Implementing community-scale batteries

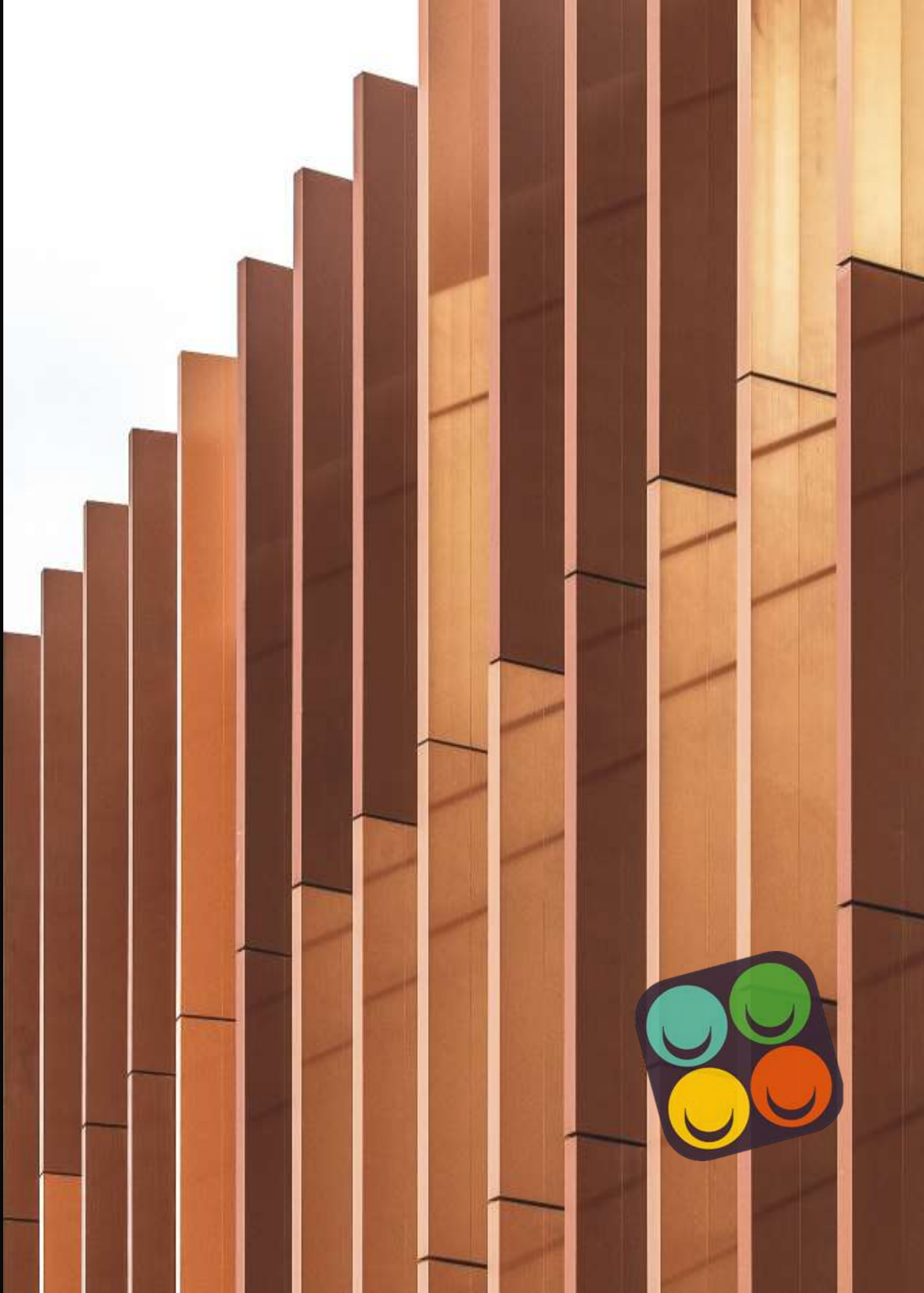
Final report for the ARENA-funded Community Models for Deploying and Operating DER project, carried out by the Battery Storage and Grid Integration Program.

December 2020

Australian National University
Canberra ACT 2601 Australia
anu.edu.au

CRICOS Provider No. 00120C

This project received funding from ARENA as part of ARENA’s Advancing Renewables Program. The views expressed herein are not necessarily the views of the Australian Government.



Executive summary

Community-scale batteries have the potential to play an integral role in Australia's transition to a decentralised grid. These batteries are connected to the distribution network and have power capacities of up to 5MW. Our work has shown that the location and sizing of this type of storage makes it uniquely suited to providing social, economic and technical benefits to the broader energy system.

There is widespread interest in shared storage and in community energy more generally, from industry, governments, new entrants, and the community at large. In Western Australia, several trial community-scale batteries projects are underway [1]. The success of these projects has led to a push to understand how best to operate community-scale batteries on the rest of Australia's electricity network, the national electricity market (NEM).

The wide-scale roll-out of community-scale batteries on the NEM faces challenges; our research revealed that projects owned by Distribution Network Service Providers (DNSPs) face regulatory barriers, retailer-owned models face trust issues, and community-owned models face logistical issues. The challenges and also the benefits are outlined in the first two sections of this report.

Over the course of this project, we have carried out a socio-techno-economic analysis of the potential for community-scale battery models to be deployed throughout Australia. The results were reported in a series of four studies, summarised in this report. The overarching goal of the project was to assess the value — for energy users, storage owners, and networks — of different community energy models. We developed open-source software that can be used to develop and test the ownership and operational models that will produce the best outcomes for customers as well as guiding the most effective use of distributed energy generation and storage.

Cost-benefit modelling work in the project revealed that ownership significantly impacted the level of savings to energy consumers [1]. For all ownership and operation models studied, a reduced local energy transport price (local use of service, LUoS) was required to financially motivate local energy exchange (both with the shared battery as well as between customers i.e. peer-to-peer, P2P). In practice, this would be essential for the use of community batteries to 'soak up' locally generated solar and thereby increase local hosting capacity.

Our stakeholder report found that industry professionals saw significant potential benefits for community-scale batteries [2]. Stakeholders agree that more public trials are needed to demonstrate the operational delivery of benefits. Although DNSP-owned battery trials will require an exemption to current rules in order to use the battery for anything other than regulated network services, our investigations have shown that — overwhelmingly — these trials and demonstrations can proceed within current rules and regulations. In this context, we do not recommend the development of regulatory sandboxes for the demonstration of community-scale battery models. Rather than invest substantial time and effort in developing a regulatory sandbox for these demonstrations, we would encourage project proponents to implement models that are consistent with current rules and regulations and which can more rapidly support the at-scale adoption of community-scale batteries. We do however recommend that project proponents seek relevant exemptions where necessary to expand the range of community-scale battery operational models that will be able to deliver benefits for all energy users.

Key lessons learned

- Community-scale[1] batteries can increase the amount of distributed energy resources (e.g. solar panels and electric vehicles) that can be integrated into the distribution grid i.e. increase hosting capacity [3].
- Network tariffs and market signals shape how the battery's actions contribute to hosting capacity [3].
- Community-scale batteries are already financially viable, particularly if FCAS markets can be accessed [1].
- The technical capability for implementing community-scale storage on the NEM already exists [4].
- Only DNSP-owned community-scale batteries currently require regulatory exemptions (and only if the battery is being used for anything other than regulatory network services). All other models we investigated can proceed within the current rules and regulations [4].
- Reduced local network tariffs are crucial for incentivising battery charging from locally generated solar energy and sale of energy to local customers [3].
- Industry professionals saw significant potential benefits of community-scale batteries, including over behind-the-meter (BTM), virtual power plant (VPP) storage. They also consider the dynamics between actors in dis-aggregated markets to be a major challenge [2].
- Householders care about more than just affordability when it comes to energy storage e.g. strong concern over battery life-cycle, promoting local energy use, reducing carbon emissions, questions of fairness and how this technology would fit in the broader energy transition to renewables [2].

---

[1] We make a note of referring to this storage as 'community-scale storage', leaving the term 'community battery' for the specific scenario where the battery is either owned by the community, operated for the community (as virtual storage) or operated to benefit the community indirectly (e.g. through profits flowing back).

Contents

Executive summary 2

Key lessons learned 3

Contents 4

Community-scale batteries: benefits 5

Social benefits 5

Technical benefits 5

Economic benefits 5

Community-scale batteries: challenges 6

Regulatory challenges 6

Social acceptances challenges 6

Research findings 7

Report 1: Financial viability of community-scale batteries 7

Third-party owned 9

DNSP owned 9

Limitations and further work 9

Report 2: Community-scale battery control strategies 9

Report 3: Stakeholder views on the potential of community-scale storage in Australia ... 11

Limitations and further work 12

Report 4: Regulatory, technical, and logistical considerations for implementation ... 13

A framework for evaluating future community-scale battery operation models 14

Four core components that define a range of possible community-scale battery models ... 16

1. Battery ownership 16

2. Stakeholder participation 16

3. Network tariffs 17

4. Services provided 18

Next steps 19

Links to project webinars 20

Contacts 21

References 22

Community-scale batteries: benefits

Overall, our research found that community-scale batteries can deliver social, economic and technical benefits.

Social benefits

A potential advantage of community-scale batteries is that they may help resolve existing inequalities in the energy system, for example between “solar haves and have-nots". They could also provide an opportunity to build engagement with customers, and to re-build trust in the energy sector. Some caution is required; battery schemes tailored to solar-PV owners (as in community-scale battery trials in WA), could in fact exacerbate energy inequity. Community-scale battery models need to be assessed on the basis of energy equity, in additional to technical and financial specifications.

Technical benefits

With the integration of distributed energy resources, we are facing both increasing peak load and increasingly unpredictable peak load, as well as increasing peak exports from household solar photovoltaic (PV) generation. Together, these challenges could cause demand and voltage management issues on the distribution network. Our analysis revealed that community-scale batteries should be explored as a viable solution to addressing these challenges. Technical benefits of this scale of storage arise from a higher level of reliable control associated with managing a larger asset, compared to the management of many household batteries, and in providing regulation and contingency services such as voltage management and backup islanded power supply. Another bundle of benefits surround the potential of the battery to reduce carbon emissions through enabling more renewable generation for both electricity consumption and electrical vehicle charging.

Economic benefits

Economic benefits from community-scale batteries arise from the efficiencies of flexibly sharing the power and energy capacity of the battery among customers as well as reducing the number of system communication and control components. Revenue can also be generated from participation in energy and FCAS markets (ownership dependent). A recent report showed that community-scale batteries are cheaper than household batteries, regardless of ownership (network, retailer or community group) [5].

Community-scale batteries: challenges

The wide-scale implementation of community-scale batteries faces some challenges. Typically, these have been framed merely in economic terms, yet the questions over how the benefits of the battery are to be distributed, how the risks are to be managed, and how all these should be governed are equally important.

Regulatory challenges

Many of the regulatory challenges relate to implementation of community-scale batteries in the disaggregated National Electricity Market (NEM) of the eastern states. The key challenge is operating the battery for network support services, in partnership with DNSPs, and at the same time operating the battery for energy market services, with energy retailers.

A further challenge in operating community-scale batteries is that, unlike household and utility batteries which are generally operated behind the meter (BTM), this type of storage will typically be located in front of the meter (FOTM). This means that electricity flows to/from the battery will use the distribution network and are required to pay network charges.

There also remain key concerns about managing the lifecycle impacts of batteries. From production to disposal, there are gaps in both the regulation of materials production and investment in recycling and reuse schemes across different jurisdictions.

Finally, there is no guarantee within the current regulatory context that community-scale batteries will not increase inequality between energy users. As community-scale batteries can be optimised to produce different values, there is the distinct risk that community-scale batteries could increase inequality. Models that enable solar customers to benefit financially from a battery are an example of this. Our research revealed a public preference for a fair distribution of the benefits of community-scale batteries. When there is an unequal opportunity within the community to invest in renewable technologies, ensuring the benefits are distributed fairly is a primary challenge for community-scale batteries.

Social acceptances challenges

Our research revealed that a key challenge will be developing community energy models that are based on engagement and transparency and that address concerns about fairness and environmental impact. Trials of consumer facing energy technology have a long way to go to meet consumer expectations and there remains challenges to overcome for this technology to be an opportunity to rebuild trust in the energy sector. There appears to be reserve among some energy users about community-scale battery models that are run as a for-profit entity.

Research findings

Our socio-techno-economic analysis of community-scale storage was carried out through four main research activities covering:

- The financial viability of community-scale batteries based on the total cost of purchasing and maintaining the battery, compared to potential battery revenue;
- Community-scale battery control strategies, including the impact of tariffs in incentivising the battery to charge from locally generated solar energy and to sell energy to customers locally;
- Stakeholder views on the potential of community-scale storage in Australia; and
- Regulatory, technical and logistical considerations around the practical implementation of community-scale batteries.

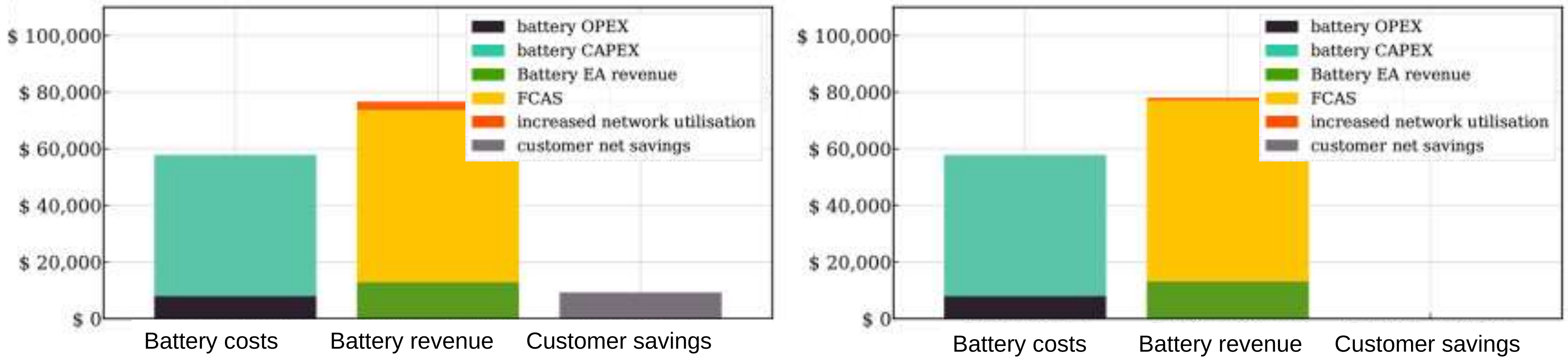
The results from these four studies are summarised, below.

Report 1: Financial viability of community-scale batteries

In this report, we calculate the total cost of purchasing and maintaining a community-scale battery, compared to battery revenue. We identify five services that can generate revenue for the battery owner/operator: (i) customer demand management, (ii) demand management for the distribution network service provider (DNSP), (iii) arbitrage from the spot market, (iv) Frequency and Ancillary markets (FCAS) and (v) network support. Maximising the simultaneous value from these revenue streams is essential for the economic viability of storage, but it will also ensure that storage is used to effectively support a reliable and secure future energy grid. We estimated the value of these services, for four different ownership models. The ownership models we investigated (which emerged from stakeholder focus groups detailed below) were:

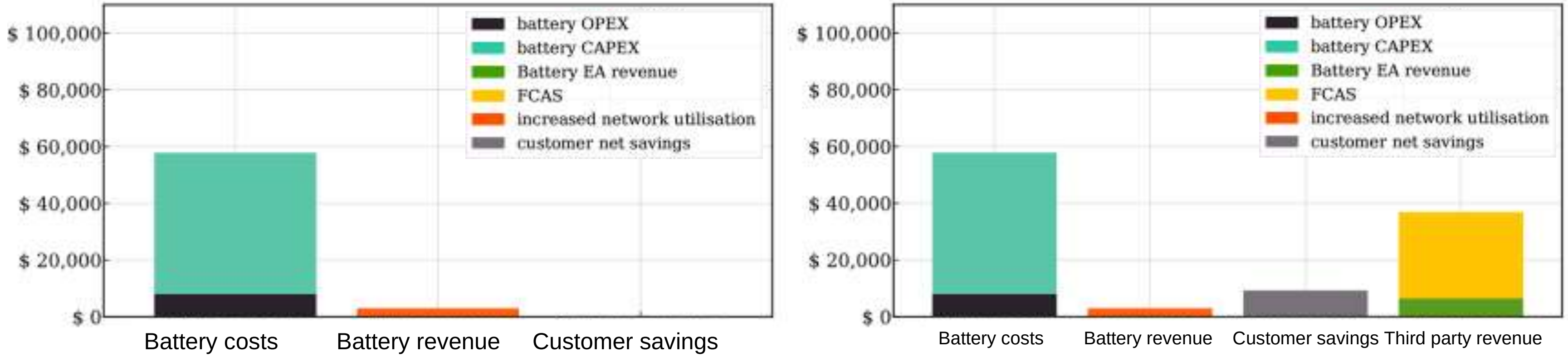
- Third-party owned, community battery
- Third-party owned, for-profit model
- DNSP owned, community battery
- DNSP owned, for-profit model

A third party could be, for example, a retailer, community group, or a local council, Costs were calculated over one year (2018). We used in-house open-source software (c3x) to calculate how a community battery would operate, given (i) the battery operation algorithm, (ii) energy demand plus solar generation and (iii) energy prices. We then calculated how the community-scale battery would impact energy flows — and associated costs — between the battery, the grid, and customers who have chosen to participate in the battery scheme. Battery costs, battery revenue and customer savings for the four models are shown in *Figure 1*. Briefly, the third party owned, community battery model is operated to maximise the profits for the battery owner as well as customers, but in the third party for profit model, the control strategy is to maximise the profit for the battery only. For DNSP-owned community battery, the battery is operated without any knowledge of market prices, as the network is not allowed to buy and sell energy on the market, and for the DNSP-owned for-profit model, 50% of the battery is leased to a 3rd party (licensed retailer) who can operate that proportion of the battery as a for-profit model (optimisation is with respect to market prices).



(a) Third party owned, community battery

(b) Third party owned, for-profit battery



(c) DNSP owned, community battery

(d) DNSP owned, for-profit battery (3rd party)

Figure 1. Costs and revenue for one year (2018) for the four models examined. For each model, the battery cost is the same, but the battery revenue and customer savings differ. Importantly, although customers are much better off with the third party owned "for community" battery, the battery owner still makes almost as much money from energy arbitrage and FCAS. Also note that for the network owned, community battery — even while not optimising for market services — customers still save money. In practice, these savings could be shared between the customers and the network e.g. via a subscription fee. For the two network owned batteries, additional revenue would in practice be added to the stack due to avoided network upgrades, if the battery was placed in a constrained part of the network, where e.g. a transformer would otherwise be needed. We have not modelled those avoided network upgrade benefits as they are network and location dependent.

For all models studied, a reduced local energy transport price (local use of service LUoS) was required to financially motivate local energy exchange (both with the shared battery as well as between customers i.e. peer-to-peer, P2P). In practice, this would be essential for the use of community batteries to 'soak up' locally generated solar and thereby increase local hosting capacity.

Third-party owned

Importantly, we found that third party owned community battery models are likely to be financially viable under current energy and FCAS market prices. They may also provide value to the widest range of stakeholders — customers, retailers, networks, battery owners — depending on how the benefits are distributed. However, to ensure the future economic viability of these models, payments for the network services they provide need to be established.

DNSP owned

For DNSP-owned community batteries, a significant challenge is getting enough revenue, as networks are locked out of the energy and FCAS markets. Without these markets, such a battery is unlikely to be financially viable without adding a significant proportion of the battery cost to their Revenue Asset Base (RAB). The DNSP owned for-profit battery could potentially be financially viable under current market conditions, if a significant proportion of the battery was leased for market participation. This model is currently being trialled in practice for a grid-scale battery — the ESCRI-SA battery in Dalrymple, South Australia, owned by ElectraNet. Reports for that project suggest the battery is working successfully as a backup power source and for frequency stabilisation, in addition to generating significant income from energy and FCAS markets for the third-party operator, AGL.

Limitations and further work

It should be noted that all our modelling was based on perfect foresight, such that the estimated revenue is likely to represent a best-case-scenario. Future work will include market, demand and generation forecasts for more realistic revenue estimates. In our models, we did not calculate how much PV energy customers had exported to the CES, for the purposes of virtual net metering. We allowed all customers (PV owners or not) to purchase energy back from the CES (at a cheaper price if LUoS was used) until the CES was depleted. In this way, customers could potentially game the system and use a greater proportion of the cheaper energy than their neighbours. In practice, virtual net metering would need to be used for this reason. A large component of our estimated revenue comes from the FCAS markets. Here we based our modelling on prices from 2018. However, it is currently unknown whether future FCAS market prices will increase or decrease but given an increasing amount of storage coming onto the market, and limited FCAS requirements, prices may fall substantially. A recent report by AECOM, commissioned by ARENA, assumed that FCAS prices in each market would reduce exponentially to 10% of current values by 2040 [6].

Report 2: Community-scale battery control strategies

A community-scale battery may offer benefits for both customers and networks, but it remains unclear how best to operate the battery such that the potential benefits can be allocated appropriately between stakeholders. For this report, we carried out an analysis of the impact of different tariff schemes on the operation of a community-scale battery, investigating how each scenario would impact outcomes for customers and networks [3].

We introduced reduced local energy and transport tariffs with the goal of increasing the charging of the community-scale battery from locally generated solar energy and discharging to meet the local demand. For all scenarios, we gave the optimiser perfect foresight. The local tariffs apply within a distinct low voltage (LV) local sub-region of the electricity system, e.g. downstream from a feeder. We use the terms remote grid, and remote market to refer to the region outside of where this 'Local Energy Model' (LEM) applies, and local grid and local market for the region within the LEM. For our calculations, 'remote' tariffs were applied to energy flows between the grid and battery, and energy flows from the grid to meet the local load. 'Local' tariffs were applied to energy flows from the battery to meet the load and from excess solar generation to meet the load. The charging/discharging pattern of the community-scale battery was dictated by an optimisation algorithm, written in-house and designed to calculate the optimal operation of the battery to minimise some objective function. Here, the objective function was the minimisation of overall cost.

This report focused on four different tariff structures;

- Tariffs that do not differentiate between energy cost and network transport cost in the local vs remote grid (Business-As-Usual (BAU) tariffs).
- Local Energy Model where the network transport tariffs are reduced in the local grid (LEM1).
- Local Energy Model where both the network transport tariffs and the energy tariffs are both lower in the local grid and the remote grid (LEM2).
- Local Energy Model where both the cost of energy and the network transport costs are determined optimally based on game theory (LEM3).

The analysis we conducted found that BAU tariffs provide limited scope for tuning the operation of the community-scale battery. This greatly restricts the impacts that the battery has on the servicing of local customer and network needs. Under financial operation the battery will pursue the arbitrage value in the remote energy tariff with no regard for local network or customers conditions. Such operation may have positive impacts — such as lowering peak energy and power imports — if the peak in customers’ net energy demand (for grid power) coincides with peak tariff periods. But it may also have negative impacts such as creating new periods of large reverse power flows when local demand is low and the battery discharges due to the remote market energy arbitrage potential.

The introduction of differentiated local energy transport tariffs in LEM1 provided a well-suited lever by which to bias the operation of the community-scale battery towards charging and discharging based on the energy flows of the local network over the remote market. Since the energy tariffs and arbitrage value are equal in the local and remote markets the difference between local and remote transport tariffs has a very direct and tractable impact on the battery prioritising charging from local energy. The battery will however still discharge into the remote market (as under BAU conditions) because generators are not charged a transport tariff for the energy they export. A future extension of our work will examine the impacts of altering this to charge for transport for both the import and export of energy, although we note that this would require a revision of NER clause 6.1.4 that explicitly prohibits the charging of DUOS for the export of energy.

While LEM2 opens additional degrees of freedom through the setting of local energy tariffs, this was found to be of limited practical use. The reasons for this were that, on the principle of fairness and to avoid perverse incentives for continuous battery cycling, we considered local energy prices to be symmetric in import and export, and that we bounded local energy prices to be less than prices in the remote market. This latter constraint was also imposed to ensure that the LEM decreased customers’ costs. In future work, we will explore the co-optimisation of local energy and transport tariffs, as it may be possible to reduce customers’ total costs with premium local energy tariffs complemented by very low local transport tariffs. The tariffs produced by game theory optimisation potentially provide a valuable reference for tariff design in that they specify the optimum tariff that results in lowest energy costs for all users.

However, for the current study, the local and remote energy prices derived from game theory were almost identical.

We also investigated the performance of community-scale batteries on the local network's solar system hosting capacity. As expected, we found that a large, shared battery was far better able to manage peak power flows into and out of the local network than residential Behind the Meter batteries of equal total storage capacity. The superior performance is due to the shared battery directing all of its power capacity to the worst peaks in aggregate net load/solar, whereas the BTM batteries are unaware of the behaviour of other customers.

In summary, this piece of analysis showed that community-scale battery systems may offer advantages over residential batteries, both for consumers as well as the electricity network. Further, if implemented with appropriate settings, the benefits can be allocated appropriately between customers and the grid. Future work will integrate energy forecasts for more accurate estimates of battery performance.

Report 3: Stakeholder views on the potential of community-scale storage in Australia

This research activity involved investigating stakeholder perspectives of the barriers and opportunities to community-scale energy storage. We drew on an interdisciplinary framework of social acceptance to new technology. The methodology involved a series of qualitative research activities that took place between July 2019 and May 2020. We spoke with 21 energy sector professionals (in the NEM) about their views on community batteries of 100kW - 5MW. We also spoke with 57 householders across 8 different locations in six States to explore their views on the concept of a shared battery. This research is the first attempt globally to consider the views of energy professionals and householders about community batteries side by side in this way.

Both energy professionals and householders identified a wide range of benefits across economic, technical, social and environmental arenas. Indeed, many participants highlighted that the advantage of community batteries was that they could provide benefits across multiple dimensions. Naturally, participants emphasised the benefits relating to their position in the energy system. For example, network benefits for DNSPs. Importantly, there was no fundamental disagreement between participants over the benefits raised. However, the point that different groups emphasise different benefits highlights the inherently political nature of model selection - any selection of models will reflect a particular set of values and may come at the expense of another group in the energy system, notably energy consumers.

Whether the proposed models of storage will be viewed as a “community battery” will depend on a range of considerations, including how householders are engaged in the design and how the benefits are distributed. Energy technology uptake generally also relies on its appeal to the public. This research activity also set out the range of benefits and concerns raised by people across a range of socio-economic contexts in rural and urban Australia. Analysis revealed some differences in expectations between the general public and energy sector professionals about feasible future models. These differences centred around questions of ownership; the general public envision a minimal role for large retailers and networks.

Our research affirms that householders are not simply concerned about energy affordability but have a range of values and expectations for future energy systems. Community-scale batteries are generally in line with values of sustainability and energy sovereignty, so long as the entity delivering the community battery can demonstrate these same values in a proposed business model. **Enthusiasm about community storage does represent an opportunity for householders to re-engage with energy systems so long as concerns about potential environmental impacts of battery and governance of the battery can be satisfied.** For some householders, a (not for profit) community battery was seen as a viable alternative to grid defection.

While both householders and energy sector participants were open to the idea of community scale storage in the energy system, all raised caveats, concerns, or challenges that would need to be overcome for it to be feasible. None of these were deemed insurmountable. Concerns/caveats/ challenges were divided into two categories: practical challenges, which often relate to the material-technical aspects of battery installation/maintenance (some aspects of which require a regulatory response), and governance and regulatory issues (perceived and real), which relate to ways in which community batteries may require changes to the current institutional frameworks to be viable.

A clear finding out of this research was that a range of models is possible, all with different value propositions, and different regulatory barriers. Many participants also raised the point that regulation of community batteries needs to be adaptable and flexible. The grid is increasingly complex and heterogeneous - with changing technical needs depending on different sources of grid vulnerability (e.g. related to being edge of grid, or high penetration PV). In addition, communities will have different goals with respect to what they want the battery to achieve. Communities are also differentiated in terms of their composition of solar owners and non-solar owners. Finally, local and state governments have their own carbon reduction objectives and are also highly differentiated in terms of their strategies around storage investments.

There was strong interest among energy sector professionals about the value of trials and demonstrations. Participants argued that demonstrations would enable the sector to understand the different financial and non-financial values storage models could bring as well as the different options for community participation.

In summary, this research found:

- Community batteries hold broad appeal for both energy sector professionals and the general community for various reasons; some of these overlap between professionals and the community, but some do not.
- Community batteries can be designed to achieve different aims and, as such, model design and ownership has implications for who benefits.
- Community batteries face several practical and regulatory barriers, although some of these are overstated and relate more to entrenched ways of doing, rather than formal rules.
- Energy sector participants welcome investment in trials and demonstrations of different models to explore their viability in 'real world' settings.
- Householders are likely to be sceptical of community battery models that cannot clearly demonstrate that they will genuinely benefit the local community. 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.

Limitations and further work

An advantage of in-depth qualitative interviews and focus groups is that researchers can obtain details and uncover motivations, attitudes, and values that would otherwise be unlikely to be revealed by other methods. A future mixed method study of attitudes towards technologies could involve a qualitative study to understand motivations followed by a survey (i.e. quantitative) study to explore prevalence of these views across different groups. However, we could not have undertaken a survey in the short time period of this study. And yet, because many of the concerns about proposed community-scale batteries were linked to the governance of the energy system, it is likely that a wide-scale, mixed method study of public attitudes towards the energy transition would be helpful for understanding the likely public responses to a range of new energy technologies, not just community-scale batteries. While each technology may have specific concerns (safety, privacy etc), our research for this project (together with research undertaken in countries like the UK) suggests there are likely to be underlying public value systems in Australia influencing attitudes to new energy technologies. A study of this kind would be extremely helpful to businesses and policy makers as they consider the range of policies and technologies associated with the energy transition.

Because concerns over ownership and distrust in the energy sector were significant public concerns, future work could examine empirically, institutional arrangements that would engender trust and participation. It is likely that this may involve control or management of the battery by a trusted organisation.

Report 4: Regulatory, technical, and logistical considerations for implementation

Report 4 outlined 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 the interviews and focus groups from the stakeholder study (report 3). The report also explored the main barriers associated with implementation — both real and perceived.

The main finding from this report was that community-scale batteries are already achievable, without major changes to current regulations [4]. However, the financial viability of almost all community-scale storage projects will require a discounted local network tariff (LUOS). DNSPs can own a battery, but cannot use it to provide contestable services, 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
- To determine how DNSPs can best procure the services that storage can provide, from storage owners within the current framework
- To determine how battery projects can 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 an 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 could include financial and technical support for community energy projects. 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 fairest and most widely beneficial models.

A framework for evaluating future community-scale battery operation models

Based on the research undertaken in this project, we have identified five essential benefits of community-scale batteries — as detailed in Table 1. The five benefits can be used as a starting guide to evaluate future trials of community-scale batteries.

Table 1: The five essential benefits of community-scale batteries.

Model component	Description
Fairness and equity	To improve fairness and equity, models must consider different stakeholders, particularly "solar haves" vs "solar have-nots" and other differing levels of resources between energy users that affect capacity to participate (financial and non-financial). Models need to consider: who gets to participate? Customers close to the battery, within a suburb or within the whole DNSP? Also important is the choice of who gets access to the battery in an outage. Are service groups critically reliant on energy supply prioritised (e.g. the elderly in a heat wave)?
Trust and transparency	To build trust in the energy system, models must be open and transparent with respect to how financial and non-financial costs and benefits are distributed amongst stakeholders and how decisions are made.
Hosting capacity	Batteries can improve the hosting capacity of the network i.e. the amount of solar generation and electric vehicles that can be connected to the network, to different degrees, based on how their behaviour relates to local network conditions.
Local resilience	Community-scale batteries can contribute to bolstering the resilience of the local community, including through local jobs and training, keeping money circulating within the community, and increasing the physical resilience of the local power supply to disturbances
Cost-effectiveness	The cost-effectiveness of a community-scale battery should be compared to other options, such as network upgrades, distributed batteries and tariff changes.


TESLA

Four core components that define a range of possible community-scale battery models

In this project, we have identified four core components that will be important to consider for the potential future rollout of community-scale batteries: (i) battery ownership, (ii) stakeholder participation, (iii) network tariffs, and (iv) the services the battery can provide.

1. Battery ownership

The ownership model of community-scale batteries is likely to materially influence the choice of stakeholder participation and service provision models. We categorise the potential owners of community-scale batteries into three groups. We do not consider any of these categories to be distinctly better suited than the others but discuss the unique attributes of each.

Retailers

Retailers are perfectly positioned to access market services and to engage customers with on-bill participation models such as tariffs and subscriptions. As mentioned above, these raise problems of network impacts and of fairness and transparency. Members of the public were wary of retailers' profit motive and the opaqueness of tariffs and bills [2].

Retailers may not be well positioned to access non-market services such as network support. To receive payment for these services they would need to establish a bilateral agreement with the DNSP.

DNSPs

DNSPs are the only stakeholders with clear oversight of where network services are required, making them the most capable of maximising this value stream. Efforts to increase the transparency of network planning and utilisation may remove this information monopoly and introduce competition into the provision of network support.

The vertical disaggregation of the NEM prohibits DNSPs from providing market services or owning an asset that is used to provide market services. Although some conditions allow this to occur, they require permission from the Australian Energy Regulator (AER) on a case-by-case basis.

A situation that is particularly beneficial for equity and hosting capacity goals and is currently allowed in the regulations is for networks to deploy community-scale batteries in situations where they are a cost-effective solution for network services. In these cases, the network receives a return on investment through network charges and — in an ideal world — the net benefits are shared amongst their customers through lower future cost of providing services.

Third parties

Third party owners could include private investors, community groups, and local or state governments, or a combination of these groups.

These organisations have the greatest freedom to innovate and may directly target benefits such as equity or decarbonisation, although these off-market approaches risk being opaque and creating unintended and/or undesirable cross-subsidies, without appropriately clear policy settings. These organisations may also lack experience in developing such installations and will require technical support (as would retailers and networks to some extent).

2. Stakeholder participation

We considered three ways in which customers can participate in a community-scale battery scheme, which have different ramifications for fairness and transparency. The interaction of these models with existing and emerging consumer protection frameworks was raised as a concern by both energy sector professionals and householders in our study [2].

Tariff or subscription model through a retailer

It is difficult for such arrangements to benefit all customers equitably. They are typically only applicable for customers who are located close to the battery and who have solar systems that are exporting significant amounts into the grid. As with most modern electricity tariffs, it is difficult to predict the likely benefit to customers as individual load and solar generation profiles play a decisive role. Although these types of offers would generally be available from retailers, some networks are pursuing similar models (currently not allowed– see [4]). In WA, such offers have been trialled by Western Power (a vertically integrated DNSP and retailer). Despite pre-vetting of customers, this trial found that some customers were worse off in the scheme [6].

Direct or indirect benefits through the DNSP

DNSPs could pass on the benefits of batteries by reducing their network charges, either through a modified network tariff or a daily discount.

This could potentially benefit all their customers, irrespective of how close they lived to the battery, although specific network tariffs may favour certain customers over others.

Direct or indirect benefits through a third party

A third party, e.g. a local council, could own the battery and redistribute profits through reduced council rates or decide to invest the profits in carbon reduction projects in line with meeting council targets. Alternatively, a third party could own the battery and return dividends to community members who invested in the battery.

These types of models are highly flexible, allowing them to target specific distributions, which may improve or exacerbate inequality. Cross subsidy risks need to be considered and minimised. If carefully managed, council ownership can be an easy way to more widely spread battery benefits.

3. Network tariffs

Network charges are a major barrier to the deployment of community-scale batteries in the NEM. This is because the energy flows between customers and the battery are levied network charges twice: once when the battery imports energy and then again when customers import energy from the battery. Given the substantial price of these charges, this double charging is prohibitively expensive.

The appropriate price for transporting energy within a small length of the distribution network is highly topical, not only for community-scale batteries but also for energy flows between customers (when some customers are exporting solar power while others are importing power). Network tariffs can be modified in two, complementary ways to address these issues.

The introduction of a local use of service (LUOS) tariff

LUOS extends the existing distinction between energy flows on the transmission network (TUOS) and flows on the distribution network (DUOS) with a third tier for flows within a small subregion of the local distribution network, as outlined in our accompanying report [3]. Because these flows only use a small segment of the network their cost — the LUOS — ought to be less than the DUOS.

We are of the view that the LUOS should be applied to all energy flows between connection points in the local area, including between customers and a community-scale battery and between customers. This reduces the costs for all in a fair, transparent and intuitive manner. Our modelling shows that an appropriately discounted LUOS is a highly effective way to get community-scale batteries to prioritise actions that service local customers and improves the hosting capacity of the network [1].

Two-way tariffs

A further improvement is to apply LUOS and DUOS charges to both exports and imports. Our modelling shows that this discourages batteries (and customers) from exporting upstream, thereby improving the hosting capacity [7]. Assuming that tariffs are altered in a net revenue neutral manner for networks, this change will improve fairness by charging solar customers for using the network to generate revenue.

4. Services provided

Community-scale batteries can provide numerous services. Their commercial feasibility will depend on accessing and “stacking” as many market and non-market services as possible.

Market services

Arbitrage of the NEM spot price is a common revenue stream for utility batteries. For community-scale batteries this is less appealing — because they are charged greater network charges (TUOS plus DUOS) — unless the battery is used to cover a market participant’s net load, for which the market participant will inevitably have to pay network charges.

Our analysis of load and solar data from the Nextgen battery trial [8] showed that residential loads (and solar) are poorly correlated with NEM prices, such that, from a price perspective, it can be financially sub-optimal to sell when generation is highest (and buy when load is lowest). In this way, energy arbitrage can actually add to peak imports/exports. A strong two-way LUOS and DUOS can help suppress these negative impacts. Ancillary market services such as FCAS represent a considerable revenue stream for community-scale batteries, as they do for utility batteries. The risk with these services is that their large power injections/draws may place extra strain on distribution networks.

Non-market services

Community-scale batteries are ideally suited to the provision of non-market services such as network support and network upgrade deferral because they are located at the level of the electricity system where these services are needed and, unlike most customer-owned batteries, they can be installed with these services as their primary purpose. This alleviates the concerns that the procurers of network services (mostly DNSPs) have regarding assurance of availability from residential batteries. Our modelling showed that, as expected, community-scale batteries were very effective at managing physical network conditions, such as preventing reverse power flows, when they were operated with this as their objective [3].

The challenge for community-scale battery models is that the current regulatory environment quite strictly separates the agents responsible for delivering these services. This issue was discussed in detail in the Implementation Report [4].

Next steps

As discussed above, there are many benefits that could emerge from the at-scale adoption of community-scale batteries in the NEM. Several trials are already underway, and our earlier report outlined how stakeholders agree that more public trials are needed to demonstrate the operational delivery of benefits [2].

Although DNSP-owned battery trials will require an exemption to current rules in order to use the battery for anything other than regulated network services, our investigations have shown that — overwhelmingly — these trials and demonstrations can proceed within current rules and regulations. In this context, we do not recommend the development of regulatory sandboxes for the demonstration of community-scale battery models. Rather than invest substantial time and effort in developing a regulatory sandbox for these demonstrations, we would encourage project proponents to implement models that are consistent with current rules and regulations and which can more rapidly support the at-scale adoption of community-scale batteries. We do however recommend that project proponents seek relevant exemptions where necessary to expand the range of community-scale battery operational models that will be able to deliver benefits for all energy users.

Links to project webinars

Energy conversations, presented by the Energy Change Institute 2020

- ✉ youtu.be/LQHNBVV-QjI

Community Scale Battery — Regulatory Reform Options, presented by the ANU, TEC and Ausgrid

- ✉ bsgip.com/news-events/events

Community-scale batteries, presented by the Energy Security Board (ESB), Ausgrid and the ANU

- ✉ bsgip.com/news-events/events

Householder perspectives of community batteries, presented by BSGIP

- ✉ bsgip.com/news-events/events/householder-perspectives-of-community-batteries

Mitchell community energy (invited) 31 August 2020

- ✉ beam.org.au/post/community-battery-webinar-now-available

Contacts

Project lead / contact author:

- ✉ marnie.shaw@anu.edu.au

Group members / contributing authors:

- ✉ bjorn.sturmberg@anu.edu.au
- ✉ chathurika.mediwaththe@anu.edu.au
- ✉ lachlan.blackhall@anu.edu.au
- ✉ hedda.ransan-cooper@anu.edu.au

Battery Storage and Grid Integration Program
Research School of Electrical, Energy and Materials Engineering
ANU College of Engineering and Computer Science
Research School of Chemistry, ANU College of Science

Australian National University
Canberra ACT 2601 Australia
anu.edu.au

References

1. Shaw, M.E. et al 2020. *Community batteries: a cost/benefit analysis* (arena.gov.au/knowledge-bank/community-batteries-a-cost-benefit-analysis)
2. Ransan-Cooper, H. 2020. *Stakeholder views on the potential role of community-scale storage in Australia* (arena.gov.au/knowledge-bank/stakeholder-views-on-the-potential-role-of-community-scale-storage-in-australia)
3. Shaw, M.E. et al 2019. *Operating a community-scale battery: electricity tariffs to maximise customer and network benefits* (arena.gov.au/knowledge-bank/operating-a-community-scale-battery-electricity-tariffs-to-maximise-customer-and-network-benefits)
4. Shaw, M.E. et al 2020. *Implementing community-scale batteries: regulatory, technical and logistical considerations* (report submitted to the Australian Renewable Energy Agency)
5. Oakley Greenwood 2020. *Financial viability of community-scale battery ownership models*, report for the Total Environment Centre (energyconsumersaustralia.worldsecuresystems.com/Report%20community%20battery%20ownership%20models%20Feb2020.pdf)
6. AECOM 2019. *Grid vs garage: a comparison of battery deployment models in providing low voltage network support and other services* (arena.gov.au/knowledge-bank/grid-vs-garage)
7. Cornwell, A. 2019. Alkimos Beach energy storage trial customer insights research (arena.gov.au/assets/2017/02/alkimos-beach-energy-storage-trial-customer-insights-research-2019.pdf)
8. Sturmberg, B. et al 2020. *A general framework for techno-economic modelling of distribution networks containing distributed energy resources* (in preparation)
9. Shaw, M.E., Sturmberg, B., Guo, L., Gao, X., Ratnam, E. & Blackhall, L. 2019. *The NextGen energy storage trial in the ACT, Australia*, Proceedings of the 2019 ACM International Conference on Future Energy Systems (dl.acm.org/doi/10.1145/3307772.3331017)