstream network and should not be required to pay for it.	Firstly, N-B do not necessarily charge locally. The extent of "local" charging will depend on the level of distributed production in relation to local demands and the location of the battery. If N-B do not charge from distributed sources, it is necessarily using the upstream network to charge. Second, when N-B discharge, the energy may be consumed locally or it may be drawn upstream, depending on local demand and supply. If drawn upstream, then N-B are using the upstream grid. Third, not using the upstream network is not a sufficient reason to avoid upstream network charges: in practice, network charges in the NEM are pancaked. The majority of rooftop solar injected to the grid is likely to be consumed locally, but network tariffs do not currently reflect this.
3. **N-B expand grid capacity:** Placing N-B deep in the distribution grid can improve transfer capacity on feeders or MV circuits (e.g. by relieving network congestion in areas with very high solar penetration). This value can be reflected in payments (from grid operators) to independently owned N-B, or through ownership of N-B by grid operators (and hence cost recovering through regulated charges), or by foregoing some part of the network usage fees from independently owned N-B.	Firstly, for it to be generally true that N-B improve grid transfer capacity it must be the case that N-B typically charge from "downstream" production, or charge from upstream production only when the grid is unconstrained. The latter may generally be the case, but it is not necessarily the case depending on solar penetration, grid hosting capacity, battery size and the correlation between N-B charging and peak solar production. Second, expanding grid capacity is of itself not necessarily valuable: for it to be valuable (and hence worthy of compensation in the form of LUoS) there must be convincing evidence that i) there are capacity constraints, and ii) N-B are the most economical solution to relieving these constraints.
4. **Even a 100% LUoS discount may be revenue neutral:** it might be argued that discounting the usage charge to N-B would encourage more frequent charging and discharging so that the volume effect (more frequent charging and discharging) would compensate for the price effect (less	It is an empirical question of whether the LUoS volume effect will compensate for the price effect, such that aggregate revenue collected from a N-B is unaffected. Even if they do (so discounts are revenue neutral) the argument for a LUoS discount when charging would apply also to BTM-B (if using the grid to charge at the same time as N-B) and B-B and also perhaps to other non-electrical forms of storage (such as electrically heated hot water or pumped hydro) that store electricity albeit in other forms.

income per unit charged), and so the aggregate revenue collected by distributors from N-B would be similar.	More generally, a discount for network usage in an intermediate electricity service (storage) raises the question of why that discount should not also apply to final consumption if such electricity is being consumers at the same time the N-B is charging?
5. **Double revenue recovery:** if N-B pay the full network charge on stored electricity, and the customer pays the full network charge when it later consumes the discharged electricity, then the network provider is getting twice as much revenue per electron of final consumption and in this sense is charging twice.	The double revenue recovery argument is a fallacy when you recognise that the electricity is being shipped twice (firstly from a producer into the battery, and secondly from the battery to the consumer) and so two sets of network charges are appropriate. Nonetheless, the argument for a LUoS discount may still be made as set out under the "local grid usage" argument (above).
6. **Inefficient by-pass:** it may be the case that if network charges for N-B are not discounted, N-B would not be viable. But if N-B do impose costs on the grid (it is mainly using the local grid) and if the cost of N-B is less than BTM-B, then discounting network charges for N-B may increase welfare if as a consequence N-B, rather than BTM-B are developed. In other words, a LUoS discount would increase the prospect that the cheapest storage solution is built and hence increase efficiency and welfare.	Firstly, a fully discounted LUoS might not be sufficient to ensure that N-B rather than BTM-B are built. Although this does not undermine the rationale for the discount, it suggests it will be ineffective. Second, welfare improvement (of a network charge discount) depends on a few conditions: (a) That N-B do not pose additional costs on the network (i.e. that it substantially is a local flow device that the local network can easily accommodate. (b) The price of storage provided by N-B (inclusive of all the costs of providing the storage service) is less (but not greatly less) than the cost of BTM-B (if it was greatly less, the LUoS discount would affect the decision to invest in N-B and thus not be necessary).
7. Consistency in the treatment of battery and generators: it can be argued that storage devices and generators should be treated comparably in their liability to network charges. This is the approach that has been adopted in Britain by the Office of Gas and Electricity Markets. On this basis, network charges to grid batteries are substantially discounted when they charge.	This is a statement of (subjective) principle, not an economic argument.

2.3 Discussion

The previous sub-section sets out various arguments and counter-arguments for LUoS discounts for N-B. Here we discuss and assess these arguments:

1. **Transaction costs:** We are not convinced that LUoS discounts as a substitute for explicit compensation for network benefits is plausible. To the contrary, we suggest that identifying, pricing and then transacting for network benefits provides a discipline on expenditure that protects consumers from inefficient expenditure incurred on their behalf. If N-B capture exaggerated estimates of the benefits (in the form of LUoS discounts that are higher than they should be) consumers are worse off for the foregone N-B contribution to network charges.
2. **Local grid usage:** It may well be the case that N-B located on Low Voltage (LV) or on Medium Voltage (MV) circuits close to high penetrations of local (behind the meter) generation is often storing surplus local production and so the power flows may often be local (assuming the N-B production is consumed locally as well, as can be expected generally). But it is not *necessarily* the case that N-B are mostly storing local production. A heavily used N-B may often involve the storage of both local and distant production (particularly if N-B charges when surplus solar is not available or if N-B is large in comparison to the amount of surplus solar that is locally available). Even if N-B could be argued to be substantially “local” (i.e. storing local production and serving local demand), this does not justify LUoS *uniquely* for N-B any more than it would justify LUoS discounts for surplus local solar production that is consumed locally. Indeed the “local grid usage” argument is even more relevant for the network charges my neighbour pays when they consume my surplus solar production
3. **Revenue neutrality:** This is a powerful argument and, if correct, suggests that there is little to be lost by offering LUoS discount to N-B. But BTM-B (when storing grid electricity) and B-B and other forms of energy storage derived from electricity (e.g. hot water) might also reasonably argue that LUoS discounts should also apply to their grid purchases, on the basis of revenue neutrality.
4. **Double revenue recovery:** It is plausible that charging full DUoS for local flows to and from N-B will recover more than is warranted if charges are set on a “user-pays” principle. For example, load connected at High Voltage (HV) or MV is not charged for the use of the (MV+LV) or LV (respectively) networks. So, by extension why should LV customers using the LV networks alone pay for the use of the HV or MV networks? But it is not necessarily the case that flows into and out of N-B are local only. Furthermore, it is reasonable to suggest that if N-B are eligible to pay LUoS to reflect mainly local flows, then as discussed above, this argument should also apply for the consumption of locally produced solar.
5. **Inefficient by-pass:** This is potentially a compelling justification, in economics, for LUoS for N-B. But it depends critically on two conditions. Firstly that there is reason to believe that, leaving network charges to one side, N-B are able to provide cheaper storage services than BTM-B. Second it must be the case that N-B do not pose additional costs to the grid. If either of these two conditions do not hold then the “by-pass” rationale for LUoS fails.
6. **Equivalence between batteries and generators:** We don’t think the argument that batteries should, in principle, be treated in the same way as generators is any more plausible that in principle they should be treated in the same way as load.

Bringing these arguments together, we think there is a plausible argument, in economics, for LUoS discounts for N-B based on the prospect that this could avoid inefficient by-pass. Arguments that N-B only use the local grid, that LUoS discounts may be revenue neutral and that it avoids double revenue recovery are also plausible. But these arguments do not apply *uniquely* to N-B. If you accept these arguments as a rationale for LUoS discounts for N-B then you should also accept them as a basis for discounted network charges for locally consumed solar.

3 If LUoS, how?

There are several ways that LUoS discounts could be applied to N-B. We consider each of the following questions below:

(a) Should LUoS discounts apply only for flows into N-B or also for flows out of N-B?
(b) Should LUoS discounts apply to demand charges and/or consumption charges and if so, how much?
(c) How should N-B LUoS eligibility be defined?
(d) If LUoS applies to N-B, should a solar sponge tariff be introduced?
(e) Is a solar sponge tariff justified to address unfairness concerns?

3.1 Should LUoS apply only for flows into N-B or also for flows out of N-B?

This is a tricky question. It may be argued that, whether the electricity is going into or coming out of N-B, it involves mainly local flows and so LUoS discounts should apply for electricity going into and coming out of N-B. Considering the economics, if the "by-pass" argument is valid then in principle the discount should apply on flows both into and out of the battery. But on practical grounds, we think the argument for discounts on flows out of N-B is more tenuous. LUoS discounts on flows into N-B are clearly beneficial to N-B since N-B directly see the benefit of LUoS discounts. But N-B does not pay network charges on flows out (these are paid by users). So LUoS discounts on these outward flows will not benefit N-B directly. LUoS discounts can potentially benefit N-B indirectly if, as consequence of LUoS discounts on outward flows, N-B are more financially viable. But it is not obvious that N-B will capture the benefit of LUoS discounts on outward flows. Instead this benefit might be captured by retailers in the form of higher margins. In this case, LUoS discounts on outward flows improves retailers' margins and not N-B or its customers. We think that in practice this is likely to eventuate, and on this basis suggest LUoS discounts should apply only to inflows to N-B.

3.2 Should LUoS discounts apply to demand charges and/or consumption charges and if so, how much?

On this issue, the method for the calculation of demand charges is important. There are many possibilities here including time-of-use peak demand charges (i.e. charges for the peak demand measured in peak and off-peak periods), critical peak demand charges (usually the average of the highest three or so peaks during a defined period) or subscribed demand (which is an entitlement to subscribed capacity and is paid whether or not the full capacity is used). Subscribed demand charges do not affect battery operation since they are paid whether or not the battery withdraws from the grid.

Subscribed demand charges will, however, affect investment decisions (because they are a cost and thus factored into investment returns).

Peak demand and critical peak demand charges may also not affect battery operation (if demand is below the peak). However, like subscribed demand charges, peak or critical-peak demand charges will affect investment decisions.

The argument against discounting demand charges is that they may not (and in some cases certainly will not) affect operational decisions and so discounts will not affect N-B *usage*. But demand charges (of whatever form) will affect investment decisions. For this reason, we think that LUoS should apply to (kW) demand charges in the same way that they should apply to consumption (kWh) charges.

However, to deal with the case that N-B could charge from upstream power flows (i.e. not just from distributed local PV supplies) we suggest that the discount for N-B should only apply when N-B are most likely to be storing distributed solar supply. This would mean, for example, LUoS discounts only apply from 10am to 4pm daily. Network charges outside these times should not be discounted.

Finally, how much should the LUoS discount be, and should it change over time? This is essentially an empirical question based on the extent to which the LUoS discount avoids inefficient by-pass. If the economics of N-B, relative to BTM, are such that LUoS is necessary (and sufficient) to ensure N-B competitiveness, then LUoS would be appropriate. If a 100% LUoS discount is not sufficient to ensure N-B competitiveness, then LUoS discounts are pointless (albeit harmless). If N-B are competitive even without LUoS, then there is no need to apply such discount (this would simply boost storage profits at the expense of network charges for all other consumers that are higher than they otherwise would be). It is impossible to know for certain the competitiveness of N-B relative to BTM-B as it depends on many factors that change over time. As a practical response, we suggest a 100% discounted LUoS at the applicable times (described above) for a period of 10 years, to any existing or new N-B, with 0% discount after that. This level of discount should be reviewed annually for new entrant N-B, with the objective of gradually reducing the discount on LUoS over time.

3.3 How should N-B LUoS eligibility be determined?

The rationale (in economics) for LUoS discounts depends on N-B being substantially local i.e. storing locally produced electricity and discharging for substantially local consumption. These conditions will not be satisfied if N-B are electrically distant from load and/or there is insufficient penetration of local solar production. It is therefore necessary to define N-B (and hence eligibility for LUoS) to help ensure these conditions are satisfied. Indicatively, we suggest that this can be done with a combination of restrictions, such as:

- N-B must be located in an area with high solar penetration (greater than, say, 20% of households within a 5 km radius);
- N-B capacity must be smaller than the actual or expected simultaneous peak local surplus solar production for households within a 5 km radius; and
- N-B must not be connected to networks above 11 kV.

These conditions are indicative only and ongoing testing and review will be required.

3.4 Solar sponge tariffs to address unfairness concerns?

We have suggested that LUoS charges for N-B have a rationale in economics, subject to various conditions. These arguments are not valid for local consumption for rooftop solar. The reason is, for example, discounting network usage for the consumption of locally produced solar is unlikely to affect consumption and production of solar. This is because electricity consumption is generally insensitive to prices. Furthermore, it is not at all clear that LUoS discounts to locally consumed solar can be implemented practically and, even if possible, the benefits are likely to be captured by retailers rather than passed on to consumers.

However, as a matter of equity, LUoS discounts for electricity stored in N-B from local solar reasonably raises perceptions of unfairness because local solar attracts the full DUoS when it is consumed locally. We suggest that if LUoS applies to N-B when withdrawing from the grid, a solar sponge tariff (i.e. discounted network charges for from 10am to 3pm) should also apply to small consumers (who are most likely to be consuming the surplus solar). Such arrangements would disproportionately benefit non-solar small consumers (because prosumers are likely to be exporting at the time that the solar sponge rates apply) and thus we think addresses the reasonable unfairness concern.

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