YARRA ENERGY FOUNDATION

Port Phillip Community Battery Feasibility Study — July 2022

Investigating the business case for a neighbourhood-scale battery in the City of Port Phillip

PORT PHILLIP EMERGENCY CLIMATE ACTION NETWORK

COMMUNITY POWER HUB METROPOLITAN MELBOURNE

Supported by

Sustainability Victoria

VICTORIA State Government

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1. Executive Summary

1.1. Background

The Metro Community Power Hub (MCPH) was established in mid-2021 as a collaborative association of community climate groups and local councils, led by the not-for-profit Yarra Energy Foundation (YEF), and funded by Sustainability Victoria on behalf of the Victorian Government. The Port Phillip Emergency Climate Action Network (PECAN) – a community climate action group based in the City of Port Phillip – has proactively investigated community batteries through the MCPH, hosting several online webinars and conducting an online survey to begin initial community engagement and education around the concept.

A community battery is an energy storage system sized between a household battery and a large, utility-scale battery which *involves and benefits the local community* by reducing emissions, energy expenses, and supporting the network. Working closely with YEF, PECAN commissioned this feasibility study to build a case for a community battery within the City of Port Phillip. The study supports PECAN's advocacy for climate action and overarching goal of facilitating emissions reductions in their local community by demonstrating both the financial sustainability and emissions reduction potential of neighbourhood-scale energy storage, as well as the benefits of community involvement in such projects.

1.2. Location

Through PECAN's community engagement activities, YEF's analysis of solar generation capacity and network infrastructure within the City of Port Phillip, and consideration of other factors such as availability of suitable land, three candidate locations were identified:

- Hotham Grove, Ripponlea 3185
- St Kilda Town Hall, Carlisle Street, St Kilda 3182
- Gordon Avenue, Elwood 3184

In each case, specific sites for battery installation remain undetermined, since this would require further stakeholder engagement and project planning by a potential proponent. The abovementioned locations denote a candidate low-voltage network centred in that vicinity. Of the three locations, Gordon Avenue offers the best opportunity for a community battery due to its relatively high solar penetration in a predominantly residential area, with the nearby Clarke offering potentially suitable land to site the battery.

It should be noted that while this location demonstrates strong potential, any recommendation to pursue a community battery here is contingent upon a strong and productive community engagement process, as ultimately its suitability and the overall success of the project is dependent on the support of local residents.

1.3. Revenue Analysis

Modelling of a proposed 150kW/375kWh neighbourhood-scale Battery Energy Story System (BESS) shows that, under our assumptions, it earns between $168,830 and $300,006 over a 10-year period in traditional markets (wholesale, contingency FCAS, and network tariffs).

Table 1: 10-year financial outcomes of modelled scenarios

Scenario	Min Year	Average Year	Max Year	Total
High	$22,348	$30,001	$43,307	$300,006
Medium	$16,255	$22,546	$30,166	$225,461
Low	$11,908	$16,883	$21,253	$168,830

These scenarios are based on different futures for the Victorian grid, from FCAS prices falling slower than expected, and accelerated coal generator closures (high scenario), to a fast falloff in FCAS prices, an orderly exit of coal, and external factors such as government contracts leading to low volatility (low scenario). We believe this gives a realistic range of outcomes that the National Electricity Market (NEM) may experience throughout the 2020s.

However, these figures do not tell the whole story. The transition from a centralised, firm power system composed of coal, gas and hydro to a decentralised, variable system of solar, wind, batteries, and flexible loads means that new markets will emerge in the 2020s that neighbourhood-scale batteries will participate in, generating additional revenue. Fast frequency response[1], operating reserves[2], inertia markets[3] and a capacity mechanism[4] are all being explored or implemented. These emerging markets reflect the increased value that the energy system will put on flexibility and which batteries will be able to capture.

[1] https://www.aemc.gov.au/rule-changes/fast-frequency-response-market-ancillary-service
[2] https://www.aemc.gov.au/rule-changes/operating-reserve-market
[3] https://www.aemc.gov.au/rule-changes/efficient-provision-inertia
[4] https://www.energy.gov.au/government-priorities/energy-ministers/priorities/national-electricity-market-reforms/post-2025-market-design/post-2025-market-design-capacity-mechanism-initiation

1.4. Earnings Analysis

Annual operating expenses (OPEX) for a low voltage-connected *single system* can be estimated at $17,000 excluding land lease fees, although the prices vary depending on the chosen technology and commercial arrangements. It assumes an Energy Management System (EMS) with "low-touch" performance, financial management and reporting.

Based on the revenue analysis detailed in section 6, a single battery system with an OPEX of $17,000 can expect to yield 10-year total net profits (as *earnings before interest, tax, depreciation, and amortisation* [EBITDA]) in the range of $0 and $135,000 depending on energy market dynamics. The Medium price modelling scenario projects 10-year total net profits of about $60,000.

This demonstrates that a single battery system is *likely* to be a profitable business in the ten years from 2023 to 2032. The profitability could be enhanced by several factors which are not yet possible to include in this analysis:

- Participation in emerging electricity markets (refer Section 8)
- Co-location of EV charging
- Possible changes to LV network tariff structures
- Monetisation of network support services
- Peak demand reduction for local businesses

Finally, the profitability can also be enhanced by scaling up to a network of battery systems, thereby reducing the operating expenses per battery system while proportionally increasing the revenue.

1.5. Conclusions

A. A single 150kW/375kWh battery system located at a suitable site in the City of Port Phillip is **likely to be a profitable business** over the next decade.

B. If energy markets generally follow the ***Low*** revenue scenario, the modelling suggests the battery will essentially **break even** over a 10-year period.

C. If energy markets generally follow the ***Medium*** revenue scenario, the modelling suggests the battery could generate about **$60,000 in net profit** (EBITDA).

D. If energy markets generally follow the ***High*** revenue scenario, the modelling suggests the battery could generate about **$135,000 in net profit** (EBITDA).

E. **Minimising OPEX is essential** for financial sustainability, and developing **economies of scale** through a network of several batteries is one – albeit challenging – way to reduce OPEX.

F. Profitability could also be enhanced through participation in **future markets**, **EV charging capability**, or possibly by providing **demand reduction services** for an "anchor customer".

G. Stakeholders should also be attentive to possible **future changes to tariffs and regulations** that favour distributed energy resources and support the ongoing decentralisation of the energy system.

1.6. Report Outline

The structure of the report is as follows:

- Section 3 outlines the *Project Context,* including YEF's conception of community batteries, consideration of system and site specifications, YEF's experience delivering Fitzroy North 1, and possible innovations for a battery system in the City of Port Phillip.
- Section 4 discusses the *Community Engagement* work that has already taken place and provides recommendations of future actions.
- Section 5 summarises the *Location Selection* process we undertook to shortlist and select candidate low-voltage networks.
- Section 6 details the *Electricity Market Revenue Analysis*, including the modelling methodology, modelled prices, and projected gross profits.
- Section 7 provides a *Business Earnings Analysis* based on gross profits and estimated operating expenses, with consideration of economies of scale.
- Sections 8 and 9 outline *Future Market Opportunities* and *Electric Vehicle (EV) Charging* respectively.
- Section 10 provides an overview of different models of *Ownership and Operation*.
- Section 11 concludes and offers some final recommendations synthesised from the preceding analysis.

2. Reference Lists

2.1. List of Tables and Figures

2.2. List of Abbreviations

Abbreviation	*Meaning*
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ANU	Australian National University
BESS	Battery Energy Storage System
CAPEX	Capital Expenditure
CB	Community Battery
DELWP	Department of Environment, Land, Water and Planning
DNSP	Distribution Network Service Provider
DR	Demand Response
EBITDA	Earnings Before Interest, Tax, Depreciation and Amortisation
EMS	Energy Management System
EV	Electric Vehicle
FCAS	Frequency Control Ancillary Services
FN1	Fitzroy North 1
kW	Kilowatt
kWh	Kilowatt-hour
LV	Low Voltage
MASP	Market Ancillary Service Provider
MCPH	Metro Community Power Hub
MW	Megawatt
NEM	National Electricity Market
NPV	Net Present Value
OPEX	Operating Expenses
PECAN	Port Phillip Emergency Climate Action Network
PV	Photovoltaic
RAB	Regulatory Asset Base
ROI	Return On Investment
SMS	Short Message Service
V2G	Vehicle-to-Grid
YEF	Yarra Energy Foundation

2.3. Glossary

Term	*Definition*
Aggregator	See Market Ancillary Service Provider
Arbitrage	The practice of taking advantage of fluctuations in electricity prices by buying (charging) when the price is low and selling (discharging) when the price is high.
Battery Control System	The cloud-based energy management system that dispatches the battery in consideration of various factors, including wholesale spot market electricity prices.
Behind-the-meter	Refers to an installation, typically residential or commercial, connected to the network through a meter. The alternative is 'front-of-meter' (see below).
Carbon abatement	The avoidance of emitting greenhouse gases; emissions reduction.
Distribution Network Service Provider (DNSP)	The business responsible for operating and maintaining the electricity network infrastructure that supplies power from high-voltage transmission substations to high-, medium- and low-voltage networks, and finally to homes and businesses.
Feeder/feeder line	A cable supplying power to properties from a low-voltage network's distribution transformer, usually at nominal 400 volts.
Frequency Control Ancillary Services	To maintain a stable frequency at 50Hz, electricity market participants provide services to support the frequency by either fast ramp up of generation (FCAS raise) or load (FCAS lower).
Front-of-meter	Refers to a network asset directly connected to the electricity network and not associated with a premises through a meter.
Kilowatt (kW)	The unit of measuring power; 1000 watts.
Kilowatt-hour (kWh)	A unit of measurement for energy; 1kWh is the amount of energy supplied if power flowed at 1kW for an hour.
Linear Constraint Programming Optimisation	A method of modelling whereby the model makes decisions in alignment with an objective, or objectives, according to a number of specified parameters.
Load	A part of an energy system that consumes power, such as a lamp, an electrical motor, or a battery when charging.

Load shifting	The practice of shifting when energy is consumed, usually to a time when it is cheaper or cleaner.
Low voltage (LV) network	The part of the distribution network that connects premises to the grid, comprising a step-down transformer, feeder lines, and service lines to meters. The distribution network is made up of many low-voltage networks.
Market Ancillary Service Provider	A party that aggregates the services of various smaller parties and their infrastructure, such as community batteries, in order to meet the minimum standards to participate in the FCAS market.
Net present value	The projected value of an investment after a specified period of time after applying a discount rate, e.g. business earnings over ten years, less the capital expenditure, less the loss of value of money over time.
Network constraint	An issue in the distribution network caused either by insufficient network capacity to meet demand, or an excess of solar energy generation, both of which cause strain on the network.
Network support	Providing services in support of the network, e.g. a BESS absorbing excess solar generation to reduce overvoltage, or discharging a BESS to meet variable loads or high demand.
Power capacity	The rate at which the battery can charge or discharge (kW); contrast to Storage capacity.
Revenue Asset Base (RAB)	An accumulation of the value of investments that a service provider has made in its network. Consumers bear some of the cost burden of the RAB through network tariffs.
Social license (to operate)	The ongoing approval extended by a community or stakeholders to a project, which affords the project an essential kind of legitimacy beyond regulatory or legal permissibility.
Solar cluster	An area characterised by the prevalence of installed solar systems, indicating strong local solar generation capacity.
Solar penetration	The ratio of power generated by solar PV to either (a) load, or (b) power generated by other sources, in a particular location.
Storage capacity	The quantity of energy (kWh) that can be stored in a BESS; contrast to Power capacity.
Transformer	The component of the network which converts power from one voltage to another, e.g. from 11kV to 400V, also called a Distribution Substation in a distribution network.

3. Context

3.1. Community Batteries

A community battery is an energy storage system sized between a household battery and a large, utility-scale battery which *involves and benefits the local community*. This last point differentiates the term “community battery” from neighbourhood-scale or mid-scale batteries, which may operate in a functionally similar manner (e.g. those operated by distribution network service providers), but without necessarily involving the community. Another potential point of differentiation is that as an organisation dedicated to facilitating decarbonisation of the energy system, YEF’s conception of community batteries places emissions reduction as a primary goal, which may or may not be a priority for other proponents of neighbourhood-scale batteries.

YEF also believes that prioritising local resident values and preferences in local energy storage projects can enhance the overall value such projects can deliver without compromising – and, in some cases, by supporting – other dimensions such as financial sustainability and environmental or network benefits. CBs therefore offer an exciting profile of benefits for a range of stakeholders and present a unique opportunity for collaboration in support of the clean energy transition.

3.2. System and Site Specifications

The battery concept modelled in this feasibility study is a Battery Energy Storage System (BESS) that is connected to a ‘feeder line’ on the low voltage (LV) distribution network. The LV network is the optimal location for a CB as it can act as a “solar sponge” by soaking up daytime solar energy generation from the surrounding neighbourhood and provide unique benefits which would not be possible ‘upstream,’ including various forms of network support, and emissions reductions.

Each LV network comprises a transformer and a small number of feeder lines extending out from the transformer (either underground or along poles) to supply power to homes and businesses. In inner-urban areas, LV networks host roughly 100-300 premises (depending on the location, these may be a mix of residential and commercial). Nonetheless, the size, number of premises, infrastructure types and other specifications of each LV network are highly variable, so the appropriate battery system and site must be selected in consideration of these local parameters.

Based on the distribution network infrastructure in Melbourne, CBs are likely to have power and connection capacities rated in the region of 100kW–250kW, depending on the specific infrastructure available at possible sites. The ideal storage capacity of a community battery depends on the amount of installed or projected solar capacity in the low-voltage network, the connection size, and the purpose of the battery. The greater the power capacity of the grid connection (kW), the more power the battery operator or contracted aggregator (Market Ancillary Service Provider; MASP) will be able to bid on FCAS markets. The larger the battery's storage capacity (kWh), the greater the emissions reduction and energy arbitrage revenue potential, but the higher the capital expenditure.

Based on YEF's analysis of the network, the cabling in the preferred candidate location (see section 5. Location Selection) supports a power capacity of 150kW, which therefore sets the maximum power capacity of the battery modelled in this feasibility study. A 150kW battery sized for 2.5-hour operation yields a storage capacity of 375kWh. Hence, the battery system size used in this study is a 150kW/375kWh battery, which we believe is the largest battery size that appropriately balances local network parameters, hardware costs and potential revenue. Compared with YEF's Fitzroy North 1 battery in the section below, the battery modelled in this study is 36% larger in power capacity and 32% larger in storage capacity.

3.3. *Yarra Community Battery Trial*

Yarra Energy Foundation (YEF) is a not-for-profit organisation providing services and advice to homes and businesses that want better energy to reduce energy bills and act on climate change.

YEF aims to deploy community batteries (CBs) with particular focus on inner-urban neighbourhoods. By capturing solar energy from residents' and businesses' roof tops and supplying that renewable energy during the evening peak, inner-urban CBs help support local production and consumption of energy, providing a range of local and diffuse benefits to many stakeholders.

In 2021, the Victorian government's Department of Environment, Land, Water and Planning (DELWP) awarded a Neighbourhood Battery Initiative (NBI) Stream 2 grant for "shovel-ready" projects to YEF. The subsequent *Yarra Community Battery Trial* project was completed on World Environment Day 5th June 2022 with the unveiling of the installed battery by the Victorian Minister for Energy, Environment and Climate Change, the Hon. Lily D'Ambrosio.

Figure 1: The Fitzroy North 1 community battery is launched by on World Environment Day, June 5, 2022.

YEF's first installation in Fitzroy North (FN1) is the product of a partnership between YEF, CitiPower – Central Melbourne's electricity distributor, and Australian National University (ANU) Battery Storage and Grid Integration Program.

YEF CITIPOWER Australian National University Battery Storage and Grid Integration Program

It was delivered with a 110kW/284kWh Pixii PowerShaper Battery Energy Storage System (BESS) and Acacia Energy as the system's retailer and aggregator.

The FN1 commercial operating model is as follows:

- The battery trades on the electricity market through retailer/aggregator Acacia Energy, buying energy when prices are low and selling when prices are high. This largely correlates with high daytime solar energy production and evening peak demand, respectively.
- The battery also offers Frequency Control Ancillary Services (FCAS) through Acacia Energy.
- The Battery Control System co-developed with ANU tracks market prices to intelligently dispatch the battery.

- The battery operates on 1 cycle / day, charging during the day and discharging during the evening peak to prioritise emissions reductions. It is possible that more frequent cycling could yield higher profits at the expense of battery lifespan.
- The battery increases the share of renewable energy in local residents' evening supply.

3.4. Possible innovations in Port Phillip

A battery in the City of Port Phillip could essentially replicate the FN1 model, with the option of some additional features. For instance, CBs offer an optimal opportunity for co-location of a "climate-friendly" electric vehicle (EV) charging station(s). The charging station(s) could be (a) simply installed nearby the battery; (b) installed behind the battery's meter in a parent/child meter arrangement and thereby be subject to the same tariffs; or (c) be integrated with the battery itself on a single meter. The charging station(s) would allow further emissions reductions by increasing the amount of low-emissions energy that could be charged into energy storage during the day, as well as providing another revenue stream.

Another significant effect of co-locating EV charging alongside the battery is the increased level of community engagement with the battery. While a CB offers local benefits and has the potential to be a place of meeting or public art feature, it is largely a static piece of infrastructure. Co-located EV charging encourages interaction with the battery, involves the battery in residents' lives, and amplifies the philosophy of community involvement in the clean energy transition.

Another possible innovation is to split the battery system across the host low-voltage network such that there are numerous battery cabinets containing battery cells with multiple connection points, all controlled by the same Battery Control System. This would allow greater power capacity (in kW) due to the multiple connection points, which would increase the system's capability to provide FCAS. It could also further benefit the local network infrastructure by addressing network constraints on multiple feeder lines within the low-voltage network.

4. Community Engagement

Community engagement is, in our experience, an essential, highly productive and rewarding aspect of a community battery project. This section details what community engagement activity PECAN has undertaken regarding a community battery within the City of Port Phillip, provides commentary on the rationale for community engagement, and describes key aspects of the community engagement strategy YEF deployed for the *Yarra Community Battery Trial* (Fitzroy North 1).

4.1. Preliminary Community Engagement Activity

PECAN have already begun preliminary community engagement activity for a community battery which has supported the development of this feasibility study. As a Roundtable Partner of the MCPH, PECAN hosted a webinar in September 2021 in which YEF Community Battery Project Manager Chris Wallin outlined a case for community batteries. This was followed by ideation among PECAN and YEF to progress plans for a community battery, including planning for a feasibility study and further community engagement.

In early 2022, PECAN conducted an online survey among Port Phillip community members on their understanding, preferences and priorities regarding community batteries. The data from this survey informed YEF's location selection process (see Section 5) by identifying clusters of solar households and engaged residents. These clusters indicated areas that are both potentially supportive of a CB project, and have high levels of solar PV penetration to maximise the battery's environmental benefits. Results from the survey were also presented by PECAN at a follow-up Q&A webinar in March 2022, in which community members were afforded the opportunity to ask questions and share their perspectives on community batteries. PECAN have demonstrated a committed and proactive approach to community engagement on community batteries, and the response from the community so far has been resoundingly positive.

4.2. Community Engagement Rationale

As part of any community battery project, it is essential that proponents undertake the development of a dedicated community engagement strategy that attends to the unique local context of any proposed site. It is also important that this strategy is flexible to adapt to inevitable changes to project details, scope or community preferences, and evolves as the project progresses. As a community battery project progresses, various aspects or are likely to remain uncertain or undetermined until the project either reaches the next phases or particular processes and decisions are complete. For these reasons, community engagement is necessarily an ongoing and parallel component of a community battery project that provides mutual benefits for community stakeholders and proponents alike.

Community engagement – from informing to empowerment – is not only essential in establishing a social license to operate; it also enhances the project across numerous dimensions. The extent to which the community can contribute to the project or determine decisions that affect them can help shape the project in ways that maximise local benefits and project successes, including civic pride, community interaction and capacity building for community energy.

Community engagement can also inform the development of appropriate commercial or benefit sharing models that align with community values and priorities; and help mitigate and manage project risks and address community concerns. By engaging with diverse stakeholder perspectives and acknowledging them as legitimate and valuable contributions, project proponents benefit by identifying and navigating otherwise unforeseen issues before they become critical threats to the project. Finally, local residents can also provide constructive input by conveying invisible aspects of the local physical and social context, such as how residents or fauna typically use the space, or which areas may be prone to flooding.

4.3. Elements of Community Engagement

YEF has received commendations for its community engagement process for the *Yarra Community Battery Trial* project, which was considered thorough, adaptive and effective. Key elements of YEF's community engagement process included:

Communications and engagement goals and objectives: This provided overarching goals for community engagement and specific objectives to achieve those goals. These objectives help to scope the community engagement strategy and processes by delineating what's essential for the project itself from other activities or aspirations that may be either "nice to have" or extraneous.

Stakeholder mapping: This process identifies the diversity of relevant stakeholders and assesses their level of interest (impact on them) and influence (impact on the project). This can help to clarify the appropriate level of participation and methods of communication and engagement.

Stakeholder impact assessment: This provided a breakdown of discrete project phases, each with specific communications and engagement objectives, identification of key stakeholders, and communication and engagement activities to be undertaken.

Engagement principles: YEF established four engagement principles and outlined how they would be applied, which provided a foundational set of values to which the community engagement strategy aimed to adhere.

- *Transparency:* YEF and partners will be honest and up front with the community about the project's goals and progression. This will include sharing updates with the community through the consultation process.
- *Listening:* YEF will seek to make space to actively listen and respond comprehensively to community's concerns, questions and comments. Through meetings, consultation and drop-in sessions, YEF will listen respectfully to community's values, priorities and needs as they relate to the project.
- *Communication:* YEF will explain clearly to the community what they can influence, how their input will shape the project team's decision-making, and communicate the outcomes of those decisions, including timeframes and the parameters that YEF and partners are working within.
- *Trust:* By putting trust in the community's ideas, knowledge, hopes and perspectives, YEF will endeavour to build trust with the community in the project, partner organisations, and the energy sector more broadly.

Levels of involvement: The International Association for Public Participation (IAP2) is the internationally recognised organisation for advancing public involvement and participation in government programs and services. The IAP2 spectrum of public participation assists with decisions about how to work with project stakeholders.

The spectrum moves from left to right, showing five progressively increasing levels of public participation and involvement. Table 2 below describes a general approach for each level, which could be expanded to describe the degree to which stakeholders could participate in different aspects of a community battery project.

Table 2: IAP2 spectrum of public participation

Inform	Consult	Involve	Collaborate	Empower
Provide balanced and objective information to assist understanding of the problem, opportunities and solutions	Obtain feedback on analysis, alternatives and decisions	Work directly with stakeholders to ensure their aspirations are understood and considered	Partner with stakeholders in each aspect of the decision including development of alternatives and identification of the preferred solution	Place final decision-making in the hands of stakeholder

Table 3: Communication and engagement channels and tools

Communication and engagement channel	Tool
Publications	Newsletters
	Reports
	Works notifications
	FAQs
Face to face engagement / consultation	Drop-in discussions
	Doorknocks
	Neighbourhood BBQ / breakfast / afternoon tea
Key contact points	Website
Site visits	Media
	Key stakeholders
Online	Website
	Project email
	Social media
Digital	Photography
Advertising	Print (local newspapers)

Negotiables and non-negotiables: It was integral that YEF could clearly define and delineate between aspects of the project that were negotiable through community engagement, and aspects that were non-negotiable (e.g. technical characteristics and tariff structures). This allowed YEF to set clear expectations around the scope of community involvement, and develop efficient and effective methods for managing their involvement at each stage of the project.

Engagement questions: Community engagement is a form of dialogue, in that there must be a two-way flow of communication and information for it to be effective. While community feedback may sometimes be forthcoming, it is essential to consider which questions to ask the community in order to fully explore community perspectives and ideas. This is especially the case where projects are technical in nature, and many community members may lack the experience, understanding or language to volunteer or fully articulate their ideas. Ensuring questions are asked in open (not leading) and accessible (easy to understand / provide feedback) ways is integral.

Communication and engagement tools: A diversity of communication and engagement tools were deployed to encourage engagement and feedback on the project (outlined in Table 3 above).

Community Reference Group: The establishment of a Community Reference Group enabled interested local residents to take an influential role in negotiable aspects of the project. The Community Reference Group facilitated formalised community involvement in, for example, site selection, battery placement, and the visual appearance of the battery (i.e. artwork selection).

Monitoring, reporting and evaluation: Monitoring, reporting and evaluation refers to the ongoing documentation, measurement, and review of, in this case, communications and engagement activities with respect to their effectiveness in achieving objectives. Iterative engagement in these critical reflective practices support the community engagement strategy to adapt to project priorities and conditions as the project evolves, maintaining relevance and effectiveness. YEF developed a monitoring, reporting and evaluation framework to ensure that:

- The project team and key stakeholders were informed and aware of community engagement activities to ensure smooth integration with other project activities
- The content of community engagement activities was documented and reviewed
- Stakeholder relationships could be proactively and effectively managed
- The frequency, methods and format of communications and engagement activities could be reviewed

- The effectiveness of the communications and engagement activities could be measured and evaluated against key objectives

4.4. Next Steps

Much of the above becomes relevant only with the opportunity to pursue a community battery project. As previously mentioned, it is important that the community engagement strategy evolves in parallel with other aspects of the project. Nonetheless, community engagement is also important in developing the case for a community battery by allowing proponents to demonstrate to potential funders, partners, allies, and the community itself that there is a strong appetite for this kind of project.

We suggest the following key actions for PECAN and other interested parties to pursue in support of a community battery in the City of Port Phillip:

- Promulgate the benefits and opportunities inherent to community batteries among the Port Phillip community, particularly among residents of areas with high levels of solar penetration such as Elwood and Ripponlea
- Advocate for the role community batteries can play in the City of Port Phillip's climate and sustainability strategies
- Capacity-building activities among the PECAN community in order to:
    - Discuss high-level aspects of community battery functions, benefits, and opportunities with neighbours, friends, and the broader community
    - Actively participate in government-led engagement consultation regarding energy
    - Engage with relevant literature including government policy, research, and reports.
- Engage in knowledge-sharing with other community groups and organisations who have pursued/are pursuing community battery projects
- Maintain an active online and community presence to build and maintain momentum with regard to public awareness and support for community batteries.
- Conduct further community engagement activities (e.g. surveys, in-person events, neighbourhood/market stalls) to gauge community preferences regarding ownership, benefit-sharing and business models.
- Build connections and alliances with other local community groups, businesses and networks who can extend the reach of messaging and build a groundswell of support for a community battery project throughout the City of Port Phillip

5. Location Selection

There are a range of technical, logistical, regulatory and social factors to consider in selecting a site for a community battery. Getting the right balance of priorities through community engagement, data analysis and project planning is essential to the success of a community battery project.

For initial scoping of possible locations for a community battery within the City of Port Phillip, YEF used satellite imaging and network mapping software to look for locations with the following characteristics within the City of Port Phillip:

- High concentration of solar photovoltaic (PV) capacity – 'solar clusters'
- Large LV network
- Concentration of solar on the same LV network
- Demonstrated interest/support in a community battery (based on PECAN's community engagement survey)
- Potential sites/land available (e.g. wide nature strips)
- Predominantly residential zoning

These characteristics are the optimal base conditions for a community battery, before considering community support and a further investigation of the network properties. For instance, siting the battery among a 'solar cluster' on the same LV network ensures that a higher proportion of the overall energy mix available on the LV network during the day is renewable, enhancing the carbon abatement potential of the BESS. However, if an apparent solar cluster turns out to be spread across numerous LV networks, the location may not be advantageous, despite first appearances.

Considering the above priorities, the three best candidate locations identified were:

- Hotham Grove, Ripponlea 3185
- St Kilda Town Hall, Carlisle Street, St Kilda 3182
- Gordon Avenue, Elwood 3184

Figures 2–4 below outline the LV networks (blue lines) supplying these neighbourhoods and the number of observable solar panels on each LV network. Solar panels are here used as a proxy for actual solar generation capacity and exported energy, since this data is very difficult to obtain.

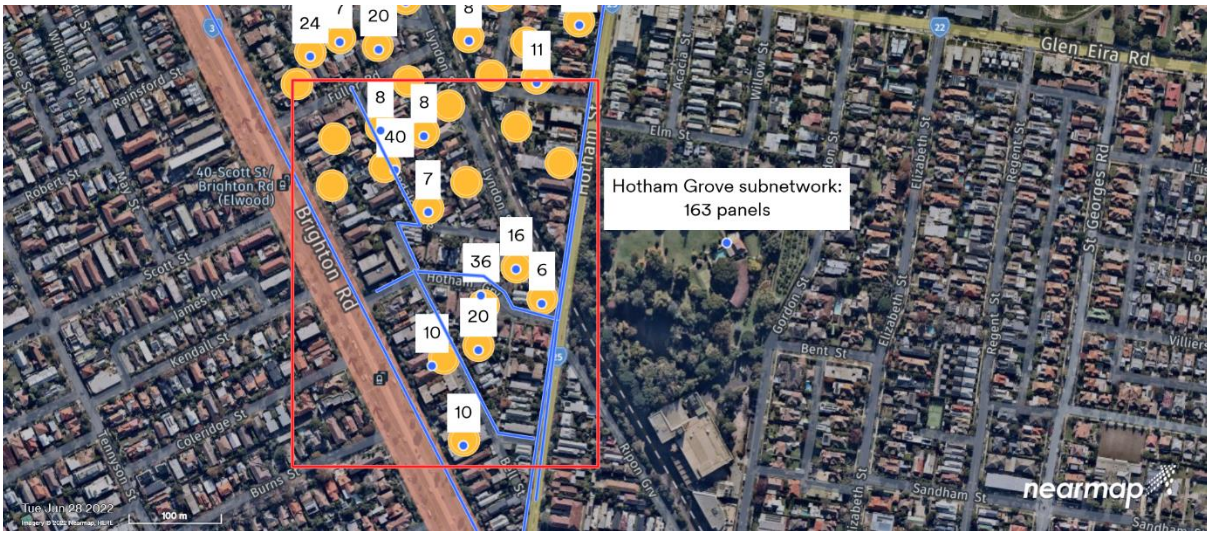

Figure 2 Hotham Grove, Ripponlea, 3185

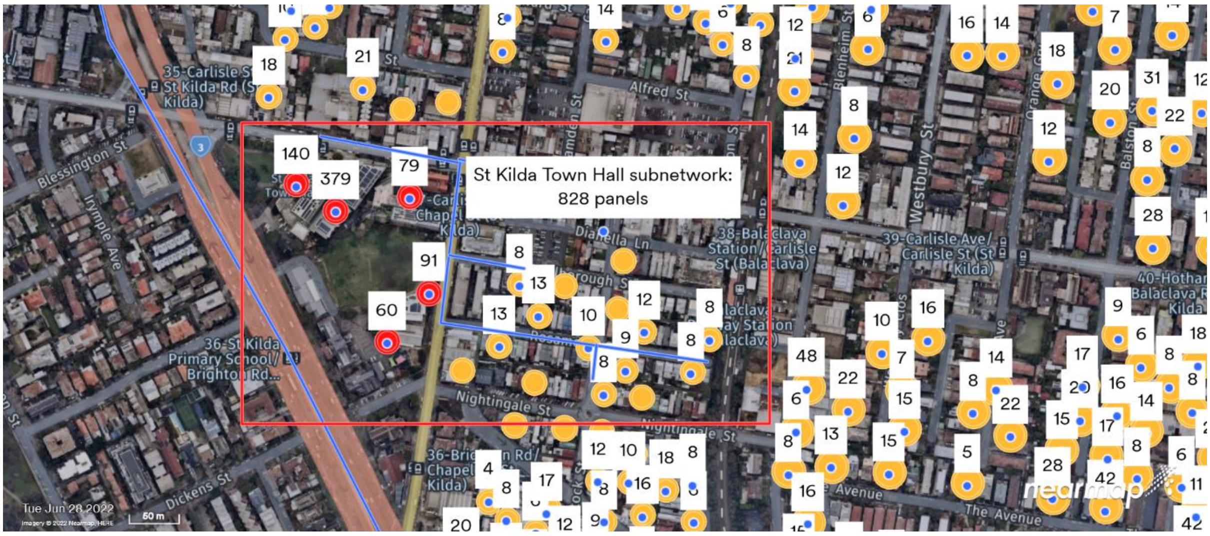

Figure 3 St Kilda Town Hall, 3182

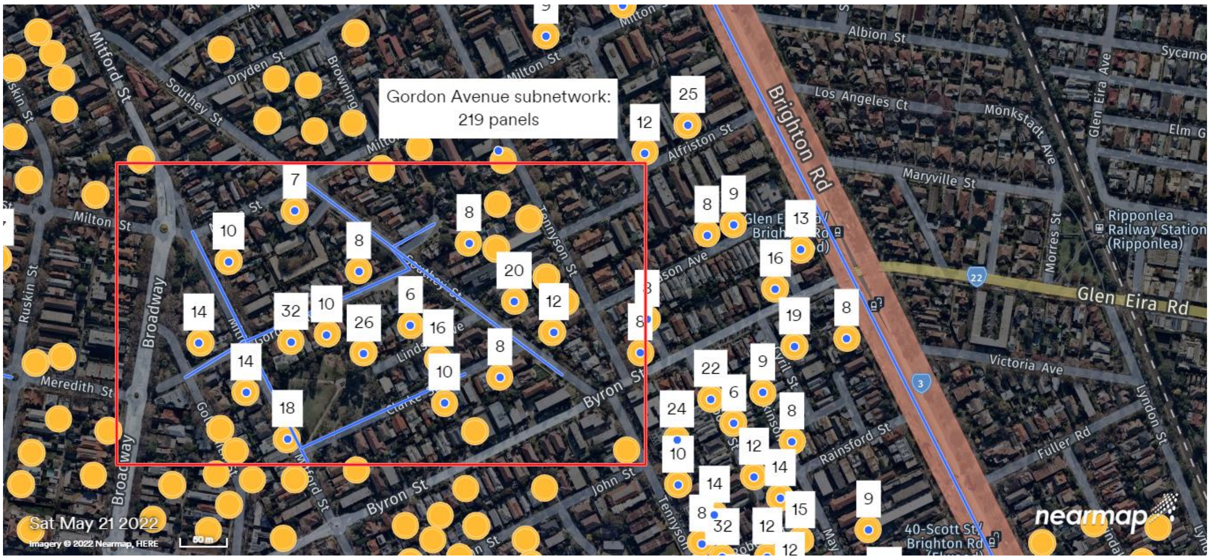

Figure 4 Gordon Avenue, Elwood, 3184

Of the three candidate locations, the Gordon Avenue location is recommended as a candidate for hosting a community battery due to:

- High local solar PV penetration
- Predominantly residential premises
- Possible site/land availability
- Size of the LV network
- Evidence of some community support for a community battery

The local LV network is relatively large, and hosts approximately 219 panels, totalling approximately 65.7kW of solar generation capacity. The area features wide nature strips and Council-owned parkland that might offer suitable installation sites. These do not feature as strongly around Hotham Grove, which also hosts less solar PV capacity. While the St Kilda Town Hall location boasts greater solar generation than Gordon Avenue overall, it services a smaller LV network, so the overall amount and distribution of benefits may be more limited.

6. Electricity Market Revenue Analysis

6.1. Modelling Methodology

For this study, a linear constraint programming optimisation method was used. Essentially, the physical system is defined (battery hardware), inputs are fed in (in this case, market price predictions), and the optimiser will simulate charging and discharging of the battery, as well as operating in capacity markets such as FCAS, in a manner that will optimise profits.

The benefit of this method is that it can co-optimise in an arbitrary number of markets and price signals[5] at the same time and can find maximally profitable solutions that human-created algorithms cannot. This method of optimisation is common in other industries and is becoming more common in leading battery control companies in the industry.

10-years (2023-2032) of wholesale and FCAS market projections are used as price inputs. These projects are based on a synthetic market pricing model which considers historical data, expected trends in markets, and generator retirements to create high, medium, and low scenarios at 30-minute granularity for both energy and FCAS prices.

In this study, the battery was limited to one charge/discharge cycle per day on average. However, there may be opportunities to cycle the battery more than that, especially in the future if there is more short-term volatility and additional markets during our transition to higher amounts of variable renewables in the grid.

[5] This can include PPAs, LGCs, demand charges, other markets, even consumer preference.

6.2. Modelled Prices

To estimate future returns of the battery, projected energy market prices must be used as an input. Our methodology for creating these prices was first to estimate yearly prices of the two biggest drivers of battery revenue: FCAS markets and peak wholesale pricing[6]. We created yearly prices for high, medium and low scenarios. The details of these scenarios are:

High

- Continued high energy prices in 2023 driven by high coal and gas fuel costs.
- An accelerated exit of coal leading to earlier than expected coal generator closures, and market volatility due to closures similar to the unexpected closure of Hazelwood Power Station in 2017.
- A slow decline of FCAS revenue to a floor of $100,000/MW/year in 2029.

Medium

- Continued high energy prices in 2023 driven by high coal and gas fuel costs.
- An accelerated exit of coal leading to some earlier than expected coal generator closures, and market volatility due to closures slightly less than the unexpected closure of Hazelwood Power Station in 2017.
- A medium decline of FCAS revenue to a floor of $70,000/MW/year in 2028.

Low

- Medium energy prices in 2023 driven by high coal and gas fuel costs.
- An orderly and on time exit of coal in New South Wales and Victoria, leading to small amounts of market volatility during the closures.
- Government intervention to reduce wholesale price volatility such as off-market agreements with generators (such as contracts for difference) leading to some oversupply of generation due to subsidisation.
- A fast decline of FCAS revenue to a floor of $40,000/MW/year in 2025.

We consider the Medium scenario to be somewhat conservative (with higher prices more likely than lower prices), but the most likely of the three. From this we create 10-years of 30-minute data (around 175,000 price periods) for each scenario that matches these yearly aggregates. For instance, if a year is expected to have a $100,000 FCAS price, the 30-minute data for that year will sum to $100,000. If we

[6] “Peak” in this report is defined as wholesale prices above $1,000/MWh

expect 10 hours of peak prices in that year, there will be 20 30-minute periods with peak prices. Day-to-day wholesale prices are based on prices from historic years with similar attributes.

We then simulate how a battery would operate over that 10-year period when exposed to those prices in order to determine what a battery may be able to earn in each of those scenarios, and in which markets.

6.2.1. FCAS Prices

FCAS revenues have been lucrative for the past few years, especially for batteries which are well suited to participating in this market. As this is a shallow market, often only requiring 500MW or less for each period, it's expected that as more utility scale batteries are commissioned during the 2020s that this revenue will fall substantially.

How fast and how far this fall will be is hard for the industry to predict, but defining a range is possible, such as a slow descent to $100,000/MW/year in the late 2020s (our High scenario), or a fast descent to pre-2015 prices of around $40,000/MW/year (our Low scenario).

The unit we use – $/MW/year – is if 1MW of FCAS raise and lower capacity is available 100% of the year. Due to the battery sometimes being full or empty, or from it participating through other markets, it won't achieve this 100% availability, but some smaller percentage of that.

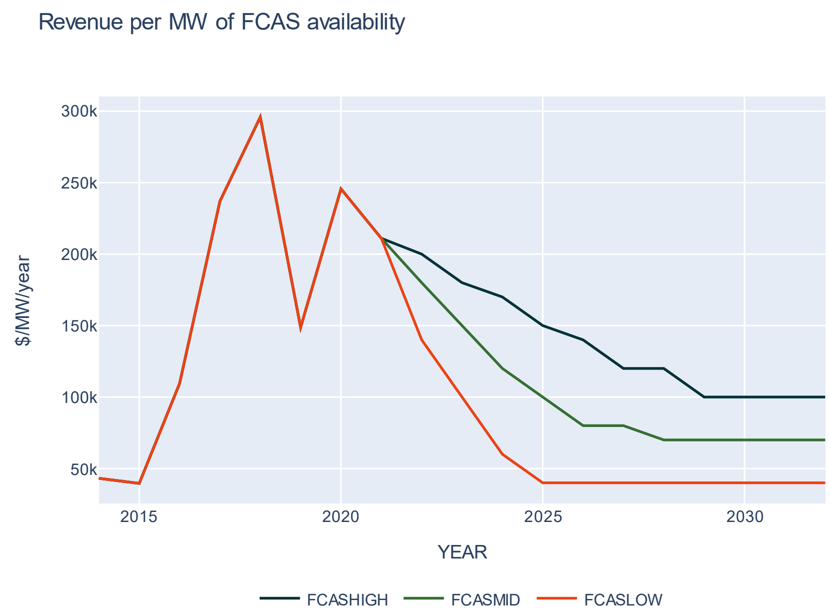

Figure 5 Historic and predicted Victorian FCAS prices

6.2.2. Wholesale Prices

While batteries make some revenue through day-to-day arbitrage, such as charging during low priced periods and discharging into higher priced periods, this revenue tends to have low volatility and makes up a valuable but relatively small part of the total revenue a battery earns.

An often larger, but more volatile part of wholesale revenue is based on peak prices, which is the few times a year the price goes above $1,000/MWh, up to the $15,100/MWh market cap. During an evening of peak prices, a battery can often earn more than an entire year of day-to-day arbitrage, therefore accurately modelling how often these peak price events occur is essential for the model.

In the short-term, wholesale volatility is impacted by high coal and gas prices reducing throughout 2023. The largest factors in the medium- to long-term are the expected dates of coal closures.

- All scenarios expect Liddell to close in 2023, and Eraring to close in 2025, based on the currently reported closure plans,[7] causing some volatility during those years.
- High and medium scenarios expect the Yallourn closure to be brought forward to 2026, and the low scenario expects the closure to occur at the currently reported year of 2028.
- High and medium scenarios expect Loy Yang A and B to have an accelerated closure during 2031 – much faster than the 2045 and 2047 dates currently reported, based on recent AEMO modelling.[8]

These dates influence the timing and magnitude of peak pricing throughout the modelled years seen below (see Figures 6 and 7 on the next page).

[7] “Generating unit expected closure years – February 2022” available at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information
[8] https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp

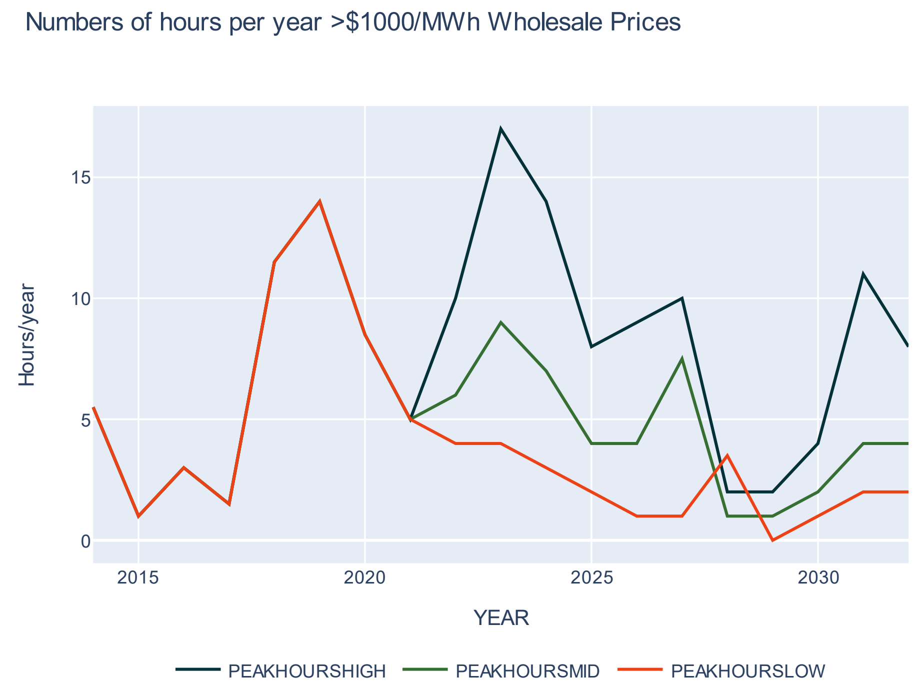

Figure 6: Historic and predicted hours of peak pricing in Victoria

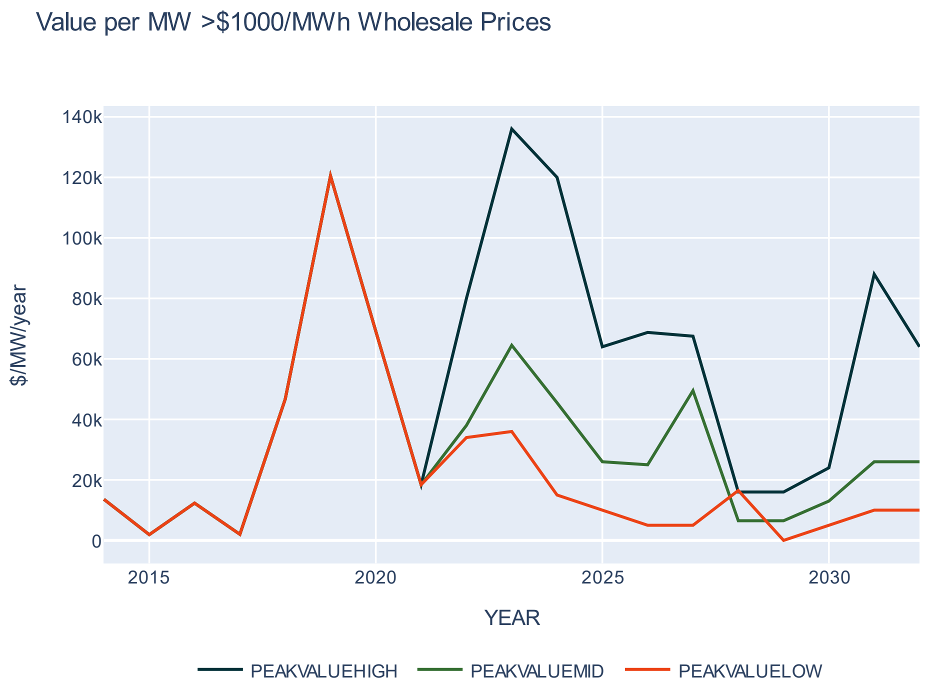

Figure 7: Historic and predicted value of peak pricing in Victoria

6.2.3. Network Prices

For network prices, we used the currently planned neighbourhood battery trial tariffs from CitiPower. These tariffs create scenarios wherein batteries can earn money when charging or discharging at different times in support of the network (the middle of the day and evening respectively). This creates a 2.5c/kWh incentive to arbitrage between daytime low prices and evening high prices.

Table 4: Neighbourhood battery trial tariffs (CitiPower)

Time band	Fixed (cents/day)	Import rate (cents/kWh)	Export rate (cents/kWh)
10am – 3pm	45	-1.5	0
4pm – 9pm		25	-1.0
All other times		0	0

6.2.4. Revenue Assumptions

This study models a 150kW/375kWh battery. The battery is exposed to wholesale energy prices and can bid capacity into the 6 contingency FCAS markets. The objective of the simulation is to operate the battery in a way to maximise gross profit from the system.

The details on the system and how it’s operated are:

- There is a 90% round trip efficiency of the battery. A higher round trip efficiency would increase wholesale revenue and network revenue of the system.
- When the battery is full it cannot bid into FCAS raise, and when the battery is empty it cannot bid into FCAS lower.
- Only the middle 80% of the battery’s stored energy is used in order to increase the longevity of the system.
- The battery’s capacity reduces by 2% per year, reducing wholesale revenue by 2% per year.

We also discount the financial results to incorporate real world inefficiencies:

- FCAS revenue is reduced by 20% to represent the bidding inefficiencies caused by 1MW bidding increments.
- Wholesale revenue is reduced by 20% to represent imperfect price predictions and bidding inefficiencies causing some missed opportunities.

6.3. Gross Profit

Modelling of the PECAN 150kW/375kWh neighbourhood-scale BESS shows that, under our assumptions, it earns between $168,830 and $300,006 over a 10-year period in traditional markets (wholesale, contingency FCAS, and network tariffs).

The reduction of contingency FCAS prices is the main driver of the downward trend, and coal generator closures causing more peak pricing events is the cause of the spikes in revenue in the mid 2020's and early 2030's.

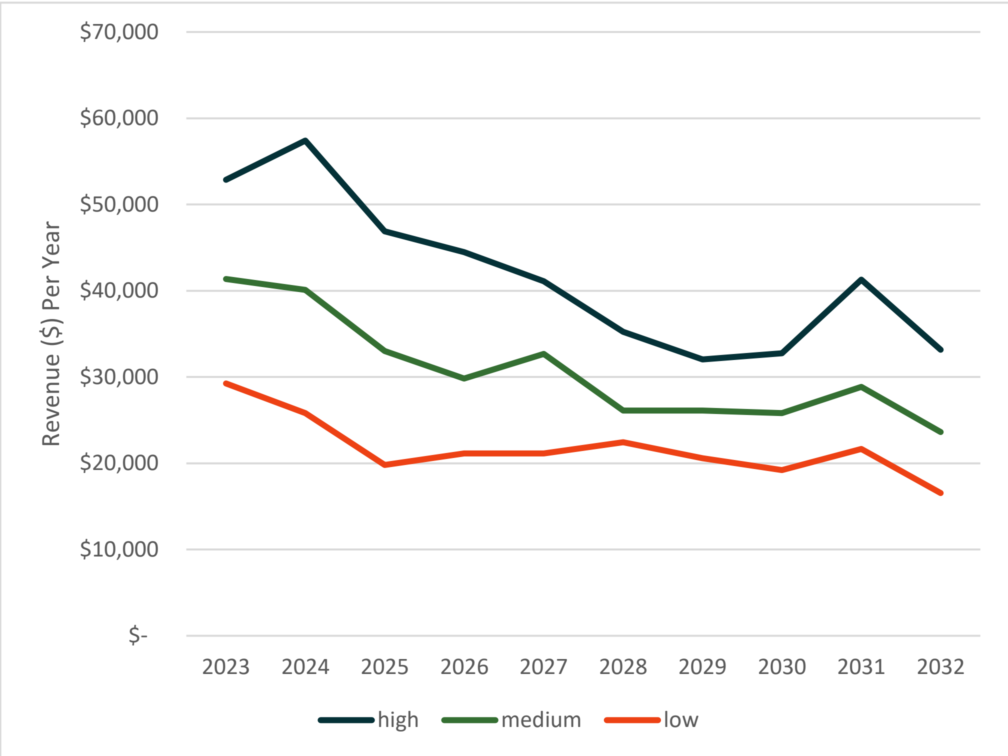

Figure 8: Comparison of revenue in High, Medium and Low scenarios

Table 5: 10-year financial outcomes of modelled scenarios

Scenario	Min Year	Average Year	Max Year	Total
High	$22,348	$30,001	$43,307	$300,006
Medium	$16,255	$22,546	$30,166	$225,461
Low	$11,908	$16,883	$21,253	$168,830

6.3.1. High Scenario

In the high scenario, the battery achieves healthy sustained profits throughout the 2020s. FCAS revenue remains high, although it gradually tapers off, and wholesale revenue is lucrative, particularly during coal generator exits.

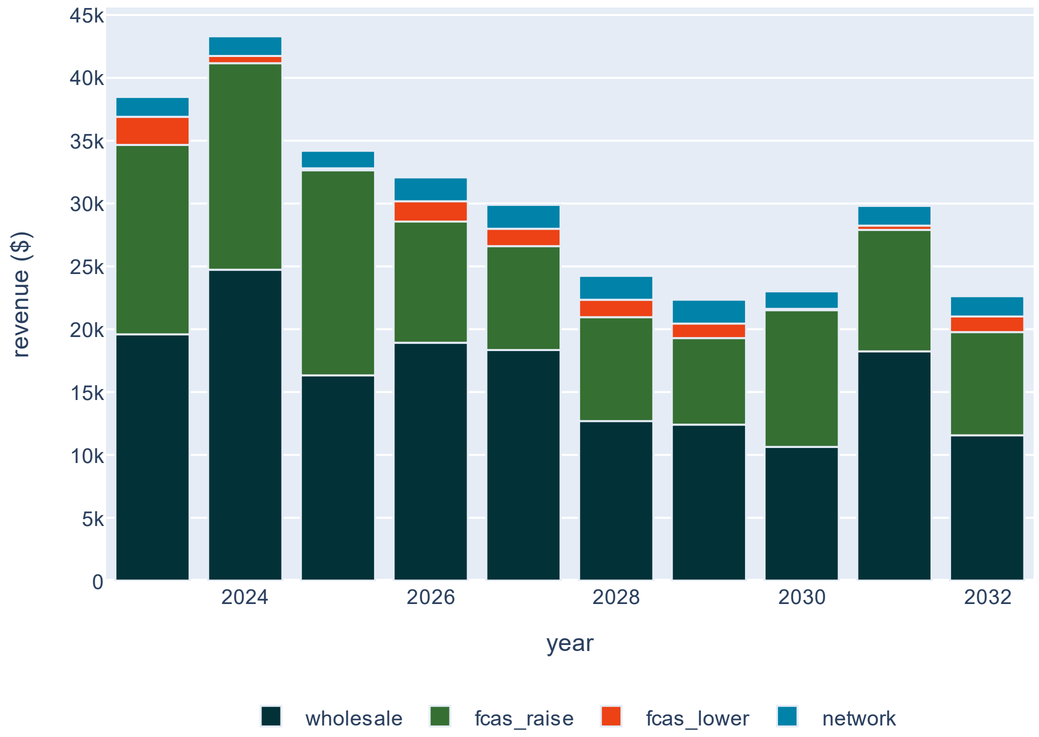

Figure 9: High scenario revenue breakdown

Table 6: High scenario revenue breakdown

Year	*wholesale*	*fcas_raise*	*fcas_lower*	*network*	*Total*
2023	19,595	15,070	2,237	1,578	38,480
2024	24,734	16,432	575	1,565	43,307
2025	16,331	16,318	153	1,394	34,196
2026	18,924	9,643	1,616	1,900	32,083
2027	18,345	8,264	1,385	1,900	29,894
2028	12,690	8,269	1,385	1,901	24,246
2029	12,408	6,885	1,154	1,901	22,348
2030	10,638	10,880	102	1,395	23,014
2031	18,239	9,664	338	1,570	29,812
2032	11,562	8,208	1,243	1,613	22,626
Total	**$ 163,467**	**$ 109,633**	**$ 10,188**	**$ 16,718**	**$ 300,006**

6.3.2. Medium Scenario

In the medium scenario the battery achieves healthy sustained profits throughout the 2020’s. FCAS revenue tapers off in the mid 2020’s and there are some wholesale opportunities during coal generator exits.

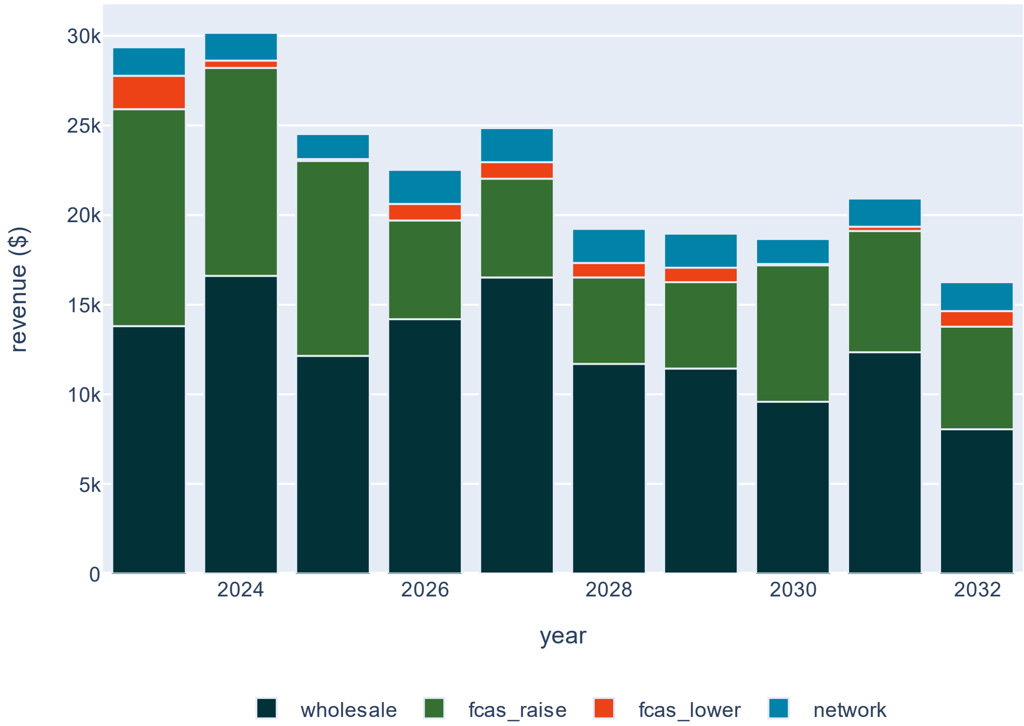

Figure 10: Medium scenario revenue breakdown

Table 7: Medium scenario revenue breakdown

Year	wholesale	fcas_raise	fcas_lower	network	Total
2023	13,804	12,104	1,864	1,591	29,363
2024	16,609	11,602	406	1,548	30,166
2025	12,144	10,879	102	1,396	24,521
2026	14,190	5,508	923	1,901	22,522
2027	16,519	5,508	923	1,901	24,852
2028	11,697	4,824	808	1,901	19,229
2029	11,437	4,819	808	1,901	18,964
2030	9,582	7,616	71	1,396	18,665
2031	12,345	6,767	237	1,574	20,923
2032	8,049	5,724	870	1,612	16,255
Total	**$ 126,376**	**$ 75,351**	**$ 7,013**	**$ 16,721**	**$ 225,461**

6.3.3. Low Scenario

In the low scenario, the battery achieves diminished profits throughout the 2020s. FCAS revenue tapers off in the early 2020s, and there are some wholesale opportunities during coal generator exits.

A key factor contributing to the depressed prices in the low scenario is outside subsidies – either through government contracts, or new markets driving the wholesale price down. This also creates an opportunity for the battery to participate in those additional markets and revenue streams. Because of this, it may be more appropriate to view the low scenario as one in which *assets will be earning more of their revenue through structures other than the current NEM markets*, rather than one in which *energy market prices are low and all assets earn less*.

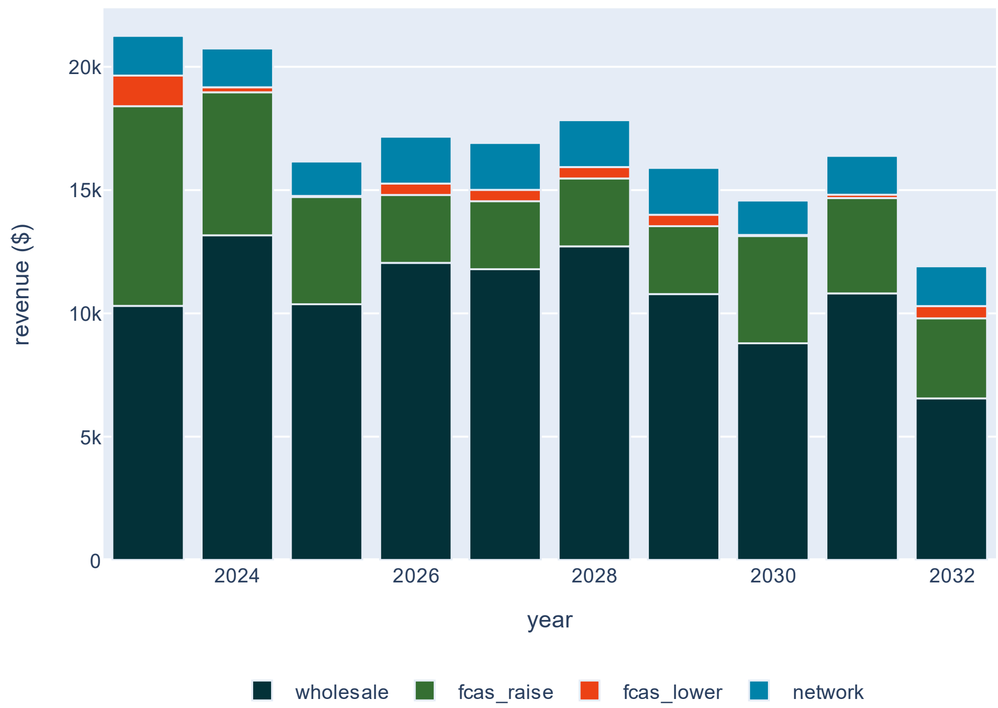

Figure 11: Low scenario revenue breakdown

Table 8: Low scenario revenue breakdown

Year	wholesale	fcas_raise	fcas_lower	network	Total
2023	10,303	8,098	1,243	1,610	21,253
2024	13,165	5,800	203	1,573	20,741
2025	10,370	4,352	41	1,396	16,158
2026	12,047	2,755	462	1,900	17,164
2027	11,791	2,756	462	1,901	16,910
2028	12,717	2,754	462	1,901	17,834
2029	10,782	2,754	462	1,901	15,899
2030	8,787	4,352	41	1,396	14,576
2031	10,809	3,866	135	1,575	16,386
2032	6,551	3,247	497	1,613	11,908
Total	**$107,322**	**$40,734**	**$4,006**	**$16,767**	**$168,830**

7. Business Earnings Analysis

7.1. Operating Expense (OPEX) Estimates

Annual operating expenses (OPEX) for a low voltage-connected *single system* can be estimated at $17,000 excluding land lease fees, although the prices vary depending on the chosen technology and commercial arrangements. It assumes a Battery Control System (BCS) with "low-touch" performance and financial management and reporting. The cost breakdown is as follows.

Table 9: Estimated OPEX breakdown

Category	Description
1. Administration	1 person for 1 day per month, approx. $4,000 p.a. excl. system costs
2. IT Operations	Hosting, software revisions & incident management: $6,000 – $12,000 p.a; (Possible upfront fee for lifetime software improvements: $20k-$40k)
3. Metering	$700 – $1,000 p.a.
4. System Maintenance	$500 – $3,000 p.a. – this varies widely
5. Insurance	$4,000 – $5,000 p.a. for public liability and property damage
6. Site Maintenance	$1,000 for anti-graffiti services – twice per annum and event-based

The following costs are excluded from the estimate:

- Software license fees. YEF's system operates with open-source software and does not incur license fees except for certain software tools.
- Off-line analysis and research.
- Retailer/aggregator costs which are netted out of market revenues.
- Land lease fees which are highly negotiable depending on the Lessor.

For a network of systems, all costs except for metering, site maintenance and possibly land lease fees would reduce substantially with volume. It is also expected that with widespread deployments, the insurance industry would develop more suitable products, in line with the perceived risk and earning potential of a BESS.

Based on the above, we have developed four basic scenarios indicating the range of estimated operating expenses:

Projected minimum possible – *A*: This is a projection of what we anticipate the *minimum possible* ongoing costs would be for a single battery system. This is unlikely to be achievable at present, but with excellent project management and lean budgeting, this might be considered a *best-case* scenario and a target for the future.

Current achievable floor (FN1 equivalent) – *B*: This is roughly what we consider to be the *currently achievable floor* of OPEX in current market conditions, based on YEF's experience with FN1. This does not reflect FN1's OPEX exactly as there are case specific factors that would not be replicable for other projects.

Recommended ceiling – *C*: This estimate represents the upper-most range of OPEX that would, on probability, yield a feasible business case for a single battery system. This nominal OPEX is just below the average revenue over ten years of the Medium revenue scenario, and is therefore considered a soft ceiling for a break-even business case.

Maximum – *D*: This estimate is the *upper limit* of every projected cost and represents what we consider a *maximum* (or *worst-case*) OPEX in normal circumstances. A single system community battery project with a projected OPEX of between *C* and *D* scenarios (or higher) would not be recommended as a feasible community battery project, and therefore is not included in further analysis.

Table 10: Estimated OPEX figures

Category	Projected minimum possible - *A*	Current achievable floor (FN1 equivalent) – *B*	Recommended ceiling – *C*	Maximum – *D*
1. Administration	$3,000	$4,000	$5,000	$5,000
2. IT Operations	$3,000	$4,400	$6,000	$12,000
3. Metering	$700	$700	$1,000	$1,000
4. System Maintenance	$1,500	$2,000	$2,500	$3,000
5. Insurance	$2,500	$4,500	$5,000	$6,000
6. Site Maintenance	$500	$1,000	$2,000	$3,000
Total	$11,200	$16,600	$21,500	$30,000

7.1. Earnings Analysis

The net profits in each combination of scenarios represent the *earnings before interest, taxes, depreciation and amortisation* (EBITDA). As noted above, this figure excludes possible land lease fees or software license fees, but it also does not account for likely 'natural' reductions in IT and administration OPEX costs through efficiency and learnings. The projected net profits (EBITDA) over a ten-year period for each combination of scenarios are presented in Tables 11–13 on the following page.

Table 11: Projected net profits of **OPEX estimate *A*** (Projected minimum possible)

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	10-year Total
High	$27,280	$32,107	$22,996	$20,883	$18,694	$13,046	$11,148	$11,814	$18,612	$11,426	$188,006
Medium	$18,163	$18,966	$13,321	$11,322	$13,652	$8,029	$7,764	$7,465	$9,723	$5,055	$113,461
Low	$10,053	$9,541	$4,958	$5,964	$5,710	$6,634	$4,699	$3,376	$5,186	$708	$56,830

Table 12: Projected net profits of **OPEX estimate *B*** (Current achievable floor [FN1 equivalent])

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	10-year Total
High	$21,880	$26,707	$17,596	$15,483	$13,294	$7,646	$5,748	$6,414	$13,212	$6,026	$134,006
Medium	$12,763	$13,566	$7,921	$5,922	$8,252	$2,629	$2,364	$2,065	$4,323	-$345	$59,461
Low	$4,653	$4,141	-$442	$564	$310	$1,234	-$701	-$2,024	-$214	-$4,692	$2,830

Table 13: Projected net profits of **OPEX estimate *C*** (Recommended ceiling)

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	10-year Total
High	$16,980	$21,807	$12,696	$10,583	$8,394	$2,746	$848	$1,514	$8,312	$1,126	$85,006
Medium	$7,863	$8,666	$3,021	$1,022	$3,352	-$2,271	-$2,536	-$2,835	-$577	-$5,245	$10,461
Low	-$247	-$759	-$5,342	-$4,336	-$4,590	-$3,666	-$5,601	-$6,924	-$5,114	-$9,592	-$46,170

Table 14: 10-year total net profits estimates of each revenue and OPEX estimate combination (revenue – OPEX = net profits)

Scenario	High	Medium	Low
A	$ 188,006	$ 113,461	$ 56,830
B	$ 134,006	$ 59,461	$ 2,830
C	$ 85,006	$ 10,461	-$ 46,170

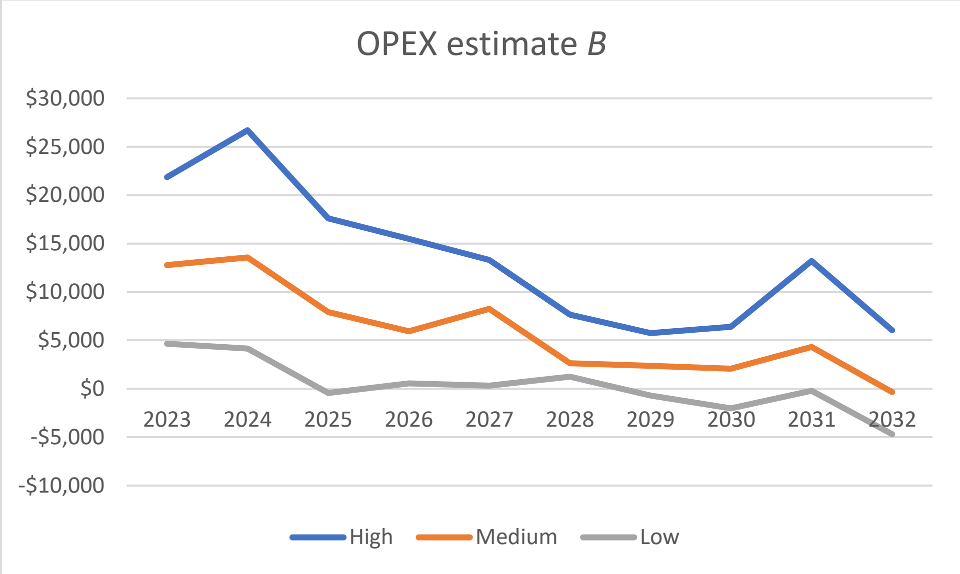

Figure 12: Projected annual net profits – OPEX estimate *B*

The data above emphasise that keeping OPEX to a minimum is integral to the financial feasibility of the battery as a single system (without considering future revenue streams such as emerging markets and EV charging). This is especially as revenue is dependent on volatile future energy markets, while OPEX is stable. It is helpful to return to Table 3 (repeated below) to contextualise estimated OPEX with the minimum, average and maximum yearly revenue for each scenario.

Table 15: 10-year financial outcomes of modelled scenarios

Scenario	Min Year	Average Year	Max Year	Total
High	$22,348	$30,001	$43,307	$300,006
Medium	$16,255	$22,546	$30,166	$225,461
Low	$11,908	$16,883	$21,253	$168,830

In Table 3 (above), the orange cells represent revenue figures that fall either at or below OPEX estimate *B* (the *current achievable floor*). The grey cells represent figures roughly equivalent to OPEX estimate *C* (the *recommended ceiling*). The green cells represent figures that would make a profit given the range of potentially viable OPEX estimates ($11,200 - $21,500).

Table 3 shows why, on the balance of probabilities, the OPEX must be kept below the recommended ceiling of $21,500 to have the best chance of financial sustainability over a ten-year period. Given revenue is projected to fall over time, if OPEX could be reduced over time, this would also enhance the business case as later years would be more likely to break even.

7.2. Return on Investment

7.2.1. Single System ROI

Were the BESS subject to an investment opportunity, the Return On Investment (ROI) could be calculated as follows. A 150kW / 375kWh system is estimated to cost $425,000, considering a capital expense to procure the BESS at $1,000 per kWh, plus $50,000 connection and miscellaneous costs. For each revenue scenario (using OPEX estimate *B*), this results in the following ROI after 10 years, not factoring in the loss of value of money over time (i.e. no discount rate applied).

Table 16: Calculating ROI for a single BESS – three scenarios

	CAPEX	EBITDA	ROI
High scenario	$425,000.00	$134,005.59	**31.5%**
Medium scenario	$425,000.00	$59,461.03	**14.0%**
Low scenario	$425,000.00	$2,829.91	**0.7%**

This means that over a 10-year period, an investment of $425,000 will return $134,005.59 in net profits under the best conditions (High scenario). Under the worst conditions (Low scenario), it is unlikely to make significant profits or incur significant losses. While it is likely that the battery system and operating model are commercially viable over a ten-year period, on a single system basis, however, the profit projection does not justify the capital investment on a purely commercial or entrepreneurial basis.

7.2.2. Scaling Up

The slim margins between annual OPEX and revenue highlight the importance of scalability. While a single battery system may yield profits over ten years, the owner/operator of the BESS would nonetheless benefit from the economies of scale inherent in operating a ‘network’ of batteries: With each additional battery, the OPEX per battery would decrease as costs are spread across multiple systems, while revenue would increase proportionally to the number of additional systems. For example, we surmise that it may be possible to reduce OPEX per battery by up to 50% for a network of 10 batteries. It would take time to develop a network of 10 batteries and energy market prices will fluctuate into the future, but this demonstrates the clear benefit to the community battery business case of scaling up.

However, for both a single system and a network of batteries with reduced OPEX, the net present value (NPV) is negative. This means that for the business case to be attractive to investment funding sources, more revenue must be generated through future market and network opportunities, and CAPEX must be reduced wherever possible. The most obvious reduction in CAPEX will likely come from falling battery technology costs through production and material innovations, and economies of scale. Since BESS use the same battery cells as electric vehicles, community batteries should benefit from reduced costs through high volume production.

8. Future Market Opportunities

The simulations in this report only consider current markets and revenue streams available to distribution level batteries. However, due to our changing energy system, new markets and revenue streams will be available in the 2020s and beyond. Some examples of these revenue streams are:

Fast Frequency Response: A market similar to current contingency FCAS markets but requiring a faster response, and which batteries are expected to be the key participant in.

Operating Reserve: A market where "fast-start" capacity is paid to be available and called upon in cases where traditional generators are insufficient to supply the system, such as high ramp rates caused by variable renewables, or correlated load patterns (such as many EVs switching on during the start of an off-peak tariff).

Inertia Market: Providing inertia services to maintain system stability. This is currently supplied by rotating generators such as coal and gas plants, but as they exit the system this will need to be procured from other sources. Batteries aren't rotational, but they can mimic this and provide "synthetic inertia" through advanced inverters[9].

Capacity Mechanisms: A fixed amount paid to generators based on how much capacity they can supply to the grid.

While it is currently difficult to predict when some of these markets come online due as they move through regulatory processes, and exactly how much revenue may be accessible in each market, we predict that participating in these future markets could generate 10-30% additional revenue over time.

[9] https://arena.gov.au/news/100-million-to-support-the-next-generation-of-grid-scale-batteries/

9. Future Network Value Streams

A ‘first-generation’ community battery system in the model of Fitzroy North 1 offers an environmental benefit to community members of the low voltage network by increasing the content of renewable energy in their evening consumption, while participating in energy markets to sustain commercial viability. However, there are possible future value streams in exchanging energy between the battery and local customers, or supporting the network itself.

Network support: Where the network is subject to peak demand constraints or excess solar exports, a community battery can be commissioned to be dispatched at critical times. This would be compensated for by network support payments.

Peak demand reduction: Demand charges are charges additional to consumption charges and are set by a property’s peak demand in a given time period (multiplied by the demand charge tariff). A business or institution could pay a fee to benefit from an innovative service of the community battery that effectively reduces their peak demand, thus reducing their demand charge. By discharging energy at the time a demand threshold is reached, a community battery could offset additional demand from the business, offsetting the peak as seen from the distribution substation of the low voltage network. This could deliver significant cost savings to the business and help to avoid costly network augmentation to manage high loads.

Demand response: Both AEMO and DNSPs have initiated Demand Response (DR) programs to manage high loads in constrained parts of the network by ‘smoothing over’ the variability of loads across the day in the distribution network. DR is known as a ‘non-network solution’ to this issue which would otherwise require infrastructure upgrades that would be unnecessary for most of the year. For example, at particular times in constrained areas, DNSPs may SMS DR program participants notifying them that they will be compensated if they can reduce their demand by a certain amount. Similarly, AEMO notifies Demand Response Service Providers who reduce their load accordingly. It is possible that CBs could provide a similar service, though perhaps in an unorthodox way.

EV charging from local solar: The owner of a PV rooftop solar installation may want to charge their electric vehicle parked in the street via the community battery that is directly connected to the charge point of the car. See also section 10 below.

EV supply to household: Based on the Vehicle-to-Grid (V2G) capability available with an increasing number of auto manufacturers, the owner of an EV may decide to use part of the energy stored in their vehicle to supply the evening consumption of the household via the community battery.

10. Electric Vehicle (EV) Charging

While it yet to be piloted, it is possible that the co-location or integration of EV charging stations with community batteries could open up a significant additional revenue stream. There is a strong rationale for pairing these two technologies at the same site:

- CB projects provide an opportunity to bundle installation, connection, earthworks, and other project costs (financial benefit).
- CBs are sites of community engagement in renewable energy; EV charging promotes interaction with, and understanding of, CBs, renewable energy and the energy system (social/educational benefit).
- Climate-friendly, affordable and convenient EV charging is of benefit to the local community (social benefit).
- EVs can significantly expand the amount of storage capacity available at the connection point by charging distributed, mobile EV batteries (40kWh-100kWh capacity). This would dramatically increase carbon abatement potential by maximising stored renewable energy, which could then be used to power homes beyond the CB's local LV network (environmental benefit).
- EV charging support load shifting from the evening peak demand period (4pm – 9pm) to the daytime peak renewable generation period (10am – 3pm), supporting the network with issues such as voltage management and variable loads (technical benefit).
- EV charging may provide an additional and significant revenue stream for the battery owner/operator.

We believe it is possible that, in the future, a single EV charging station's revenue could offset the OPEX of a single system (e.g. $10,000p.a. – $30,000p.a.). While this remains to be demonstrated in practice, it should be noted as EV charging co-location is potentially lucrative and likely to be trialled.

11. Ownership and Operation

11.1. Overview

Given we are experiencing the nascence of community batteries, there are few well-developed models for their ownership or operation. For this reason, this section outlines perspectives from current research and case studies, as well as YEF's own experience with Fitzroy North 1.

The existing energy system – the physical infrastructure, economic markets and regulatory environment – does not comfortably accommodate the community battery concept. Despite the clear benefits CBs convey, they also disrupt existing ways of doing things, and are difficult to categorise neatly for the purposes of tariff design or regulation. They are either a load or a generator depending on whether they are charging or discharging, and their various objectives – emissions reductions, profitability, network support – are occasionally in tension. CBs are also an emerging technology endowed with both great enthusiasm and uncertainty. As they establish their niche, CBs offer a kind of bargain by demonstrating their significant value to the energy sector, yet at the same time, compelling it to change. Grappling with this complexity is a challenge for all stakeholders, from the sceptical to the supportive.

For these reasons, there is a degree of ambivalence among stakeholders regarding who is best placed to own and operate CBs. For instance, while distribution network service providers (DNSPs) are in many respects ideal candidates, they face two significant hurdles: (a) in the NEM, DNSPs are barred from participating in energy markets under the AER's ring-fencing guidelines; and (b) they may be subject to a lack of trust in the energy sector by local communities. DNSPs therefore have minimal incentive to deploy neighbourhood-scale batteries outside of those intended purely to provide network support (although they could own the battery and lease its capacity to a third party under a waiver on ring-fencing rules agreed with the AER).

Local community groups are also sometimes suggested as owners or operators of community batteries. However, community members themselves have been ready to point out the challenges of community organisation, questioning the capability of most community groups to manage the requisite governance and financial processes, or whether they would possess sufficient technical understanding to effectively operate the battery.

These examples (and Table 13, following page) demonstrate that the stakeholders with appropriate resourcing and capacity to own and operate a community battery in practice are unlikely to be able to cultivate the requisite trust or social license to do so. Inversely, at face value, those who might have appropriate standing in their local community are unlikely to be suitable battery operators.

11.2. Models of Ownership and Operation

As community batteries remain an incipient niche in the energy market, it is unclear what model of ownership and operation is most effective and delivers the best profile of benefits to stakeholders. Below, we outline – in general terms – some combinations of ownership and operation we consider potentially viable and note possible challenges and benefits each conceptual arrangement might face.

1) **Not-for-profit / social enterprise owned and operated:** This is currently the arrangement for Fitzroy North 1 (owned and operated by YEF). In this arrangement, the owner/operator requires both technical and commercial expertise or the capacity to resource this externally and would require good standing within the community to establish trust and social license. It may be effective to incorporate aspects of model 3 by allowing for community investment in a form of 'hybrid ownership'.

   Advantages to this are that the owner-operator is ideally committed to equitable distribution of benefits and positive, community-minded governance, and likewise enjoys the benefit of community support. Disadvantages include limited financial and other resources, the possible necessity of outsourcing specific capabilities for operation, and the rarity of this combination of expertise and community standing.

2) **DNSP owned, fully or partially leased to third party:** This model addresses the issue of NEM ring-fencing guidelines by enabling the DNSP to own the battery without benefiting directly from its participation in the NEM. The DNSP could either segment the battery and use some of its capacity purely for network support and lease the remaining capacity to a third party to operate or lease the entire capacity – especially if the lessor's operating model was beneficial to the network. In this case, the DNSP's business model depends on revenue from a fixed lease fee, and it could potentially add the battery's CAPEX to its Regulatory Asset Base (RAB). The third party would operate the battery to profit from the various energy markets (minus the lease fees).

   This model capitalises on the existing expertise and structures within the DNSP without sacrificing the benefits to be had from participating in markets (including the environmental benefits from arbitrage), but may not be viable for the third party depending on the balance of revenue and fees. It is also unclear whether adding battery costs to the RAB could engender inequitable distribution of costs and benefits among the public. The extent to which a battery following this model could be considered a 'community battery' (rather than simply a neighbourhood-scale battery) is also questionable, unless the third party operator was a community-led or focused organisation.

3) **Community owned, operated by not-for-profit / social enterprise:** This model is similar to model 1, but enables community involvement through investment. This could be done in a number of ways similar to existing community-owned renewable energy projects, including through a co-operative, community investment fund or similar. In this case, the ownership model may depend to some extent on the battery's business model – for instance, whether it involves a form of subscription, special benefits for 'shareholders', the possibility or otherwise of virtual net metering or virtual storage, etc.

   A key advantage of this model is the level of community empowerment and participation in the clean energy transition and the path this could break for others in the space. It also avoids the challenges of community-led operation of the battery (e.g. scarcity of technical expertise and financial resources, undeveloped or insufficient governance structures). However, the variable net profits and financial risks of a community battery relative to its CAPEX may not present investors with an appealing proposition. It may be difficult for investors to achieve a strong return on their investment, and community ownership occur due to something akin to values-based donation rather than entrepreneurial investment. As such, a disadvantage of this model is the difficulty in raising funds from a community, and the unlikely availability of loan capital to backfill the missing funding. Combined with uncertainty on returns, this model can be challenging.

4) **Privately owned and operated (retailer or other):** In this model, a private commercial business (such as a retailer, technology company, start-up, etc.) takes on ownership and operation of the battery alone. A private entity may well have the financial resources to manage financial risks and recruit sufficient technical expertise to operate the battery. An obvious challenge for the business would be establishing trust among local residents, and a concern may be the commitment of the business to environmental and community benefits – especially as it would, in all likelihood, pursue a profit-first business model. It is unlikely that this model would constitute a 'community battery'.

   In the case of retailer ownership, attractive retail tariffs could be offered to customers who choose to change retailers. This option would only be attractive to the retailers if there were a shift en masse to their customer portfolio. As community batteries become more widespread, this option could eventuate.

5) **Local government owned, operated by third party:** Councils are in some respects well suited to owning community batteries, as they are local infrastructure assets and align with local government sustainability and community engagement priorities. A council could also either contract the operation of the battery by a third party by paying them a fee-for-service, or lease the battery to a third party as in model 1, thereby reducing the complexity of council involvement.

   Councils have the advantage of being generally stable organisations with strong governance structures and financial resources, the capacity to hire or contract expert professionals if required, and are trusted by the community. However, as community batteries are yet to be 'normalised' as accepted and valued parts of the energy system and society, risk-averse councils may be hesitant to commit financial or other resources to ownership or operation of community batteries, and may be cautious regarding the potential for any adverse public sentiment.

6) **Public institution owned, operated by third party:** Depending on the institution, this model could work in a similar way to model 5 in that the institution would engage an external party to manage the battery on its behalf. The public institution could be a university, a hospital, a school or similar, and its role and involvement would depend very much on its capability to engage with the project and its requirements. This model has promise if the battery were able to provide significant benefits to the institution as an 'anchor customer' – for example, the battery could significantly reduce demand charges, or operate behind-the-meter and provide energy storage while still participating in certain markets.

   Public institutions generally enjoy good standing within their local communities, and often have well-developed governance processes and project management capabilities. However, there may be limited energy expertise, and the arrangement with the third party would determine the scope of community benefit that could be derived from the battery.

Table 17 Comparison of possible owner/operator candidates

	DNSPs	Retailers	NFPs / social enterprises	Community groups	Public institutions	Local governments	Commercial businesses
Sufficient technical expertise	Yes	Yes	Maybe	No	No	No	Yes
Effective and robust governance structures	Yes	Yes	Yes	No	Maybe	Yes	Yes
Can participate in energy market	No	Yes	Maybe	Maybe	Maybe	Maybe	Yes
Trusted by community	No	No	Yes	Yes	Yes	Yes	No
Can take on financial risk	Yes	Yes	Maybe	No	Maybe	Maybe	Yes
Can develop and deliver project	Yes	Yes	Yes	Maybe	Yes	Yes	Yes

12. Conclusions and Recommendations

This report addresses the opportunity presented to community batteries as emerging technologies in volatile markets and outlines the business case of a single community battery system, based on the concept YEF developed for Fitzroy North 1 battery. There is, therefore, a level of uncertainty inherent to the analysis, and we have tended towards using conservative estimates to avoid setting unrealistic expectations. However, although this uncertainty can impede precision, it may also give rise to more favourable market conditions than those modelled in this report. The COVID-19 pandemic, global conflict, subsequent supply chain issues, and soaring fuel and energy prices are significant interventions in business-as-usual market dynamics. The Australian energy crisis of this winter (2022) is far from resolved, and it remains unclear what effects this may have on the various energy markets and any implications for the profitability of LV energy storage.

What does seem clear is that the next decade will see an unprecedented growth in distributed energy resources (DER) and energy storage of all kinds. The integration of these resources with the existing network infrastructure will be challenging for all key stakeholders, and community batteries are one of several options that must be trialled to support the clean energy transition and decentralisation of the energy system. We believe that community batteries are a cost-effective, multi-functional and elegant solution to a complex suite of challenges facing the energy system, that provides significant environmental and community benefits. Our hope is that local communities can play a key role in this transition, and that community participation will engender an equitable, accessible, democratic, and decarbonised energy system.

This study indicates that a BESS in the City of Port Phillip can be profitable and would be financially viable. Net profit is expected to be positive in every year of the High scenario, the first 9 of 10 years in the Medium scenario, and despite making a profit in only 5 of 10 years in the Low scenario, still makes a modest net profit over 10 years. We consider the Medium scenario to be somewhat conservative (with higher prices more likely than lower prices), but the most likely of the three.

The revenue analysis considered three values streams: wholesale spot market arbitrage, FCAS markets (raise and lower), and network tariff arbitrage. Of these, wholesale spot market arbitrage makes up the highest proportion of revenue, followed by FCAS (predominantly raise), and then network tariffs. FCAS revenue appears less certain than wholesale arbitrage when comparing the three scenarios.

The slim margin between revenue and OPEX means the road is long for community batteries to become attractive to investors. As such, community battery projects currently rely on alternative funding sources such as government grants for implementation, as the payback period is significant. However, as BESS systems use the same battery cells as electric vehicles, they are expected to benefit from volume production cost reductions, which will improve the ROI. However, this applies to future systems.

For a greater return on a Port Phillip system, new revenue streams need to be developed in both energy markets and network opportunities. The latter will be enabled with innovative tariffs in the low voltage network, were they to become a reality in the medium term. A second priority is to reduce operating costs with economies of scale of a portfolio of systems. It is estimated that a portfolio of 10 systems would reduce the operating expenses of each system by 50%. In order to lower construction costs, a necessary improvement is to standardise connection methods to remove the need for engineering works for each connection point.

Beyond purely financial considerations, community batteries offer a pathway to a greater supply of renewable energy in customers' consumption. They promise to unlock monetary and environmental value in solar generation which is currently curtailed, enable more solar to be installed, avoid costly network augmentation, and reduce costs and emissions from issues such as overvoltage, that may be quantified in the future. While these benefits do not translate into battery revenue streams, they may facilitate support from the local council and favourable land lease fees.

It is impossible to convert into financial metrics the range of substantive, intangible and potential future benefits that community batteries can provide, and that has not been the intention of this report. However, applying a purely financial lens overlooks the fact that the decarbonisation of the energy system is an existential imperative. As such, a low ROI is not detrimental to the case for community batteries. Rather, it is an indication of the current landscape of opportunities for community batteries, and their emerging status and function, within an energy system on the precipice of rapid transformation. We suggest that community batteries are a unique solution to enable this decarbonisation, and it is encouraging that even at this early stage, the business case appears profitable in the medium term.

We recommend that a BESS in the City of Port Phillip would deliver significant environmental and social benefit – especially in terms of capacity-building and knowledge-sharing for future projects – while being a financially sustainable. Each new community battery project offers the opportunity to trial different models and other innovations, such as EV charging or multiple connection points. The learnings from such a project can help progress towards for more lucrative and beneficial solutions for local communities.

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