Neighbourhood Battery Feasibility Report

August 2022

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work, and we pay our respects to Indigenous Elders
past, present and emerging.
Sovereignty has never been ceded.
It always was and always will be, Aboriginal land.
We recognise and respect their continuing
connection to the land and their environmental
stewardship over thousands of years.

info@villagepower.com.au
VillagePower.com.au

Village Power

NBI Feasibility Study v3

August 2022

Disclaimer

This report has been prepared by Village Power as part of the reporting requirements for the DELWP Neighbourhood Battery Initiative Stream 1 grant.

While Village Power will freely share the ideas and development of the business model, please contact us for more information or for a conversation. Copying this report without the permission of Village Power is not permitted

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Executive Summary

Village Power (VP), with the support of Darebin City Council and a Neighbourhood Battery Initiative (NBI) grant from the Victorian Department of Environment, Land, Water and Planning (DELWP) has conducted a feasibility study into the financial viability and key sensitivities for a ‘neighbourhood-scale’ community battery. The model tested in the feasibility study is to combine direct community engagement via a subscription service, with wholesale market arbitrage to finance a 500kWh battery sited in the Jemena network. The battery has a 500 kWh storage capacity, with a maximum charge/discharge rate of 200 kW.

It is proposed that the battery will operate as a solar energy ‘soak’ at time of peak solar export and supply energy in response to consumer demand both directly from subscribers and from market signals. The battery will also charge overnight taking advantage of cheaper renewable power to make this energy available at morning peak demand time.

This model will provide a number of benefits:

- The ‘solar soaker’ function has the potential to provide network support, providing voltage stability and potentially reducing the need to augment network sub-stations to relieve voltage constraints;
- The direct subscriber involvement can provide financial incentives for subscribers to install, or supplement existing solar power, contributing to decarbonisation of the grid. Direct communications via the subscription service can also influence consumer behaviour towards more efficient use of the electricity grid;
- A local community battery is seen by the community as a positive step towards energy and climate resilience, even without direct community involvement (as demonstrated by the Yarra Energy Foundation (YEF) ‘solar soaker’ project in the CitiPower network);
- A successful community battery project run as a social enterprise with direct consumer involvement can supply power to energy poor households or households that can not install solar panels (e.g. renters or apartment dwellers);
- Aggregation of power from community batteries can provide renewable energy based-network support by supplying Frequency Controlled Ancillary Services (FCAS) for the electricity grid;
- The subscriber base, and broader community membership of the social enterprise, will provide investment support for the project and be used for education on energy efficiency and for direct demand management which could reduce peak energy use (which tends to be more carbon intense).

Village Power has tested the financial and technical feasibility of installing a 500 kWh neighbourhood battery, in a modular shipping container enclosure, supported by an Energy Optimisation system (EOS) which can identify where and when the battery will provide most value to balance value to the community with revenue to cover the cost of operations.

Findings from the project will be shared and used to support other communities to implement batteries.

Important elements of the feasibility study was work done by Enhar (engineers) to identify suitable sites for installing batteries, and subsequently to design the technical connection architecture. This work identified two primary sites, owned by Darebin Council, within the overlapping Darebin Council/Jemena area, each suitable for connecting a 500 kWh neighbourhood battery to the low voltage network with a maximum 200kVA connection.[1] These sites are at the Melbourne Innovation Centre, 2 Wingrove St, Alphington, and Newman Reserve, Preston. As well as the site study, outputs of this work include:

- Battery Energy Storage Service (BESS) specifications – ready to go to tender for the battery
- Draft connection agreement for the network – requires confirmation of BESS
- Estimates of the cost of preparing the site and installing and commissioning the battery
- A fully costed business plan to test the commercial feasibility of a neighbourhood battery based on an 18-month dynamic pilot in preparation for full commercial roll-out. This includes modelling of revenue potential from subscribers and the market.
- Planning for integration of battery performance and billing information and provision on-line to the network, the retailer partner and the subscriber base.
- Architecture and planning for an energy management algorithm that will allow dynamic changes to pricing to test consumer behaviour, will track and optimise energy flows
- A business structure and marketing plan which will help VP to build community support for subscription and investment.
- Consultation with community through outreach, surveys and community meetings to build support and to provide feedback on the VP model for battery operation

While a neighbourhood battery can provide a wide range of benefits, most of these are very difficult to monetise. Financial modelling indicates that network charges are a critical sensitivity. VP has kept Jemena informed throughout the project and they have indicated that they are prepared to offer a trial network tariff designed specifically for neighbourhood batteries. The outcome of the modelling indicates that providing financial benefits to subscribers is net revenue neutral at best, which means that operational costs would need to be covered from wholesale market arbitrage ('peak-shifting'). Preliminary calculations, as well as trial batteries in the field (in particular, the YEF Solar Soaker project) indicates that this should be possible – with potential significant upside of accessing the FCAS market through aggregation with other batteries not included. In summary, the financial benefits of a neighbourhood battery are not particularly attractive, but operating as a social enterprise makes it viable and enables the non-financial community benefits.

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[1] kVA is a measure of apparent power: it tells you the total amount of power in use in a system. In a 100% efficient system kW = kVA. However electrical systems are never 100% efficient and therefore the kVA will always be more than the kW value. Ref: https://powerelectrics.com

The next phase of the project is to pursue a grant to purchase, install and commission a battery, put in place supporting business and investment structures, and start a communications and marketing program to attract investment and subscribers so that Village Power can conduct an 18-month trial of to demonstrate and fine-tune the business model. It is anticipated that it will take 12-18 months to deliver a fully operational battery, so Village Power hopes to start the pilot project in the first half of 2024.

1. Background

Establishing a strong business case for community-scale ‘neighbourhood’ batteries is challenging in a physical and regulatory system that is designed to deliver energy from large, distant generators to individual households and businesses. Arguably the most significant benefit of a neighbourhood battery is local peak-shifting where there is significant penetration of rooftop solar power which can create voltage constraints on a network in the middle of the afternoon when solar power is at its peak and demand is generally low. However, current regulations mean that the sector arguably best placed to extract value from a community battery – the distribution network service providers (DNSPs) cannot offer a financial service directly to consumers. This complex environment makes it hard for neighbourhood batteries to be financially viable, which has resulted in lack of development of this opportunity.

This means that the organisations driving change are often small community-based organisations with non-financial incentives. Village Power is the initiative of a small group of dedicated volunteers who are passionate about renewable energy, acting on climate change and creating a new model for energy sharing. Local to the Alphington, Fairfield and Ivanhoe areas, we come from a diversity of backgrounds, but we all share a commitment to empowering the community to achieve carbon neutral electricity.

VP has a vision for 100% carbon-neutral electricity driven by local participation. We set out in 2018 with the idea of developing a model to share excess solar power generated from our roof-top panels with our neighbours to provide locals with an incentive to put as much solar on their roof as they could. Sharing renewable energy would also provide people without access to solar-friendly rooftops with local, renewably generated, energy. We quickly realised that while this was a viable model ‘behind-the-meter’ there were no established business models for grid-connected (‘in-front-of-the-meter’) batteries.

With a Neighbourhood Battery Initiative (NBI) grant from the Victorian Department of Environment Land Water and Planning (DELWP) we have conducted a feasibility study and refined our ideas to identify a business model that will deliver on our vision. We plan to establish a model that can be easily replicated in many other locations across the national electricity grid. Scaling up will unlock additional value for communities and partners and will further advance progress towards 100% renewable power.

1.1. Project phases - method and approach

Village Power is working towards being ready to apply for funding to buy and install the Village Power Neighbourhood Battery (VPNB) in the second half of the year and commence the operation of the dynamic neighbourhood pilot in the first half of 2024.

Key pieces of work which have been completed are:

- Identified legal structure for Village Power to purchase the first battery – and how that structure will evolve when adding subsequent batteries
- A fully costed business plan to test the commercial feasibility of a neighbourhood battery based on an 18 month dynamic pilot. This test period will be used to test the operation of the battery and verify the value streams that contribute to the business case.
- The identification of a service partner to develop and deliver the energy management algorithm that will allow dynamic changes to pricing to test consumer behaviour, will track energy flows and will provide tracking and billing services for consumers and to retail partners for billing.
- Confirmation of the preferred location, including support from the landholder (Darebin Council) and DNSP (Jemena) support for the location
- A marketing plan which will help VP to deliver subscribers in 3 stages:
    - Community support
    - Investment
    - Subscription
- The development of the battery specifications in preparation for tender
- Preliminary design and specifications of battery connection and energy optimisation systems

2. About Village Power and the NBI project

2.1. Village Power and Darebin Council

Village Power is a community owned social enterprise with the goal of contributing to 100% renewable communities by seeding community batteries in urban suburbs. We have worked in close partnership with Darebin Council to develop the ideas.

In 2019 Darebin Council provided funding for Village Power to construct a financial model to support the business case for a community-scale[2] battery. This work demonstrated that a community battery could not be financed solely by trading on the difference between the amount that residential solar power owners are paid by their retailer for their excess power to the market and the amount another consumer is willing to pay for renewable energy (residential energy arbitrage). The study highlighted that several sources of revenue would be needed to pay for the battery.

In 2021 Darebin Council offered to auspice the NBI grant application to DELWP and to explore the possibility of hosting the battery on Council land.

2.2. Why neighbourhood batteries

Increasing battery storage across the country is vital to taking full advantage of solar and wind energy and in driving the transition to a 100% renewable energy market. Community batteries contribute value right across the electricity system, in particular adding value to key distributed energy resources (DER) – Figure 1.

Solar households will charge the battery during the middle of the day and draw from the stored energy in the evenings. Any excess electricity stored in a community battery above local community needs can be sold into the grid when it is needed most. A single community battery shared among up to 150 households will also allow households that cannot install solar – like apartment owners and renters – to draw from excess electricity stored in community batteries.

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[2] In this document 'community-scale' and 'neighbourhood' battery are used interchangeably to refer to battery energy storage systems that are smaller than 'grid-scale' commercial energy storage systems but larger than normal residential batteries. A neighbourhood battery would usually be located close to where electricity is being both consumed by homes and generated from rooftop solar, and the size can range from 100 kW to five megawatts (MW) (see https://www.energy.vic.gov.au/batteries-and-energy-storage/neighbourhood-battery-initiative for example).

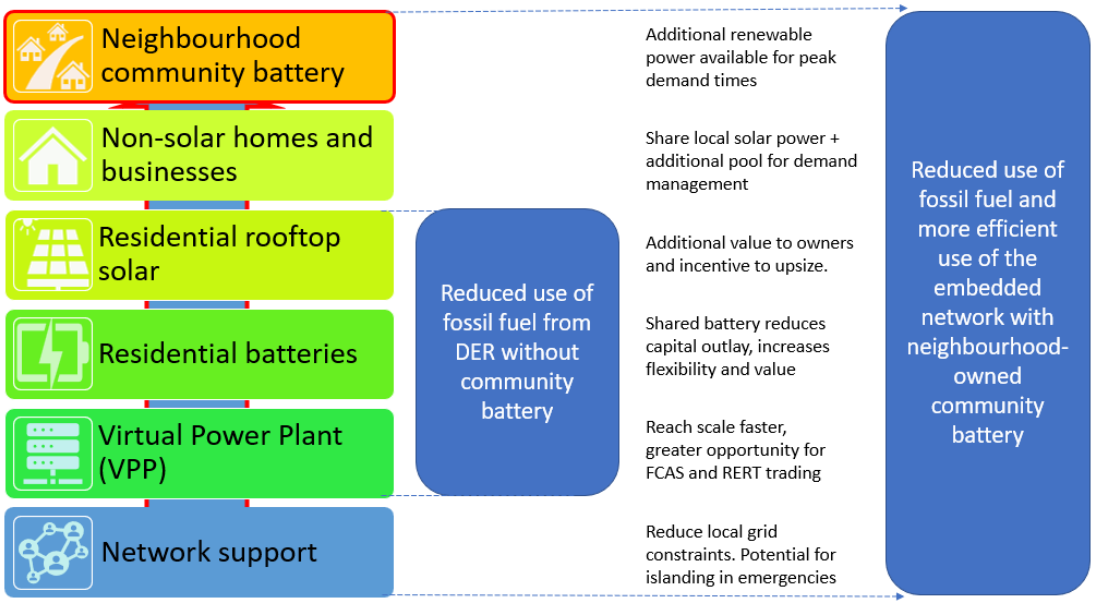

Figure 1: How a community-scale battery adds value to all DER elements. FCAS - Frequency Control Ancillary Services - and RERT - Reliability and Emergency Reserve Trader - are mechanisms to maintain power system reliability and security – FCAS and RERT contracts for energy generation depend on scale and earn significantly above normal market wholesale contracts.

2.3. Community consultation

Over past three years we have spoken to many members of the general community through holding information stalls at the Alphington Farmers' Market. This visibility in the community has resulted in many stopped-in-the-street chats with people wanting to learn about VP and our progress.

We have operated a website for the past three years and now have a register of 150 people interested in VP. We have used the register database to email out progress messages and meeting invitations.

As part of the idea development, we held two community energy forums, one co-hosted with the Northern Alliance for Greenhouse Action (NAGA) in June 2019 and one with the City of Melbourne and the Australian Energy Foundation in October 2019. We have also met with numerous community energy groups, including developing a close relationship with the Banyule Clean Energy Group (our neighbouring Council), attending the regular Community Scale Batteries Working Group meetings (hosted by the Total Environment Centre) and attended other community group meetings to represent VP, including the Darebin Climate Action Network. This interaction has been an efficient way to assess and include community attitudes and lessons from other projects.

In the past six months we held three community outreach events to refine our model: two webinars and one in-person meeting. The first in-person meeting in November was attended by 12 people, which was a reasonable response given the circumstances of the recent Covid lockdown. We held webinars in February 2022 and June 2022 and we were pleased to have 23 and 26 people attend, respectively. Each event was intended to introduce our vision for *zero carbon energy* and the work we have been doing. These sessions have tested and refined our model and were opportunities to test the vision and the appetite for change in behaviour.

All of this interaction has reinforced the high level of interested in community batteries and lots of questions about the national and Victorian energy systems.

3. Business model design

3.1. What problem are we trying to solve?

Neighbourhood batteries make the local grid more efficient and more stable. They can act as a 'solar soaker' and increase the capacity for renewable energy in the local network by reducing thermal constraints. This is as far as most neighbourhood battery projects go in providing benefits to the community. However, by engaging directly with the community, the Village Power model gives subscribers increased financial return on solar panels, which will provide additional incentives for locals to install panels – contributing to the decarbonization of the grid. There is also the opportunity for people without solar panels to subscribe and buy local renewable energy – providing an additional source of revenue for the VPNB. This direct engagement offers an opportunity to educate energy users and shape behaviour to make the grid more efficient.

This community interaction increases the complexity of the project. This in turn increases the cost, as the energy operating system needs to be more sophisticated and must communicate with the subscriber base. However Village Power believes it will deliver significantly greater benefits.

The VP proposed neighbourhood battery pilot is shown schematically as Phase 1 in Figure 2 below. Phase 1 will operate as a pilot project for 18 months and will test:

- Subscriber behaviour: when (time of day) and by how much excess residential power charges the battery, and when (time of day) subscribers 'withdraw' power from the battery
- How many subscribers the battery can support (target for the pilot is 150). (Note – the subscribers do not all have to be on the same feeder as the battery – subscription is essentially a virtual accounting of the value that solar power provides to the system, so subscribers can come from anywhere in the Jemena network.)
- The revenue model: timing of subscriber withdrawals relative to electricity market retail opportunities
- Billing and energy management systems (provided by VP partners)
- Willingness of the community to invest in a community battery to determine the viability of raising significant capital funding in future.

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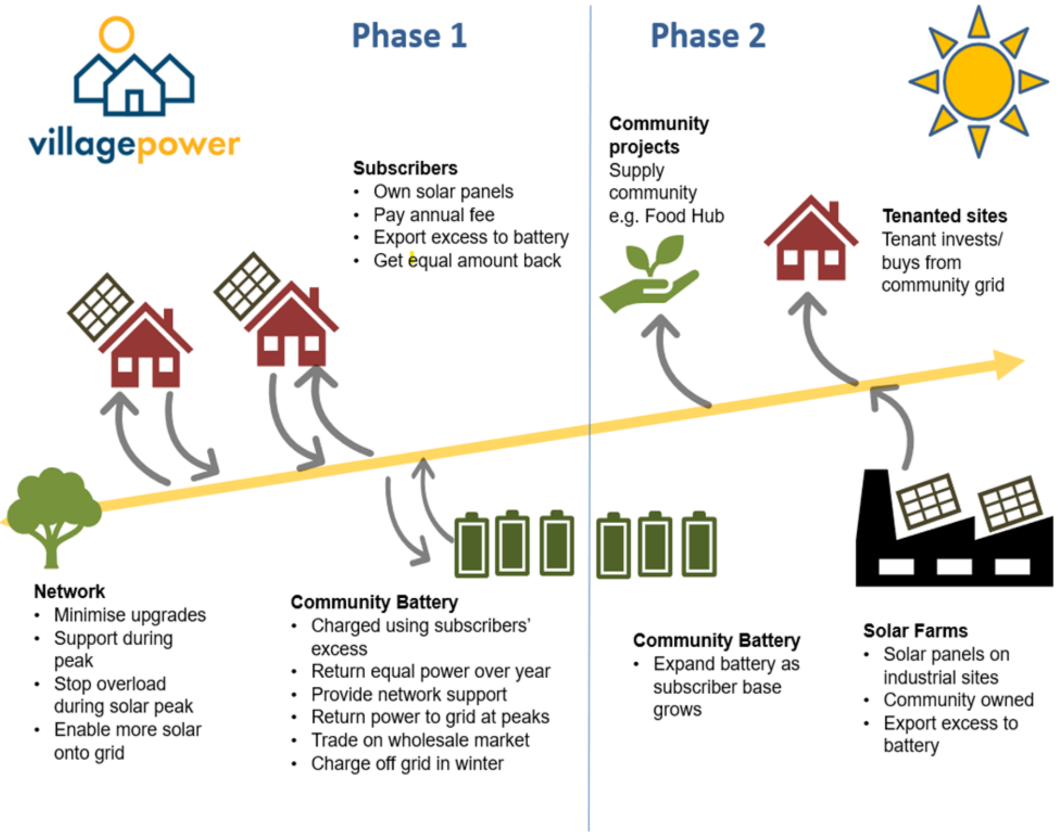

Figure 2: VPNB phases

This model is completely scalable. It can be implemented anywhere in the national electricity market in front of the meter but is most valuable where there are existing network constraints.

The opportunity to benefit from neighbourhood batteries increases dramatically with scale. Aggregating battery power opens access to the Frequency Control Ancillary Services (FCAS) and Reliability and Emergency Reserve Trader (RERT) markets – these are contracts that the Australian Energy Market Operator (AEMO) uses to maintain power system reliability and security. FCAS and RERT contracts for energy generation depend on scale and earn significantly above normal market wholesale contracts. The VP vision is for a network of neighbourhood batteries, either owned by VP or by partners. Lessons from this pilot project will guide the design of future battery installations.[3]

Village Power has planned a phased implementation starting with a pilot installation of a single community battery providing services to subscribers and network support. Once the feasibility is demonstrated and the kinks ironed out then we envisage scaling this up, either with other social enterprises implementing the model, or VP investors, to provide the full suite

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[3] VP is a social enterprise and plans to publish the results of the trial and share the model with local councils and other interested social enterprises to encourage the establishment of a network of neighbourhood batteries.

of services. This could include selling power to non-solar homes and businesses, incorporating solar farms or other community energy, working with councils and State government to increase local residential and small business solar, and with our retail partner to implement demand management.

3.2. Capital costs

Village Power commissioned Donegans to create a Business Plan for the phases of the project (*July 2022: Village Power Business Plan 1.1)*. The information cited here was sourced from the *Business Plan* and other resources listed in the *Related Documents* section (Appendix 1).

Battery & establishment costs

The main cost for the project will be the battery and inverter; initial installed cost estimates for a battery of 500 kWh to 1 MWh is $800/kWh storage. This would indicate a cost of $400k for a 500kWh battery. This estimate has been supported by a number of different sources, including estimates from Enhar (*Site Suitability and Connection Design*) and Shinehub. This equipment can be packaged in a standard 20ft shipping container to be installed onsite.

Battery costs (not including battery management, inverters and installation) have dropped significantly in the last decade. Bloomberg New Energy Finance reports that[4] Lithium-ion battery pack prices, which were above $1,200 per kilowatt-hour in 2010, have fallen 89% in real terms to $132/kWh in 2021. Further reductions are anticipated with forecasts showing the cost halving to around $75/kWh by mid to late 2020's. The battery component is approximately 50% of the total installed cost, so a 50% battery cell cost reduction will see a reduction in installed cost of around 25%. This initial cost is why the VPNB requires a grant for the first neighbourhood battery, but we believe that subsequent batteries can be funded from the proceeds of the business.

An updated budget cost of $460k for a containerised 560 kWh battery with a 200 kW/400V connection and battery controls was received in June 2022.[5]

Energy Optimisation System (EOS)

A second significant cost is establishing, integrating and testing the energy optimisation system. The EOS is a complex algorithm that optimises the energy flows, identifying whether the greatest value is to send power to the grid or back to subscribers. Value can be defined in terms of avoided CO_2 or cost.

The Village Power model is much more complicated than other neighbourhood battery models as we seek to directly engage the community in order to provide incentives to build

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[4] https://about.bnef.com/blog/battery-pack-prices-fall-to-an-average-of-132-kwh-but-rising-commodity-prices-start-to-bite/ Accessed August 1, 2022.

[5] Received from ShineHub on request from VP. A 560kWh battery was the size proposed by Shinehub in an indicative response to the BESS specifications.

additional solar power. This means that the VP EOS is significantly more complex and expensive than the battery management systems needed by other projects.

An important component of the neighbourhood battery model is the interface between the low-level battery software, the retailer, the wholesale energy market and Village Power. LO3 is working with Village Power on:

- Preparation of the Energy Optimisation System (EOS) architecture
- Preliminary design mock-ups of subscriber mobile apps and operators web pages explaining the function of the energy optimisation system.
- Modelling the performance of the battery and EOS scenarios to be used in the battery trial
- Integration with the retailer/billing system and other stakeholders including the DNSP

LO3 is also providing cost estimates and the requirements to fully explore, design, modify or otherwise furnish the final system including interaction with Village Power, the retailer, the DNSP and any other stakeholders needed for the system management.

LO3 provided the initial revenue modelling based on an energy optimisation algorithm co-developed with VP, and quoted $175,000 to establish and integrate all of the connections needed for the EOS. (This was consistent with the establishment costs quoted by other providers during the EOS tender process.) During the next phase the VP Project Team will issue a new tender for the final EOS; possible options include a number of open source providers (such as RedGrid[6] https://ioen.tech) as well as the battery provider. The business model used the LO3 estimate in order to be conservative, but open source providers may reduce the final cost considerably.

Site preparation and grid connection

Another cost is connecting the battery to the grid. Networks treat community-scale batteries as small generators and the cost of connection is determined by the size of the connection and the quality of the existing network infrastructure. The size of the connection depends on the total storage and how fast the battery is discharged. The faster the discharge the larger the connection. The large grid support or power back up batteries have large connections with the capacity to discharge all the stored power in around 1 hour. For utility purposes the discharge time is typically in the 2 to 4 hour range. Connection costs also depend on any network augmentation that would be required – this will depend on the physical location of the battery (cost will increase with distance from the transformer) and the power profile of the network in the chosen location.

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[6] Source: Redgrid/Manningham NBI Project

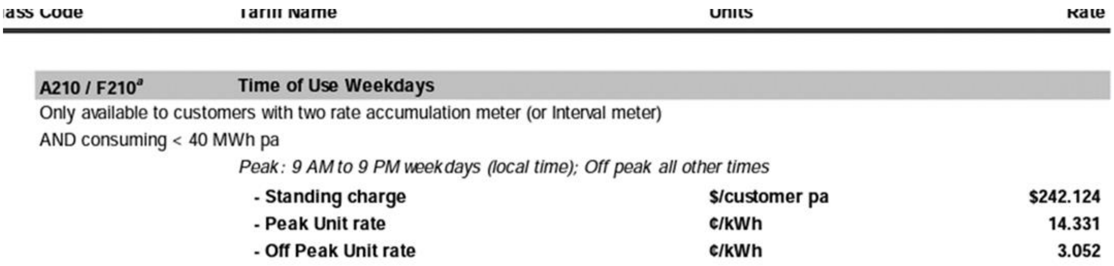
Advice from Jemena was that keeping the size of the battery connection below 200kVA would significantly reduce the cost of connection. This puts an effective ceiling on the size of the neighbourhood battery. Indicative costs for the connection range from $10 k to $50k. Enhar (in consultation with Jemena) estimate $30,000 for connection at the preferred Wingrove Road site (Enhar, March 2022: *Site Suitability and Connection Design - Final Report*).

Site preparation costs are highly dependent on the final location – however all sites will require a concrete foundation, protection by bollards and/or security fence and a connection to overhead power lines. Site preparation costs are estimated at $90,000.

3.3. Tariffs

There are two sources of tariff – both are volume tariffs and are included in the model as an additional per kWh charge on energy flows into or out of the battery.

Network tariffs are levied by the DNSP, and depend on the function, volume and value of the power flows and DNSPs have some discretion in how these are levied. Advice from Jemena is that the VP battery would fall under a small-scale commercial tariff A210/F210 (see Figure 3) and therefore network charges would be levied at 14.33 c/kWh during peak periods and 3.052 c/kWh during off-peak periods[7]. LO3 modelling indicated that these tariffs would be prohibitive for the business model as it would not be possible to cover the costs of the subscription.



ass Code	Tariff Name	Units	Rate
A210 / F210[a]	**Time of Use Weekdays**		
Only available to customers with two rate accumulation meter (or Interval meter) AND consuming < 40 MWh pa			
	Peak: 9 AM to 9 PM weekdays (local time); Off peak all other times		
	- Standing charge	**$/customer pa**	**$242.124**
	- Peak Unit rate	**¢/kWh**	**14.331**
	- Off Peak Unit rate	**¢/kWh**	**3.052**

Figure 3: Jemena commercial tariffs for small-scale generator. (Source: Jemena Tariff Structure Statement 2022: https://jemena.com.au/documents/electricity/2021-2026_tariff-structure-statement.aspx)

Jemena has indicated that they are willing to consider a trial tariff based on time of use and designed for neighbourhood batteries. This will be confirmed during the establishment phase of the VPNB. Financial modelling here uses tariffs proposed to the Australian Energy Regulator by CitiPower for a 'non-distributor owned community battery'[8] – see Table 1.

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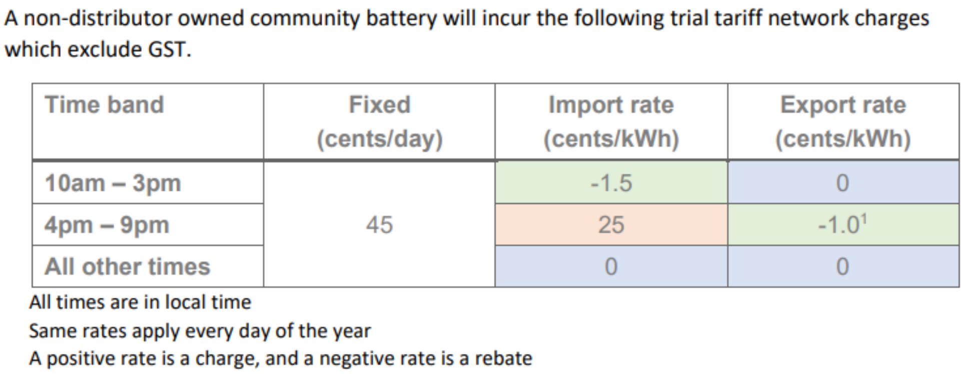
[7] Source: correspondence with Jemena on application for a small generator connection.

[8] AER, 2022. CitiPower Trial tariff notification 2022-23. Available at https://www.aer.gov.au/system/files/CitiPower%20-%20Tariff%20trial%20notification%20-%202022-23_1.pdf

Table 1: Trial tariffs for a non-distributor owned community battery, proposed by Citipower.



A non-distributor owned community battery will incur the following trial tariff network charges which exclude GST.

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

The retailer will also charge a volume-based tariff to cover billing and accounting expenses. This will be confirmed when a retail partner is identified, but is modelled here at 2 c/kWh[9].

3.4. Operating expenses

The battery and connection will be installed on land provided by Darebin Council. The Control system for battery will be installed with the battery but operated from the power management operation site. Village Power will be a tenant of Darebin Council, hence insurance on site will be covered by Council but the battery will be a Village Power cost – this is being investigated. An allowance has been made in the budget for Professional indemnity and Cyber protection insurance[10]. No premises are envisaged in the short-term as Village Power will operate as a virtual entity. Village Power requirements will be limited to record keeping, marketing materials, website, mailing lists and financial records. These are currently held in cloud-based files. Most significant IT infrastructure will be provided by partners and the battery supplier.

Operating costs per annum

- EOS annual service fee $10,000
- Battery servicing (insurance) $4,000 est
- Site lease, maintenance and security $3,000 est
- Insurance $5,000 est
- Manager/ Administration $10,000
- Marketing $5,000 est
- Financial services and reporting $3,000 est
- Auditing $2,000 est

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[9] Estimated based on preliminary conversations with retailers

[10] As part of the battery installation process a Disaster recovery plan will be completed.

3.5. Financial overview

Preliminary modelling demonstrates that a community scale battery trading in the market without community participation, with 50% of the price of the battery ($300k) covered by a grant the battery pays itself off in 9 years (Figure 4). Noting that we are not including FCAS revenue here.

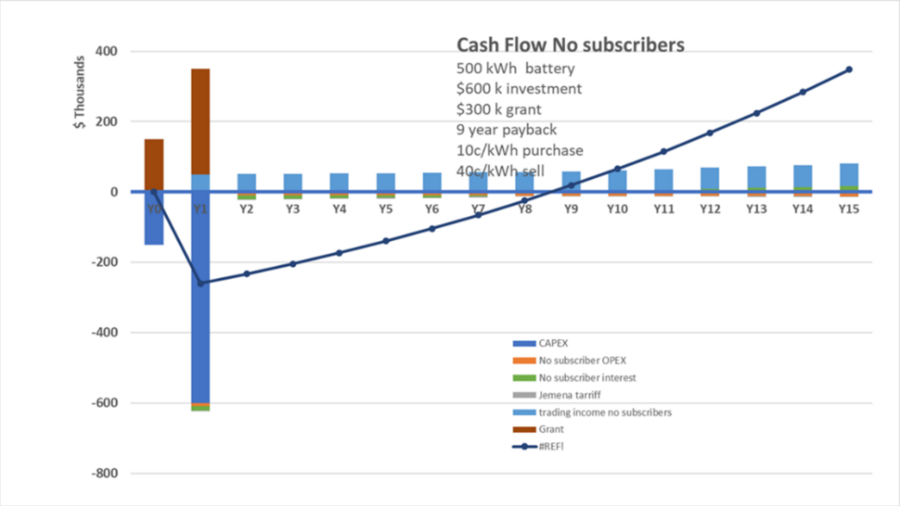

Figure 4: Investment and projected revenue for a community battery trading in the market. The modelling here assumes a $300,000 grant.

Adding subscribers increases the complexity of the modelling and can actually add cost (depending on the network tariffs assumed), however it has indirect financial benefits as described at the start of Section 3. Figure 5 shows that if subscribers pay a 50c/day tariff, a 7.5c feed-in rate and a 15c buy back price, the model essentially breaks even. This pricing is assumed to be attractive to subscribers and does not have an impact on the payback time for the battery. These figures are consistent with the modelling done by LO3 on subscriber revenue. Note: the initial subscriber offering will be refined by the Village Power Community Panel (see Section 8.2 – Governance) in consultation with the retail partner.

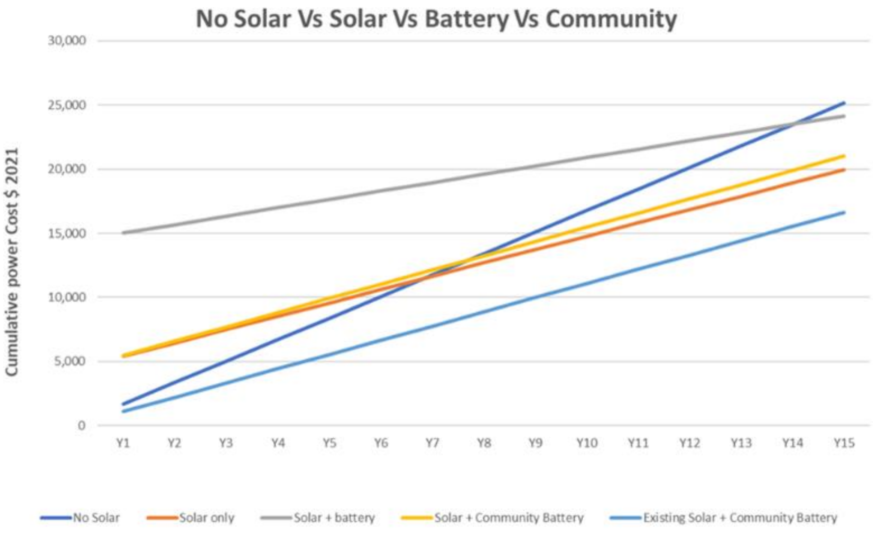

Figure 5: Impact of battery power pricing on different customer groups. This modelling uses a 7.5c feed-in tariff and a 15c buy-back price and is likely to be attractive to subscribers as the return (shown here as a payback period in years) is considerably better than a residential battery. The feed-in tariff and buy-back price is cost neutral for the neighbourhood battery project but will be tested during the pilot phase of the project.

With the current regulatory structure – in particular with current network tariffs and the inability to access the value created for the network, it is challenging to make the subscription model work. With 50 subscribers capped at a maximum of 7 kWh/day into the battery we get a 20 year payback with current modelling (Figure 6). A time of day-based trial tariff, as discussed in Section 3.3, makes this scenario significantly more attractive.

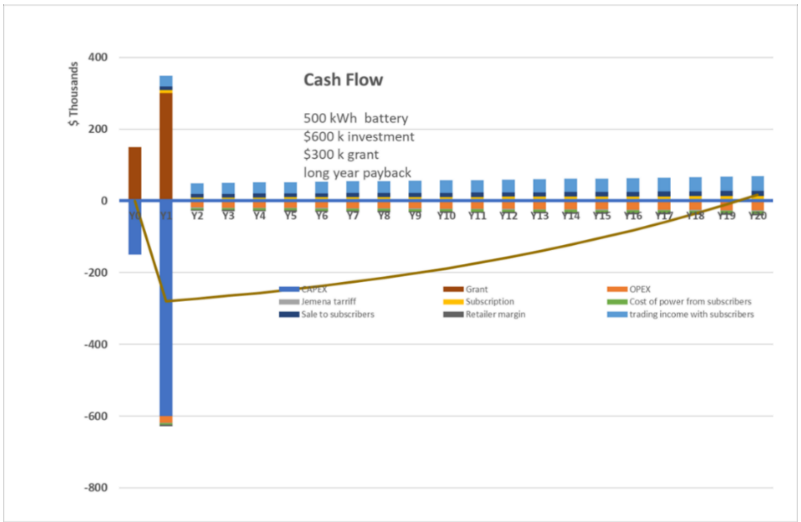

Figure 6: Worst case revenue modelling for the battery. This case assumes commercial tariffs (12c for both charging and discharging), charging the battery only once a day and a $300,000 grant. This results in an unattractive return on investment.

The model can be improved by charging twice a day (see Figure 7). The battery can be charged every day through the year using excess solar and at night by purchasing 'green' energy from the grid. This model would support potentially more subscribers but has the advantage of income from peak shifting power, as well as some marginal income from the subscribers. Noting that FCAS and other network revenue have not been included in this model – these revenue streams are unpredictable and depend on aggregation with other BESS so have not been included but have the potential to make actual income significantly higher.

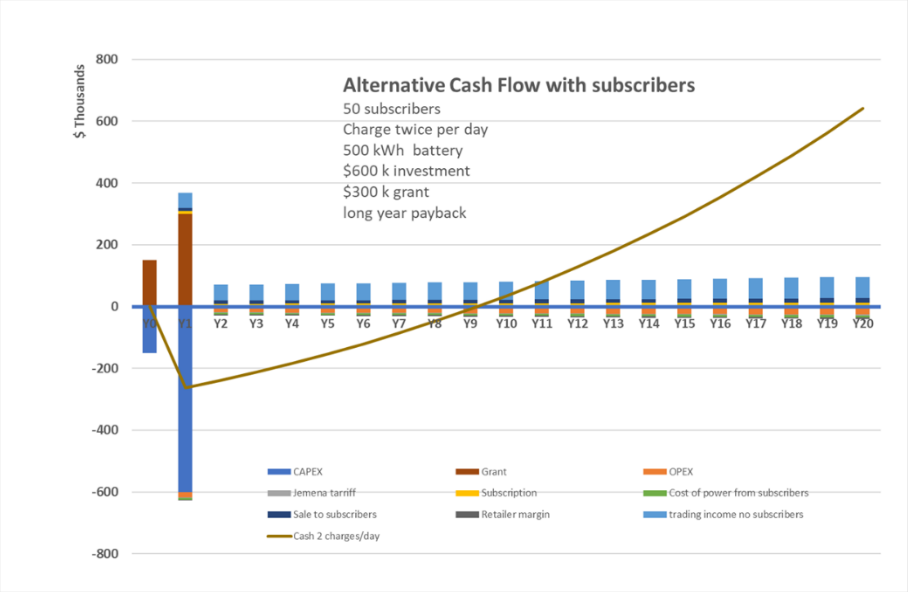

Figure 7: Revenue modelling if the battery is charged twice a day showing a reasonable return on investment (represented by payback years). Note - previous assumptions have not been changed, so the model can be improved with bespoke network tariffs and reduced investment (with a grant, or in the future, with reduced battery prices).

3.6. Subscriber revenue modelling

LO3 constructed a financial model for VP customizing an 8760 (annual, hourly) load profile specific to this use case. The profile includes an average load profile for a Melbourne, VIC residential customer with 4.4 kW solar photovoltaic (PV) who participates with 200kW/500kWh battery. LO3 used the National Renewable Energy Laboratory (NREL) tool - Renewable Energy Integration and Optimization ("REopt")[11] to create the bespoke residential + solar and battery load profiles as inputs into the model. To ensure the load profile is optimized properly, the load profile was built to optimize against the Indigo Power residential retail rate.[12]

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[11] https://reopt.nrel.gov/

[12] Indigo Power was chosen as a reasonable representative of retailers that are supportive of community energy. The model is not very sensitive to retail prices.

The outcome of the modelling indicates that providing financial benefits to subscribers is net revenue neutral at best, which suggests that operational costs would need to be covered from wholesale market arbitrage ('peak-shifting'). Preliminary calculations, as well as trial batteries in the field (in particular, the YEF Solar Soaker project) indicates that this should be possible – with potential significant upside of accessing the FCAS market through aggregation with other batteries not included.

As VP considered how to incorporate wholesale market participation, understanding best-fit arbitrage hours is key. VP will seek to identify hours of the day, throughout the year, to optimize financial return. Below, the battery import and export charts show when the battery is neither importing or exporting, where the battery could be participating in the wholesale markets.

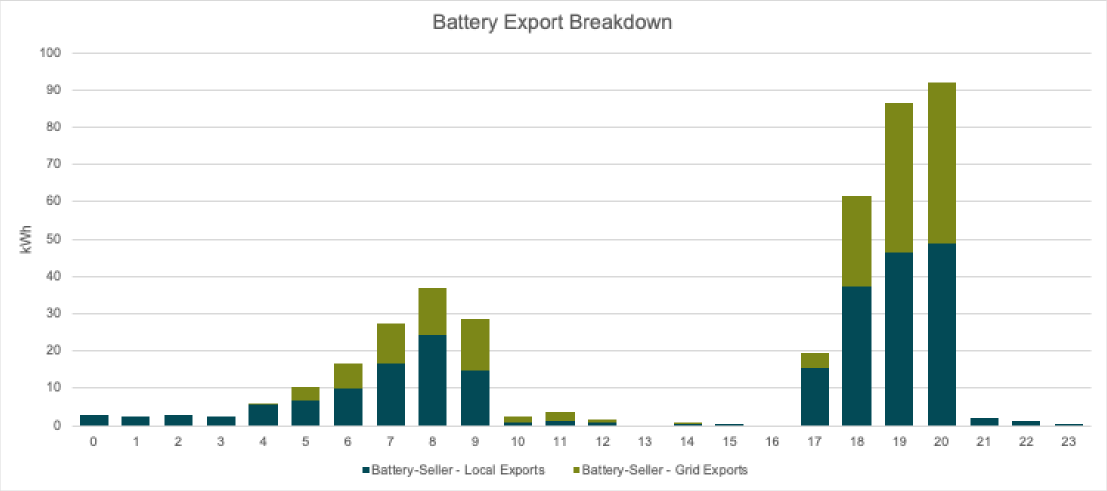

Figure 8: Hourly battery exports for July (Source: LO3 model). This chart shows when the subscribers buy power back from the battery (dark blue) and when the battery sells back into the market (green). This participation in the wholesale market will allow the battery operator to participate in FCAS markets. Figure 9 shows that battery charging periods are asynchronous with times of peak export. It is this pattern that provides the 'solar soaker' function.

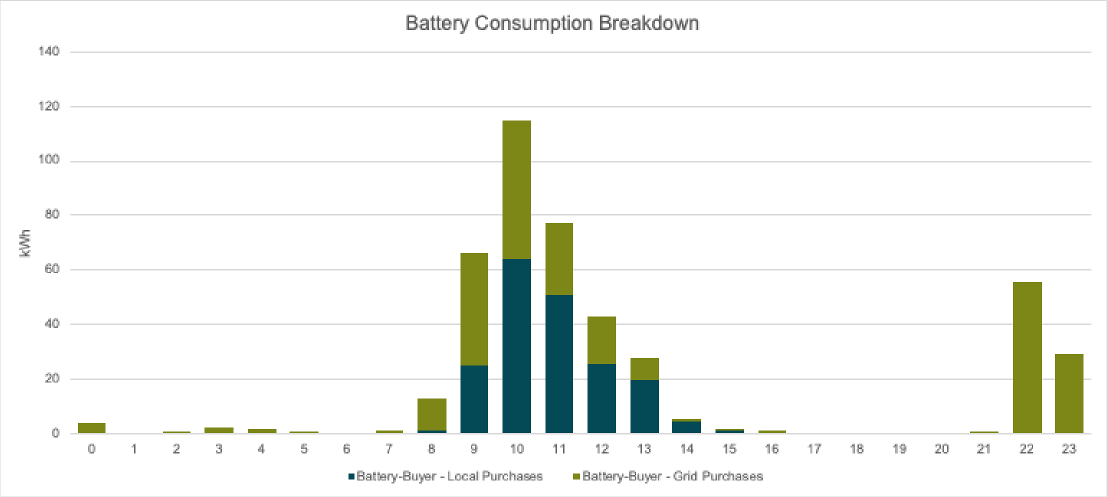

Figure 9: Hourly battery consumption for July (Source: LO3 model). This figure shows the pattern of battery charging: dark blue represents battery charging from subscribers and green shows the battery topping up from the market. As this is an example of a theoretical day in July in Melbourne, solar exports are low, so to achieve full charge the battery will also buy from the market. There is a second charging period after 10pm at night – this second charging period allows the battery to sell back into the morning peak. The battery operator can ensure that this charging is from renewables by having a 'green' contract which buys renewable energy certificates.

4. Site assessment and engineering requirements

The proposed Village Power Neighbourhood Battery will sit in front of the meter and will have 500 kWh of storage capacity to support 100 to 150 households with solar panels. It will require a 200 kVA connection to the grid. The battery will be operated to discharge during times of peak demand and charge at times of peak solar production to act as a 'solar soaker' and smooth power flows in the local section of the grid.

Eight sites were identified by Darebin Council and Village Power as potential locations for the battery. This was based on Council ownership, space to safely install the battery and site usage and development plans. The sites were then assessed using the ranking criteria described in Section 4.1 and the results of this initial assessment are provided in Appendix 2.

After the initial assessment a preferred site was identified at 2 Wingrove St[13]. This site is currently sub-let by Darebin Council to the Melbourne Innovation Centre (MIC) and therefore it was Council's preference that an additional Council-owned site, at Newman Reserve in Preston, was included in the next step – which was for Jemena to provide an additional assessment of connection feasibility (Section 4.2).

4.1. Site ranking criteria

The full list of criteria used to evaluate and differentiate between the sites are:

Available Space

The battery will be housed in a standard shipping container with a footprint of 6 m x 2.5 m. A minimum area of 30 m^2 to 50 m^2 is preferred to locate the container and have a fence for security.

Land Ownership

A preference is to have the battery located on land owned by City of Darebin. If not, the land must be available to Village Power.

Access

There must be adequate access to enable the construction and maintenance of the battery.

Network Provider (DNSP)

Jemena

Proximity to adequate power connection.

Distance to adequate power connection will have a significant impact on the cost of installing the battery as the connection cost will increase with distance.

Local Network Constraint

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[13] Note: Table 2 in Appendix 2 lists two possible locations at 2 Wingrove St. As these access the same transformer, for all subsequent evaluation these were treated as a single site.

Identify if there are any thermal or voltage constraints in the network area[14]. These constraints can lead to solar export curtailment and can reduce the opportunity for new panels in the area. Batteries can help alleviate both thermal and voltage constraints as they can 'soak up' peak solar flows. One of the key value drivers for a battery in front of the meter is to support the network and minimise the need for network upgrades so locating the battery in an area with network constraints will enable the impact of the battery on the network to be assessed.

Penetration of Solar in the area

The purpose of the battery is to enable greater penetration of rooftop solar in the area. A battery will enable midday peaks to be managed and will allow more rooftop solar to be installed. It is desirable to locate the battery in an area with high penetration of rooftop solar to enable an assessment of battery on peak feed in times.

Proximity to Dwellings

While the battery poses minimal risk and would have minimal noise impact, it would be preferred to not locate the battery close to houses. The experience from WA batteries suggests a minimum separation distance of 20 m from the battery to residences is desirable to reduce noise.

Community Impact/Amenity/Visibility

Any other identified benefit or disadvantage of the site to the community.

Safety – Fire risk

While the battery will be designed to comply with regulations and fire risk is very low, there have been fire incidents associated with some battery sites. The site should be evaluated to determine if there are any flammable materials or fire sensitivity nearby.

Safety – Collision risk

The battery should be in a location where there is minimal risk of impact from vehicles.

Planning Issues

Recent changes to planning requirements: the *Victoria Planning Provisions Amendment VC220* will make neighbourhood battery installation significantly more straightforward than in the past. This amendment supports the efficient delivery of neighbourhood batteries into the electricity distribution network by treating them as a "minor utility installation' and exempting them from planning permit requirements in all zones except the Public Conservation and Resource Zone.[15]

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[14] Voltage constraints arise from high power flows across an impedance, for example if there are high solar exports over a section of the distribution network, that can cause overvoltage as power flows along distribution lines and in reverse through the local distribution transformer. Thermal constraints occur when components such as conductors and transformers overheat due to high currents, especially in high ambient temperatures. Sun incident on large numbers of solar panels in an area can create both voltage and thermal constraints, but generally voltage constraints are the first to emerge, and often at lower export levels than would lead to thermal constraints. (Source: correspondence with Allan O'Neill. See *Related Documents* section)

[15] It is worth quoting here the justification for the amendment as this supports the premise of this entire feasibility report: "Neighbourhood batteries provide multiple benefits to the community as a public utility. Battery storage technologies support the decarbonisation of Victoria's electricity system; provide network benefits such as voltage management and mitigating minimum and/or peak demand; provide market services, including wholesale electricity market trading and Frequency Control Ancillary Services

Proximity to the Village Power target market

A successful pilot project requires 100-150 homes with solar power to sign up to the battery project, therefore community buy-in is important. Village Power has been doing initial community consultation work to engage the local community. This work has been centred around the Alphington Farmers Market and the Darebin Parkland communities. Proximity and visibility to this area is seen as a positive for community engagement.

4.2. Connection feasibility and constraints

A preliminary feasibility assessment, based on desktop assessment, was conducted by Jemena on the 2 Wingrove St site in Alphington and the Newman Reserve site in Preston (see *Related Documents* section - Jemena, March 2022: *Preliminary Advice - Village Power - Rev1.0 FINAL*). This assessment considered what would be needed to allow Village Power to install a 200kVA / 500kWh Battery at each of the identified sites and covered:

- Confirmation of available capacity at each site;
- High level scope of works for any augmentation required; and
- High level indication of connection complexity and costs (i.e. High, Medium, Low)

This preliminary advice considered Jemena's network development plans and load forecasts for the supply area.

The outcome of the assessment is shown in detail in Appendix 2 Table 3 and can be summarised as follows:

Criteria	2 Wingrove St	Newman Reserve
Export maximum	0 kVA	200 kVA
Import limit	40 kVA	200 kVA
Complexity	Medium	Low
Cost	Medium	Low
Final ranking	2	1

(FCAS); and provide consumer battery access services, helping to expand the benefits of storage to more energy users." Source: https://stfpbsprodapp01.blob.core.windows.net/amendmentfiles/1dd69bb8-cec1-ec11-983e-0022481198eb_87179b95-56b4-4242-8b30-c2118b4c2909_VC220%20Explanatory%20Report%20Approval%20Gazetted.pdf

Newman Reserve was considered suitable by Jemena without network augmentation, to accommodate the full 200kVA export and import levels.

This assessment demonstrated that the Wingrove St site is significantly constrained, which Jemena identified as presenting a problem as the export and import limits could not be increased without network capacity technology upgrade or by implementing a dynamic operating envelope.

4.3. Preferred battery site

Jemena's initial assessment of these sites concluded that the Wingrove St location favoured by VP and closest to the battery's likely user base would be unsuitable because:

- within the low voltage (LV) zone served by the relevant local substation, the relatively high proportion of consumers with rooftop PV meant that there was no available hosting (export) capacity to accommodate battery discharge additional to customer PV exports.
- at times of maximum customer demand (consumption) through the local substation, only 40kVA spare capacity would remain for battery charging.
- Jemena concluded that "*the battery would be required to operate at a static fixed export limit of 0kVA and maximum charging capacity of 40kVA*".

The site that Jemena preferred (Newman Reserve) was at a larger, lightly loaded and relatively new local substation remote from the customers likely to be users of the VP battery.

Village Power preferred the Wingrove St site as it presented the possibility of assessing how a battery operates in a constrained area, and it is also closer to the identified locus of community support – the Melbourne Farmers' Market, and Darebin Parklands. However, a dynamic operating envelope was not considered to be a feasible option as Jemena did not have the communications, monitoring and control systems available for the site. "Simpler time-based operation could also be considered. This has not previously been done for an embedded generation system on the Jemena network and is unlikely to be available prior to 2026"[16].

Jemena's assessment methodology effectively assumes that VP's battery would or might operate with a profile similar to that of the existing consumer base within an LV zone – discharging power at times of high solar PV generation and export and seeking to recharge at times of maximum consumer demand.

Both these scenarios are counter to the intention of operating the battery as a 'solar soaker'. All DNSPs stand to benefit from appropriate integration of local batteries into their networks and should be prepared to offer the necessary flexibility in connection assessment and tariffs to support trials of this technology. These trials may require bespoke solutions to ensure that safety and reliability of the local electricity networks in the short term. Jemena has stated that

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[16] Jemena Preliminary Advice – see *Related Documents* Section

they are willing to offer a trial network tariff designed specifically for neighbourhood battery operation. Ultimately they could transition into more standardized tariffs and dynamic connection arrangements developed under programs such as the Distributed Energy Integration Program (DEIP) run by Arena.[17] The section below discusses in more detail the benefits and options for a DNSP.

4.4. Assessing the benefits of a battery to the DNSPs

Village Power commissioned an issues paper on the role that neighbourhood or community batteries can potentially play in local distribution networks. We sought to explore the value to the network and the options for connection and tariff structures. This report (available in full in Appendix 3) concluded that neighbourhood batteries providing value to the local distribution networks, providing energy storage services which:

- Store energy at times of plentiful supply, typically from exported rooftop solar PV generation, for release at times of higher demand and more expensive supply.
- Are accessible to households and small businesses unable to install household batteries for financial or logistical reasons.
- Can directly support and improve the utilization profile of local network assets such as LV distribution circuits and transformers.
- Allow higher levels of rooftop PV penetration while deferring the need for local network capacity upgrades.

However, the experience of VP in seeking to establish the feasibility of a community battery has found that the way in which at least some distribution network companies assess the ability to connect batteries into their network may present a barrier to what VP would see as optimal siting – which would be in an area where high solar penetration has the potential to cause system constraints, and therefore solar exports may be curtailed.

Jemena’s initial assessment of VP’s proposed battery in effect assumed that it could operate like a very large solar PV generator or load, potentially producing and consuming power at times that might overload available network capacity, when in practice the battery’s operation would be counter-cyclical to existing energy flows from solar PV generation and consumer loads. The Jemena network does not currently have the ability to monitor the battery in real-time, and therefore their preference is for the battery to be sited at a network location relatively remote from its users and distant from more highly loaded parts of the network.

Case studies from other neighbourhood battery proposals who shared their experience with VP indicate a wide variety of approaches from network companies. Even a brief review of broader policy, regulatory and technical initiatives in response to the growth of “distributed energy” across the distribution sector shows that the rate of adaptation across this sector is quite uneven, despite encouragement from key stakeholders such as the Australian Renewable Energy Agency, Australian Energy Regulator, and governments.

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[17] https://arena.gov.au/knowledge-bank/deip-dynamic-operating-envelopes-workstream-outcomes-report/

VP's experience indicates that more active "buy-in" and engagement on these issues from all distribution businesses, not just a subset, will be required to fully establish the potential for community batteries. All DNSPs, who stand to benefit from appropriate integration of local batteries into their networks, should be prepared to offer the necessary flexibility in connection assessment and tariffs to support trials of this technology. As governments at both state and federal levels are already sponsoring programs including trial battery rollouts and wider regulatory reform supporting growth of distributed energy resources, they should also take an active role in ensuring that local network businesses in all relevant jurisdictions are positively supporting these initiatives in their engagement with trial proponents.

In a recent meeting with Jemena (June 23, 2022), they indicated that they would be willing to consider a connection with a dynamic operating contract that specifies a (seasonally specific) operating 'envelope' for the battery – this means that VP would be penalised if the battery operates in a way that is inconsistent with a 'solar soaker'. The proposed LO3 system could provide some of the necessary functionality to monitor the performance of the battery and ensure that it operated within the agreed seasonal constraints. The details are still to be developed.

5. Battery and system requirements

5.1. Connecting to the network

Household or business users of a neighbourhood battery would typically use their access to its energy storage and release capacity in a similar fashion to a user with their own household battery. This is because the underlying drivers for energy storage and consumption would be similar. Users could “deposit” excess PV-generated power in their neighbourhood battery “account”, and “withdraw that deposit” at times of higher consumption, in effect increasing their PV self-usage and reducing their personal energy draw from the upstream power system.

Where those users are located in the same LV section of the distribution network as the battery, this pattern of use could particularly assist in reducing demands on nearby distribution assets including “local substations” which are the smaller pole-mounted or kiosk-style transformers serving each LV section of the network, transforming power between the higher-voltage distribution feeders typically operating at 6.6 to 22 kilovolts (kV) and the 230 / 400 volt LV reticulation to homes and small businesses. In areas of high rooftop PV penetration, it is often this “last mile” of the network that comes under stress when consumer demand is low and PV generation is high, as exported power flows in reverse through the LV network and local substations.

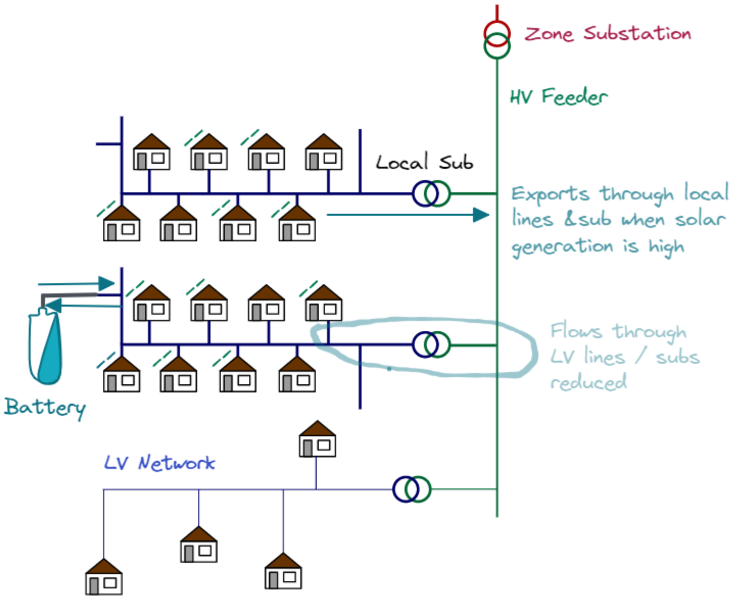


Figure 3: Distribution Network Schematic – solar PV and battery impacts [Source: O’Neill, Allan, May 2022: Neighbourhood batteries – assessing capacity to connect]

If a battery was instead located in a different LV section of the network from its users, those users’ contribution to capacity utilization levels and patterns within their own network section would not necessarily change, but their usage of the battery’s services could still benefit utilization of distribution network assets further upstream, for example at larger “zone substations”.

For maximum local network benefits, a neighbourhood battery would ideally be located physically and electrically close to its users. As these users would typically be customers with substantial rooftop PV installations with total export capacity potentially approaching limits on local network assets, there is an obvious case for neighbourhood battery installations targeting exactly those parts of the network.

5.2. The battery

The proposed battery will be a containerised system with batteries, chargers, inverters, transformers and a battery management system. The battery systems will fit in a standard 6 m x 2.4 m container (or smaller), it will be fully insulated and compliant with relevant Australian standards and regulations.

Images from the Shinehub proposal of a typical containerised battery are shown in Figure 10. This facility is shown as an indicative representation of a neighbourhood scale battery.

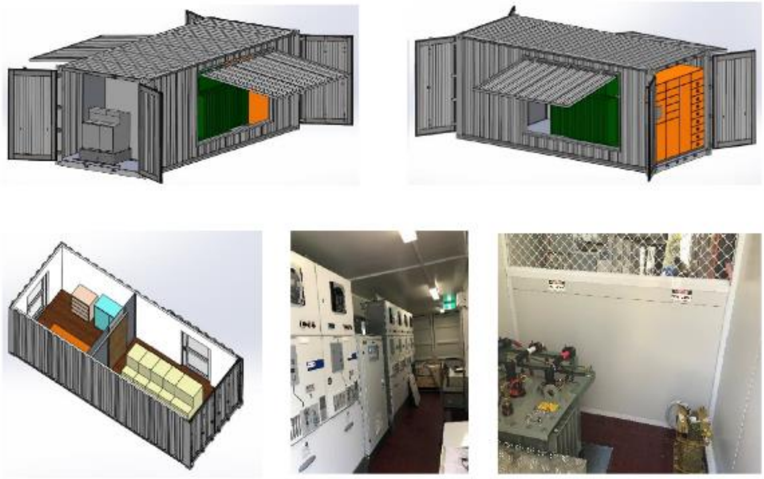


Figure 10: Typical containerised battery - images provided by Shinehub.

Figure 11 below shows a larger 1,100 kWh battery installed in a new housing development in WA. This system has a larger sized container, and is fenced off for security.

Figure 11: Alkimos Beach 1.1 MW battery in WA

5.3. Battery Energy Storage System (BESS) specifications and connections

Village Power commissioned Enhar engineering company to draft the BESS based on the initial business model. They have provided detailed specifications that include how the site should be prepared, technical requirements to deliver on the business model, safety requirements including fire suppression, protection of the site, and standards that apply to the wiring, container and connection. The specifications also include monitoring and communications system requirements to ensure that the battery management system integrates seamlessly with the energy optimisation system and provides data streams which can be used to monitor and optimise performance. The interaction between the different components is shown in Figure 12, and the BESS specifications are available in *Related Documents* (Appendix 1).

5.4. Energy optimisation system

The energy management and accounting system is a critical part of making the model work. The EOS will identify where and when the battery can provide the most value in order to balance value to the community with revenue to cover the cost of operations.

The EOS software will need to track energy in and out for subscribers as well as energy in and out of the battery in response to market signals (see Figure 12). This requires a sophisticated algorithm to assess where the battery power is most valuable at any point in time. Luckily, these systems are available in the market today and are used to manage energy on scales ranging from embedded networks and microgrids, to dedicated market generators. Energy management will need to be augmented by accounting systems which handle customer billing and reconciliation, in particular to a retail partner and (potentially) a different power aggregator partner who will trade on the wholesale market. In the VP pilot plan all of these functions will be outsourced.

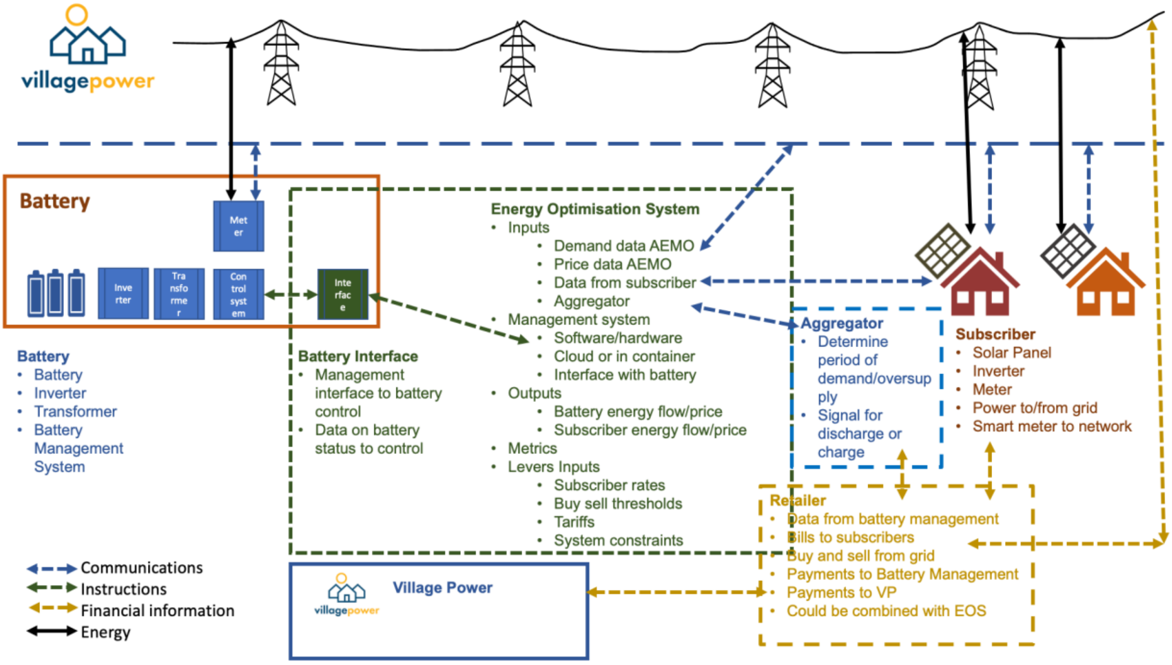


Figure 12: Interfaces between the different components and partners of the VPNB

System Design

Village Power commissioned LO3 to design the architecture and the interfaces between the different components of the VPNB (Figure 12). As part of this work, they modelled energy flows and potential revenues from the VPNB subscriber base. Village Power intends to go to market for the final system, but the work with LO3 has provided a strong basis to understand the implementation (and potential price) of the final EOS.

Technical Architecture

LO3 proposed the use of their Pando platform to provide reporting, analytics and flexible data visualisation and integration with the battery, the subscribers, the retailer partner, the DNSP and the battery manager. Pando can control and manage a range of energy, financial and control signals sent and received throughout the community battery system. The proposed system includes hardware components (at minimum a battery, but also potentially customer meter gateways and/or solar inverters), multiple software systems (at minimum, Pando, the battery energy management system – "BEMS", a retailer's billing system and potentially also an aggregator's platform and additional control systems) and multiple stakeholders within the market (Village Power, residential solar subscribers, AEMO, a retailer, an aggregator and Jemena).

The below diagrams (Figure 13 and Figure 14) outline the core services which will be needed by the community battery project.

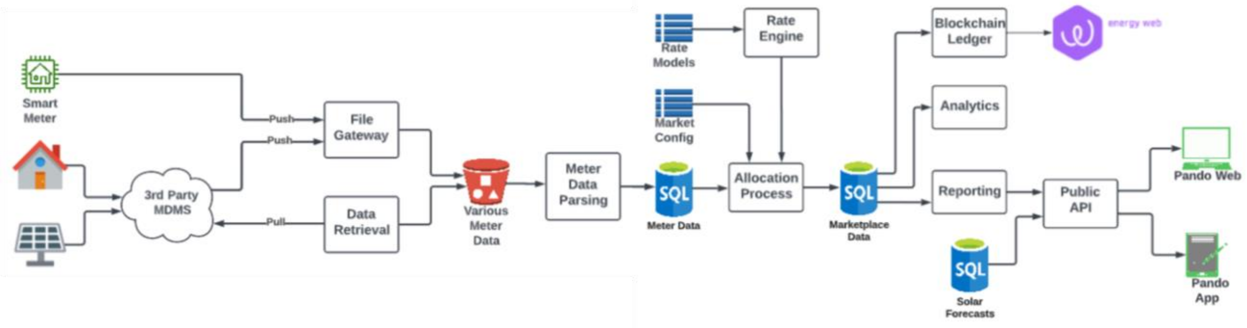


Figure 13: General Platform architecture. (Source: LO3 proposal to VP)

The contemplated community battery pilot involves multiple integrations between Pando and other software systems and databases. The proposed overall project architecture is detailed below:

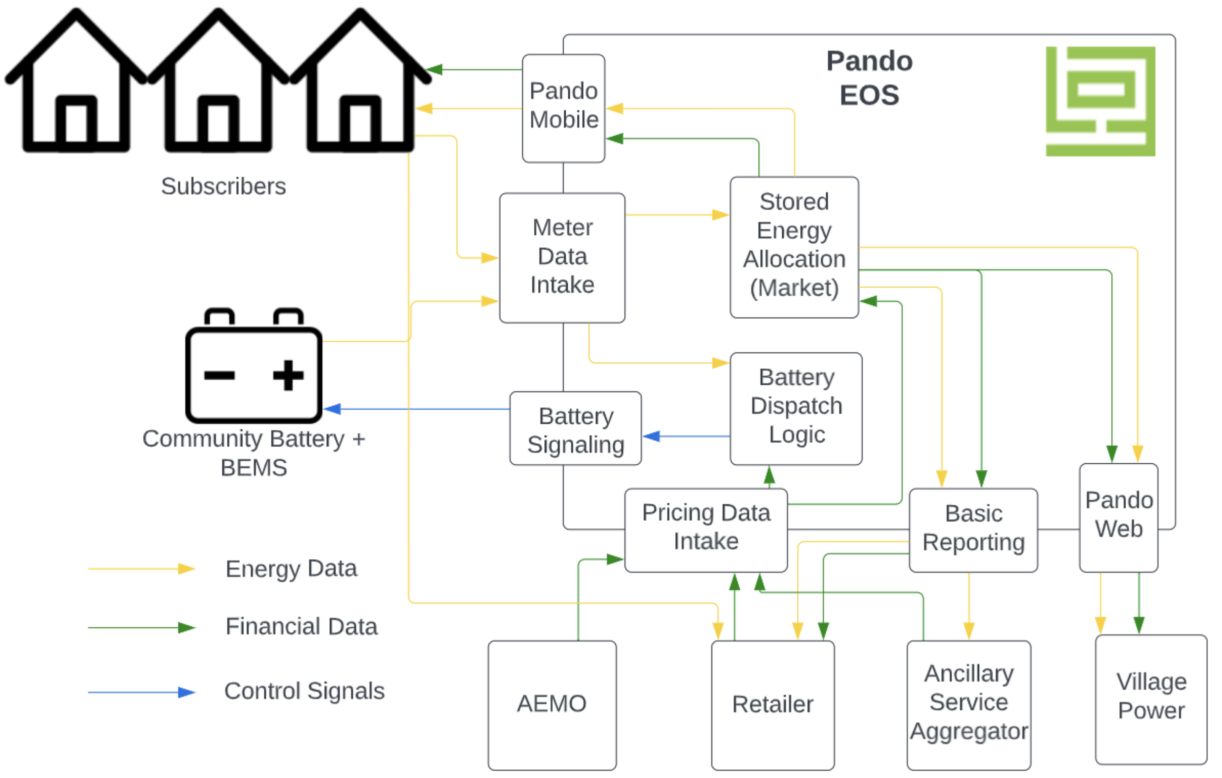
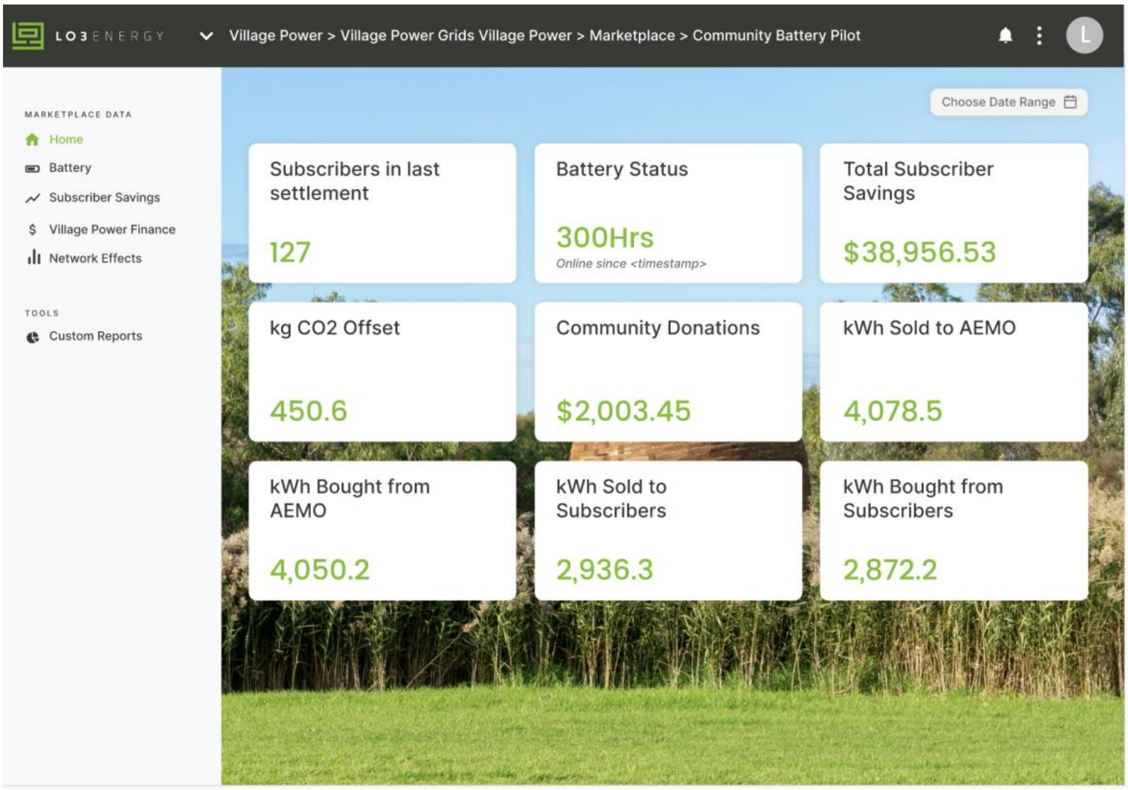


Figure 14: Village Power Community Battery EOS architecture

Web App

Architecture and 'mock-up' pages for the web application have also been prepared. The web app is designed to provide data to the operator VP and other stakeholders such as Jemena. This web app provides data on battery performance, financial data and network impact and performance. User stories were used to guide the design (see also Section 0) of the mock-up pages below – the relevant user story is given in the caption of each of the following Figures 15-20.



Subscribers in last settlement: 127

Battery Status: 300Hrs
Online since <timestamp>

Total Subscriber Savings: $38,956.53

kg CO2 Offset: 450.6

Community Donations: $2,003.45

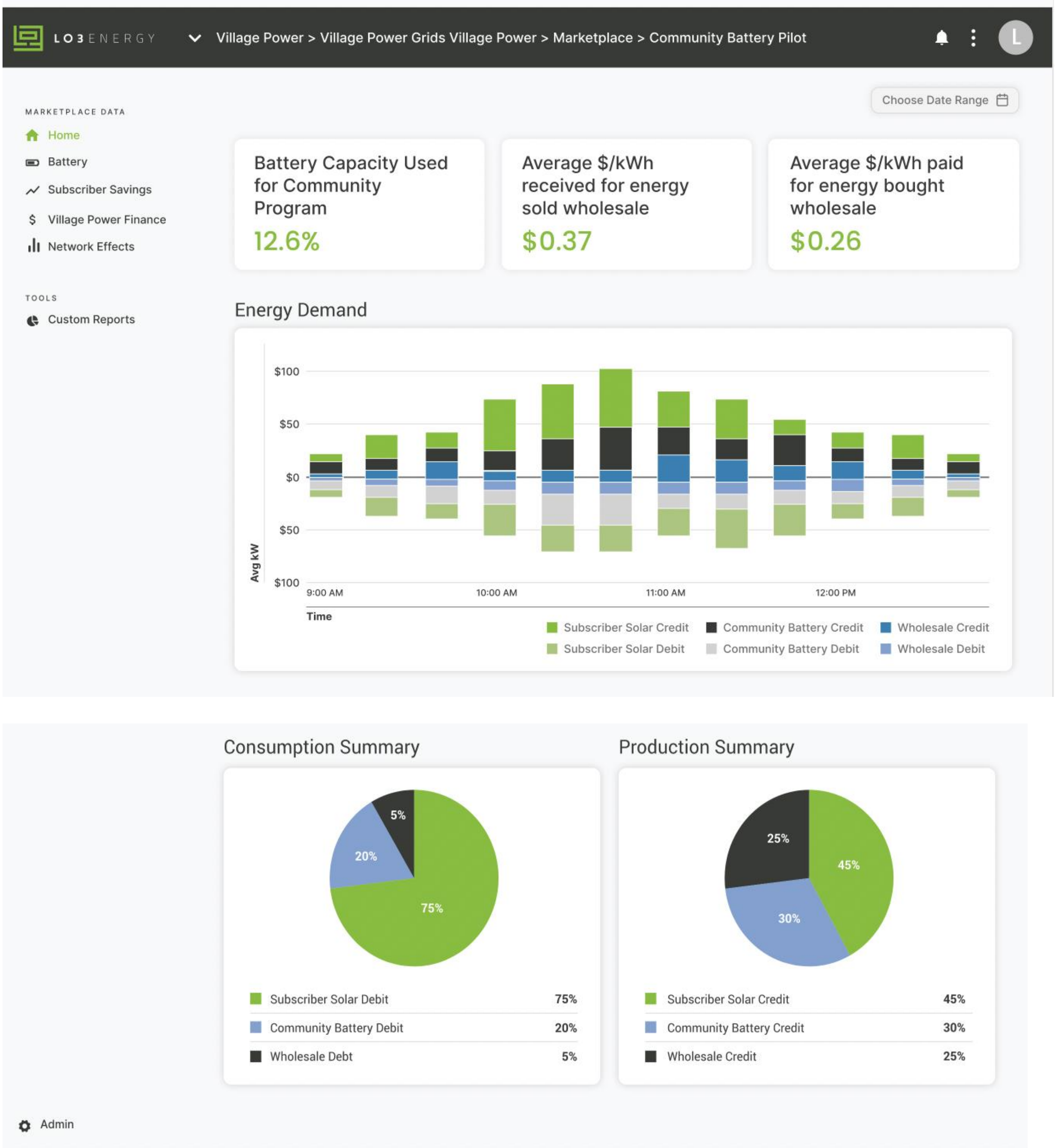
kWh Sold to AEMO: 4,078.5

kWh Bought from AEMO: 4,050.2

kWh Sold to Subscribers: 2,936.3

kWh Bought from Subscribers: 2,872.2

Figure 15: Home page for users. "As an administrative user, I can view the home dashboard and see the total number of participants participating in the market currently, total virtual battery charge and discharge (kWh and AUD) for the market for a selected period of time. I can also see the community battery program service fee costs such as total AUD accrued from the volumetric subscription fees, to date."



Battery Capacity Used for Community Program
12.6%

Average $/kWh received for energy sold wholesale
$0.37

Average $/kWh paid for energy bought wholesale
$0.26

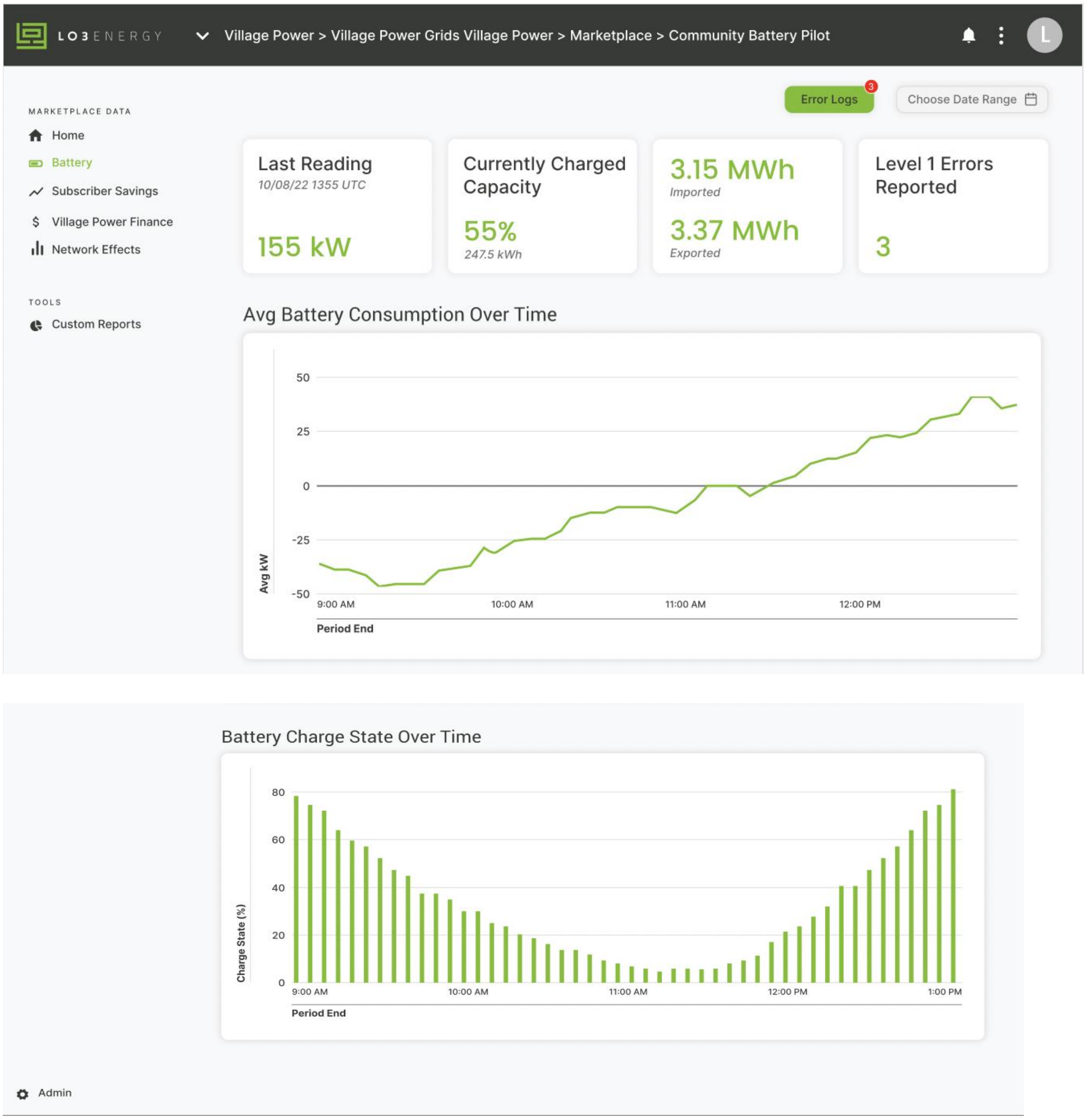
Consumption Summary

🟩 Subscriber Solar Debit	75%
🟦 Community Battery Debit	20%
■ Wholesale Debt	5%

Production Summary

🟩 Subscriber Solar Credit	45%
🟦 Community Battery Credit	30%
■ Wholesale Credit	25%

Figure 16: Market Activity Pages: "As an administrator, I need to view both individual and aggregated user buy and sell transactions to identify anomalies and trends to make informed decisions regarding future battery purchases or enrollment requirements."



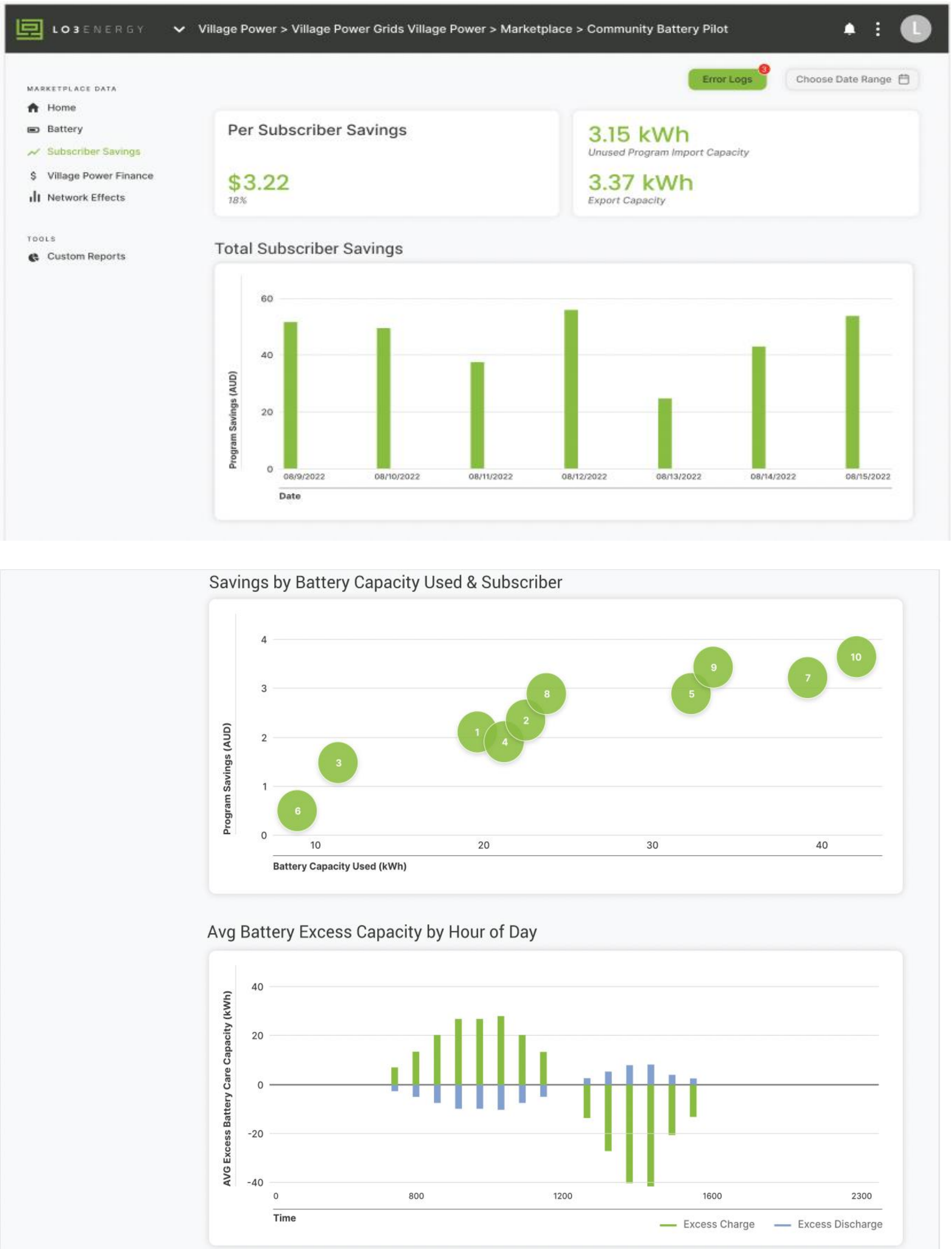
Last Reading
10/08/22 1355 UTC
155 kW

Currently Charged Capacity
55%
247.5 kWh

3.15 MWh
Imported
3.37 MWh
Exported

Level 1 Errors Reported
3

Figure 17: Battery Operator page: "As an administrator, I need to view details regarding the health, uptime and performance of the battery to ensure users are receiving the full benefit of the battery. I need the battery dashboard to signal if the battery is not working so I can communicate with the battery manufacturer."

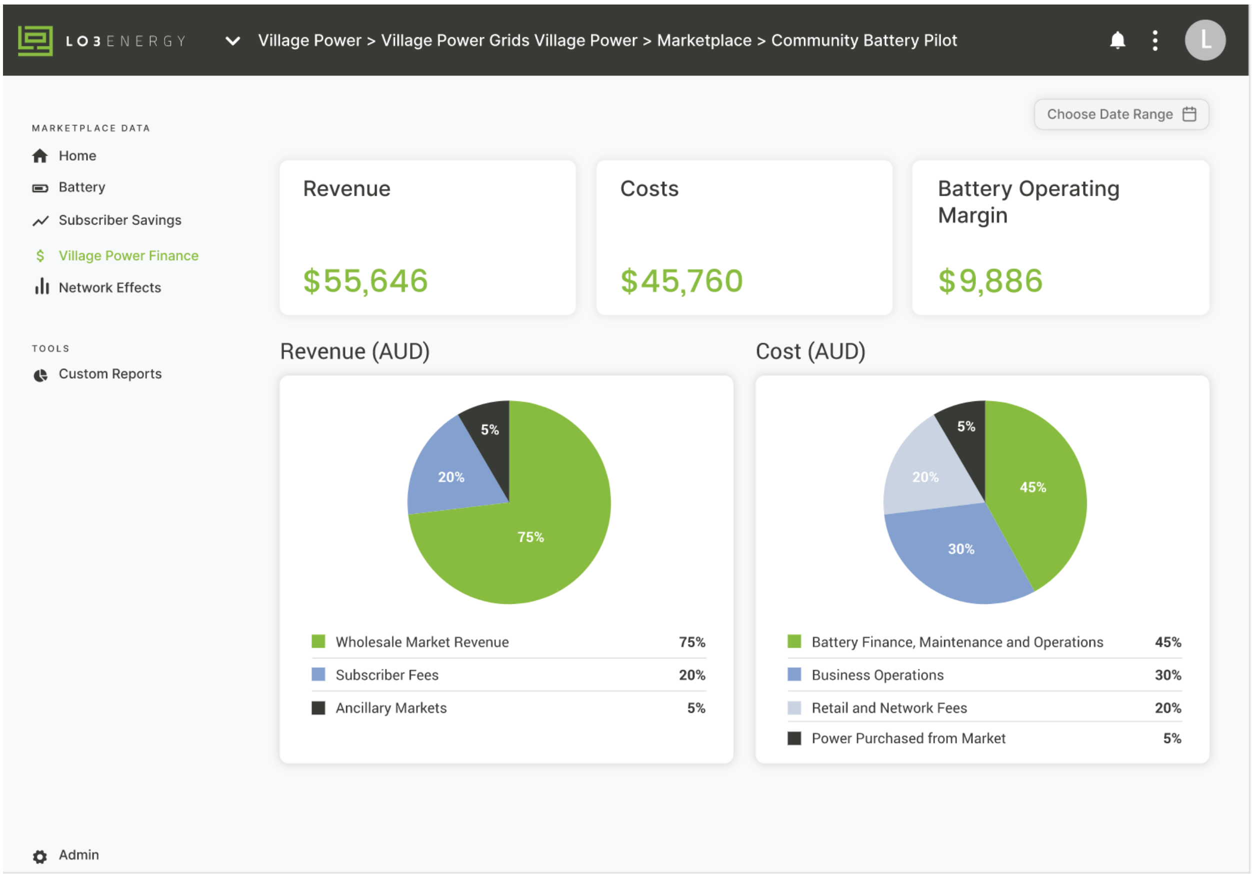


Per Subscriber Savings
$3.22
18%

3.15 kWh
Unused Program Import Capacity

3.37 kWh
Export Capacity

Figure 18: Subscriber pages: "As an administrator, I want to view the financial benefits to the subscribers and the unused capacity to identify additional savings and or benefits to the market."



Revenue	Costs	Battery Operating Margin
$55,646	$45,760	$9,886

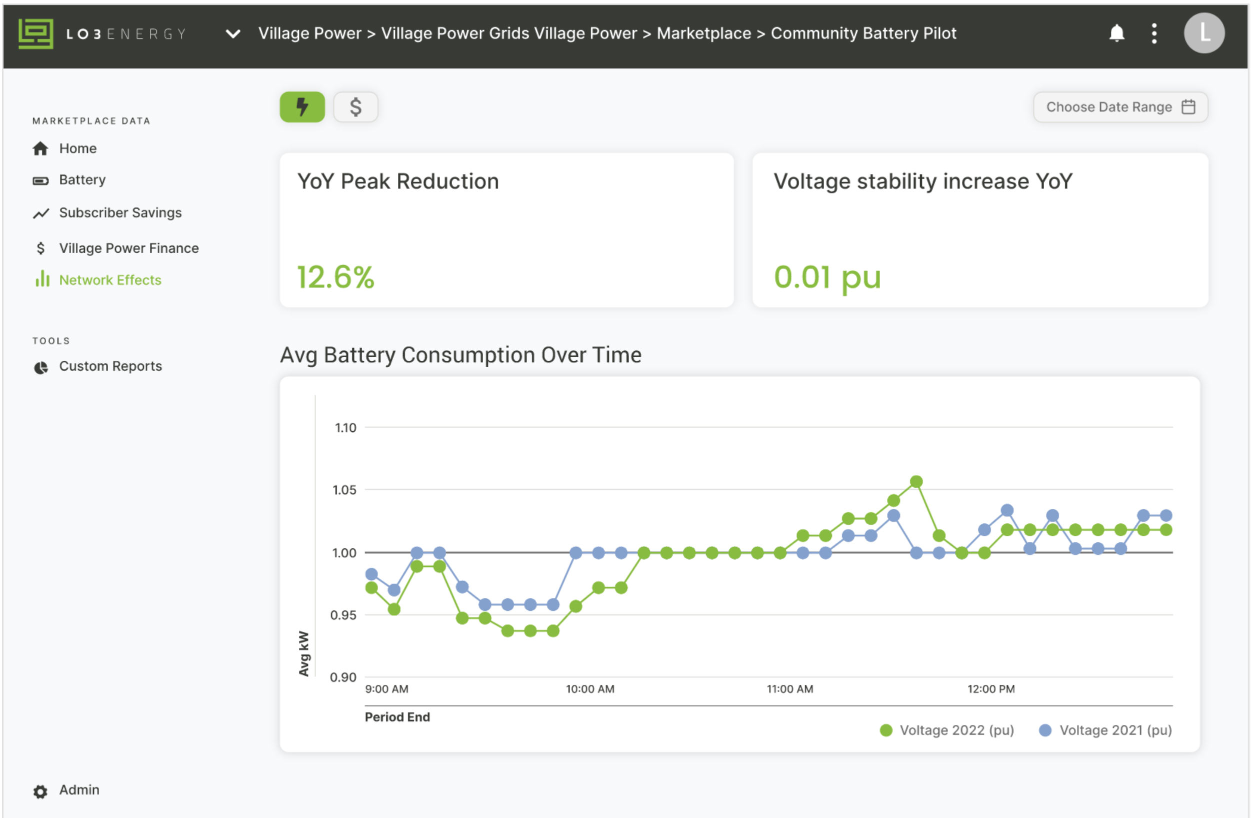
Revenue (AUD)

🟩 Wholesale Market Revenue	75%
🟦 Subscriber Fees	20%
■ Ancillary Markets	5%

Cost (AUD)

🟩 Battery Finance, Maintenance and Operations	45%
🟦 Business Operations	30%
▨ Retail and Network Fees	20%
■ Power Purchased from Market	5%

Figure 19: Financial pages: "As an administrator, I need to view the subscriber costs, battery operating costs and potential revenue created by the market. I want to view these costs as a % of a total to understand where costs are high so I can make informed economic decisions."



YoY Peak Reduction

12.6%

Voltage stability increase YoY

0.01 pu

Figure 20: Network effects page: "As a DNSP I need to see network impacts to assess the value of the battery for potential future investments."

Mobile App

In the same way, preliminary design and mock-ups of the mobile app that will be available to the subscriber base have also been prepared. Examples of some of the mobile app mock-up pages and the user stories they address are shown below in Figure 19.

In the last hour, your community battery has imported 43 kWh and exported 23 kWh of clean solar energy

Community has replaced 41% of grid imports with clean energy provided by comm battery program

Figure 21: Participant mobile app page examples: User Story – "As a participant, I can view my individual solar, battery, and traditional/retail energy consumption data and associated costs. I want to track how much I am charging the battery with their excess solar."

6. Community benefits, ownership and marketing

6.1. Community benefits

A core element of the VP model for neighbourhood batteries is community *ownership* of the battery as part of their solution to addressing climate change. Our intention is to support members of the community to take positive action around their use of energy. Support for community energy will be tested in part by community willingness to invest in the battery, but there will also be the opportunity to join a community group that collectively looks for ways to increase awareness of energy systems and use.

In addition, our business structure will be designed so that profit returns from the battery operations will be invested into the community. However profit is expected to be low and certainly not immediate (see Section 3).

The ultimate test of community recognition of this beneficial model would be replication by other communities. VP intends to share all learnings from our investigations as well as to design an ownership structure that facilitates replication.

6.2. Ownership structures

Given the high establishment costs and learning necessary to implement a financially viable community battery, Village Power will establish a two-tier business model. The primary tier will enable communities to establish and operate batteries to service their areas. Each community would operate as a discrete business entity. Over time, there would be multiple community battery entities (see Figure 22, Village Power Community and entities Alpha/ Beta/ Gamma).

The overhead services to support the communities will be provided by a single entity, as represented by Village Power Services (VP Services) in the operating model below.

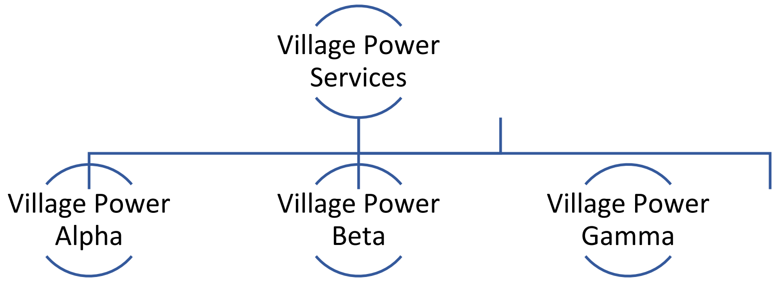


Figure 22: The Village Power community of batteries

For the purposes of the first battery trial, Village Power will continue to operate as a single Incorporated Association. The above model would be established for subsequent batteries for other communities.

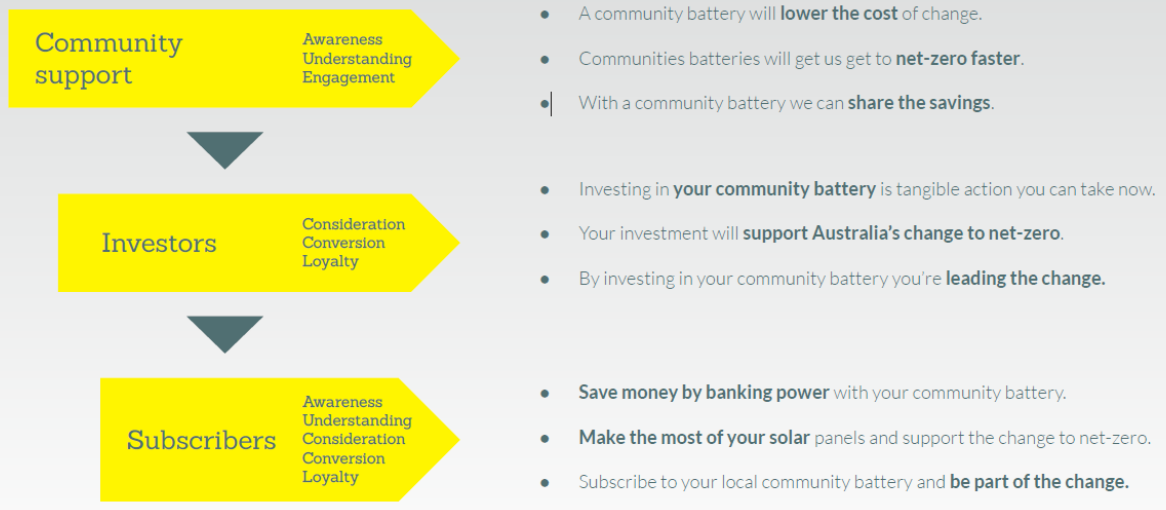
6.3. Marketing plan

The marketing plan for the delivery stage reflects the need to communicate with and engage three sets of stakeholders. The first are the community supporters that will join Village Power Incorporated as members. VP membership will appeal to people to:

- Take positive action on climate change by enabling community reduction of our carbon footprint
- Be part of a ground-breaking community battery initiative and secure its success
- Shape the community enterprise that operates the battery
- Learn about the energy market and role and challenges of local renewable energy
- Contribute ideas on how we can expand the impact of Village Power

The second group will be local community investors. These may be a subset of VP members. The appeal to this group is for those that want to literally part own the solution and contribute to getting it off the ground. The total investment amount for the first battery would be approximately 10% of the capital cost.

The third group are subscribers or customers of VP power. This may be a subset of the other groups or completely independent. However, these people will need to reside in an area operated by Jemena and preferably relatively close to the battery.



- A community battery will **lower the cost** of change.
- Communities batteries will get us get to **net-zero faster**.
- With a community battery we can **share the savings**.

- Investing in **your community battery** is tangible action you can take now.
- Your investment will **support Australia's change to net-zero**.
- By investing in your community battery you're **leading the change.**

- **Save money by banking power** with your community battery.
- **Make the most of your solar** panels and support the change to net-zero.
- Subscribe to your local community battery and **be part of the change.**

Figure 23: Messaging to different stakeholder groups (Source: Hive for Village Power)

VP worked with the HIVE Creative group to develop a marketing plan based on the steps identified in Figure 23.

HIVE conducted research into the number of people and households within close proximity to the Newman Reserve site in Preston and identified the priority audience segments as follows:

1. Environmentally-minded locals (≈13,392 people)

    After COVID, 26% of Australians mentioned climate change and global warming as the biggest problem facing the world (Roy Morgan, 2021).

2. Owner occupier - with solar installed (≈2,440 homes)
3. Renters - with solar installed (≈1,692 homes)

    Roy Morgan research shows 21% of Victorian households own a Home Solar Electric Panel (March 2017).

4. Local business owners - with solar installed
5. Those living within 500m of the battery

    Most-likely to be concerned about the physical appearance and impact of the battery.

The local resident base population: 51,509

The local dwelling base population: 19,680

The marketing plan lays out marketing objectives, actions, success measures and budgets for each of these three groups. Essentially the marketing would be conducted as a series of actions that layer over previous actions.

7. Pilot phase: identifying value to stakeholders

It will have become clear by now that a successful neighbourhood battery takes multiple strong relationships – see Figure 24 below

Figure 24: Examples of the range of partnerships that will be needed to contribute to the VP NB network

VP, with the support of Enhar engineers, developed 'user stories' to illustrate the experience of the different partners. This approach was used to inform the development of the EOS (Section 5.4). A user story is intended to state how a service is experienced or what a user needs without asserting the solution for how that need is to be met. This approach allows the requirement language to be accessible to non-technical people who will own and operate the system (among other users).

The user stories for the Village Power network include:

Subscriber with Solar

As a rooftop solar owning household member, I want to become a part owner of a community battery. Among the benefits I expect are that my excess solar is used to charge the battery and then in the night-time, the battery will discharge and I will access my own solar power instead of grid power. I expect the neighbourhood battery to be better value than a dedicated home energy battery I might otherwise buy. I want to also support my neighbourhood socially. I expect the battery to provide resilience to the neighbourhood.

- The project furnishes comparative costs and benefits of a common home battery e.g. Tesla Powerwall versus the VP battery ownership share.
- The project can explain how and how much the battery will improve local power quality
- There is some output of the project that the neighbours can share apart from electricity (such as profits)

OPTION: As a subscriber to the neighbourhood battery I want to see my daytime excess solar power used to charge the battery. At night, the battery will discharge, and I will access my own solar power. I want this to occur so that I use local power not grid power. I expect the battery power to be cheaper than the energy retail rate. I expect to still buy some grid power as the battery is shared and I know I need more power than my share of the community battery can provide.

- The system provides a feed that shows the subscriber's imported battery power for the day, the week etc.
- This may also show grid import.
- The feed may show volume, cost, savings, CO2 avoided, deaths avoided, global heating reduced, etc.
- In reality, the battery does not serve electrons to specific subscribers. Instead, an averaging effect among various network participants levels supply and demand.
- The reporting mechanism is a web page or phone "app"

Subscriber without Solar

Subscribers without Solar will not be part of the pilot phase of the battery. It is envisaged that in the future the battery will provide a service for subscribers without Solar panels.

Operator (Village Power)

As the operator of the shared battery, I want to see how much power has been used to charge the battery and how much has been discharged. I need to see this so that I know that the battery is performing properly. I need to see a report of the volume of power exchanged and I want to see that the battery cycles as deeply as possible each day. This way I know subscribers are making good use of it. A report shows the battery functional volume over time, which slowly drops

- A report shows any offline time, any errors from the hardware
- Any serious issue is sent on a real time feed, such as the battery being offline, a thermal event, vandalism, hacking and so on.
- The report is a web service

Retailer

As the contracted energy retailer that provides direct access to wholesale rates for electricity, I need the battery to report to my system on the volume of charge and discharge. I need this information so that I can create a bill for each subscriber to recoup the import cost of energy for the battery and reconcile subscriber imports.

- There is a scheduled report that is sent electronically to the retailer. It may be in an energy wholesaler or machine readable digital format as required by the retailer
- The retailer creates the entire subscriber bill, or the retailer creates a bill addendum or a completely separate bill.
- Market or industry standards are listed for compliance in each service component
- Metering is compliant with Jemena DNSP requirements and National Electricity Rules

Distribution Network provider (Jemena)

As the network provider, I need to provide the neighbourhood battery connection. I also need the battery to be installed where there is adequate capacity. I need the battery to perform safely according to Australian Standards so it does not harm network assets or other connected users.

- In future, the battery might address local congestion as directed by the network provider
- In future, the battery may contribute to avoiding dynamic operating envelope (DOE) curtailment
- The battery may charge or discharge based on detecting local voltage

Owner (e.g. community cooperative)

As the owner of this battery I need to be able to assemble a clear narrative on the costs and benefits of the battery to the subscribers and the network. I want to do this so that the subscribers are happy to pay a subscription and continue to use the battery. I want to furnish information from this project to stimulate regulatory reform in support of deploying more neighbourhood batteries to achieve a higher penetration of local solar generation and progress to a zero emissions energy system. I want to demonstrate that this Neighbourhood battery concept is financially viable. As part of the dynamic VPNB pilot we will explore:

- different scenarios around demand and penetration rates of solar
- different scenarios around daily tariff and usage tariffs, to subscribers
- network scenarios such as the services of the battery avoiding infrastructure asset replacement costs in the DNSP RAB
- various value stacks and how “partitioning” the battery (that is, allocating a proportion to not discharge except for FCAS or local power support) will provide financial benefits

  - the potential for predictive charging based on predicted demand, weather etc
  - the value of VPP integration for FCAS revenue and other benefits
  - the potential value of "local energy trading" within the distribution zone

Aggregator

As the aggregator of this battery for FCAS market participation, I need to be able to include this battery in my portfolio of battery assets which operate on the various FCAS ancillary markets. I want to do this so that FCAS revenue is maximised from the battery and shared with the owner Village Power in accordance with the agreements.

As the aggregator of this battery, I need metering of the battery to be compliant with the appropriate interoperation standards.

8. Next steps

With the support of the NBI Grant from DELWP, Village Power is now fully prepared to establish and test the Village Power Neighbourhood Battery model. We set out in 2018 with the idea of developing a model to share excess solar power generated from our roof-top panels with our neighbours and to engage the community to contribute to a more efficient electricity network and 100% carbon-neutral electricity.

Village Power, with the support of Donegans, have prepared a detailed business plan which will guide the next phase. This business plan integrates the detailed financial modelling of the battery during operation, provided by LO3 with an assessment of the cost of establishing and operating a business.

We are now ready to make this a reality. Next steps include (approximately in order, although many of these can happen in parallel):

- Build Village Power Inc including building our project delivery team, deliver on the marketing plan to engage new members and start to build interest in community investment
- Establish Technical Advisory Committee and Community Panel (see Figure 13), working with the retail partner, to provide advice and oversight and consult on final design of pilot including subscription package.
- Establish partnership with retailer/aggregator
- Seek capital funding for the purchase of the battery. Grant funding will be needed because of the complexity of the proposed business model and the difficulty of a single entity capturing and monetising the value available to the network from the neighbourhood battery. Once the business model is established (and making the assumption that the cost of batteries is expected to fall in the future) it is expected that subsequent batteries will not need this initial injection of capital.
- Confirm site, sign lease and request planning permission for the battery installation.
- Develop prospectus and commence community fundraising.
- Continue conversations with Bendigo Bank about establishing a loan/line of credit, using the battery as collateral, to ensure there are no cashflow problems prior to establishing a revenue stream from selling power.
- Procure battery using battery specifications and tender documents already prepared.
- Compare options for EOS partner, including LO3 proposal, open source partner and integration with battery supplier. Select EOS partner
- Prepare site for installation, including network connection agreement and community artwork. Install battery.

- Integrate battery system with EOS and establish and test links to retail and network partners
- Communications planning for launch including working with retailer on marketing plan for Subscribers and Customers.
- Commission battery and start 3 month trial period to monitor battery performance and customer behaviour
- Launch full-scale 18 month NB pilot

8.1. Retail EOI

It is not the goal of VP to become a retailer, so VP needs to have a relationship with at least one retailer. A retail partner is needed to provide access to residents (as current regulation means that only one entity can have access to residential meters) and can provide accounting and billing services. VP can offer a retailer significant additional value for their subscribers, and potentially can help lock in customers (customer 'churn' is a significant cost for retailers, therefore this is an attractive prospect).

VP will secure a relationship with a retailer that operates within the Jemena network.

8.2. Governance

During the feasibility assessment for the VPNB (covered by this report) VP has regularly met with Darebin City Council (weekly) and representatives of the DELWP NBI Team (monthly). The project was managed by the VP project team which consisted of:

- Graeme Martin – Marketing and business structure
- Judith Landsberg – NBI Stream 1 Project Manager
- Antony Perri – Technical and financial modelling
- David Craven – Community relations
- Antony Jones – Accounting and project finance

The next stage of the project will require deep expertise in a number of areas and coordination across multiple streams of work. This will be provided by the structure shown in Figure 25, with additional support from consultants as necessary.

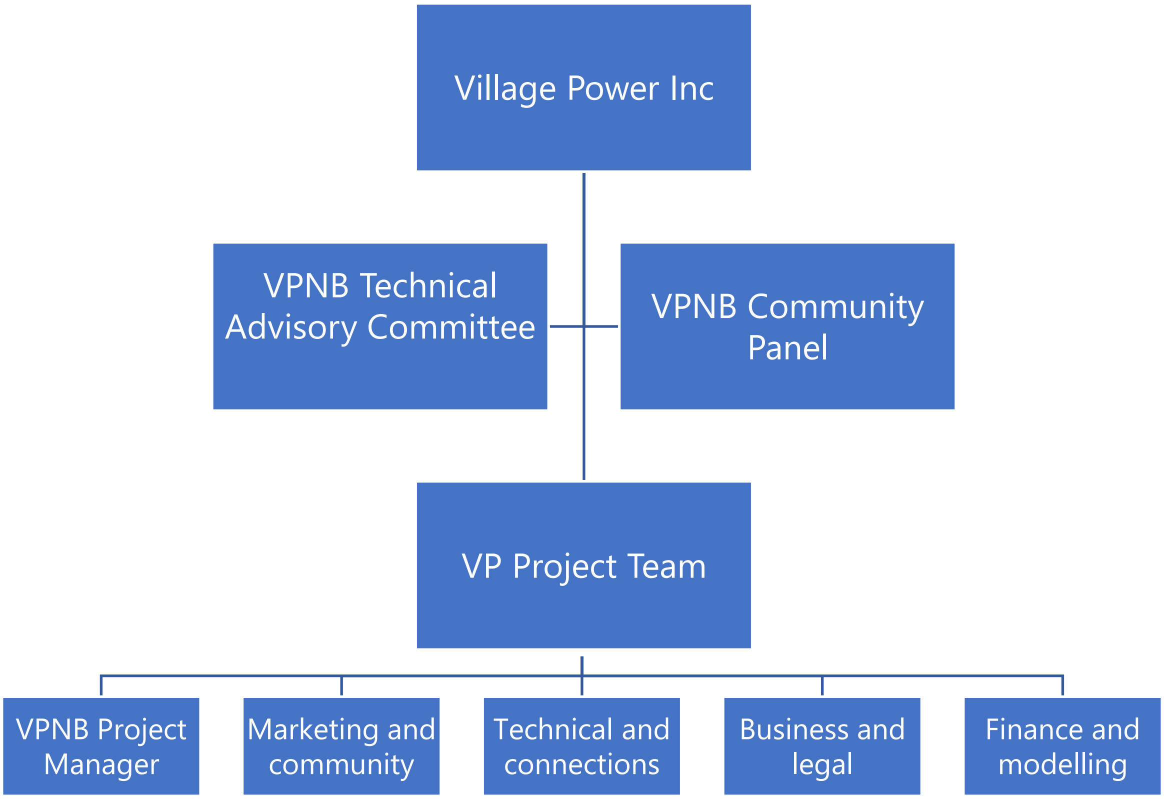


Figure 25: VPNB Governance Structure

Technical Advisory Committee: Will meet monthly to monitor project progress, review any potential risks arising and to confirm the next set of tasks and to issue and review tenders. Membership will consist of VP Technical and Connections team, VP current and past Directors, Jemena, Darebin Council, EOS and retail partner representatives. This team will have an advisory role only.

Community Panel: Will meet monthly, meetings may be more frequent early in the project. Membership will be invited from Village Power ordinary members, VP Marketing and Community team, relevant community stakeholders – for example Melbourne Farmers Market – and representative from Darebin Council Communities team and the VPNB retail partner. This Panel will provide advice on the location of the VPNB and the design of the initial pilot phase of the model, including subscription costs and benefits. They will review the performance of the VPNB in the pilot phase and advocate for the project to the community.

Appendix 1: Related documents

Village Power commissioned work from a number of consultants and partners to answer key questions during the development of the model and drafting of the Feasibility Report. Content from the following documents, which include VP internal discussion documents, was used in this Feasibility Report, and will guide the next phase of the project. The documents are available on request or on the Village Power website www.villagepower.com .

O'Neill, Allan, May 2022: *Neighbourhood batteries – assessing capacity to connect FINAL* (also provided as Appendix 3)

Donegans, July 2022: *Village Power Business Plan 1.1*

Enhar, March 2022: *Site Suitability and Connection Design - Final Report, P00419_C002_002*

Enhar, March 2022: *General Specifications BESS v2, P00419_C001_001*

HIVE, June 2022: *VILP Village Power Marketing Strategy 2022 v2*

Jemena, March 2022: *Preliminary Advice - Village Power - Rev1.0 FINAL 2022.03.11*

LO3, August 2022: *Village Power Community Battery Architecture & Design Summary Phase II*

LO3, August 2022: *Village Power Economic Model July 2022.xls*

Village Power, December 2021: *VP Business Structure Report 1.0*

Appendix 2: Site assessment

Eight sites were initially identified by Darebin Council and Village Power as potentially suitable for battery location. These sites were evaluated and ranked using a traffic light ranking. The purpose of these rankings is to help rank the options and select the preferred option/options for further study.

Advantageous	Identified advantage for selected criteria, over other options
Neutral	No significant differentiator
Negative	Option has significant disadvantage compared with other options
Show Stopper	Option does not comply or can't be progressed

The option evaluation is presented in Table 2.

Table 2: Initial site evaluation

Option	1 MIC	2 MFM	3 DAEC	4 Mott Reserve	5 IW Dole reserve	6 Hardman Reserve	7 TW Andrews Reserve	8 Carawa dve Depot
Address	2 Wingrove St Alphington	2 Wingrove St Alphington	401 Bell St Preston	276A Bell St Preston	1 Dole Ave Reservoir	859 Plenty Rd Kingsbury	7 Strathmerton St Reservoir	15 Carawa Drv Reservoir
Postcode	3078	3078	3072	3072	3073	3083	3073	3073
Land								
Land Ownership	Darebin/ MIC	Darebin/MIC	Darebin	Darebin	Darebin	Darebin	Darebin	Darebin
Available Space	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate
Planning Issues	Industrial	Commercial	Industrial/ comunity	Parks/ residential	Parks/ residential	Parks/ school	Parks/sport/residential	Industrial
Network								
Network provider	Jemena	Jemena	Jemena	Jemena	Jemena	Jemena	Jemena	Jemena
Network Constraint	Yes	Yes	No	No	No	Yes	Yes	No
Solar Penetration	30%	30%	17%	17%	12%	11%	10%	minor
Connection								
Description	On site near transformer	170 m to TX in MIC	Pole mounted transformer adjacent	500kVA transformer adjacent to park.	500kVA transformer 200 m away.	500kVA transformer adjacent to park.	Transformer within leisure centre plant area	Jemena terminal 200m away
HV Connection	Yes 22kV	Yes 22kV	Yes 22kV	Yes 22kV	Yes 22kV	Yes 22kV	Yes 22kV	Yes 22kV

Option	1 MIC	2 MFM	3 DAEC	4 Mott Reserve	5 IW Dole reserve	6 Hardman Reserve	7 TW Andrews Reserve	8 Carawa dve Depot
Proximity to HV power connection	20 m	10 m	30 m	20 m	200 m	10 m	10 m	50 m?
LV 22kV/400V Transformer	1 x 500 kVA & 1 othe?	500 kVA	500 kVA	500 kVA	500 kVA	500 kVA	500 kVA	1500 kVA
Distance to TX	20 m	200 m to Kelvin 170 m to MIC	30 m	20 m	200 m	20 m	20 m	Up to 100 m
Access & Clearance								
Access	good	goods	good	good	good	good	good	good
Clearance to houses (m)	150 m	70 m	30 m	20 m	40 m	220 m	40 m	250 m
Clearance to buildings	20 m	5 m	10 m	60 m	60 m	220 m	20 m	20 m
Ability to fence off	Yes	Yes						
Security	Within MIC	Within MIC	Public access	Public access	Public access	Public access	Fenced area	Within depot
Community Impact								
Proximity to the VP market	Yes	Yes	No	No	No	No	No	No
Potential market nearby	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Community Impact	Positive	Positive	Neutral	Some loss of amenity	Some loss of amenity	Some loss of amenity	Neutral	Neutral
Safety – Fire risk/collision risks	Gravel, industrial bldg. near	Concrete industrial bldg. near	Carpark	Park	Carpark	Carpark	Concrete industrial bldg. near	Industrial bldg
Safety risk collision	Need bollards	Separate from traffic	Carpark	Park separate from traffic	Carpark	Carpark	In plant area	Carpark

Table 3: Final site assessment including Jemena connection assessment

Option	**MFM**	**Newman Reserve**
Address	2 Wingrove St Alphington	Newman Reserve, Preston
Postcode	3078	3072
Land		
Land Ownership	Darebin/ MIC	Darebin
Available Space	Adequate	Significant

Planning Issues	Commercial	Amenity
Network		
Network provider	Jemena	Jemena
Network Constraint	Yes - significant	None
Solar Penetration	30%	10%
Connection		
Description	4m to 400V power pole. 170 m to TX in MIC.	3m to 400V power pole. 3m to TX. Jemena want a TX connection.
HV Connection	Yes 22kV	Yes 22kV
Proximity to HV power connection	170m	3m
LV 22kV/400V Transformer	500 kVA	500kVA
Distance to TX	200 m to Kelvin 170 m to MIC	3m
Access & Clearance		
Access	good	Good – some vegetation may be disturbed
Clearance to houses (m)	70 m	70m
Clearance to buildings	5 m	No buildings. Transformer is 3m away
Ability to fence off	Yes	Yes
Security	Within MIC	Required
Community Impact	Minimal	Significant
Proximity to the VP market	Yes	To the south
Potential market nearby	Yes	Yes. Some commercial.
Safety – Fire risk/collision risks	Concrete industrial bldg. near. Hardstand is elevated.	The park lawn, shrubs and trees are combustible. Collision risk from lawnmower. Fencing required.
Safety risk collision	Separate from traffic	Separate from traffic

Appendix 3: Neighbourhood Batteries - assessing capacity to Connect

A report provided by Allan O’Neil, Independent Energy Market Consultant.

May 2022

Report Scope and Disclaimer

This report has been prepared for its sponsor Village Power based on information provided by the sponsor, publicly available data and information, and limited discussions with relevant industry participants. The report addresses a limited set of general issues identified through Village Power’s project development and feasibility work, and does not constitute regulatory, engineering or other technical advice.

1. Report Overview and Structure

This report is organized as follows:

- Section 2 provides a general overview of the operation of neighbourhood battery storage and its impacts on and benefits for distribution networks
- Section 3 discusses factors involved in seeking to connect a neighbourhood battery to the network, drawing on the experience of the Village Power (VP) project, and focusses particularly on how network capacity to connect is assessed, with a brief discussion on network tariff issues. Relevant case studies from projects similar to VP’s are provided.
- Section 4 discusses more generally how issues like those encountered by VP are being dealt with by the distribution sector and its key stakeholders, noting quite uneven rates of progress across businesses and jurisdictions.
- Section 5 provides a brief conclusion and recommends more widespread support from DNSPs for neighbourhood battery trials and an active role for governments in ensuring this support

2. Neighbourhood batteries – what they do

Like any rechargeable battery, a neighbourhood battery stores and releases energy, converting between electric power and stored chemical energy.
Neighbourhood and home-installed batteries would both typically be used to time-shift electricity, storing at times of plentiful or lower cost supply and releasing power at times of scarcity and higher cost. The high penetration of rooftop photovoltaic (PV) generation in many Australian suburbs means that times of excess local supply are now commonplace in

many homes and across many parts of the distribution grid[18]. But without local energy storage, times of higher demand and tighter supply still arise regularly outside solar generation hours. These trends are a major driver for the installation of batteries as their technology advances and costs decrease.

2 For example, in South Australia the very high per-capita penetration of rooftop PV means that at times the state's entire distribution network can effectively become a net supplier to the main transmission grid, as total rooftop PV generation exceeds underlying consumption within the network.

2.1 How batteries would affect customer load and export profiles

Batteries enable local storage of energy excess to immediate needs, and additional supply when demand is higher. For a home with a battery and rooftop PV this evens out exports to and consumption from the grid and increases the self-consumption of PV-generated electricity. On a distribution network, equivalent operation of a neighbourhood battery would similarly even out net demands on upstream parts of the network, yielding better utilization of those network assets. Figure 1 and Figure 2 below illustrate these impacts.

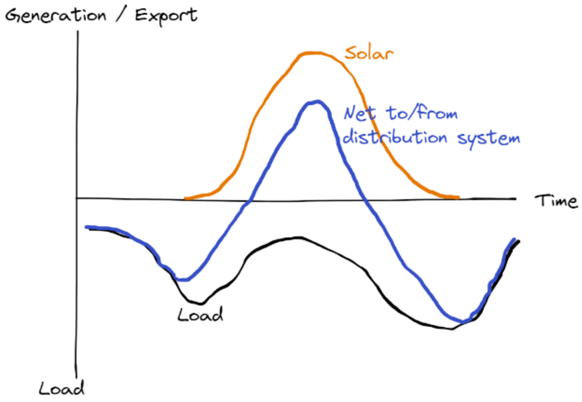


Figure 1: Load, solar generation, and net flow profiles

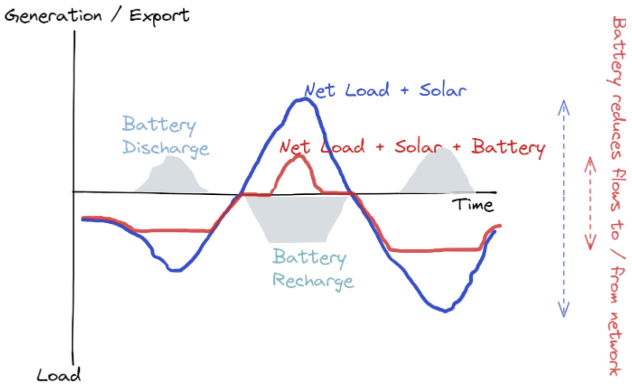


Figure 2: Net profiles with battery storage / discharge

Compared to home batteries, neighbourhood batteries can potentially offer:

- Lower capital costs through economies of scale
- Access to energy storage for consumers unable to install their own battery for physical or financial reasons
- More direct visibility and control of electricity storage and discharge volumes and timing, assisting network operators in operation of their assets
- Potential to provide "ancillary" services to the distribution network such as voltage or power factor control, and even to the wholesale electricity market though frequency control ancillary services (FCAS).

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[18] For example, in South Australia the very high per-capita penetration of rooftop PV means that at times the state's entire distribution network can effectively become a net supplier to the main transmission grid, as total rooftop PV generation exceeds underlying consumption within the network.

2.2 How would network flows be affected?

Household or business users of a neighbourhood battery would typically use their access to its energy storage and release capacity in a similar fashion to a user with their own household battery, because the underlying drivers for energy storage and consumption would be similar. Users could “deposit” excess PV-generated power in their neighbourhood battery “account”, and “withdraw that deposit” at times of higher consumption, in effect increasing their PV self-usage and reducing their personal energy draw from the upstream power system.

Where those users are located in the same low voltage (LV) section of the distribution network as the battery, this pattern of use could particularly assist in reducing demands on nearby distribution assets including “local substations” which are the smaller pole-mounted or kiosk-style transformers serving each LV section of the network, transforming power between the higher-voltage distribution feeders typically operating at 6.6 to 22 kilovolts (kV) and the 230 / 400 volt LV reticulation to homes and small businesses. In areas of high rooftop PV penetration, it is often this “last mile” of the network that comes under stress when consumer demand is low and PV generation is high, as exported power flows in reverse through the LV network and local substations.

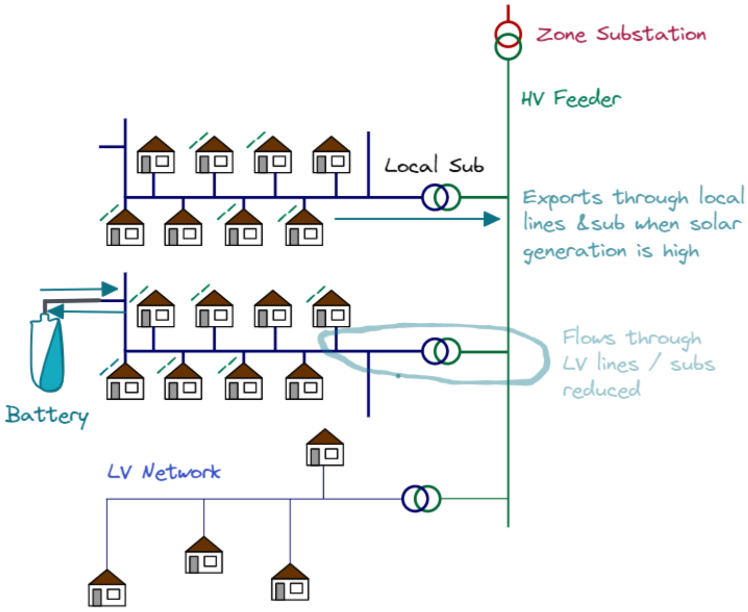


Figure 3: Distribution Network Schematic – solar PV and battery impacts

If a battery was instead located in a different LV section of the network from its users, those users' contribution to capacity utilization levels and patterns within their own network section would not necessarily change, but their usage of the battery's services could still benefit utilization of distribution network assets further upstream, for example at larger "zone substations".

But for maximum local network benefits, a neighbourhood battery would ideally be located physically and electrically close to its users. And because these users would typically be customers with substantial rooftop PV installations, with total export capacity potentially approaching limits on local network assets, there is an obvious case for neighbourhood battery installations targeting exactly those parts of the network.

3. Connecting to the network

This section documents issues arising from Village Power's experience in seeking suitable sites and terms for connection of its proposed neighbourhood battery into the local distribution network.

3.1 How do networks assess available capacity?

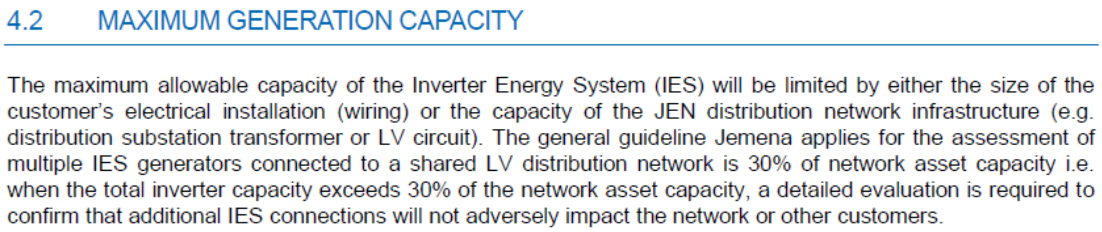
While neighbourhood batteries are a very recent innovation, local "embedded" generation – predominantly solar PV – is not, having grown very rapidly since the mid-2010's. Electricity distributors ("distribution network service providers" or DNSPs) have developed methods to assess and control the quantity of generation capacity their networks are able to host while maintaining compliance with the various voltage, power quality and safety standards they must deliver.

As most community or neighbourhood batteries would be connected into LV sections of the distribution network, closer to customers and where solar-driven capacity constraints typically first emerge, we focus on network capacity to connect at this voltage level.

In theory, depending on the location, layout, design, and condition of distribution assets within individual LV sections of each network, their "hosting limits" – maximum allowable levels of small-scale embedded generation – could vary considerably across a network area. Determining them might rely on studies using measurement data taken from different parts of the network across a range of times and demand conditions.

Assessing connection of new generation or battery capacity would ideally also consider its expected operational profile and any associated load (for example where a business's embedded generation output would be predominantly used within its own facilities rather than exported to the grid).

But in practice, based on Village Power's experience, some distributors appear to apply a more generic framework for developing LV hosting limits, scaling the maximum available in any section to a fixed proportion of local substation capacity. For example, Jemena's **Connection Guidelines for Inverter Energy Systems**[19] read as follows:



4.2 MAXIMUM GENERATION CAPACITY

The maximum allowable capacity of the Inverter Energy System (IES) will be limited by either the size of the customer's electrical installation (wiring) or the capacity of the JEN distribution network infrastructure (e.g. distribution substation transformer or LV circuit). The general guideline Jemena applies for the assessment of multiple IES generators connected to a shared LV distribution network is 30% of network asset capacity i.e. when the total inverter capacity exceeds 30% of the network asset capacity, a detailed evaluation is required to confirm that additional IES connections will not adversely impact the network or other customers.

To then assess how much of this 30% notional capacity remains available, embedded generators are effectively treated as uniform in their operational characteristics, with their capacities simply added together to determine how much hosting capacity is being utilized, and how much remains "spare".

This approach implicitly assumes that generators and batteries within a network section might operate simultaneously at maximum output, with little or no diversity in their operational profiles.

For small scale rooftop PV systems on households, an assumption of uniform behaviour and "worst case" simultaneously peaking output might currently be reasonable, although this will change as more households install their own batteries or other technologies which store or self-consume a larger share of their home's solar PV production.

However this approach would be quite inappropriate for neighbourhood batteries. These will almost certainly operate with a profile complementary to the consumption and rooftop PV generation profiles of its users, storing energy at times of high PV generation and export, rather than discharging even more onto the grid. And at times of high local demand and minimal PV generation, a neighbourhood battery would operate as a local supply source, offloading demand from upstream distribution assets, not adding to it.

Furthermore, unlike most rooftop PV generation whose output passively follows available sunlight, a battery is an inherently controllable device whose operation can be managed dynamically to accommodate time-varying local network conditions and constraints.

So a generic approach to assessing usage of available hosting capacity which in effect assumes that a battery would mimic the operational profile of a very large rooftop PV

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[19] Available at https://jemena.com.au/documents/electricity/embedded-generation-guidelines

installation, is clearly inappropriate and would almost certainly lead to batteries either being forced to locate in lightly used parts of the network where they would provide minimal local benefit to that network, or not being installed at all.

Finally, if all DNSPs were to use – as suggested in Jemena's guidelines – a blanket network-wide percentage of local substation capacity to determine maximum hosting capacity in each LV network section, this would be likely to further constrain the possible size and location of neighbourhood batteries within the important "last mile" of their networks and forego valuable opportunities to use their controllability to augment that hosting capacity.

3.1.1. Case Study – Village Power Neighbourhood Battery

VP's recent experience in seeking to develop an investment case for a neighbourhood battery in the Jemena metropolitan network of Melbourne highlights some of these issues.

VP's proposal, which is being developed under the Project Development stream of the Victorian government's Neighbourhood Battery Initiative, is a for a LV-connected neighbourhood battery rated at 150 kilovolt-amperes (kVA) maximum discharge rate and storage capacity of 500 kilowatt-hours (kWh), sufficient to serve roughly 100 household users. VP identified four potential sites in part of Jemena's network relevant to its stakeholder group and sought advice from Jemena on the ability of each site to host its proposed battery.

Jemena's initial assessment of these sites[20] concluded that:

- The location favoured by VP and closest to the battery's likely user base would be unsuitable because:
  - within the LV zone served by the relevant local substation, the relatively high proportion of consumers with rooftop PV meant that there was no available hosting (export) capacity to accommodate battery discharge additional to customer PV exports.
  - at times of maximum customer demand (consumption) through the local substation, only 40kVA spare capacity would remain for battery charging.
  - Jemena concluded that "*the battery would be required to operate at a static fixed export limit of 0kVA and maximum charging capacity of 40kVA*".
- The site that Jemena preferred was at a larger, lightly loaded and relatively new local substation remote from the customers likely to be users of the VP battery.

Jemena's assessment methodology effectively assumes that VP's battery would or might operate with a profile similar to that of the existing consumer base within an LV zone – discharging power at times of high solar PV generation and export and seeking to recharge at times of maximum consumer demand.

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[20] Jemena Electricity Networks (Vic) Ltd, Preliminary Advice – Village Power Neighbourhood Battery, March 2022

Both these scenarios are inherently extraordinarily unlikely for any plausible customer-driven usage of local battery storage, which would see this operating in opposite fashion to the assumptions made in the Jemena assessment.

3.1.2. Case study – ADP/FlowPower neighbourhood battery proposal

This proposal envisaged a large neighbourhood battery being developed as part of a new residential precinct on the outskirts of greater Melbourne, to support net-zero emissions goals for the overall land and housing development. With the aims of optimizing the value of high residential solar PV uptake by future residents (required under land development controls) and supporting overall local network capacity, the proponents proposed a relatively large battery (~1,000 kVA) to store exported PV generation from across the precinct. A battery this size, serving multiple LV sections would be most economically connected to the higher voltage distribution feeder serving the development area, however – unlike the VP case – the DNSP (Jemena) in this case sought the restructuring of the proposal into multiple smaller batteries each serving individual LV substations and circuits.

In the project proponents' view, without accompanying financial assistance in the form of bespoke network tariffs and / or payments for the local LV network support provided by the smaller batteries – neither of which were offered by the DNSP – the multiple-battery approach would be uneconomic given the significantly higher unit costs incurred for smaller batteries and duplicated connection assets, as well as the higher network charges the DNSP proposed to apply to each of these multiple batteries.

3.2 Network tariffs

This paper's primary focus is on neighbourhood battery location and capacity assessments, but the choice and application of network tariffs to batteries is also likely to impact their economic viability. Distribution network tariff structures have generally been developed by considerations of cost recovery and equitable sharing amongst network consumers based on reasonably straightforward measures such as kilowatt-hour throughput and, for larger customers, maximum demand. Furthermore it has been a reasonable assumption that consumers contribute to utilization of all levels of the distribution network involved in carrying energy from grid bulk supply points to their particular voltage connection level.

For the reasons outlined above, neighbourhood batteries' effect on the utilization of network assets is likely to be quite different from typical customers', with flows in most cases counteracting those of their users. The intended operation of a neighbourhood battery would be to reduce peak demands on the network and improve utilization – thereby reducing network costs. Development of appropriate network tariffs that recognize this fundamental difference will be very important. Simple application of existing tariff structures and prices to neighbourhood batteries is unlikely to reflect their actual contribution to network costs and utilization.

3.2.1. Case study – Yarra Community Battery Project

This community battery, of similar size to VP's proposed project, is located in North Fitzroy close the Melbourne CBD and is about to commence operation. This project received funding from the Implementation stream of the Victorian Government's Neighbourhood Battery Initiative.

While available hosting capacity was not a constraint on location of the Yarra battery, the project proponents realized that existing regulated network tariff structures if applied to the proposed battery would severely compromise its financial viability. They worked with the local DNSP CitiPower, which developed an appropriate tariff structure[21] reflecting both costs and benefits that operation of the battery at different times would bring to the local network. This tariff structure provides rebates to the battery for charging and discharging at times which are "counter-cyclical" to the typical household + PV energy flows outlined earlier in Section 2.1.

4. Alternative approaches

It should be clear by now that a specific and technology-responsive approach from DNSPs to assessing the location and operation of neighbourhood batteries is required. This would cover:

- How batteries' operational profiles and controllability are accounted for in determining their impact on the network's hosting capacity.
- How that hosting capacity is assessed, including services that neighbourhood batteries could provide to augment that capacity.
- How financial arrangements between batteries and DNSPs would operate, covering distribution network tariffs and possible compensation for network services.

There are important initiatives currently underway across the sector to trial different approaches to these issues and many others arising from the broader penetration of consumer-level active energy resources. These include:

- ARENA's Distributed Energy Integration Program (DEIP)[22]
- Trials of Dynamic Operating Envelopes (DOEs) – real-time mechanisms to signal and manage limits on and utilization of local network capacity[23]
- Development of DNSP trial tariffs for home and neighbourhood batteries and other distributed resources, within the framework of the National Electricity Rules overseen by the Australian Energy Regulator[24]

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[21] CitiPower, Tariff trial notification 2022-23, February 2022; available at https://www.aer.gov.au/system/files/CitiPower%20-%20Tariff%20trial%20notification%20-%202022-23_1.pdf

[22] https://arena.gov.au/knowledge-innovation/distributed-energy-integration-program/

[23] https://arena.gov.au/knowledge-innovation/distributed-energy-integration-program/dynamic-operating-envelopes-workstream/

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

A concern is that the timeline for these initiatives and the general implementation of any resulting changes to DNSP regulatory frameworks and practices may unduly delay initial rollout of neighbourhood battery capacity, as some DNSPs wait for results from these initiatives and trials before being prepared to pilot their own approaches or work with proponents to optimize the location and operation of neighbourhood batteries.

As an example of this potential for delay, the ARENA-backed workstream on Dynamic Operating Envelopes (DOEs) is seeking to promote and drive the adoption of practices and standards providing (amongst other things) for “smarter” control of rooftop PV systems and management of maximum exports at times of system stress. A full DOE framework, where availability of real time network data and dynamic export (or import) limits could inform and manage operation of large amounts of distributed generation or battery resources within distribution networks, could significantly enhance efficiency in network asset investment and utilization, and facilitate the development of neighbourhood battery projects such as VP’s. However the formal introduction of DOEs across the sector appears to be still some years away, and progress towards this goal by way of trials is far from uniform across DNSPs, evidenced by the following status chart from the recent Outcomes Report published under ARENA’s DOE workstream (Figure 4):

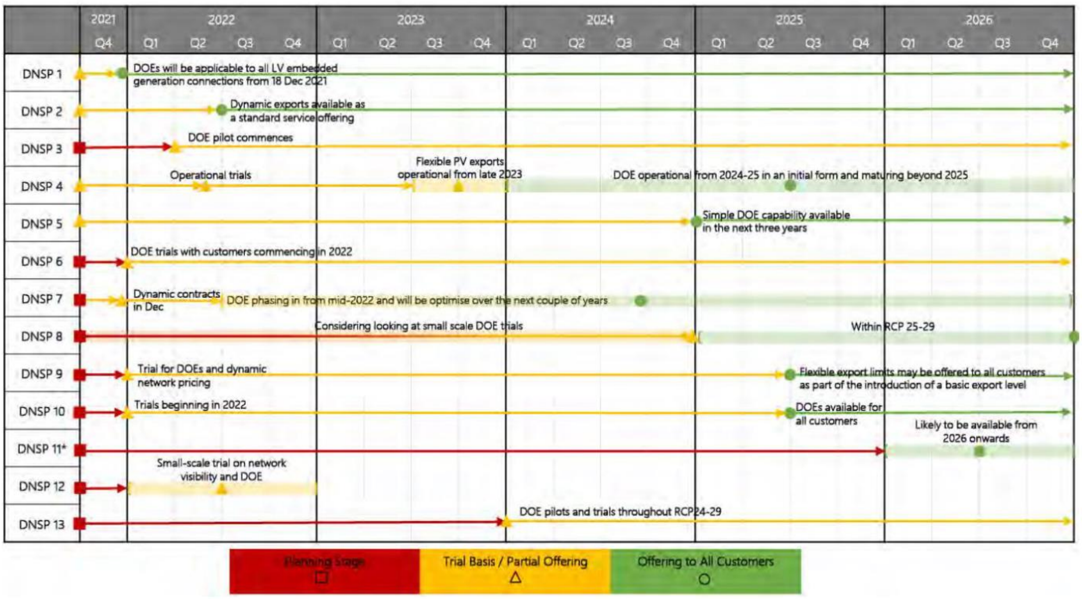

Figure 4: Overview of DOE implementation – from DEIP Dynamic Operating Envelopes Outcomes Report, March 2022 (p9)

But this need not necessarily stifle the adoption of earlier, intermediate approaches (eg some form of “DOE-lite”[25]) for specific proposals such as neighbourhood battery trials funded under government initiatives. Given the controllability and data visibility available in

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[25] For example, this could comprise fixed seasonal and time of day profiles for maximum rates of battery charge and discharge, tailored to the specific conditions at proposed battery locations. Monitoring and enforcement of these limits for a single site would be straightforward given the data and communications capability inherent in existing inverter and metering technology.

current battery and inverter technology, the relatively small number of installations proposed under trial programs such as the Victorian government's Neighbourhood Battery Initiative, it should be possible for DNSPs to engage with proponents on development of workable and mutually beneficial approaches to their siting and operation.

The Australian Energy Regulator has carved out a form of "regulatory sandbox" from its standard controls on network pricing and tariff design to facilitate development and trial of new approaches in this area[26]. While some DNSPs are taking advantage of this flexibility, for example to develop battery-specific network tariffs (Table 1), it appears to be at the option of each DNSP whether, when, and how far to proceed along these lines.

Table 1: DNSP tariff trials covering community / neighbourhood batteries under National Electricity Rule 6.18.1C

State or Territory	DNSPs proposing tariff trials for 2022-23, including specific community/neighbourhood battery tariffs
Victoria	CitiPower Powercor United Energy
New South Wales	Ausgrid Essential Energy
ACT	Evoenergy
South Australia	-
Queensland	-

Clearly, key stakeholders such as ARENA, the AER, governments and some DNSPs themselves are seeking to support innovation in this area, but the pace of change is uneven and there appears to be no stakeholder with a specific mandate to force a faster rate of progress.

5. Conclusion and Recommendations

If programs such as the Victorian government's Neighbourhood Battery Initiative and equivalents in other jurisdictions are to be successful in investigating and establishing the case for neighbourhood batteries across a full range of distribution businesses and environments, there needs to be more active "buy-in" and engagement on these issues from all distribution businesses rather than a self-selected subset.

All distribution network service providers (DNSPs), who stand to benefit from appropriate integration of local batteries into their networks, should be prepared to offer the necessary

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

flexibility in connection assessment and tariffs to support trials of this technology. These trials may require bespoke solutions to ensure that safety and reliability of the local electricity networks in the short term. Ultimately they could transition into more standardized tariffs and dynamic connection arrangements developed under programs such as DEIP.

As governments at both state and federal levels are already sponsoring programs including trial battery rollouts and wider regulatory reform supporting growth of distributed energy resources, they should also take an active role in ensuring that local network businesses in all relevant jurisdictions are positively supporting these initiatives in their engagement with trial proponents.

Author’s Qualifications and Experience

Allan O’Neil B.Sc. (Hons), MBA is a consultant specializing in energy markets and has over twenty-five years’ experience in the eastern Australian energy industry. He has worked for major electricity and gas retail and generation companies in wholesale trading, risk management, pricing, portfolio management and forecasting roles, and operated as an independent consultant advising a wide range of energy industry participants and stakeholders since 2015.

Glossary and Abbreviations

AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
BtM	Behind the Meter
DCC	Darebin City Council
DER	Distributed Energy Resources. These are solar panels and residential batteries which are owned by consumers but connected to the electricity grid
DNSP	Distribution Network Service Provider
Electrical energy	energy = power x time, measured in kilowatt hours
FCAS	Frequency Control Ancillary Services – a network benefit when the demand and supply balance is close to being outside the safe operating window
FIT	Feed-in-tariff. The amount that retailers will pay for excess residential solar power.
MIC	Melbourne Innovation Centre – one of the proposed sites for the battery
MWh	Megawatt hour (see kWh)
V	Volts
kV	Thousand Volts
kWh	A kilowatt hour is the standard measure of energy supplied in the retail market (technically it is a unit of power, rather than electricity). In the wholesale market the measure is MWh – megawatt hours – or 1000 kWh
PV	Photovoltaic
VP	Village Power
VPNB	Village Power Neighbourhood Battery
VPP	Virtual Power Plant