Implementing community-scale batteries: regulatory, technical and logistical considerations

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1 Executive Summary

Due to their unique size and position in the grid, community-scale batteries have the potential to play an integral role in Australia's transition to a decentralised grid. Our social research revealed that there is enthusiasm for storage of this scale, both from householders and energy sector professionals [1]. In a cost-benefit analysis, we found that community-scale storage is economically feasible [2], and can provide more effective local energy management in distribution networks, compared to the equivalent capacity of household batteries [3]. In Western Australia, where regulations allow state-owned utilities to own and operate community-scale batteries, several trial community battery projects have already proven successful [4], [5].

This report outlines the regulatory, technical and logistical considerations needed for the practical deployment and operation of community-scale batteries in the national electricity market (NEM). The report was largely informed by interviews and focus groups carried out with energy industry professionals from a range of sectors including networks, regulators, community energy groups and a retailer. The report also explores the main barriers associated with implementation – both real and perceived.

The key lesson from this project was that community-scale batteries are already achievable, without major changes to current regulations. However, financial viability of almost all community-scale storage projects will require a discounted local network tariff (LUOS)[1]. Distribution Network Service Providers (DNSPs) can own a battery but cannot use that battery to provide contestable services, as outlined in Section 3, unless a regulatory exemption is given. However, DNSPs can procure network services e.g. voltage and demand management, from third-party operators within the current framework.

The key challenges for the implementation of community-scale storage are:

- How to manage service contracts to multiple parties e.g. retailers and DNSPs.
- How to balance the provision of services, to benefit all stakeholders e.g. energy users *and* the network.
- How best can DNSPs procure the services that storage can provide, from storage owners within the current framework (see 3.3 for more detail).

[1] a rule change request to effect this change has been submitted by the Australian Council of Social Services and the Total Environment Centre

- How can battery projects secure finance, when the energy transition is making market forecasts difficult, many services the battery can provide are not yet priced, and the 5 minute market settlement that will be introduced in 2021 will have a likely positive but unknown effect on battery storage?

To motivate the at-scale adoption of community-scale storage on the NEM, the following changes should be considered:

- Allowing the market participant class 'Small Generation Aggregator', that can be used for battery storage, to provide ancillary services (FCAS), avoiding the need to separately register as a ancillary service provider.
- Reward (via market or otherwise) non-energy services that can be provided by battery storage, that are not currently rewarded, including increased hosting capacity, fast frequency response, synthetic inertia, emissions reduction, and resilience.

Moving forward, trials will provide an opportunity to develop solutions for the challenges listed above. The focus should be on ensuring that smaller market participants, including community groups, are not locked out of the market. This is a particular risk if DNSPs begin to invest in community-scale storage, as their market dominance could give an unfair advantage. Specific schemes could be established to support community energy projects, for example, provision of financial and technical support, as outlined in the Local Power Plan [6]. Trials will provide insight into the regulatory and market changes that are required to ensure the viability of community-scale batteries, with a focus on the most fair and widely beneficial models.

Contents

2 Community batteries: ownership and operating models

In this report, we outline regulatory, technical and logistical considerations for a range of potential models of ownership and operation of community-scale batteries. In practice, different ownership and operation models will be required for different scenarios. For example, rural areas might require a different model compared to an urban scenario. A suburb with a high penetration of solar generators might require a different model compared to one with high penetration of electric vehicles. The grid is increasingly complex and heterogeneous - with changing technical needs depending on different sources of grid vulnerability. Communities will have different levels of interest in how involved they want to be in their local energy system, the resources available (from e.g. state government or local council subsidies) to invest in carbon reduction from electricity as well as the number of households who cannot directly purchase distributed energy resources (DER).

In our earlier cost-benefit analysis [2], we considered that the batteries will either be owned by Distribution Network Service Providers (DNSPs), or by a third party. The third party might be, for example, a local council, a community group, an electricity retailer, or a private investor. A third-party owned battery could either be (a) operated to benefit all stakeholders (energy users, the battery owner and the network operator) or (b) operated only to profit the battery owner. Third parties are allowed to participate in market trading (both energy and FCAS) which will increase the financial viability of these models. Providing network services for a local DNSP will further increase the financial viability. Mechanisms for the DNSP to pay the battery owner for these services already exist, as discussed in more detail in 3.3.

2.1 Retailer and Aggregator ownership

A retailer might be keen to offer virtual storage as an extra service for customers. Retailers are well positioned to access market services and to engage customers with on-bill participation models such as tariffs and subscriptions. This is a natural extension of the existing roles and mechanisms that retailers already have in order to engage with customers. However, through our earlier work [1], we see two potential issues with this model of ownership:

- Members of the public are wary of retailer's profit motive and the opaqueness of tariffs and bills.
- A retailer who is operating a community-scale battery for purely economic returns (including participation in wholesale and ancillary services markets) may push networks beyond

their physical and operational limits. We have directly observed the potential for this outcome in our research [7].

One way to address the latter issue would be for the community-scale battery operator to be given near real-time information about the potential for voltage or thermal constraints at any given time, for example with a dynamic operating envelope [8]. With this information, the battery could also offer network services and to receive payment for these services, as outlined in section 3.3.

Alongside electricity retailers, there is an emerging category of providers that are specialising in aggregation capabilities. This includes small generator aggregators (SGAs), DER aggregators and market ancillary service providers (MASPs). An aggregator may want to add the community battery to their demand management fleet. Fully identifying and articulating the role of these aggregators in enabling community-scale batteries is an important area of future research.

2.2 Local council or community group ownership

As outlined in our earlier report [1], having community involved will likely increase the acceptance of community energy projects. The Local Power Plan[2], developed by the independent MP for Indi, Helen Haines, highlights the fact that, when communities are meaningfully involved in renewable energy projects, it creates more local jobs, creates new sources of income for people, and increases access to cheap, local electricity [6]. Some stakeholders we spoke to also highlighted that community involvement can facilitate efforts around demand management, as there is a sense of ownership and "care" towards a community asset [1].

However, with this model of ownership, there are also challenges. In particular, communities, private investors and local councils do not, in general, have the resources and expertise to manage a storage asset. The workaround is for the community to contract out the management of the asset to a third party, e.g. the local DNSP, or another energy business. The Local Power Plan provides a 'blueprint' for how best to support community energy projects, essentially via financial investment, a co-investment scheme and a public underwriting scheme for mid-scale community energy projects to overcome a failure of the market to fully price their technical and social benefits. The plan also includes establishing 'Local Power Hubs' to provide technical expertise locally, and the establishment of the Australian Local Power Agency (ALPA), an independent statutory body, to administer and coordinate the Local Power Plan schemes [6].

[2] Marnie Shaw is on the expert panel for the Local Power Plan

2.3 DNSP ownership

An advantage of DNSP ownership is that the DNSP can choose the battery location based on network constraints. A DNSP-owned battery could be either (a) operated only for network support i.e. demand/voltage management, with no market participation or customer interaction or (b) operated for network support and leased to a third party who is a fully licensed market participant, for energy and FCAS market trading. The third party can operate that proportion of the battery with a for-profit model, optimising with respect to market prices – some part of that third party revenue would go to the DNSP as a lease fee. The DNSP can also add the portion of the battery costs that are directly attributed to the provision of network services to the regulated asset base (RAB) [9]. An example of this model is the ESCRI battery in South Australia [10].

Under current ring-fencing rules, DNSPs must not have any relationship with the third party market participant. This rule is discussed in detail in the regulatory considerations section 3. In some scenarios, however, DNSPs can be given a regulatory exemption to sell energy to customers, for example, where batteries are being operated as part of stand-alone-power-system in fringe-of-grid scenarios, as discussed in section 3.3

2.4 Stakeholder participation

The ownership of the battery will strongly influence how stakeholders participate in the operation of the battery and who benefits from the battery's operation. The main stakeholders are:

- Energy users
- Battery owners
- DNSPs
- Retailers and Aggregators

Energy users include households and businesses, solar and non-solar owners, and there are a range of ways they could interact with a community-scale battery. Through this project, we have considered three ways in which energy users can participate in the operation of a community-scale battery, each with different ramifications for customer benefits, including fairness and transparency:

1. Customers could sign up for a specific community-scale battery energy tariff or subscription

- These types of offers would generally be available from retailers, although some networks are investigating similar models [9]. See section 3 for regulations relating to DNSPs.
- In WA, such offers have been trialled by Western Power - a vertically integrated DNSP and retailer.
- Tariffs could take advantage of the flexibility of the battery for particular customer groups with particular energy requirements, not only over a day but also over a year, e.g. farmers, and schools.
- Note that it is difficult for such arrangements to benefit all customers equitably. In Western Australia (WA), they have only been offered to customers who are located close to the battery and who have solar systems that are exporting a significant amount of energy into the grid.
- Like most modern electricity tariffs (time-of-use, demand based), it is difficult to predict the likely benefit to customers, without careful analysis of individual load and solar generation profiles. For example, in the Alkimos trial, despite pre-vetting of customers, some customer's electricity bills increased in the community-scale battery scheme compared to prior [11].

2. Customers could receive benefits through their DNSP.

- DNSPs can pass on the benefits of batteries with cost-reflective network tariffs.
- This would benefit all their customers, irrespective of how close they lived to the battery.
- Specific network tariffs may favour certain customers over others e.g. customers who want to or are able to, take advantage of time-of-use tariffs.

3. Customers could be connected to the battery through relationships outside of the electricity market.

- For example, a council could own the battery and redistribute profits through reduced rates.
- Alternatively, a third party could own the battery and return dividends to community members who invested in the battery.
- A school could buy a community battery, and the school community could join a virtual power plant (VPP) together to share the electricity.

- These types of models are highly flexible, allowing them to target specific distributions, which may either improve or exacerbate inequality.
- Such models tend to be opaque with come with the risk of cross-subsidising particular groups of customers.

2.4.1 Customer protection frameworks

In Australia, customer protection frameworks are being adapted to reflect the changing energy market, and it will be important for these frameworks to consider storage technologies, and community energy resources. For example, if a discounted local network tariff applies, will this discount be passed on to customers? Will customers still be able to choose their supplier freely? The recently-developed principles set out by the Council of European Energy Regulators explicitly include consideration of how customers will access community energy resources [12]. The principles laid out are as follows:

- consumer rights should be safeguarded, even if customers engage in sharing,
- consumers need to be adequately informed of the conditions of their supply, regardless of its source,
- consumers need to be able to choose their supplier freely, and
- consumers that participate in an energy community, or engage in energy sharing, should not lose access to vulnerable consumer protection measures.

2.5 Services provided

The position of community-scale batteries within the energy system makes them well suited to providing both a combination of market and non-market services. Market services include both energy market and ancillary services markets such as frequency control ancillary services (FCAS), as outlined in more detail in section 3.2. Non-market services include the use of the battery to provide network services, including demand management, management of thermal and voltage constraints, together with resilience benefits (this was noted in the 2019-20 National Energy Market (NEM) Summer Operations Review Report [13]). Non-market services could also include the use of battery storage to achieve sustainability goals e.g. emissions reductions. See section 3.3 for more details. The feasibility of community-scale batteries is widely considered to hinge on their ability to provide many services simultaneously [1]. New regulations could support the ability of batteries to efficiently provide these services and to be rewarded for doing so.

3 Implementing community-scale batteries: regulatory considerations

As outlined in section 2, the battery will either be owned by a DNSP or by a third party. For third party ownership of community-scale batteries, we have not identified any existing regulatory limitations. Community-scale battery ownership by a DNSP is allowed but is more complex due to existing rules and regulations around what services DNSPs can deliver with batteries they own. These rules and regulations are intended to prevent networks from exploiting their natural monopoly power i.e. to maintain market contestibility. Essentially, NEM rules and regulations only allow DNSP owned assets to deliver regulated network services, such as supporting voltage in weak parts of the network or deferring a larger network investment[3]. Chapter 6.2 of the national electricity rules (NER [7]) defines how the AER classifies the services that a DNSP provides, including whether a service is a distribution service or not. Chapter 6.17 of the NER defines the rules around ring-fencing, including how services that can be provided on a competitive basis must be legally and functionally separated from the regulated network services that a DNSP provides.

In practice, this rule may result in DNSPs being discouraged from installing batteries on their networks, as the inability to access energy or FCAS markets limits the ability of the battery to provide value and therefore makes it an "inefficient" investment. According to the NER, networks are not allowed to recover investment that is inefficient. On this reasoning alone, DNSPs are disincentivised to purchase batteries over more traditional pole-and-wire solutions. It is important to note, though, that mechanisms are in place to allow DNSPs to pay for the network services a battery can provide, as discussed in more detail in 3.3.

Some parties feel that the rules excluding DNSPs from contestable services prevent utilities from innovative and more efficient energy solutions, which could include community-scale batteries [9]. Still, market contestability is crucial; innovative energy retailers are growing in number in Australia and they should not be disadvantaged by DNSPs owing storage assets. As stated eloquently by Tim Nelson, where entities have a competitive advantage bestowed upon them

[3] Note that DNSPs may be given an exemption to provide contestible services (i.e. sell energy to customers) in fringe-of-grid scenarios, where community-scale batteries can provide a cheaper and more efficient solution than remote grid infrastructure, see [14] for more detail.

by economic regulation, appropriate ring-fencing should be in place to ensure that information asymmetry is not used to the detriment of consumers [15].

In the broader shift to a decentralised energy system, the rules separating DNSPs from market services are being challenged, as many believe that DNSPs are in the perfect position to own and operate assets that are playing an important role in managing the grid, including community-scale storage. In the meantime, DNSPs can apply for waivers of some clauses in the ring-fencing guideline. As such, there are no absolute restrictions preventing a DNSP from owning a community-scale battery and leasing part of that battery to a third party for contestable services. And procuring non-network services from third-party operators of storage devices is already allowed.

3.1 Network Tariffs

Existing network tariffs are currently a major barrier for the feasibility of community-scale batteries in the NEM. This is a consequence of these tariffs being developed for an energy system in which power only flowed in one direction: from large, centralised generators to small consumers. They are subsequently not fit for purpose in an energy system with two-way power flows throughout the distribution network. Updating the design of network tariffs is a major undertaking, but the outcome will not only positively impact the feasibility of community-scale batteries, but also the integration of DER more broadly.

There are essentially four network tariff changes being proposed or trialled on the NEM.

1. The creation of a local use of service (LUOS) tariff, that applies to flows of energy that originates and terminates within a local sub-region of the distribution network. Outside of the local sub-region, the currently-used distribution use of service (DUOS) tariff would continue to apply, as shown in Fig. 1. The introduction of a LUOS tariff would reflect the fact that transporting electricity a shorter distance is fundamentally more efficient and therefore ought to result in reduced costs for consumers. The idea of LUOS was flagged in a recent rule change proposed to the AEMC by the Australian Council of Social Services and the Total Environment Centre [16].

2. Allowing DNSPs to charge network tariffs to households for the excess solar PV power they export into the network (currently prohibited by clause 6.1.4 of the NER). Although controversial, this charge would simply levy those customers for the network service they are using when exporting. This rule change has been brought to the AER by St Vincent de Paul [17] and also separately by South Australia Power Networks [18].

3. Many DNSPs are trialling more cost reflective network tariffs e.g. a demand or time-of-use (TOU) tariff [4].

4. Some DNSPs are trialling network tariffs that reflect demand response provided by customers [19].

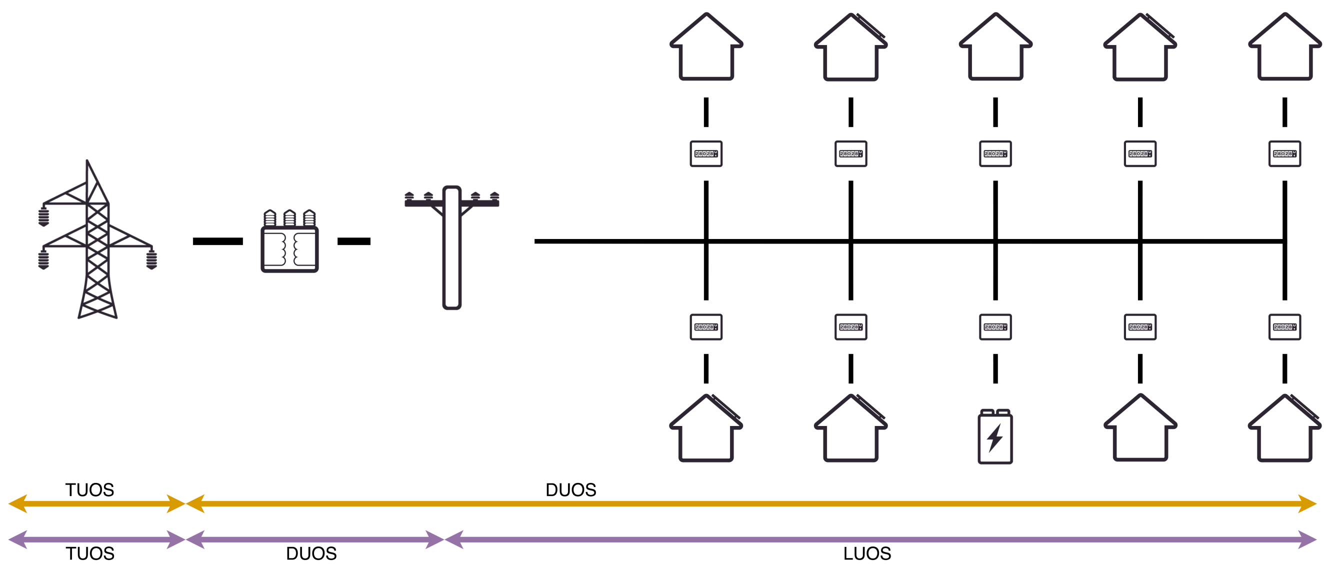

Figure 1: To enable community-scale batteries there are benefits to moving from the existing TUOS / DUOS tariffs (orange) to a TUOS / DUOS / LUOS tariff (purple).

Our modelling suggests that the introduction in particular of a LUOS tariff, and the application of that tariff to both imports and exports, would support the feasibility of community-scale batteries and the associated positive impact of storage on the distribution network [3]. In effect, greater value would be placed on energy that is produced and consumed within close proximity, thereby encouraging greater local self-sufficiency.

While not a network tariff solution, another idea is to exclude energy flows to and from the battery from NEM settlement altogether i.e. effectively 'net metering' battery energy flows to and from customers [9]. While a simple solution, this idea goes against the principle of market-based solutions for energy services. As stated by Mowat Energy in Ontario, 'It is important to ensure from the beginning that the pricing structure is genuinely reflective of the economic value of this 'contribution' to the system.' [20].

All of the above rule and tariff changes raise important questions regarding equity and practicalities. A central concern for the regulatory system is that modifying tariffs and charges can

[4] https://www.aer.gov.au/networks-pipelines/network-tariff-reform

create new cross-subsidies and general distortions of equity. The current postage stamp pricing regime means that all customers in a distribution network are charged the same network tariffs regardless of where they are located within the network. The introduction of localised pricing sub-regions opens the possibilities for greater disparities between sub-regions.

With respect to community-scale batteries specifically, caution must be taken to ensure we do not disadvantage customers who are not participating in a particular battery scheme. The regulatory system exists to prevent this. Rule 6.18.4 of the National Energy Rules (NER) prevents a DNSP from charging customers with similar connection and usage profiles differently. In practice, this can by waived by the AER, based on rule 6.18.1C which allows changes to tariff structures assuming it makes up < 0.5% of annual revenue and the total revenue from this tariff and related tariffs is no greater than 1%. Retailers will be expected to respond to this change in network tariff and pass the savings on to customers.

Therefore, for community-scale batteries, further research is urgently required, before implementation of proposed new network tariffs, to investigate the impact on different customer segmentation groups. A specific example for a community-scale battery scenario, will be to test whether customers who are participating in the battery scheme are ultimately paying similar network costs to non-participating customers.

3.2 Provision of market services

In Australia, we have a gross pool market which does not allow parties to trade energy bilaterally. Only financial derivatives can currently be traded directly e.g. power purchase agreements (PPAs). Therefore, the use of the battery to participate in the wholesale and ancillary services markets requires the operator to either register as a market participant or to recruit the services of a registered market participant. One option is for community-scale battery storage projects to register as a Small Generation Aggregator (SGA) for which generating units must be less than 5MW[5]. Two dispatchable unit identifiers (DUIDs) are required; one for load category and one for generation category. A separate market registration or registrant is required to manage FCAS trading (Market Ancillary Services Provider, MASP). Currently, the only participant who can provide FCAS from a generating unit is a registered Market Generator. Furthermore, FCAS bids currently need to be greater than 1MW, which may limit the provision of FCAS by some battery owners. Also, the fastest FCAS response (4 seconds for regulation and 6 seconds for contingency markets) does not take full advantage of battery capabilities such that the speed

[5] Generating units 5-30MW may also be allowed by application to AEMO

and flexibility of FCAS services provided by the battery are currently not fully valued [6]. A recent ARENA report highlighted the need to consider new revenue streams for services that are both required and that batteries can provide, including fast frequency response (FFR), simulated inertia and system strength Australia [21].

AEMO recently submitted a rule change request to address the issues of how battery storage will register and participate in the NEM [22]. Specifically, they propose amending the NER to define a new type of market participant (a bi-directional resource provider) and set specific obligations for participants of this type. The Clean Energy Council agreed, in a submission for the process, that "the framework for new storage market entrants is unclear and ambiguous" [22]. Interestingly, market participants Tesla, Neoen and Reposit wrote in their responses to the rule change, that they did not feel a new market category was required, and that the current rules, in general, accommodated storage. Tesla did recommend that the SGA framework be expanded to allow small generating units to provide FCAS, as they have the technical capability to provide such a service [22]. And Tesla also made the practical suggestion that the two battery DUIDs could be paired in the NEM dispatch engine (NEMDE), to avoid the need for conservative bidding behaviour [23].

Finally, the Energy Security Board (ESB) post 2025 future market design program is also considering how a market framework could be created for non-energy services, including procurement of operating reserves, frequency control, inertia, and system strength [24]. In summary, the following regulatory issues are currently in discussion and directly impact the feasibility of community-scale batteries:

- The SGA framework could be expanded to allow small generating units to provide FCAS.
- Mechanisms for pairing dual battery DUIDs required for storage systems, to optimise bidding.
- Allowing FCAS bids less than 1MW.
- Creating a new FCAS market or faster response < 4 seconds, to take advantage of and reward the speed and flexibility of battery capabilities.
- A potential market framework for non-energy services, including emissions reduction, inertia and system strength, and resilience.

[6] Although responding faster means more capacity can be bid in some cases

3.3 Provision of non-market services, including network support

Payment for network services will be critical for supporting the business case for community-scale storage. However, an issue identified in our social research was that DNSPs may feel insecure that network services will actually be delivered [1]. In the US, such services can be secured via scarcity pricing and capacity markets, or through resource adequacy payments [25]. In the UK, new flexibility markets enable owners of DER to be paid for flexible electricity demand or generation [26]. More recently, flexibility services are also being trialled in WA [**?**].

Currently in Australia, on the NEM, DNSPs can pay for network services via specific schemes designed to promote non-network solutions relating to demand management, including the demand management incentive scheme (DMIS), the innovation allowance and via the regulated investment test for the distribution grid (RIT-D).

For the RIT-D, a DNSP can state a need for network support (e.g. voltage management) and seek a solution by tendering on the competitive market for it. The DMIS scheme provides electricity distribution businesses with an incentive to undertake efficient expenditure on non-network options relating to demand management. The innovation allowance on the other hand, will reduce the risk distributors face with research and development costs in demand management projects that could reduce long-term network costs. Following the extreme events over the summer of 2020, AEMO is also calling for regulatory processes to consider how to better consider energy security and resilience benefits in network projects [13].

Other services that the battery could provide, but which are difficult to monetise, include increased community engagement and increased energy equity, defined as how equal access to energy, energy services and energy choices is across customers.

4 Implementing community-scale Batteries: Technical Considerations

Irrespective of the model, enabling community-scale batteries will require additional technological capabilities. This will potentially include new metering, integration, telemetry, and control capabilities, as shown in Figure 2. These new technological capabilities will need to be orchestrated through a community battery provider which may be one of several types of organisations outlined previously in this report.

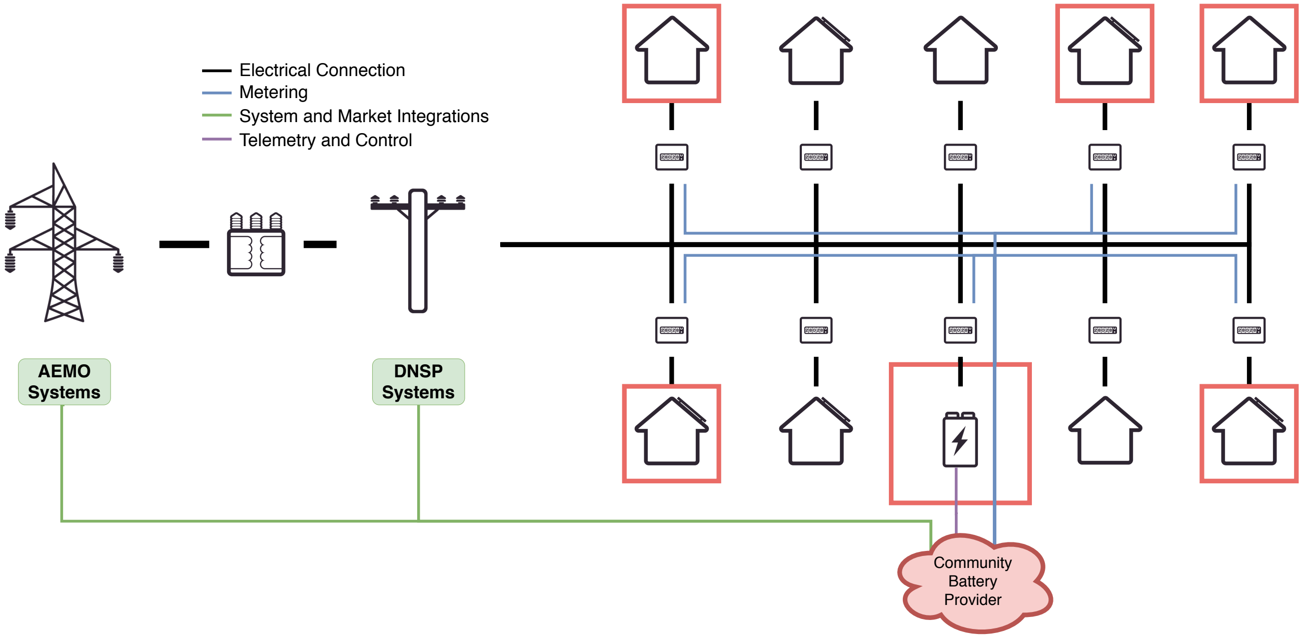

Figure 2: Implementing community-scale batteries may require new metering, telemetry, integration, and control capabilities. In this diagram the participating users in the community battery model are highlighted in red.

4.1 Metering

As with the operation of behind the meter virtual power plants (VPPs), community-scale batteries may need to have near real-time visibility of the connection point behaviour of participating customers. This will require the installation of new metering capabilities that are able to provide individual connection point (or customer load and generation) updates in near-real time (on the order of seconds). Should this capability be required then new metering and communications should only be needed for participating customers (as shown in Figure 2 where only participating customers highlighted in red have new communications capabilities shown by the blue lines). These new metering capabilities are typically provided by low cost check meters that are installed in the premises switch board and which communicate metering data back to a cloud-based server using either the customer internet connection, or a dedicated 3G or 4G wireless connection. These check meters are typically not NMI approved meters but are equally accurate in recording electrical power flows (see e.g. the devices developed by Wattwatchers [27]). Such metering capabilities are already available through several Australian technology providers who typically capture the data through a cloud-based platform, providing access through a web-based API where it can then be used by the community battery provider to inform the optimisation and control of the community battery.

It is worth noting that such metering is only necessary if the behaviour of the community battery must respond to the behaviour of the participating customers and connection points. This requirement will arise when the community battery is responding to a tariff or incentive where it is necessary to match supply and demand within a local network area. This may arise when

- There is a local use of service (LUOS) tariff in place which is essentially net-metering local flows of energy. It is worth noting that ascertaining the amount of local energy flows eligible for LUOS charges may also require metering at the boundary of the “local” subregion within which LUOS apply (such as the distribution transformer).
- The community battery is delivering network services where there is a need to minimise the electrical powerflow of all systems within a local network area. For example to alleviate network thermal or voltage constraints.
- There is a need to ’measure out’ a subscription-based energy storage allocation as has been done in WA. [5]

To unlock the greatest possible benefits of this new metering infrastructure, it would be advantageous for the metering to allow all stakeholders (consumers and DNSPs) to view this data in near real-time. Only with this sort of monitoring will consumers, and their agents, be able to adjust their behaviour to take advantage of locally available power generation.

Specialised metering may be necessary for the community battery if it is participating in the delivery of FCAS. The technical delivery of FCAS is governed under the Market ancillary services specification (MASS) details of which can be obtained at [28]. The most obvious requirement of the MASS is the need for high speed metering that can measure the connection point power flow at an interval of 50 milliseconds or less for the purposes of auditing the delivery of the FCAS service. This differs markedly from the interval metering required for energy market participation which requires a single energy value in each market interval of 30 or 5 minutes. Should the community battery be participating in the AEMO VPP Trial [29] then alternate metering arrangements and topologies may also be valid [30].

4.2 System and Market Integration

To enable participation in AEMO-run markets for energy and ancillary services, community-scale batteries may also require an integration with the market systems (or with an electricity retailers internal systems). Should the community-scale battery be operating in a manner that is network aware, or should it be providing network support to a DNSP, then integration with internal DNSP systems may also be required. These integrations are shown in green in Figure 2.

Integrating directly with AEMO-run markets is a well defined process[7], although the expertise required to navigate the process is largely limited to existing market participants. The prudential requirements can be a significant hurdle for small organisations, leading some aggregators and new market entrants to choose to work with existing market participants, rather than have to undertake these integrations directly.

Integrating with DNSP systems is often much more complex given the lack of standards to support the integration of DER. For this reason, there is a proliferation of non-standardised approaches, for example Evoenergy's IoT Hub [31]. Although many approaches are valid, it would be far better to create a unified standard for DNSP integration of DER more broadly and several initiatives are underway to try to achieve this including OPEN [8] and SDIWG [9].

4.3 Optimisation and control

The choice of optimisation and control system will need to be chosen based on the ownership and stakeholder participation model that is being implemented for a given community battery project. The relevant tariffs and services that the community battery is offering will then determine the particular objective(s) that are being optimised and controlled for operationally. The optimisation and control capabilities will need to ingest the relevant metering data from participating users (typically via a web-based API as outlined above in Section 4.1), including the telemetry data from the community scale batteries installed in the grid. Through this project we have demonstrated how the optimisation can be achieved [3].

To support the optimisation and control of community batteries over a rolling horizon there is also the need to use solar, load and potentially price forecasts. While AEMO make some price forecasts available[10], the accuracy of these forecast prices is questionable, particularly as price volatility in the NEM has been shown to be increasing [32]. Thus far, load and solar forecasting has typically been implemented in various proprietary ways by individual market representatives and aggregators. Community battery providers may need to work with these organisations to gain access to these capabilities.

Once again, there are several Australian and international technology providers who can provide appropriate optimisation and control systems that would be suitable for operating a community-scale battery. However, to our knowledge, the implementation of such an optimisation and

[7] https://aemo.com.au/en/energy-systems/market-it-systems

[8] https://www.energynetworks.com.au/projects/open-energy-networks/

[9] https://aemo.com.au/en/consultations/industry-forums-and-working-groups/list-of-industry-forums-and-working-groups/deip-sdiwg

[10] https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/data-nem/market-data-nemweb

control system that implements a community-scale battery operating model has yet to be undertaken in the NEM.

5 Implementing community-scale batteries: logistical considerations

5.1 Management and governance

A community-scale battery project will require management and governance structures, in order to manage the following (potential) range of relationships:

1. The relationship between the battery owner and the battery operator (if separate entities),
2. The relationship between the battery owner/operator and the local DNSP. This will likely be a bilateral agreement where the DNSP agrees to pay for the provision of particular network services and the battery owner/operator agrees to provide those services.
3. The relationship between the battery owner/operator and market participants, potentially including retailers and registered FCAS providers. This will not be required if the battery owner/operator themselves registers as a market participant.
4. The relationship between the battery owner/operator and the consumers/prosumers, although this is likely to be through a retailer.

In establishing management and governance structures for battery projects, it will be helpful for organisations to consider the findings in our social research, which highlighted a lack of trust in the energy industry. Householders are likely to be sceptical of community battery models that cannot clearly demonstrate that they will genuinely benefit the local community [1]. A strong preference was shown for models that are simple to interact with, owned by local government and that are run as a not-for-profit entity. Moving forward, community-scale battery trials will provide an opportunity to create an efficient and standardised negotiation process, for the multi-party contracts that will be required for community-scale batteries.

5.2 Placement, safety and end-of-life management

Without network maps detailing areas of constraints, it becomes difficult for a battery owner to know where a battery investment may yield good returns. Currently only DNSPs have access to this information. Moving forward, it has already been recognised that it will be important for DNSPs to provide visibility on where network services are needed. Without this information, our social research identified a potential issue that batteries could potentially be installed in suburbs where householders had the resources to invest, but where it would provide a negligible positive effect for the network [1].

A further consideration in placement of the battery is establishing how the landholder will be compensated or involved as a stakeholder. Potential physical locations for the battery include (i) existing DNSP owned locations including substations, pad mounts (for distribution transformers), poles (for pole mounted batteries), and (ii) private landholdings, including residential location, commercial building etc.

Given that community-scale batteries will be installed within a residential or commercial activity zoned area, safety is also a critical consideration. Installing a battery within high population density areas raises concerns about the risk of traffic collisions with the battery as well as the potential for unintentional or malicious tampering. These considerations become increasingly relevant given that it is unlikely that physical access restrictions to such assets can be put in place. Alongside safety risks, there are likely to be other risks and associated financial liabilities that must be better understood. Further consideration of these issues is a vital area of future work for enabling the at-scale deployment of community-scale batteries.

Our social research revealed that stakeholders want to understand how batteries would be recycled, reused or disposed of after their useful lifetime [1]. Whilst such questions are much broader than community-scale batteries, understanding and addressing these concerns is likely to be vital to obtaining the social license to operate a community-scale battery within a suburb or community.

6 Summary and next steps

Community-scale batteries have the potential to play an integral role in Australia's transition to a decentralised energy system, due to their unique size and position in the distribution grid. Our research revealed enthusiasm for storage of this scale, from both householders and energy sector professionals [1]. Advantages of community-scale batteries include economies of scale, resulting in lower cost [2] as well as, potentially, better energy management in distribution networks, allowing increased hosting capacity for rooftop solar [3]. Beyond these techno-economic factors, though, our social research revealed a broader range of advantages that could be captured with community-scale batteries, including (i) improving the fairness of the energy system, (ii) building trust in the energy system by sharing value transparently and (iii) bolstering local resilience, including socially, economically, and electrically.

In Western Australia, where regulations allow state-owned utilities to own and operate community-scale batteries, several trial community battery projects have already proven successful [4], [5]. For practical implementation of community-scale storage Australia-wide, this report has identified four key elements that will be important to consider:

- Battery ownership – what regulatory considerations might arise due to ownership? How will battery ownership influence the prioritisation of benefits to different stakeholders?
- Stakeholder participation – what is the legal and operational relationship between different stakeholders (e.g. energy users, DNSPs, retailers, community groups) and the battery? How do stakeholders benefit from their participation?
- Network tariffs – what network tariffs are applied to energy flows into and out of the community battery, and how do network tariffs unlock or impact the benefits that can be delivered to stakeholders?
- Services delivered – what market services, such as energy arbitrage and frequency support, can community-scale batteries deliver? What non-market services, such as network support (demand response, voltage regulation), do community-scale batteries deliver? How can services be value-stacked to maximise the battery's utilisation and cost-effectiveness? What technology is necessary to enable this?

Community-scale batteries are already achievable without major technology developments and without major changes to current regulations. However, as outlined in this report, some models face regulatory barriers, and all models face logistical challenges. Demonstration projects will enable the sector to understand the logistics of different models, and the options for community involvement. Notwithstanding these challenges, it is important to understand the benefits that could emerge from the at-scale adoption of community-scale batteries. We are confident that there is now a path for community and suburb scale battery storage to complement residential and utility scale battery storage to power our electricity grid into the 21st century.

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