Local Use of System (LUoS) Tariffs Re-considered

Network pricing to Grid-Side Batteries

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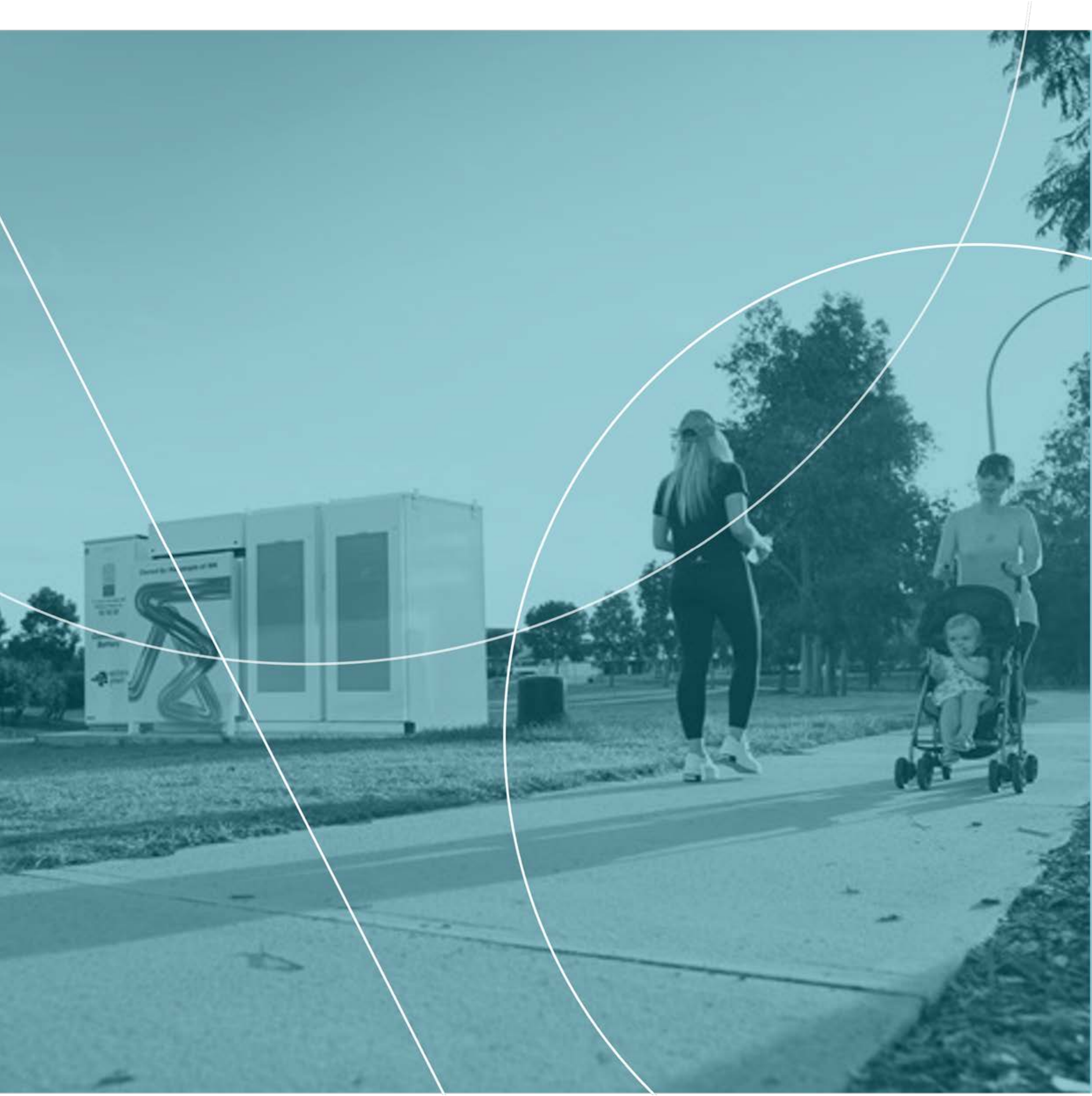

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1. LUoS then and now

The concept of a 'LUoS tariff' was first developed as a means for incentivising the installation of rooftop PV by recognising that:

- a customer with a PV system uses less energy from the upstream portions of the network during daylight hours,[1]
- as will other nearby customers when that PV system exports electricity.

The advent of grid-side batteries has re-opened the discussion of whether and how reduced use of the upstream portions of the distribution network (and possibly the transmission network) due to distributed generation should be reflected in pricing.

The Total Environment Centre commissioned Oakley Greenwood (OGW) to consider this issue, particularly in light of:

- The AEMC rule changes that established cost-reflectivity as the basis for the setting of network tariffs (2014)[2] and identified the conditions under which charging and rewarding customers for the use of the network to export electricity is justified (2021)[3].
- The advent of another round of tariff structure statements which would provide an opportunity to expose network customers to these concepts, how they might operate in practice and the potential benefits they might provide.

The TEC brief explicitly requested that our consideration be undertaken with regard to grid-side batteries, given the recent increase of interest in and programs encouraging the deployment of these devices. However, as will be discussed throughout the paper, the principles used in developing a 'LUoS' for grid-side batteries can very readily be applied other DER applications including rooftop PV, demand response, the operation of VPPs or small solar farms connected to the low voltage distribution system. It also addresses (and removes the need for) the special arrangements contemplated under peer-to-peer trading.

1.1. What do we mean when we talk about LUoS tariffs?

The basic element of the LUoS tariffs that were put forward to incentivize the installation of rooftop PV was a discount based on the reduced use of the upstream portions of the distribution and transmission networks on the part of these customers (both those exporting and importing the electricity from the PV system).

We have adopted the intent of the earlier formulation of a LUoS tariff but worded it in a slightly different but more generalisable and more easily operationalised form. That is, that:

> *The network tariff to be applied to grid-side storage devices should be based on the impact of their operation on network costs.*

1 A customer with a PV system and in-home battery is also likely to use less energy during evening peak periods, though that DER technology configuration was not common at the time LUoS tariffs were first considered.

22 AEMC 2014, *Distribution Network Pricing Arrangements*, Rule Determination, 27 November 2014, Sydney.

3 AEMC, *Access, pricing and incentive arrangements for distributed energy resources*, Rule determination, 12 August 2021.

In our view, this starting point more fully reflects the concept of cost-reflectivity that has been enshrined in the rules since 2015 as the basis for the development of network tariffs[4].

It is also our view that the application of existing network tariffs to grid-side devices may not provide price signals that incentivise them to be operated in the most efficient manner[5]. By contrast, the combination of cost-reflective network pricing (CRNP) for both the consumption (import) and export of electricity by a grid-side storage device should, *if correctly developed and applied*, provide economically efficient price signals for both the deployment and operation of these devices. Further, that basis should also be able to be extended to the development of tariffs that would apply to behind-the-meter (BTM) storage devices.

The following limits to the discussion of the development of cost-reflective, two-way pricing for grid-side battery storage should be noted:

- The type of 'LUoS' tariff discussed here is only concerned with network-related costs and benefits
- It is not concerned with impacts on the wholesale market, the environment, jobs or the economy
- These can be addressed through other price signals or financial arrangements.

1.2. Why are we talking about LUoS tariffs again?

New and emerging grid-connected DER technologies such as grid-side battery storage systems change the options for balancing supply and demand in electricity networks. Of most relevance, their operation can reduce the costs of supplying electricity as compared to meeting that demand entirely through the central generation system. More specifically, DER can reduce ***network costs*** where it:

- ***Reduces demand*** within a local area at times when a network asset upstream is congested and would otherwise require augmentation.

  As an example, a battery connected to the distribution network can do this by exporting energy to provide energy to help satisfy local demand.

- ***Increases demand*** within a local area at times when solar export would otherwise either (a) result in an over-voltage condition within the local area, or (b) create a thermal constraint on an upstream asset.

  A battery connected to the distribution network can do this by charging during these times in order to 'soak up' excess local solar export.

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4 In fact, the original formulation of a LUoS tariff is demonstrably not cost-reflective. For example, such a tariff could provide a discount for export at times when that export could impose costs on the network. This would be the case on mild, sunny days (as occur not infrequently in spring and autumn) when there is very little underlying demand on the network leading to over-voltage conditions that would require network expenditure to accommodate.

5 From a network perspective, a grid-side battery will operate most efficiently when it imports or exports the amount of energy that produces the greatest downward pressure on network costs at that specific location at that specific time. From the perspective of the electricity sector as a whole, maximum efficiency will be provided when the operation of the grid-side battery puts the maximum downward pressure on total electricity supply chain costs.

By contrast, the application of network tariffs in their current form and structure to grid-side devices does not provide a price signal that would incentivise them to be operated in the most efficient manner. This is because current network tariffs are both (a) volumetric (they are charged on how much energy a customer consumes, which is not the primary driver of a network's costs), and (b) postage stamped (the same price is applied to all customers within a particular tariff class regardless of where the customer is located. This does not reflect that fact that local demand rather than system-wide demand is the more important determinant of network costs). Simply put, current network tariff structures are not reflective of the marginal cost of delivering energy to the customer at different times (i.e., under different network operating conditions).

1.3. Why a new form of tariff is needed for DER customers

Traditional and most current network tariffs seek to recover the full (sunk, fixed, and variable) costs of the distribution and transmission systems from end customers that use the network to consume electricity. Under this approach:

- Most end customers – especially residential and small-to-medium non-residential customers – use and are charged for the cost of the entire transmission and distribution networks
- But some customers – typically very large industrial customers – that connect to the transmission network or the high-voltage (HV) portion of the distribution network are not charged for use of the lower-voltage parts of the network that they do not use.

However, these arrangements do not provide a price signal that will incentivise customers with DER technologies to operate them in the most efficient manner with respect to costs they impose on (or reduce for) the local distribution network.

What is needed is a tariff for grid-connected DER customers (i.e., those that are not conventional, consumption-only customers[6]) that provides a price signal that reflects the impact that the use of that device has on the cost incurred by the network operator. For example, where the use of the DER device reduces costs in the network, they should see a price signal that reflects the cost reduction the use of the DER device provides.

It is worth noting that this logic is the basis for the avoided TUoS charges that embedded generators receive as a result of their energy injections into the distribution network. The type of network pricing we are discussing here would extend this logic to the distribution system.

6 Typical conventional, consumption-only customers should, in theory, also see a price signal in relation to the cost reductions they provide, for example when they reduce peak demand on the network. This is ostensibly what cost-reflective network pricing (CRNP) and two-way export pricing should achieve, if done correctly.

2. Pricing theory questions underpinning 'LUoS' tariffs

2.1. Key issues

If we accept that grid-connected customers with DER devices should see a price signal that reflects the cost reductions they provide (and cost increases they cause) to the network, we then need to consider which of three approaches to the recovery of fixed/sunk network should serve as the basis for the development of the 'LUoS' tariff[7]. Specifically, should it:

1. Simply reflect a reduction (or increase) to existing network tariffs, reflecting the costs that the network avoids (or incurs) as a result of DER operation. In such a case, the 'LUoS' tariff would:
   a. Be derived as the standard NUoS for the customer *minus avoided costs or plus LRMC*[8]
   b. Provide for the same level of recovery of fixed/sunk costs[9] from the customer as would the existing tariff.
2. Solely reflect avoided costs/marginal costs (e.g., SRMC/[10]LRMC), which would provide for no contribution from the customer to network fixed/sunk costs
3. Reflect the avoided costs/marginal costs (e.g., SRMC/LRMC) of the network, with any contribution to fixed/sunk costs based on a bespoke assessment of the customer's standalone cost (i.e., a bespoke fixed charge for that customer and type of connection).

Each approach will impact both efficiency and equity differently:

- Option 1 ensures grid-connected customers that are charged 'LUoS' tariffs will make an equitable contribution to the recovery of fixed/sunk costs. However, if the recovery of the fixed/sunk costs makes their project uneconomic relative to if they had only been charged based on Option 2 (avoided cost/marginal cost), it will lead to an inefficient outcome
- Option 2 ensures efficient connection and operational decisions are made by the customer facing the 'LUoS' tariff, however this may be perceived as being inequitable by some customers as it provides no contribution to the network's fixed/sunk costs

7 We note that the change to NER 6.18.5(f)(2) and the AER's Draft Export Tariff Guidelines states that export changes should reflect the long run marginal cost of providing export services. This suggests that the export charge itself is meant to be entirely forward looking. Further, the AER's Guidelines explicitly state that the costs associated with providing a network's intrinsic hosting capacity should not be recovered in the export charge. However, the tariff we are discussing in this paper would apply to both the export and import activity of the grid-side battery. As such, it would not be improper for the import part of the LUoS tariff to include a contribution to residual costs. However, as we stress in the text, it would not be efficient for this charge to make the operation of the grid-side battery uneconomic, as this would sacrifice the benefits it could potentially provide to the network and network users. It should also be noted that the AER's Draft Export Tariff Guidelines (p 20) state that "export charges may reasonably recover both long run marginal and residual costs associated with providing export services". It should also be noted that The AER's Draft Export Tariff Guidelines state that "export charges may reasonably recover both long run marginal and residual costs associated with providing export services".

8 Long-run marginal cost.

9 In terms of the amount of fixed/sunk cost recovered per kWh.

10 Short-run marginal cost.

- Option 3 is likely to lead to efficient outcomes, whilst also ensuring that the grid-side battery provides some contribution to fixed/sunk costs, which benefits other network users and is likely to be seen as more equitable given that the use of the network is necessary for the grid-side battery's existence and business case. However, this option will have materially higher administrative costs, as it will require calculation of (and perhaps negotiation around) the amount that each grid-side battery could contribute to fixed costs without compromising its commercial viability (and possible relocation, resulting in the loss of any benefit it could have provided to the network and other network users.

We believe there is likely to be merit in starting with Option 2 and moving towards Option 3 over time as grid-side batteries become more common and more commercially viable. These price signals would, in effect, be a new suite of network tariffs, and hence would take the place of existing network tariffs for these types of customers.

2.2. Additional principles

While the most important principles for the development of a 'LUoS' tariff as described above are (a) cost-reflectivity for both the import and export of energy, and (b) consideration of the proper contribution to fixed/sunk network costs that is included in the tariff, other principles that should also be considered include:

- To the extent possible, each component[11] of the 'LUoS' network tariff should be cost-reflective in its own right
- The price signal should be targeted at the party whose actions are primarily responsible for the associated impact on cost
- Price signals for export should incentivise investment and export (or use of generation) in the right place, at the right time and in the right amount
- Price signals for consumption should also be cost-reflective, so that the consumer can accurately judge the value derived from the consumption of electricity in a particular location and at a particular time as compared to the actual cost of supplying that amount of electricity at that location at that time

In summary, any tariff/price signal developed for DER sources of local generation (including export for battery systems) should be cost reflective. Further, there is no point in making such a price signal non-cost reflective in order to 'make up for' the non-cost reflectivity of other price signals in network tariffs or elsewhere in the electricity value chain.

11 That is each component of the tariff, including the level of any demand or energy charge whether for export or import, and any capacity or fixed charges that are included.

3. Application to a grid-side battery

3.1. Why a grid-side battery offers a good example

A grid-side battery offers an excellent means for considering how a 'LUoS' tariff might work because:

- There is no ‘legacy’ tariff for these customers (i.e., the parties that will own and/or operate these batteries) that might impede the adoption of an efficient price signal
- The battery owner will almost certainly be a commercial operator[12] whose sole product is electricity; that is, a party that should be capable of understanding and dealing with more complex electricity price signals given that they will form a significant portion of the operating costs to that business[13].

A tariff provides important information for potential investors on the best places to consider for deploying a grid-side battery. Further, because these investors will have purely commercial motives (or at least quantifiable objectives[14] and the need to operate at least without incurring on-going losses), they are likely to ensure that they have the flexibility to respond to the price signals contained within the tariff, meaning that the price signal within the tariff can materially impact investment decisions related to the size, location and operation of the battery.

Where the LUoS tariff is cost-reflective with regard to both import and export, responding to the price signal will be in the battery owner’s commercial interest and the economic interests of all other users of the network. Importantly:

- Where the battery owner ignores a price signal about behaviour that adds costs to the network it will pay its share of those costs
- Where it ignores a price signal that would reduce network costs or responds to a price signal that reduces network costs, other customers will be no worse off

We have therefore sought to assess whether a 'LUoS' tariff would support efficient investments in grid-side battery technology by a third party (non-network) provider, assuming away any other limitation. For that investment, we have conceptualised two scenarios:

- Where its operation requires additional costs to be *incurred* by the network service provider in order to service its requirements, and
- Where its operation allows the network business to *avoid* some costs.

In both cases, the costs or benefits to the network are considered with regard to the base case scenario; that is, where the grid-side battery does not exist. By considering the addition of the battery on this at-the-margin basis:

12 That is, they will be operating the battery for a profit or for some other quantifiable objective function such as reducing costs and/or emissions for the community, as compared to a residential user who will likely have led rigorously quantified objectives.

13 Other than the capital cost of the battery itself, the operating costs of the battery are likely to be comprised of the cost for charging and discharging the battery (i.e., electricity costs), information costs (to track the wholesale and other revenue streams whereby the battery can earn money, and possibly other information such as upcoming weather and local customer loads and exports), and the costs of personnel needed to operate the battery in response to available information.

14 Certain operators of grid-side batteries (e.g., local councils or community organisations) may have social and/or environmental objectives, but they will still almost certainly want to operate on a commercially sustainable basis.

- Where the operation of the battery imposes cost on the network, the 'LUoS' tariff will levy a charge on the grid-side battery customer
- Where the operation of the battery reduces network costs, the 'LUoS' tariff will provide a rebate to the grid-side battery customer.

3.2. Reflecting costs imposed and reduced in the network tariff for a grid-side battery

Following on from the above:

- Charges would be applied to the battery owner for the charging of their battery:
  - During periods when the network is otherwise *not congested* (i.e., the majority of the time) noting that:
    - This should reflect the average SRMC[15], recognising that the whilst the marginal cost of flows from centralised generators and from de-centralised generators is likely to differ, the difference is likely to be small and the overall quantum is likely to be very small/immaterial during non-congested periods. As a result, for the purpose of the network tariff, there should be no need to differentiate whether the electricity charging the battery is coming from central generation or local (DER) generation sources
    - No geographic differentiation is likely to be required outside congested periods either as the SRMC at those times is likely to be very similar (and very small) across the different parts of the distribution network
  - During periods when the network *is congested*[16] *from a consumption perspective*[17]
    - It is reasonable to assume that any flow into a grid-side battery during an otherwise peak demand period will come from a centralised generator because any decentralised energy that was being exported during that local peak demand period, even absent that battery, would have been consumed locally due to the peak demand condition anyway. In other words, where a peak demand condition exists prior to the addition of a grid-side battery, charging during that period will only serve to increase peak demand upstream of the battery.
    - Therefore, the charge should be based on the (upstream) LRMC, as battery charging at this time will add to the load on those portions of the network. This charge should be locational, to reflect specific characteristics of the network within which the grid-side battery is located.
- Rebates applied to the discharges (export) from a grid-side battery:
  - During periods when the network is otherwise not congested (i.e., the majority of the time) should reflect the fact that discharging during periods where there is no congestion avoids few costs
    - At the extreme, a rebate equal to the avoidance of those costs (average non-peak SRMC) could potentially be justified.

15 That is, the SRMC that is an average across time and location (as compared to one that is specific to a location and a time.

16 Although a grid-side battery is unlikely to be charging much during these periods.

17 Where the network is export congested, the opposite would occur. That is, the battery would be charged for *discharging* into the grid, as it would be adding to the constraint, and/or adding to the amount of distributed energy that needs to be curtailed as a result of that constraint.

- During periods when the network is congested[18] upstream of the battery's connection point, the rebate should be based on the following considerations:
  - Avoided TUoS could be credited to the battery owner, based on the battery's specific location / discharge patterns (and what that means for the DNSP's TUoS bill), plus
  - Avoided DUoS costs, based on the battery's location and the LRMC of the upstream (higher voltage) portions of the network.

These considerations are summarised in Table 1 on the following page in terms of the grid-side battery's operation (i.e., charging or discharging) and network conditions both upstream and downstream of the battery. This is something of a simplification as the distance between the battery and different types of congestion will also affect the level of the battery's impact on network conditions (and therefore the value it provides). As a result, determination of the impact and value of (particularly larger) grid-side batteries will be extremely locationally specific and may need to be addressed on a bespoke basis.

Table 1: Structure and basis of the components of a 'LUoS' tariff applied to a grid-side battery

Charge / Discharge	Time period	Basis for Pricing	Tariff/Credit	Locational or Postage
Charging	Non-congested periods	SRMC of supply	Tariff	Postage
	Upstream peak demand (congested) periods	LRMC of supply, upstream voltages (peak demand)	Tariff	Locational
	Downstream export congested periods	LRMC of supply (hosting capacity)	Credit	Locational
Discharging	Non-congested periods	SRMC of supply (as a proxy for avoided cost)	Credit	Postage
	Upstream peak demand (congested) periods	LRMC of supply, upstream voltages (peak demand)	Credit	Locational
	Downstream export congested periods	LRMC of supply (hosting capacity)	Tariff	Locational

The table uses the following definitions:

- The 'SRMC' of a distribution network is the variable operation and maintenance expenses it incurs in transporting and delivering one more or one less unit of electricity
- The 'LRMC' in any particular distribution network area is the annualised cost of the project that would be needed to provide the capacity needed to accommodate the expected increase in either export or import of electricity.

In summary, this is a cost-reflective tariff with two-way pricing:

- The tariff described in detail above provides a cost-reflective price signal to both the charging and discharging of the grid-side battery

18 Where the network is export congested, the opposite would occur – that is, the battery would receive a rebate for *charging* from the grid, as it would be relieving the constraint, and / or reducing the amount of distributed energy that needs to be curtailed as a result of that constraint.

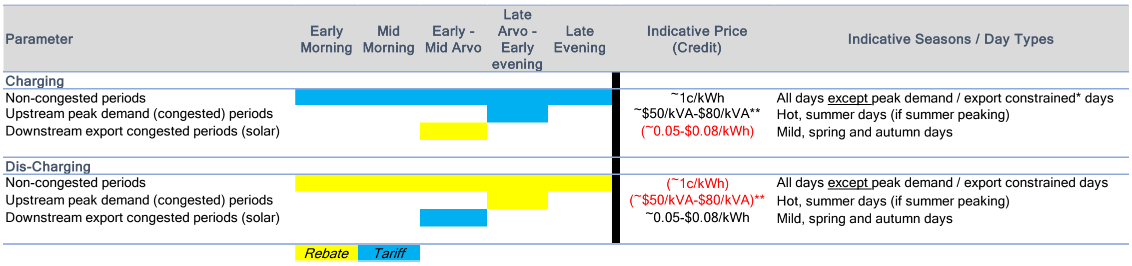
- That price signal can result in either a charge or a credit to the grid-side battery operator depending on the impact of the battery's operation on the present and future costs to be incurred by the network.

Conceptually, similar thinking could be adopted in the context of two-way export pricing which is discussed further in section 3.5 below.

3.3. Illustrative example

The figure on the following page presents an illustrative example of what a charging arrangement for a grid-side battery might look like.

Figure 1: Illustrative example of a charging arrangement for a grid-side battery



* 'Export constrained' days are those on which curtailment is most likely to take place and are characterised by relatively low levels of underlying demand and relatively high levels of potential PV export (which is a combination of the level of PV installed in an area and the level of irradiance available on the day). Mild sunny days in spring and autumn are the types of days on which PV is most likely and most frequently likely to be export constrained.

** The use of $/kVa for tariff for charging during periods of upstream peak demand congestion and discharging during periods of downstream export congestion reflects the fact that these cost drivers are related to *demand* rather than energy. Alternatively, these periods could be charged in $/kW or even c/kWh over a relatively short period of time.

The key features of the illustrative tariff arrangement shown in Figure 1 include[19]:

- A low charge (credit) for charging (discharging) outside of peak demand periods and periods when export might otherwise be constrained;[20]
- A high charge (credit) for charging when the upstream parts of the network are likely to have otherwise been congested, for example, on hot summer days in the late afternoon/early evening[21]; and
- A credit for charging during times when export may have otherwise been constrained.

Charging rates and times could be differentiated by location, particularly those related to peak demand periods and periods of peak export.

3.4. Issues in implementing a LUoS tariff

The table below provides our recommendations on the key issues regarding the implementation of a 'LUoS' tariff for grid-side batteries.

19 There might also be some level of fixed charge in the tariff depending on which of the three options discussed in Section 2.1 is followed.

20 The 1c/kWh charge for charging or discharging at time when the network is not congested is an indicative figure that reflects the fact that the marginal cost of transporting energy in the distribution system when it is not congested is very low. It is quite likely the actual marginal cost at these times is actually less than 1c/kWh.

21 Noting that the application of these prices could be callable, with the relevant days nominated in advance (e.g., 24 hours' notice provided).

Table 2: Key implementation issues of a 'LUoS' tariff

Issue	Choices
How should the price be structured?	Recommended that it include both: • $/kWh: to recover variable O&M (SRMC) costs • $/kVa: to provide a price signal regarding consumption behavior that can be expected to require additional capital investment (LRMC)
How geographically specific should the costs be?	Where costs materially differ by region, postage-stamping will result in price signals that: • Reward investment and behaviour that may not affect costs in the near term • Under-reward investment and behaviours in regions where costs are higher than the average (postage stamped) price.
How dynamic should the prices be? • Static (same all year round)? • Seasonal? • Fully dynamic to reflect critical periods?	The more dynamic the price signal can be in terms of when it is in place, the more accurately it can reflect the benefits provided to the local network
Who should be on the receiving end of the tariff?	The more sophisticated the party and the more dispatchable the consumption/export, the more dynamic the price signal can be In the case of a commercially operated grid-side battery, it should be reasonable to assume that it should be the owner of the grid-side battery But the same principles could be used as the basis of a tariff for: • End customers with DER devices (or their agents) • And potentially to consumption-only customers

3.5. Implications for other tariffs

3.5.1. Peer-to-peer (P2P) trading

'LUoS' tariffs were originally proposed as a means for discounting network charges to customers that could be assumed to be consuming energy exported from nearby rooftop PV systems. However:

- The combination of CRNP and two-way export pricing as explained above should, if correctly developed and applied, provide the right price signals for both consumption and the deployment of BTM devices, and
- Where current network tariffs do not have this structure, the focus should be on introducing these structures and features.

Moreover, we note that the approach to pricing recommended here would provide a cost-reflective two-way price signal to customers with DER (or DR) that accords with the principle noted in the second dot point in Section 2.2:

> *The price signal should be targeted at the party whose actions are primarily responsible for the associated impact on cost*

Such a price signal will provide the clearest and most specific reflection of the value provided or cost imposed by the DER system to the network. Any sharing of that value with end customers would dilute the impact of the price signal to the owner of the DER. And any additional incentive provided to the non-DER customer over and above the price signal provided to the DER owner would represent double counting of the benefit.

By contrast a two-way cost-reflective pricing regime would reflect the impact of the non-DER customer's consumption on the network as follows:

- Where the local network is experiencing high levels of demand on a congested upstream asset, the non-DER customer would receive a price signal that would reward reducing consumption (while a DER customer would receive a price signal encouraging export)
- Where the local network is experiencing a surplus of local generation, the non-DER customer would receive a price signal that would reward increasing consumption (while a DER customer would receive a price signal discouraging export).

We note that software and hardware systems are being developed that can be used to enable the establishment and accounting needed for commercial arrangements for P2P or for arrangements between a grid-side battery and end customers (with or without) rooftop PV (Appendix 1 provides information on three such systems). However, these systems are more appropriate at the retail level as they would presumably be used to detail the all-in price that the generating (or storage) party would charge the end customer for its product/service. In the case of a grid-side battery owner, the price signals encapsulated in a CRNP with two-way export pricing would comprise economically efficient input costs that the battery owner could take on board in the price of its services to the end customer.

3.5.2. Other forms of DER and DR

The table below provides brief comments on how a two-way, cost-reflective network tariff pricing might relate to other types of DER and customers with some source of flexibility in their consumption of electricity.

Table 3: Potential applicability of two-way cost-reflective network pricing to other types of DER and DR

Other sources of DER/DR	Comment
Rooftop PV (with or without local storage) Standalone BTM batteries	The lack of control over export by these devices limits their ability to respond to cost-reflective price signals - but also increases the likelihood that the operation of these devices will impose costs on the network which will ultimately be borne by other customers It should be noted, however, that the DER owner could respond to these price signals in other ways, for example by increasing their load in the middle of the day to use PV generation that might otherwise face an export charge
Rooftop PV and battery storage (w/orchestration)	Orchestration provides the ability for the DER facility to respond to price signals from all parts of the electricity supply chain In fact, the availability of price signals for additional sources of value increases the value of orchestration to both the end customer and the VPP operator
DR • Interruptible loads • Shiftable loads	An interruptible load (by definition) can respond to price signals Like a grid-side battery, it can control its consumption and therefore within limits can consume or not based on a price signal; unlike a battery it cannot inject into the network A shiftable load can simultaneously reduce demand in one period and increase it in another; where those periods can be known with relative certainty, the end customer can benefit from a time-differentiated tariff

3.6. Summary

In summary, our view is that:

- Network tariffs that include two-way, cost-reflective pricing offer the best opportunity to foster the economically efficient integration of DER with grid-based electricity, and are superior to a LUoS tariff as originally conceived
- Grid-side batteries offer an ideal opportunity to introduce this approach to network tariff setting because:
  - There are no 'legacy' tariffs for these customers that might impede the adoption of an efficient price signal
  - The owners of these sorts of batteries will almost certainly be a commercial operator whose sole product is electricity; that is, a party that should be capable of understanding and dealing with more complex electricity price signals given that they will form a very large portion of the input costs of that business
- In short, it should be easier to introduce a cost-reflective network tariff with two-way export pricing for these customers than for any other existing type of network user.
- An application of this type of tariff (for instance in a trial or perhaps even a simulation) could provide evidence of its feasibility (i.e., the ability to develop such tariffs, acceptability (based on the reactions to, and commercial outcomes of, the grid-side batteries subject to them) and their applicability to other types of customers

  It should be noted that this type of tariff could also have material dynamic efficiency benefits. For example, these types of tariffs would provide impetus to the value proposition of market intermediaries that could use them to deliver value to BTM DER owners and the electricity value chain. For example, a VPP operator would be in a position and sophisticated enough to use these price signals in combination with information on participating customers' load profiles and the state of their DER systems (e.g., BTM battery state of charge), other price signals in the market (e.g., wholesale energy prices, FCAS prices) and weather forecast information in ways that the individual customer would be unlikely to be able to arrange on his/her own. This would result in a level of mobilization of these resources to the benefit of participating DER owners – and all electricity customers – that would not be possible in the absence of these price signals.

Perhaps most importantly, this type of tariff would provide information that could close the loop about the interaction between the siting and operation of DER and the demand forecasts on which network and generation infrastructure expansion decisions are made. In other words, the introduction of LUOS-type tariffs that reflect a network business's forecast costs/cost drivers, could influence how much DER is installed in different locations within the distribution system and how it is operated based on those price signals, which in turn flows back into the network business's forecast costs. This sort of interaction (i.e., a cost reflective price signal reflecting a network business's forecast costs affects the level of DER investment and its operation which in turn affects a network business forecast costs) has not previously needed to be assessed.

Appendix A: Solutions for enabling commercial arrangements for P2P and neighbourhood battery trading

A number of systems have been developed (several in Australia) to account for solar export within peer-to-peer trading arrangements. The opportunity to extend the use of these systems it to manage community batteries or distribution batteries is a relatively small step. Selected examples are discussed below.

- Powerledger is a global company that offers a number of solutions and platforms to track peer-to-peer energy trading using blockchain systems to trace the electrons. They have systems that manage both across the grid and within embedded networks. Their systems not only trace the energy but also allow users to set prices between themselves. Their grid solution has been used in Fremantle, WA to allow 36 households to trade excess energy with each other via a battery. CUB Australia uses Powerledger to enable 500 participants to trade their excess solar PV for beer credits in their "peer to peer" loyalty campaign. The scheme is rolling out across the entire east coast of Australia.

- Enosi have a different approach by accessing smart meter data to trace, match and settle energy production and consumption through their Powertracer platform. The system is being currently used by manufacturing firm Hunter Douglas where they sell any excess solar PV generation from their facilities direct to their workforce. The sharing concept was realised using the energy traceability platform developed by technology innovator Enosi, and a new contract for energy supply offered by Simply Energy, the Australian retail arm of French energy giant Engie.

- SwitchDin is a suite of technology solutions that are relatively inexpensive but aims to solve several challenges for DER. The solution is a combination of hardware and software. The hardware can interface with a range of DER devices via communications to not only gather data and information but also provide control and orchestration of vendor independent distributed devices and manage real time control- for example curtailment of a solar PV output. All the data rich information is stored in a cloud-based data warehouse. Lake Macquarie City Council uses SwitchDin to provide distributed energy asset monitoring and management for 29 council-owned sites across the local government area, providing the council with data visibility and management through a single portal. The technical solution is finding a home with the likes of Energy Queensland and Horizon Power in the management of rooftop solar PV penetration and distribution batteries for remote islanded communities and microgrids.