YARRA ENERGY FOUNDATION

Neighbourhood Battery Initiative

Final Report: Yarra Community Battery Project

October 2022

This report was prepared by **Yarra Energy Foundation** (YEF) upon completion of the YESS FN1 Community Battery Project in Fitzroy North – Melbourne, with grant funding from the **Victorian Government** under the **Department of Environment, Land, Water and Planning** (DELWP) **Neighbourhood Batteries Initiative** (NBI).

Authors

Chris Wallin

Energy & Storage Programs Manager

Yarra Energy Foundation

Lachlan Hensey

Energy & Storage Project Officer

Yarra Energy Foundation

Tim Shue

Chief Operating Officer

Yarra Energy Foundation

information@yef.org.au | +61 3 7037 6040

The project included significant contributions from a group of dedicated partners the Victorian Government's Department of Environment Land Water and Planning, the City of Yarra, CitiPower, The Australian National University's Battery Storage & Grid Integration Program, Pixii, Acacia Energy, Ventia, Mill Software, and Polarium. Sincere thank you to everyone involved, with special thanks to the Community Reference Group.

Photographs by Matt Krumins, courtesy of the City of Yarra.

Battery artwork by Hayden Dewar. *Set the controls to harness the sun*, 2022, acrylic and aerosol paint, 220 cm x 310cm x 80cm.

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1. Introduction

1.1. Yarra Energy Foundation

Yarra Energy Foundation provides services and advice to communities and businesses who want better energy, to achieve a net-zero emissions future.

Yarra City Council established the Foundation as an independent not-for-profit in 2010, and the council remains our core funder. We partner with others to bring expert sustainability services beyond Yarra's borders and are governed by an independent board of directors.

1.2. Community Batteries

A community battery (CB) is an energy storage system sized between a household battery and a large, utility-scale battery that *involves and benefits the local community*. The latter 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.

1.3. Yarra Energy Storage Systems

YEF has a vision to deploy hundreds of community batteries across the CitiPower network and beyond. This vision, called Y*arra Energy Storage Systems* (YESS), is the basis of a partnership between YEF, CitiPower and the Australian National University (ANU) Battery Storage and Grid Integration Program (BSGIP).

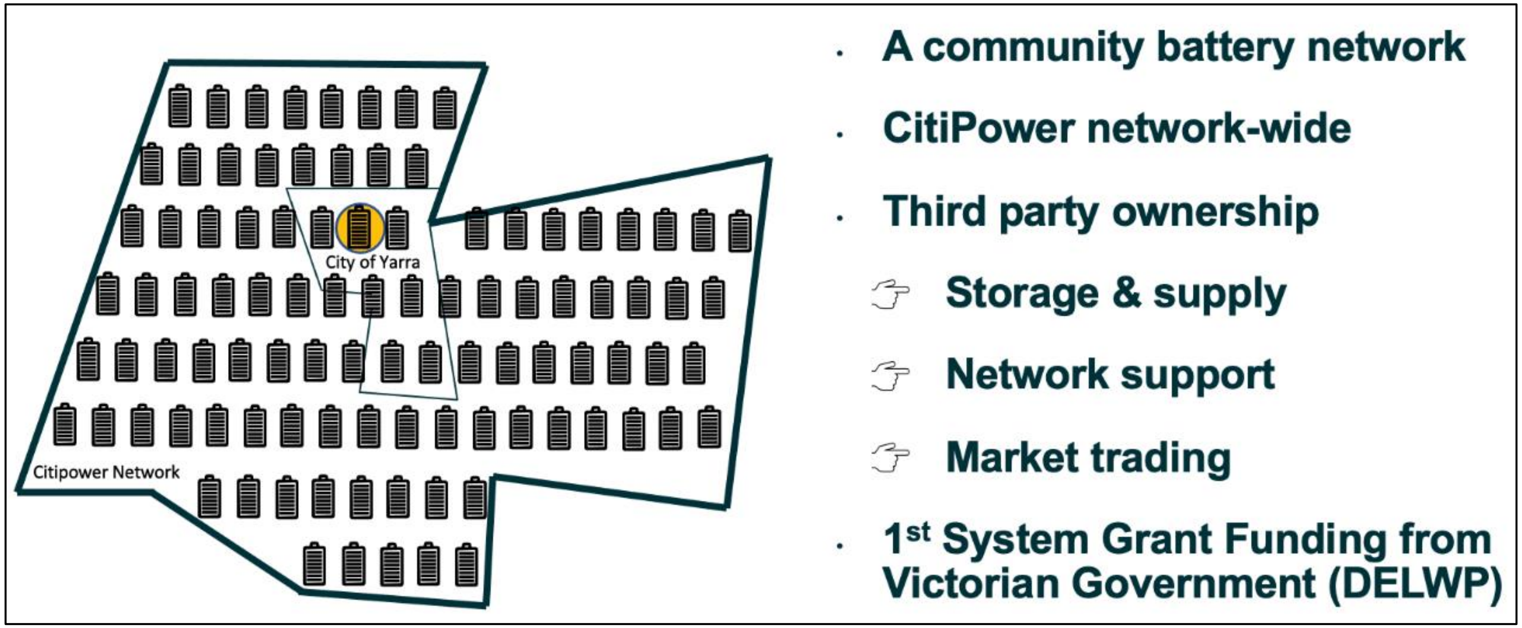


Figure 1: The Yarra Energy Storage Systems vision

The partnership was formed in early 2021, initially as an investigation by CitiPower and YEF into the viability of CBs, and later joined by ANU's BSGIP organisation. As will be seen in the technical section of this report, the background intellectual property created by BSGIP was well-suited for use in the development of the control system of the Yarra battery energy storage system (BESS). BSGIP's goals were also well aligned with YEF's commitment to the community.

In late 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 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 Action, the Hon. Lily D'Ambrosio.

The Fitzroy North 1 (FN1) project was delivered with a 110kW/284kWh Pixii PowerShaper Battery Energy Storage System (BESS) with Acacia Energy acting as the system's retailer and aggregator.

Figure 2: The Fitzroy North 1 community battery was launched on World Environment Day, June 5, 2022.

1.4. Structure of this report

This report discusses each major facet of the Fitzroy North 1 (FN1) project as presented below in the form of the roadmap that YEF and partners followed.

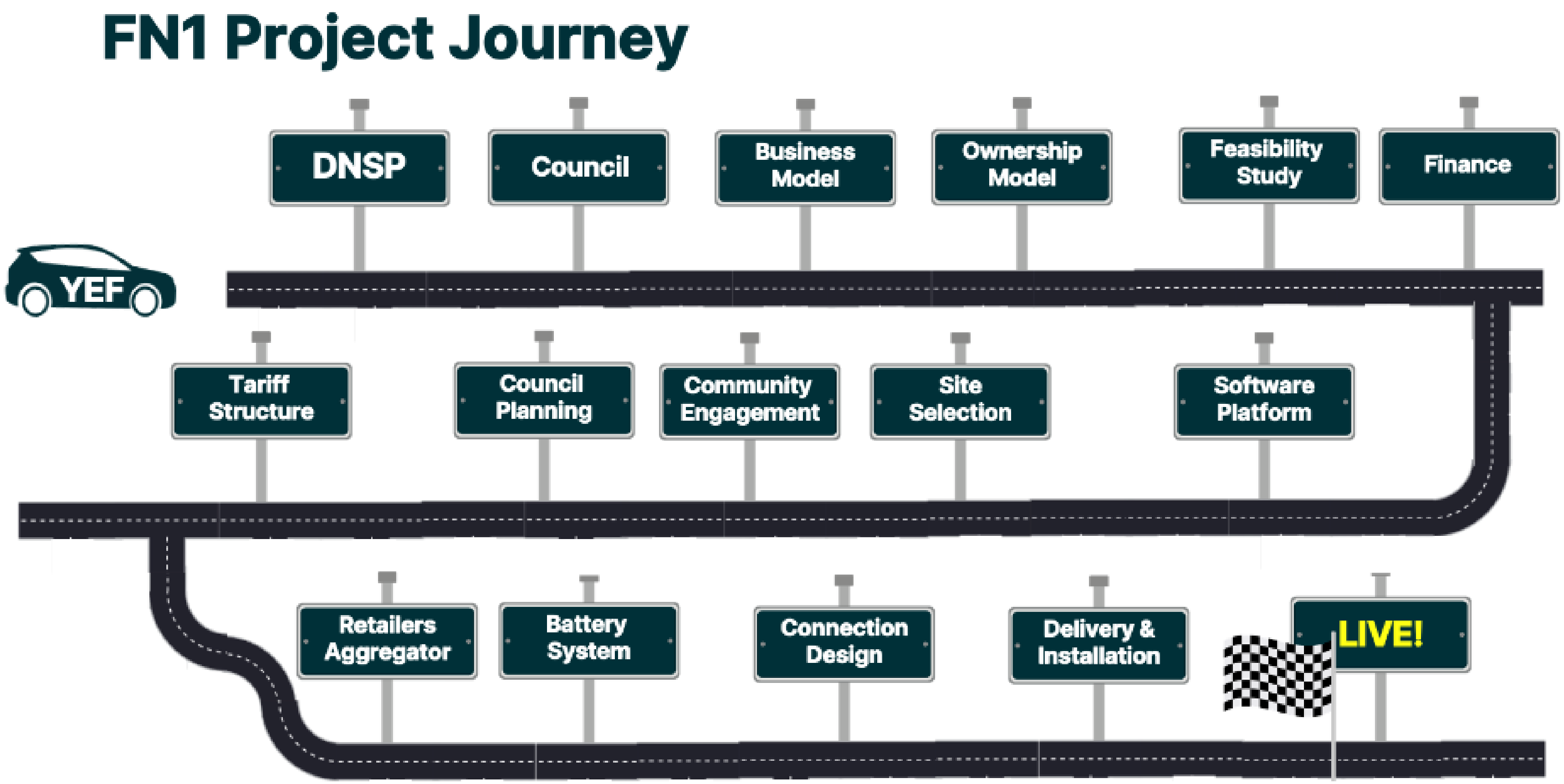


Figure 3: Fitzroy North community battery project journey, illustration of key steps from inception to launch.

All areas are included in five major sections that cover the technical, business, siting, community, and connection aspects of the project.

A summary of all sections is provided below.

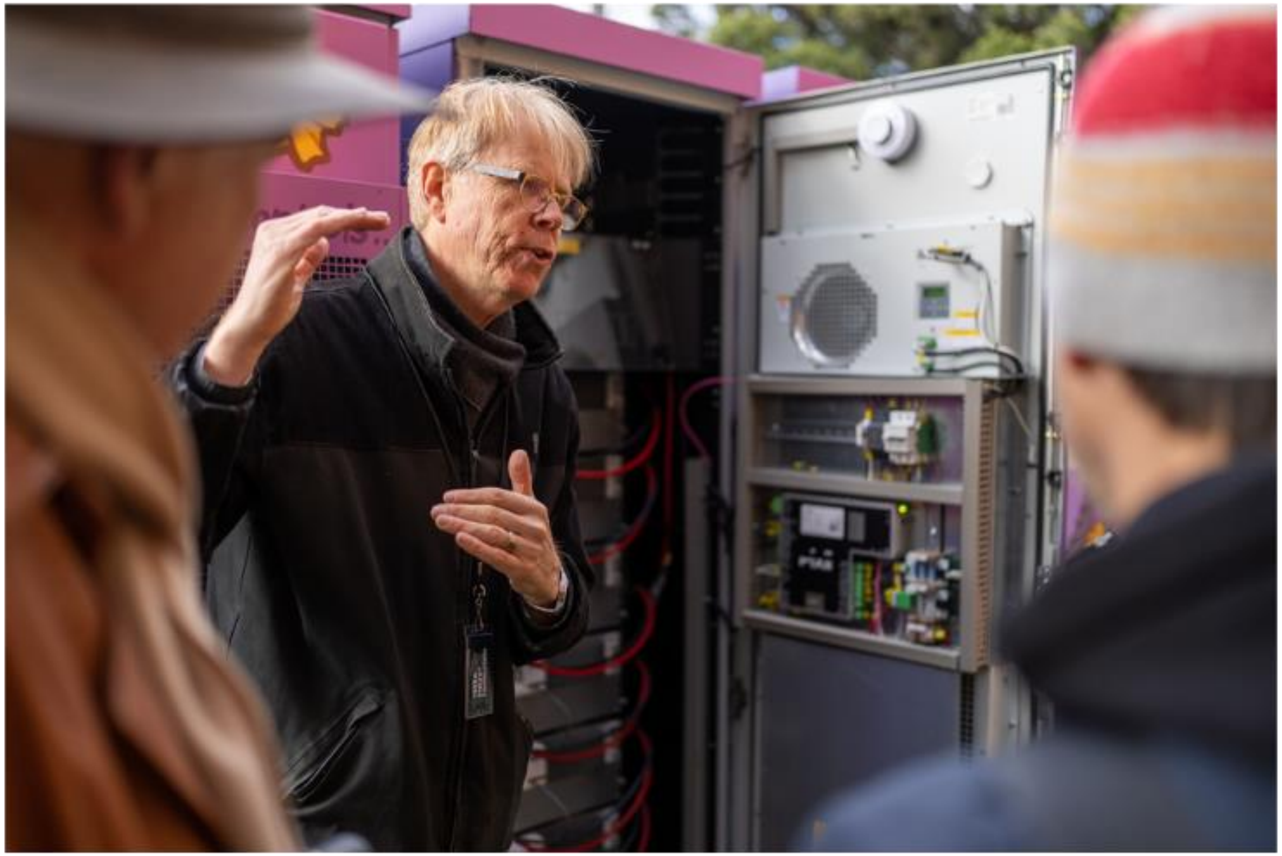
- Section 2: the project objectives and strategy.
- Section 3: the process of qualifying and procuring the BESS.
- Section 4: the development of a viable business model and tariff.
- Section 5: the site selection process
- Section 6: YEF's community engagement strategy and experience.
- Section 7: the connection process.
- Section 8: the final conclusions, including remaining questions.

Each major area of the project is discussed in three steps:

1. How we started
2. What we learnt
3. The outcome

The purpose of the three steps is to demonstrate that *you don't need all the answers to get going*. The understanding we had at the beginning changed as we progressed, which made us change our approach, which in turn led us to an outcome we did not foresee at the outset. This is often the nature of innovative projects.

This document is both the final report submitted to DELWP and a guide to assist proponents of other Community Battery (CB) projects in their planning and decision-making.



2. Project Objective and Strategy

YEF’s main objective for this project was:

To prove to industry and community at large that low voltage-connected mid-scale community batteries are commercially viable.

Achieving this objective could catalyse wide-spread adoption of YEF’s business model, an outcome that will contribute to accelerating the big energy transition.

To this effect, it was important to position the project as the first in a series of replicable systems rather than a trial with unknown continuation.

Our strategy is as follows:

1. Focus on inner-urban environments

Inner-urban neighbourhoods are the most challenging due to space constraints and population density. They are also a beneficial context for CB implementation because of greater localised production and consumption.

Moreover, an inner-urban CB is the ‘hard case’ because (a) the population density brings noise, safety, and aesthetics to the forefront, and (b) suitable sites on common or private land are difficult to find. The success of this project could see the model easily replicated in less challenging areas of outer suburbs and regional areas.

2. Keep the business model simple

As a first implementation, it is important to ensure that the system has a solid foundation to build upon for future generations of the technology, additional value streams and benefits, novel use cases, and for ease of replication – i.e., “walk before you run”.

3. Add value streams as practical

In line with the earlier point, the first system would provide a base value stream to the community and the network, such as trading on the electricity market for both energy and Frequency Control and Ancillary Services (FCAS).

As the business, regulatory environment, and industry mature, more value streams can be added to the commercial model.

For example, new markets may emerge that the battery could participate in.

4. **Establish a replicable infrastructure for future systems**

The work required to qualify a suitable hardware platform, a software solution and commercial arrangements will benefit, and can be leveraged for, future installations.

5. **Make our infrastructure available to others**

An implication of YEF's main objective is that the project aims to show that CBs can be sustainably operated by third-party organisations and others beyond existing energy market participants or distribution network service providers (DNSPs).

To support CB proliferation, YEF have publicised our technical solution and commercial arrangements. All software developed with grant funding is intended to be placed in the public domain, allowing others to leverage its functionality.

6. **Source locally and environmentally where possible**

In alignment with YEF's *raison d'être*, we aimed to source all solutions with the least embodied carbon emissions, where possible. This aim was a criterion in the procurement process for the BESS.

7. **Investigate community ownership**

As the recipient of the Victorian Government grant, YEF is both the owner and operator. However, YEF would like to investigate economical and practical ways for community members to become shareholders of their local battery system in the future.

3. The Technical Solution

3.1. How we started

In 2021, there was no community battery-oriented equipment or Energy Management System (EMS) available on a manufacturer's price list, and most manufacturers offered either household or grid-scale batteries.

Typically ranging from 100kW to 5MW in power capacity, mid-scale BESS were usually targeted at commercial and industrial sites and connected *behind-the-meter* (BTM). In some cases, these systems could trade on the electricity market through the retailer's proprietary EMS.

EMS platforms were sold for use in Virtual Power Plants (VPP) of household batteries, grid-scale batteries or as Distributed Energy Resources Management Systems (DERMS) for electricity distributors and gentailers. However, there was no existing software for *front-of-meter* (FOM) community batteries.

We decided to carry out a BESS procurement tender after having engaged with two dozen battery manufacturers, both local and international. We also conducted a request for information with prominent software service providers in the BESS industry.

3.2. What we learnt

Hardware

We found that there were three main categories of battery systems in the market:

1. Lithium-ion-based systems
2. Flow batteries
3. Other or emerging chemistries and solutions

Of the three options, only Lithium-ion-based systems were financially viable and had a small enough footprint for an inner-urban setting – particularly the Nickel-Manganese-Cobalt (NMC) chemistry, which is the most energy dense.

There were concerns about the safety of lithium-ion technology because of past fires, the Victorian Big Battery fire during commissioning having raised the spectre of danger.

Our research provided substantial evidence that in 2022, **there would be no reason for a high-quality Lithium-ion battery system that has passed all inspections and tests during commissioning to catch fire**, unless the external environment were ablaze. This supported our ultimate choice of a NMC lithium-ion-based BESS manufactured by *Pixii* (Norway).

The tender also revealed a major finding: *only BESS systems that come off a production line can be price competitive.*

Since affordability is dependent on economies of scale, bespoke battery systems cannot compete on price. Unfortunately, this was a blow to the local industry, which is currently largely bespoke. Although some Asian manufacturers made bids substantially below our stated $1000/kWh threshold for submission, their systems were not technically compliant.

We also discovered that most systems had a noise level of more than 70dB at 1m, which we deemed as problematic. For an idea of noise levels, consider the following table.

Table 1: Comparison of ambient noise levels

Sound	dB	Comparison
Garbage disposal, dishwasher, freight train at 15m, diesel truck (60km/h) at 15m	**80**	Twice as loud as 70dB; possible damage in 8-hour exposure
Car at 80km/h at 8m (77dB), freeway at 10am at 15m (76dB), radio or TV audio, vacuum cleaner (70dB).	**70**	Arbitrary base of comparison; upper 70s are annoyingly loud to some.
Conversation in restaurant, background music, air conditioning unit at 30m	**60**	Half as loud as 70dB; fairly quiet.
Quiet suburb, conversation at home, large electrical transformers at 30m.	**50**	A quarter as loud as 70dB.
Library, bird calls (44dB); lowest limit of urban ambient sound	**40**	An eighth as loud as 70dB
Quiet rural area	**30**	
Whisper, rustling leaves	**20**	
Breathing	**10**	Barely audible

Given the population density of inner-urban areas, the noise the system emitted was a primary selection criterion so we could ensure that the CB was not disruptive to nearby neighbours.

Software

To meet our main objective of commercial viability, it became paramount to keep the cost structure (ongoing operating expenses) very lean. The cost structure is detailed in section 4. We considered several software options, discussed below.

For a fee, a community battery could be managed by a retailer, thus bypassing the need to find an EMS platform. The retailer would dispatch the system based on its own market participation software platform. This would be much simpler, particularly if the cost to modify their platform were absorbed by the retailer. However, this surrenders a level of agency and oversight on current and future functionality, and the model would only be replicable in partnership with that retailer.

The cost of modifying existing VPP and DERMS platforms to accommodate the needs of a CB could be absorbed in the capital expense of the initial procurement. However, we found that the annual license fees expected by the supplying organisations could never be offset by the projected revenue of a single system.

The Battery Storage and Grid Integration Program (BSGIP) at ANU had developed economic modelling software (c3x) used for research on CBs. BSGIP was interested in expanding c3x to becoming an operational platform. Most importantly, c3x was open-source, meaning that there would be no licensing required for its use.

3.3. The outcome

Hardware

The selected system was a *Pixii PowerShaper* 110kW / 284kWh in three panels, plus a combined meter panel / switchboard. It was by far the most competitive and appropriate offer, both commercially and technically. Unfortunately, the company is not local, but it demonstrated the strongest environmental credentials of embodied energy and recyclability.

The Pixii battery panels are made of:

a) Converters called '*Pixiiboxes'* (rectifying AC to DC, inverting DC to AC) in rows of three – one per phase, and each rated at 3.3kW.

b) Battery modules supplied by *Polarium* (Sweden), operating at 48VDC and each storing 12.9kWh. The maximum DC current is 100A per panel. The battery cells within each module are sourced from *Northvolt.*

Each panel has a controller called a 'gateway' which can be configured for independent operation or as part of a bigger system. In the latter case, a 'master' is configured with the other panels becoming 'clients', thus appearing to an EMS as a single logical system.

Panels produced for Australia are fitted with an air-conditioning unit which is the main source of noise. Thanks to internal acoustic insulation, the PowerShaper was the quietest of all submissions to the tender with a maximum of 63dB at 1m.

The final system installed by *Ventia* on behalf of *Pixii* came with three panels for a total of 110kW / 284kWh in the following configuration:

- Master: 30kW / 90kWh
- Client 1: 40kW / 90kWh
- Client 2: 40kW / 103kWh

YEF is currently considering an upgrade to make all panels equivalent for a total of 120kW / 309kWh.

Figure 4: A Pixii PowerShaper battery panel like those installed in Fitzroy North

Figure 5: The Fitzroy North community battery comprising multiple Pixii PowerShaper battery panels.

The *Pixii* system was priced competitively regarding both procurement and maintenance fees. It met all technical requirements. These can be summarised as follows.

- adequate system size,
- technical compliance including adherence to relevant standards and rules, noise level, safety, and footprint.
- total installed and ongoing cost
- delivery lead time,
- warranty on parts and performance
- environmental credentials
- FCAS capability

Pixii met our environmental requirements thanks to the following:

- Battery cells by *Northvolt* are manufactured with 100% renewable energy
- Up to 95% of all materials in NMC cells can be recycled into producing new cells.

The system comes with a combined meter panel and switchboard of the same dimensions as the battery panels. As a public asset, the visual appearance plays an important role in cultivating local support, showcasing the battery, and enhancing rather than detracting from the surrounding environment. The meter panel / switchboard is the leftmost panel in the picture of the installed battery on the previous page.

Software

We decided to use a major part of the NBI funding to expand the c3x modelling tool and turn it into an operational platform, the *Battery Control System* (BCS). It will be open-source and therefore available for others to use in future BESS deployments beyond YEF.

The BCS comprises an *Optimiser* developed by **ANU** as the domain expert and creator of the c3x modelling platform. The optimiser makes minute-by-minute decisions on how to dispatch the system for every 5m time interval over the following 24 hours, and for each electricity market the system participates in. The system can also operate in two other modes: *Schedule,* in which specific, static parameters are set by which the battery makes time-band decisions (e.g., charge between 11am and 4pm below a price threshold, discharge between 4pm and 9pm above another price threshold); or *Manual*, in which the BESS responds to direct commands.

Mill Software is a software company specialised in mission-critical applications for the telecommunications industry. They are the system integrator and provide the IT infrastructure and support for the project. Their main role is to provide data pathways between the trading plans and the system dispatch. This is carried out through the Controller and Adapter modules with associated subsystems. Mill also provide the user interfaces for internal management and supervisory access as well as the alarms, operational control, and reporting.

The architecture is shown below.

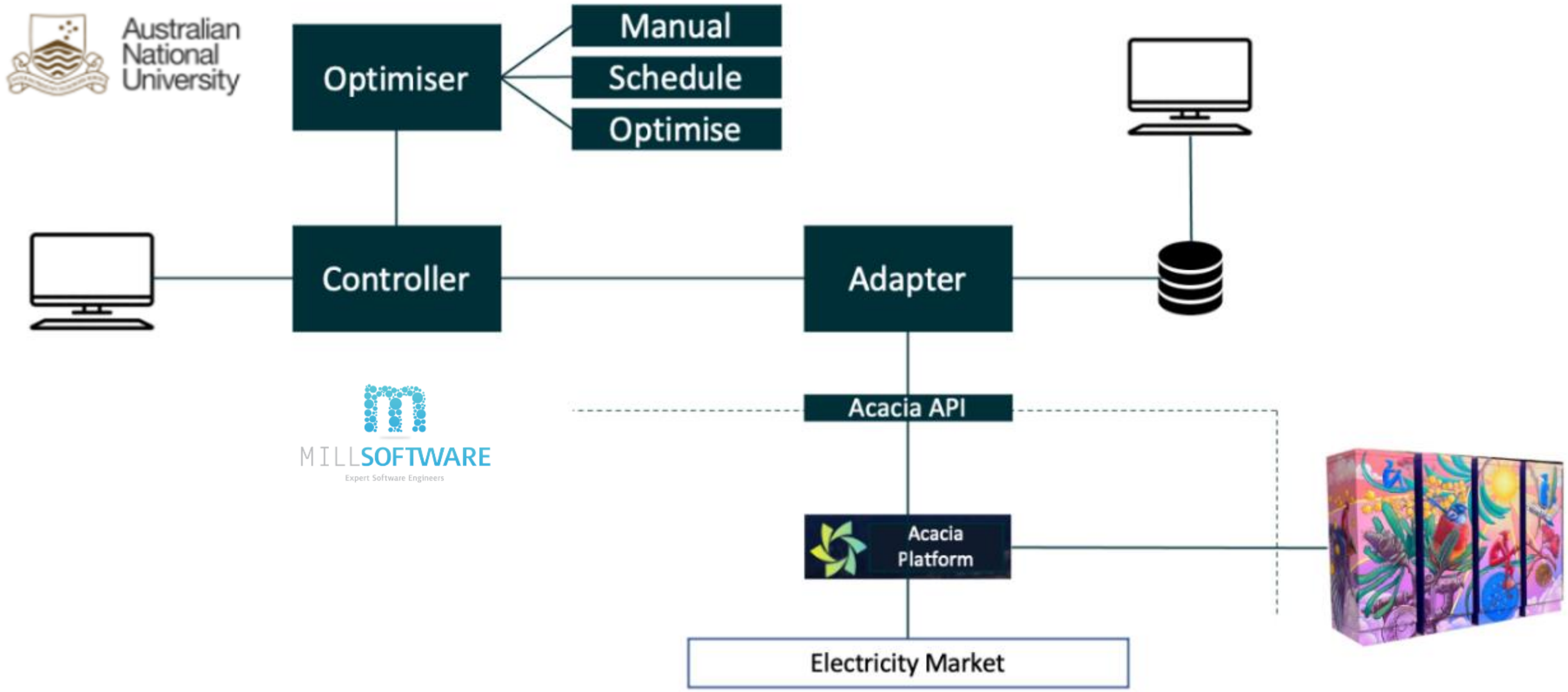


Figure 6: Diagram of FN1's software control architecture.

For the purpose of market participation, the FN1 system is aggregated by **Acacia Energy**, the Financially Responsible Market Participant (FRMP), who dispatch the system upon YEF's instructions (see section 4 for more details).

4. Business Model and Tariffs

4.1. How we started

At the time this project commenced, the main precedent in CBs were in Western Australia, where 13 systems had been deployed by Western Power under the *PowerBank* denomination. Ausgrid was also in the process of installing their first CB in Beacon Hill, NSW. In both cases, the focus was on '*virtual storage*' which consists of storing the exported energy from solar customers and allowing them to import that same energy at night.

United Energy had deployed two pole-top batteries on Melbourne's bayside. Their role was primarily to reduce peak demand on certain days of the year, and lease to a retailer the use of the asset the remainder of the time. While technically not *community* batteries, they can be considered neighbourhood batteries.

Feasibility Study

Our first point of call was to recruit an energy consultant to assist us in developing a feasibility study, knowing however that there was little knowledge of community batteries in the industry. This led us to carry out a Request For Proposal (RFP) and three companies made submissions. We selected CutlerMerz in a co-design capacity, allowing us to review initial results and provide inputs.

The final report indicated a significant financial upside to the project, based on revenue from both solar and non-solar customer subscription fees. It assumed a zero-network tariff for the battery and subscribers importing from the battery. It also implied a negotiated arrangement with CitiPower.

The assumptions made in the study were not validated during project execution. YEF's work with CitiPower on LUOS tariffs (see below) led to a different set of assumptions. However, the CutlerMerz study was an excellent starting point for the ensuing conversations with CitiPower and electricity retailers.

Note: YEF have developed our own feasibility study service since the beginning of the FN1 project. It is based on the above-mentioned c3x modelling platform. We carry out economic modelling for all front-of-meter community batteries and behind-the-meter installations with solar generation, Electric Vehicle charging and internal consumption.

LUOS and Market Trading

Initially, YEF took the same approach as Western Power's *PowerBank* model and began exploring commercial arrangements.

There was no tariff for community batteries, but thanks to YEF's partnership with CitiPower, we had the opportunity to discuss potential low voltage network trial tariffs. The concept of *Local Use of System* (LUOS) was actively discussed in the industry and a draft trial network tariff was eventually defined as:

- Off-peak tariff at peak times for customers subscribing to the CB
- Peak tariff at peak times for non-subscribing customers.

The off-peak network tariff at peak times would allow the battery to bill a subscription fee to the customer, the total cost being less than the peak network tariff. This would result in a small discount of 5-10%.

To bid on the Frequency Control and Ancillary Services (FCAS) market, AEMO requires market participants to have a minimum 1MW power capacity. This required YEF to look for a retailer to aggregate the BESS with other assets. Such a retailer, also called a retailer/aggregator, would own or manage all assets registered in their portfolio and for each electricity market.

4.2. What we learnt

As the project progressed and our conversations in the industry and with community members evolved, we discovered several factors that would change our thinking.

1. **A community battery waiver tariff is essential.** A major factor in determining business profitability is the network tariff. On small or medium business tariffs, a battery business would pay a demand charge and a per- kWh charge. Our modelling shows that the business case substantially deteriorates under such conditions.
2. **In CitiPower's network, tariff concessions would only be given to any customer – household, business, or CB – who changed their consumption patterns to benefit the network.** This meant that the CB would benefit from a tariff concession because it supports the network, mainly by reducing demand during the evening peak.

   On the other hand, customers on the same LV network would not receive any benefit because it is assumed that they would maintain the same consumption profile as before the battery was installed. This view was shared by the AER who promoted a bi-directional tariff of charge and reward.

The new tariff policy meant that the expectation of a small discount to subscribers of the CB could no longer be met – at least not from a tariff perspective. The only option would be to share the profit generated by the CB with the local community.

As discussed later in this report, setting that expectation on a first-of-its-kind system was a significant risk to YEF. It also begged the question on how to share the profit equitably and without further complexity.

This situation posed a challenge for YEF. How would we articulate the value to communities if there were no financial benefits?

3. **Virtual storage is not economically viable.** As we modelled the service of storing customer-exported energy and supplying that energy in the evening, we realised that there were on average not enough solar customers for a reasonable service fee. The energy retailing, billing and customer service was also complex and required a more substantial and costly infrastructure.
4. **Virtual storage may not be seen as equitable.** If there were 30 solar customers on a low voltage network of 200 customers, only 15% of the local population would benefit from the use of common land and the installation of a dedicated asset for at least a decade.

   On the other hand, if 85% of local residents have solar panels, or non-solar households can purchase cheaper renewable energy from solar exporters, this point is of less significance.
5. **There was no other independent CB project**. The only other organisation involved in the CB space that was not a commercial retailer, gentailer or DNSP was Enova Energy – a community-owned, not-for-profit retailer. At the time, Enova Energy were preparing to launch a 1MW / 2MWh CB with plans to offer power purchase agreements to its customers/owners. Unfortunately, this project was not realised, and Enova have since ceased operations.
6. **The FCAS industry is dominated by the large gentailers**. Very few second-tier companies offered FCAS in Victoria. This meant that we would engage with either a large corporate organisation or a smaller company with a current or near-term planned FCAS aggregation capability.
7. **FCAS is a shallow market**. Even with additional ancillary services being introduced by AEMO, the FCAS market will be serviced by many batteries, predominantly of grid-scale. It is unlikely that FCAS revenue to a mid-scale battery will be of significance in years to come.
8. **Arbitrage is the only predictably monetizable value stream**. Buying at low prices and selling high remains

the most predictable source of revenue for a community battery.

The energy crisis at the time of writing created a significant price spread between the solar dominated mid-day and the coal dominated evening. However, it is anticipated that volatility in electricity prices will reduce over time as fossil fuel generators are retired. This calls for other forms of revenue generation.

9. **Most CB proponents tend to overlook Operating Expenses (OPEX).** To our surprise, most of our industry contacts overlooked the running costs of a battery and assumed that revenue would flow to profit. Their focus was on the Capital Expense (CAPEX) and the revenue, which they took for direct profit from operations. As shown in the next subsection, OPEX is a significant reducer of profit.

4.3. The outcome

YEF decided to stick to our strategy of a very simple business model and remain transparent to customers. We made the following decisions.

1. **For now, only trade on the electricity market.** Our first system would generate revenue purely from trading on the market for both arbitrage and FCAS. The spot price can act as a proxy for the value of renewable content of the energy supply, which is also much higher in daylight hours when the battery is scheduled to charge. In later revisions, and as the storage industry and regulations mature, value streams would be added.
2. **Limit trading to benefit the environment**. Instead of buying electricity whenever the price is low (e.g., in the middle of the night), we would charge the battery in the window of 10am to 4pm (when solar generation is the greatest), and discharge between 4pm and 9pm (one cycle per day). In this way, we maximise the renewable content of the stored energy and offset fossil fuel generation that is predominant in the evening and overnight.
3. **Focus on the environmental benefit.** Our message to the community changed from including a small financial benefit to only focus on the fundamental value of a CB in our climate crisis: to reduce greenhouse gas emissions. At the time of writing, it was difficult to

quantify the impact of a CB on emissions, although the baseline (minimum) emissions reduction could be calculated based on the emissions intensity of the grid when charging and discharging.

4. **CitiPower introduced a CB tariff.** The tariff is an essential foundation for the BESS as a business – without it, it would not be possible to financially justify its operation. As shown below, the tariff is bi-directional, meaning that it rewards network supportive behaviour (charging in the middle of the day / discharging during peak demand times), but penalises charging at peak demand times.

Table 2: CitiPower's non-distributor owned community battery trial tariff[1]

Time band	Fixed (cents/day)	Import rate (cents/kWh)	Export rate (cents/kWh)
10am – 3pm	45	-1.5	0
4pm – 9pm		25	-1.0[1]
All other times		0	0

All times are in local time

Same rates apply every day of the year

A positive rate is a charge, and a negative rate is a rebate

However, for an independently owned system, there are two issues. First, the waiver tariff process of the AER requires a waiver tariff to be submitted by the end of February to be effective on 1st July of any given year. If a DNSP has not made the application in time, the opportunity is missed until the following year. This is not to say that there should not be appropriate checks and balances, but that the process should be more flexible, so that innovative projects can be rolled out without major delay.

Also, a waiver tariff is only valid until the end of a DNSP's 5-year price determination period. This means that the tariff may then be discontinued, potentially undermining the commercial viability of a battery project mid-way through its life. A CitiPower analysis showed that a community battery on the non-distributor owned CB trial tariff could earn up to $2,000 per annum if supporting the network; on a small/medium business tariffs it would cost $25,000, which is prohibitive for a front-of-meter BESS.

5. **Partner with Acacia Energy for market participation.** Acacia Energy is a specialised electricity retailer for commercial & industrial customers. They manage similar assets to the FN1 system and aggregate systems to meet the minimum threshold of 1MW power capacity for the FCAS markets.

   All future YESS systems would be managed in the same way as FN1 and only incur a minor cost of extra hardware and AEMO registration. However, were a non-Pixii BESS chosen, the integration would incur more cost.

   Working with a smaller and specialised retailer/aggregator was an advantage for the YEF team over the large gentailers. Acacia's ability to accommodate the innovative nature of FN1 was key to meeting the deadlines of the project. Large gentailers would typically operate at scale with set parameters and limited flexibility in comparison.

The resulting business model is very simple, as shown below.

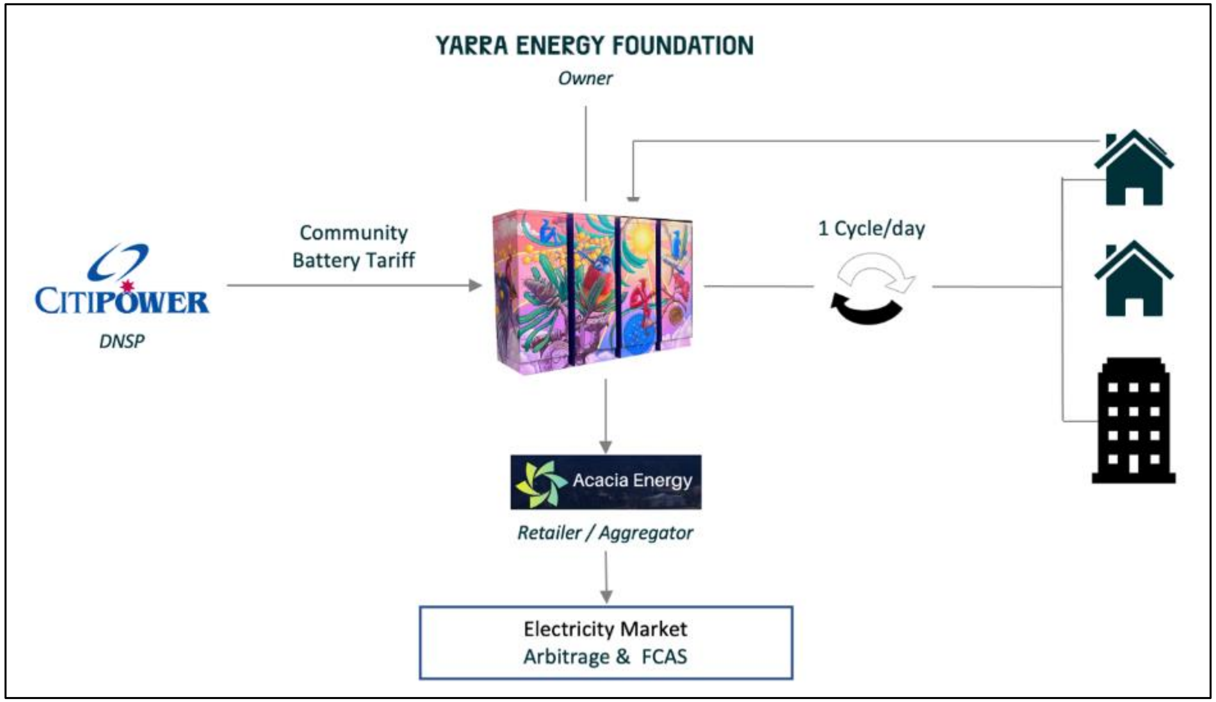


Figure 7: Community battery business model

The FN1 system has only two commercial relationships: with CitiPower and Acacia Energy. For a first system, it simplifies the business management imperatives, and allows the system to prove itself on a basic set of value streams.

6. **OPEX is substantial for a single system**. Annual operating expenses (OPEX) for a low voltage-connected *single system* can be estimated at $17,000, although the prices vary depending on technology and commercial arrangements.

The estimate **includes**:

- Administration of the CB business
- IT Operations, for hosting, management, and maintenance
- Metering
- System maintenance
- Insurance
- Site maintenance

The estimate **excludes**:

- 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 mid-scale BESS.

While the OPEX per battery would decrease, 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.

7. **Single System ROI is not attractive**. For a single system – and further modelling showed that even for a network of up to 10 batteries with reduced OPEX – the net present value (NPV) for typical discount rates is negative. This means that for the business case to be attractive to investment funding sources, given the current level of CAPEX, more revenue must be generated.

5. Site Selection

5.1. How we started

Our task was to identify a site that would be suitable for a community battery. At the time, the only references were the Western Power PowerBank pilot projects and a behind-the-meter installation in Yackandandah. More importantly, YEF set the objective to select a first site within the City of Yarra, i.e., in the tighter streetscape of inner-urban Melbourne.

The inner-urban setting is particularly challenging because of the scarcity of common land and the proximity of neighbouring properties.

However, if we could demonstrate that it can be done, our solution could apply to any environment including outer suburbs.

At the outset we had 2 main criteria:

1. High solar PV penetration in the neighbourhood
2. Available common land

YEF has since developed a comprehensive list of site selection criteria from the learnings of the Fitzroy North project and subsequent studies.

Thanks to our partnership with CitiPower, we received a list of the distribution substations in the City of Yarra ranked by demand constraint. The most constrained areas were of greatest interest to CitiPower. Their data also featured the installed solar PV capacity by distribution substation. The analysis allowed us to identify two attractive neighbourhoods, which we subsequently visited and walked around.

5.2. What we learnt

1. **Community acceptance is fundamental despite planning permit exemption**. It is clear to YEF that no installation can take place unless the community is on board. Even prior to the planning approval exemption being granted, YEF's principle was prior community acceptance, and we were ready to move to another site if the community was not receptive. This remains our principle now that the exemption is effective, and we

hope that other parties involved in CB projects adopt our principle.

2. **There is relatively low solar PV penetration in the CitiPower network**. The numbers range from single digits up to 20% with some higher outliers in various locations. By comparison, the Powercor and United Energy network feature substantially higher penetration across multiple postcodes.

   However, the picture is constantly changing as more solar installations are carried out. Anecdotally, it was comforting to learn that the rumour of a future community battery in the Fitzroy North neighbourhood motivated some residents to undertake a solar installation.

3. **There are many more criteria to consider.** To mention a few, prior to receiving planning permit dispensation, we discovered the limitation imposed by overlays, such as heritage overlays. There could be an environmental impact depending on the surroundings and the underground services. The presence of a larger customer, or as we call it an 'anchor customer', with or without a large solar array, could open opportunities or challenges. The available land would attract varying land lease fees depending on the owner.

4. **The proximity of a network connection point will reduce cost.** Our final placement of the battery system is close to a power pole on the footpath of Michael St. CitiPower have a low-cost connection method of mains installation from 'pole-to-pit' if the pole is within a few meters of the pit. More complex connections involve CitiPower's Connections Engineering team and attract higher costs.

5. **There was a widespread inclination to 'hide' the battery.** The fear of rejection by the community led to suggestions by council and others that the battery should be out-of-sight and without any impact on everyday life. If we were to proceed with that goal, the site selection process would have been quite different.

   However, instead, YEF was in favour of 'showcasing' the battery to inspire other communities to follow our initiative. Luckily, our approach was cautiously supported until the local community embraced the idea. A major factor in the community's acceptance was their idea to have the battery painted, which YEF and Pixii welcomed. Their selection of the artist, and the impressive artwork further strengthened their feelings for the battery.

6. **The process of sourcing network data is challenging.** Our partnership with CitiPower allowed us to receive guidance from their engineers for our first project. However, the company is not set up to cater for such requests, particularly as the demand rapidly increased.

The alternative was to work through C4Net, an independent, member-based, not for profit company with an area of focus on the local energy systems, spanning distribution networks to consumers. C4Net received funding from the Victorian Government for data queries on Victorian Networks.

It became clear that C4Net is well suited to undertake consumption studies but unable to identify in a timely and cost-effective way substation ratings, solar export capacity, maximum demand, and feeder maps, all of which are essential in assessing the viability of a site.

5.3. The outcome

Our community engagement process (refer to section 6) validated the site selection and we proceeded with site planning activities.

Planning Permit Exemption

As mentioned earlier, the project benefitted from a planning permit exemption from the Victorian Minister for Planning. Until the exemption was approved, YEF worked with a town planner on the planning application to Yarra City Council.

The exemption was a real boon for the project, and the outcome of the leadership of, and YEF's cooperation with, the NBI team at DELWP, together with inputs from other project such as Powercor's Tarneit community battery. More importantly, the exemption was added to the Victorian planning scheme and rolled out across the state, thus allowing all future projects to benefit.

On a lighter note, YEF's town planner *Priority Planning* may be remembered as the only town planner in Victoria who made a community battery planning application.

Final Placement of the battery

The site selection did not mean that the exact placement of the asset was known. And many additional considerations to the site selection criteria were brought up in YEF's work sessions with the local community. Some of these were:

- How visible should it be?
- Would the placement create a more secluded area that may attract unwanted visitors and activities?
- Could the space between panels become a 'mailbox' for illegal traffic?
- Would underground services impact pit location and cable runs?

These and many other perspectives were brought up by our participating community members (see section 6 for details). The final placement was a combination of both technical and community requirements and took a few weeks and several site visits to be decided.


75mm

6. Community Engagement

6.1. How we started

Once a neighbourhood was identified as having good potential for a CB, YEF undertook an initial desktop assessment of the area followed by a walk-around tour. Identifying a possible site in Fitzroy North gave credence to the option, and we decided to engage with the local community.

From the very beginning of our engagement, we decided on a fundamental principle:

Gain the support of the local community or move to another area.

However, our community engagement strategy was not designed solely to establish a social license to operate. We felt that CBs represented a unique opportunity to facilitate community participation in the clean energy transition by promoting collaboration between the energy sector, government, project proponents and the community itself as project partners.

We also faced the reality that CBs were relatively unknown among the public. Hence, education and knowledge-sharing activities were necessary first steps to enable dialogue. To that effect, we undertook a series of webinars on the concept of CBs and their benefits (at the time, in-person meetings were sporadic due to the risk of COVID-19).

The webinars were general in nature and attended by the wider community. With recordings and other material posted on our website, we made direct contact with the Fitzroy North residents. We pursued the following:

- **Letter drops**. Thanks to data provided by CitiPower, we learnt the boundaries of the low voltage network to which the CB would connect. Letters were dropped to the 200 or so households and businesses within the catchment, and another 50 just outside because of their proximity to the target location.
- **Webinars**. Specifically, YEF ran two webinars for the community local to the catchment, with a primary focus on Q&A. We also solicited interest in joining a Community Reference Group (CRG), an opportunity taken up by six people. The CRG would act as a representative body for the whole local community.
- **Online 'drop-in' sessions**. YEF hosted several such sessions for anyone to join and set their own agenda of topics and questions.
- **Local meetings and communications**. From that point on, the project team began a dialogue over video, on-site, and at the local pub.

6.2. What we learnt

The journey along community engagement was one of the most rewarding parts of the project, yet full of risk and uncertainty given our main principle – to gain the support of the local community or move on from the area.

> The first instinct was to hide the system; the opposite of what was decided after engaging the community.

We discovered several things:

1. **The first instinct was to hide the system**. As mentioned in the previous section, whether council or community members, the expectation was of an unsightly collection of metal boxes that would be disapproved of by the public.

   YEF was convinced that there could be an aesthetic appeal, but more importantly, the system needed to be seen to inspire others to think about shared storage. It would take some work to convey the value of this other approach.

2. **Experience of community consultation had been disappointing**. The energy sector is seen among the least trustworthy in Australia. The perception is that community consultations are a proxy for presenting information and not a two-way communication with the ability to influence outcomes. Our aim was to change that perception.

   In the Fitzroy North community, there had been issues with the installation of a distribution substation and an incident in a nearby neighbourhood. Certain council initiatives had also raised complaints. Although a generally ‘green’ neighbourhood, residents were understandably keen to protect their local interests.

3. **The level of technical understanding was low**. In every webinar or in-person event, there was a small number of engineers and passionate hobbyists keen to ask detailed questions, and a large majority of people with scant understanding of energy, networks, and retailers. We were therefore compelled to present the project in the most accessible way possible and paint a picture of electricity production, storage, and supply that everyone could understand.

4. **Retailers are not allowed to undertake community engagement**. Because of inappropriate door-knocking

and tele-sales practices, energy retailers are prohibited from contacting potential customers directly. This significantly limits their abilities undertake community engagement.

5. **The top 3 questions**.
    a. How big is it?
    b. Will it blow up?
    c. Is it noisy?

   This put the emphasis on footprint, safety, and noise. We had to prioritise these criteria in the selection process of the BESS.

6. **Environment and reducing bills were equally important**. The concern about climate change was voiced equally with the desire to reduce energy expenses (even prior to the 2022 energy crisis).

7. **People instinctively think they would need to sign up to the CB**. Without prior guidance, most people figured that the battery would be divided into home battery-equivalent partitions and accessed via a subscription model.

   In fact, the subscription model seemed to provide a schema for understanding how the battery might function or interact with the network. As the model we presented was different and did not require anyone to sign up, it sometimes took some time to clarify. Effectively communicating the commercial and operational model, and the nature of the benefits afforded by the battery, remains a minor challenge.

6.3. The outcome

We had the chance to work with CitiPower's community engagement officers and benefit from their guidelines and documentation. ANU's social researchers were also available to coach on the findings from their surveys and studies into community members' response to the concept of CBs. This led us to define our own framework of engagement, outlined below.

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 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 commercial or benefit sharing models that align with community values and priorities. 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.

Elements of Community Engagement

YEF has received commendations for its community engagement process for the FN1 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 endeavoured 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 3: 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

YEF worked across the spectrum with the community. Here are some of the main outcomes.

- We informed to educate on the principles of a CB, the network, and our project.
- We consulted on the concerns they may have and involved them in the assessment of noise levels from the vendors.
- Both the site identification and the final placement involved them, and we collaborated to make a decision.
- The community was fully empowered to select the artwork they would see every day in their neighbourhood.

Negotiables and non-negotiables: 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 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.

Table 4: Channels and tools used for engagement

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)

Community Reference Group: The establishment of a Community Reference Group (CRG) 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 these could be measured and assessed.

Community Decisions

Through our communications, the YEF team covered the many aspects of the system, business model and site requirements. Of these, certain decisions were made from the CRG's recommendations.

1. **Final placement of the system**. After much deliberation, it was decided that the system would be showcased rather than hidden. It would be placed at a slight angle from the wall of the substation for easier spotting from the intersection. The exact placement was suggested by one of the CRG members and the first stake was planted as can be seen below.

Figure 8: Planting the first stake in the ground indicating where YEF and the Community Reference Group agreed to locate the battery.

2. **The BESS selection was weighed toward lowest noise possible**. The procurement process was close to the end and a decision on the shortlisted submissions was imminent. The candidate with the lowest measured level was Pixii with 67dB at 1m and 49dB ambient noise, for an estimated 63dB with low to no ambient noise. The result applied to the proposed configuration of three panels with air conditioning.
3. **The CRG proposed to have the system painted and selected the artist**. Without any prompt from YEF, the CRG brought up the idea of painting the system, which was endorsed by YEF and Pixii. The art procurement officer at City of Yarra assisted the CRG in the procuring the artwork.

   A panel made of the CRG and YEF's Chief Operating Officer was formed to evaluate 4 submissions out of 5 artists invited. The winning concept by Hayden Dewar was chosen for its original design and strong alignment with the function of the BESS.

   "Set the controls to harness the sun" describes the transition to a renewable future with the help of 'Solarquins', little characters enlivened by the sun, by recycling the old and ushering in the future.

Figure 9: Hayden Dewar's concept "Set the controls to harness the sun" 2022

Figure 10: The concrete pad was installed with space for an additional panel in the future.

4. **Future upgrade of the BESS**. Upon request by the CRG, YEF changed the layout of the BESS by making space on the concrete pad for a 4th battery panel, were the community to raise capital in favour of more storage.

7. Connection

7.1. How we started

The connection process with any electricity distributor, CitiPower or other, is, from a customer's perspective, rather long and time-consuming. However, each step adds another essential level of knowledge about the operational implications of an asset as versatile as BESS. As such, the process is warranted and reduces the risk of an unsafe or non-compliant installation being energised.

There was little understanding of the connection method and cost in the early part of the project. As a result, it was difficult setting a budget without not-to-exceed costings for connection.

The partnership with CitiPower allowed us to progress the definition of the system and the capacity at the connection point. However, the connection method required the involvement of another part of the organisation, the work of whom started much later.

7.2. What we learnt

Some of the lessons learnt are technical in nature and require some understanding of electrical systems and reticulation.

1. **Multiple parties need to be scheduled to complete the process**. These include:
    a. The BESS installer (in our case Ventia)
    b. The retailer for control equipment installation wireless connectivity (in our case Acacia Energy)
    c. The Electrical Inspector
    d. The CitiPower Inspector
    e. The connection installation contractor (CitiPower's contractor)
    f. The CitiPower overhead team (for overhead connections)
    g. The metering company

    CitiPower's e-Connect portal sequences most of the activities with gateposts to be addressed with inputs before subsequent sections are enabled.
2. **The initial connection request should be made at project inception**. A complex connection process takes a 6 to 9 months' duration to allow for proper allocation of resources and field work. Less time increases risk to the delivery schedule. It is also likely that identical or similar connection work for multiple battery installation sites would require less time, particularly if the same crew carried out the works.
3. **CitiPower see the battery as a load**. Even though the battery operator may define the battery's function as to balance the energy by time shifting to reduce peak

demand, CitiPower see the battery as a load because they cannot have control. In the unexpected event that the battery would start charging at 100% in the middle of the evening peak, the excessive load on the distribution substation may cause a blackout in the LV network.

4. **A generator deed is required as well**. Despite being considered a load, the battery's ability to export electricity must be documented and assessed by CitiPower. While it does not risk a blackout, generation can cause voltage fluctuations that may switch off downstream inverters or affect electronic equipment.
5. **Each zone substation has an HV earthing grid along its perimeter.** At our first site visit with the CitiPower inspector, all representatives from YEF and our delivery partners discovered that a High Voltage (HV) earthing grid runs externally to the walls of every zone substation, approximately 1 meter out and 1 meter deep in the ground.

   Moreover, CitiPower requires all Low Voltage (LV) earthing to be segregated by minimum 1 meter from HV earthing. This is not the case for all networks and in some cases, the two grids can be bonded.
6. **Inner-urban installations have the best protection.** Where segregation from an HV earthing grid is required, as it was in our case, low soil resistance allows fault currents, in the event of a fault, to rapidly flow back to the substation and trip the protective devices to make the surrounding area safe.

   Because inner-urban settings have so many densely run underground services (water, gas, sewage, electricity, etc), fault currents can easily find metallic surfaces to flow back to the source. This is a good thing. It means that fault currents will likely not spread elsewhere and will likely not raise the voltage on metallic surfaces to dangerous levels for humans.

   By contrast, outer suburban with sparsely located underground services present higher soil resistivity, which causes fault currents to spread to possibly more distant metallic surfaces. The remedy would be to locate the installation further away from other electrical installations, particularly HV ones.

7.3. The outcome

The connection process for the FN1 project took about 3 months, which was a compressed timeframe. Some of the complexity was mitigated by the relatively straightforward connection method, as the asset was to be located close to a power pole. However, YEF is planning on longer timescales for future projects, even for simple 'pole-to-pit' installations.

In our case, we are also leasing land from CitiPower, which required a lease agreement to be signed. The negotiation and execution of that agreement ideally would have preceded the connection works, but had to be incorporated into the process as best as possible.

Future Projects

With the planning approval process being exempt, and assuming resumption of typical supply chain delivery times, the connection process appears to be a major factor in determining project duration. The first 5 steps of future projects could be summarised as follows:

1. DNSP contact
2. Site selection
3. Feasibility study and finance application
4. Community and council engagement
5. Connection request

The first 4 steps validate the project at the selected site, which gives enough confidence that it can materialise. At that point, the connection request should be made as early as possible. The lead times for connection could be longer than those of the equipment delivery.

In cases of a more complex connection, such as tapping into LV lines across a road, the procurement of the BESS depends on the cost of that connection, which can be onerous. That cost is given at a much later stage of the connection process, and CitiPower is not set up for providing that information at the onset. This is an issue flagged in section 8.

As a result, the subsequent steps to a network request being received by CitiPower, could be:

6. Brief a CitiPower Customer Development Manager
7. Carry out a site visit with a CitiPower officer
8. Receive and execute the Letter of Offer and make the payment

At this point, the connection method is known as well as:

- the power capacity at the connection point, and
- the associated cost.

These two numbers will allow for a battery system to be sized and a tender to be issued to industry.

8. Conclusions

In conclusion of the project, the project team took stock of the effort expensed, how we met our goals, the key learnings, and what it means for the future.

8.1. What it took

The project was funded up to $950,000 with $800,000 provided by the NBI grant and the remainder by contributions from YEF and CitiPower. The total cost including in-kind work and contributions by project partners was nearly $1.5M.

Software development represented more than half of the total funded work.

The total battery system cost including installation, connection and artwork came in at about $1,100/kWh. This number is much higher than expected due to the connection and artwork costs. For the hardware alone, including installation, the cost was well below $1,000 per kWh.

The funding agreement with DELWP was signed in October 2021 and the system went live less than 9 months later on World Environment Day 5th June 2022.

8.2. Project Self-Assessment

Considering YEF's project objectives of section 2, the following assessment can be made (Table 5).

Table 5: Project self-assessment

1.Focus on inner-urban environments	**Yes**
2.Keep the business model simple	**Yes**
3.Add value streams as practical	To be developed
4.Establish a replicable infrastructure for future systems	**Yes**, the Pixii hardware, Acacia retailing, the BCS software platform, and the YESS steering committee will be retained for the next project
5.Make our infrastructure available to others	**Yes**, either with YEF as a contracted operator or by making the BCS software open source for others to leverage.
6.Source locally and environmentally where possible	**Partly**, all software development was local, as was the artwork. Unfortunately, the best compliant hardware solution was imported.
7.Investigate community ownership	**To be explored further**, this has been discussed with the CRG and postponed until there is a track record of consistent business performance of the battery

8.3. Key Learnings

Our key learnings are summarised below. An important input came from a retrospective workshop held on 12th July 2022 with the extended project team. A copy of the slides is provided in Appendix 1.

1. **The project required significant collaboration**. The extended project team of YEF, ANU, CitiPower, Mill Software, Acacia Energy, Pixii and Ventia worked successfully together to deliver on time within the allocated budget. Our relationship with DELWP's NBI team was of tremendous help and allowed the team to address key challenges such as data access and planning application.

   The project steering committee made up of YEF, CitiPower and ANU executive management provided a forum for governance and helped make decisions on key strategic questions.

   The Fitzroy North community near the corner of Michael St and McKean St, after some initial reservations, became great supporters of the project. It culminated in a most successful launch on 5th June 2022.

2. **Software is complex**. The bulk of the project funding was spent on software development, both trading algorithms and system integration. The relatively short development time of 9 months from concept to live performance forced the team to keep the software as simple as possible.

   A major component was the integration with Acacia Energy's operational and bidding platform. With a code path involving ANU, Mill, Acacia and Pixii, defect resolution was challenging at times.

Key learning: keep software as simple as possible.

3. **The connection process was too short.** As described in the Connection section, more time should have been allocated.

Key learning: make the connection request as early as possible.

4. **Commissioning can be improved.** Energising the hardware and enabling the cloud control requires a process of commissioning each sub-system before the whole system. The relatively short connection process reduced site testing time so the sub-systems and system were commissioned in parallel. This resulted in a functional system on launch day but follow-on work to fully enable system operation.

Key learning: plan the commissioning schedule from the start.

5. **Conveying direct benefits to consumers is challenging**. Even before the 2022 energy crisis, reducing energy costs was a primary concern to community members. When it became clear that the immediate benefit was environmental and that there would be no financial bonus to consumers, it was harder to articulate an answer to the question "What's in it for me?". Future work on local tariffs and exploring other business models may change this situation.

6. **Batteries are too expensive and revenues too low.** This is the main conclusion on commercial viability. At the time of procurement, the cost of a mid-scale BESS installed was below $1,000/kWh. A 400kWh BESS would cost up to $400,000 not considering any other project costs. For a positive NPV after 10 years with a 10% discount rate, the annual net profit for distribution would need to be $60,000, a significant ask.

   Our conclusion is that batteries would need to at least halve in price or more, and additional revenue streams would be needed. As the Electric Vehicle industry ramps up production of lithium batteries – creating economies of scale, and as new services are defined for the battery, this could well become a reality.

   An imperative is to reduce operational costs, i.e., the running costs, which limit net profit. This can mainly be achieved by scaling the business to a network of hundreds if not thousands of systems.

Key learning: plans for networks of batteries rather than single ones.

7. **It is still early days**. As demonstrated by our inability to find insurance cover until the very last week before the launch, the wider industry beyond energy is still unaware of community batteries. It will likely take many more projects and ongoing education to forge their place in the economic landscape.

8.4. Future Projects

Being the first system, substantial work was required to resolve the many challenges the project had to overcome. This will be much simplified for subsequent systems that will leverage the outcomes of FN1. A summary of the main areas of focus for future systems can be seen in the circled areas of the FN1 Journey diagram below.

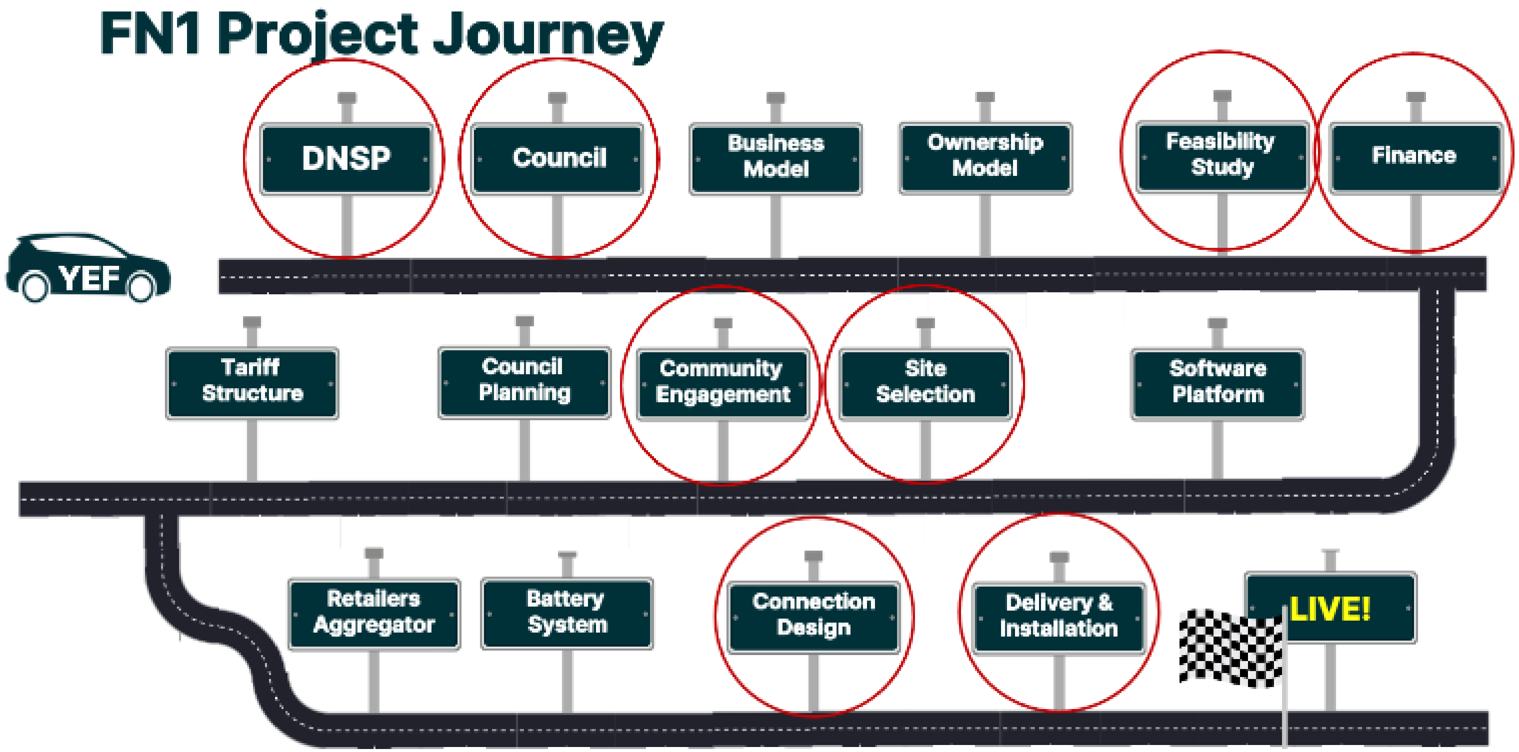


Figure 11: The Fitzroy North community battery project journey, highlighting main areas of focus for future systems.

8.5. Remaining Questions

The FN1 project was a fantastic learning opportunity, and the extended team is in an excellent position to undertake future projects. Many questions remain though. Some of these are covered below.

1. **How can CBs scale?** What ownership and operational models would most likely allow a deployment at scale? How would they be financed? Relying on grant funding does not suffice in the long run. Realistically, the business case would need to attract investors, whether retail or wholesale, to the order of hundreds of millions of dollars or more. For that to happen, battery prices must drop by half – as per our internal analysis, and the revenue potential boost by at least 50% for the floodgates to swing wide open. Alternatively, governments could mandate DNSPs to roll-out CBs with funding from increased tariffs or other means.
2. **What role should state and local government play?** The nascent community battery industry is made up of community energy groups, DNSPs, not-for-profit organisations such as YEF, with interest from councils and some retailers. If a deployment at scale with replicable systems is the best way to support the newly announced Victorian storage target, do state and local governments have a contribution to make? Should innovative ownership models or support roles be investigated?
3. **Can tariff reform unlock new value in the LV network?** In the absence of local tariff reform, retailers may cut special deals but are limited by the 10-20% margin they make on electricity sales. Some gentailers may bring a marginal improvement.

   Lower local network tariffs could play an important role to reduce energy bills. They could be an incentive for innovative services to be introduced by retailers and battery owners. Charging and discharging energy to and from Electric Vehicles would be an example. Retailers would package these network tariffs into attractive plans for consumers in LV networks with a CB.
4. **Should the DNSP have control?** The connection agreement gives a limit to the amount of energy imported or exported at any time. The limit on imports is determined by both the feeder cable capacity and the rating and loading of the transformer at the distribution substation. Because the DNSP cannot control the battery, <u>the conservative and safest choice is to see the battery as a load</u> that may be added in peak demand times. This limits the battery's effectiveness.

   One solution is for the DNSP to have some form of control that it could activate in the abnormal event that a community battery would start charging at full capacity during the evening peak, whether due to malfunction or speculative reasons. With the safety of control, the power capacity limit could be solely determined by the current carrying capacity of the feeder cables, i.e. by how much power they can take.

5. **How could grid connection costs be standardised?** One challenge in procuring a BESS is knowing the other costs in the project budget. Not knowing the connection cost at the start is a leap of faith in some cases, or an undersized system in others. Currently the connection process does not provide upfront cost estimates, although it is the most needed when developing the business case for the BESS. How can this be addressed?

6. **How will communities be consulted?** With the benefit of a planning approval exemption, community batteries have a chance to be deployed at a faster pace. What does it mean for local communities? What replaces the formal consultation that the planning application process included?

   YEF’s focus was and remains value to the community and we spent significant time and effort during the FN1 project to ensure that their voice was heard and made a difference. It would be detrimental to this nascent industry if commercial companies were to disregard community acceptance. Councils could possibly play a gatekeeping role, but to our knowledge, this has not yet been explored.

Appendix 1: FN1 Retrospective

On 12th July 2022, the extended FN1 project team met to review performance and lessons learnt. The following slides are a summary of the inputs.

What went well?

Community engagement
Lots of new knowledge/learnings
Collaboration/partnerships/NBI Team
Leadership, Scope discipline, intercompany coordination
Visibility/media attention/launch

What didn't go so well?

Compressed time for CitiPower processes (eConnect, lease)
Software integration and completion
Hardware and software commissioning
Communicating direct benefits to consumers
Finding insurance covers

What have we learned?

You don't need all the answers to DO something
The most complex are software and connection process
How to articulate the benefits of community batteries
YEF is well positioned for community engagement

What still puzzles me?

What is the grid connection cost
What role should local gov play
How to optimise control software
How tariff reform is possible
How can community batteries scale

Wind (what helped us forward)

Partnership with CitiPower and ANU
DELWP and City of Yarra support
Planning exemptions
Community support
Existing technology

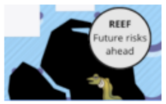
Anchor (what held us back)

First move disadvantages, unknowns
No direct financial benefit to customers
Informing/educating while delivering
Lack of / poor regulatory support for CBs
Costs and $/kWh
No qualified insurance company

Sun (what made us feel good)

Community engagement, feedback
Launch event
Artwork
Government support
Being part of a climate action community
Equity in communities - not just profit

Reef (future risks ahead)



Costs and business case uncertainty
Lack of innovative tariffs for residents
Change of gov policy
BESS technology still too expensive

Appendix 2: List of Abbreviations

Abbreviation	*Meaning*
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ANU	Australian National University
BCS	Battery Control System
BESS	Battery Energy Storage System
BSGIP	Battery Storage and Grid Integration Program (ANU)
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 project, i.e., the YEF community battery project
FRMP	Financially Responsible Market Participant
kW	Kilowatt
kWh	Kilowatt-hour
LV	Low Voltage
MW	Megawatt
NEM	National Electricity Market
NPV	Net Present Value
OPEX	Operating Expenses
PV	Photovoltaic
RAB	Regulatory Asset Base
ROI	Return On Investment
V2G	Vehicle-to-Grid
YEF	Yarra Energy Foundation

Appendix 3: Glossary

Term	*Definition*
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.
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 the main component in a Distribution Substation in a distribution network.