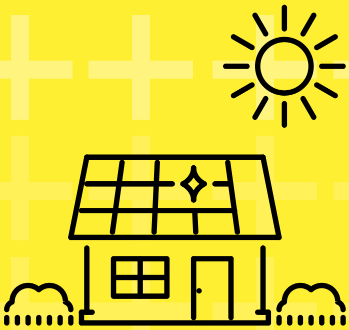


Community-Scale Batteries

A guide for community members across Central Victoria to learn more about community-scale batteries.

Proudly produced by Hepburn Energy

Welcome to the Community Scale Batteries Resource

Acknowledgments

The Community-scale Battery Booklet was authored by Marie Lakey, Taryn Lane and Carlena D'Arma. This booklet shares content, graphics and findings from technical studies provided by Orkestra and builds on a social feasibility study from Hepburn Energy. We also summarise research from the University of Melbourne's Sustainability Business Clinic provided for this project.

We'd like to thank Orkestra, the Sustainability Business Clinic, the Central Victorian Greenhouse Alliance and Hepburn Shire Council for contributing to this work. We also sincerely thank the State Government's Neighbourhood Battery Initiative and Community Power Hub Program for funding this project.

CENTRAL VICTORIAN Greenhouse Alliance

Hepburn Energy

Hepburn SHIRE COUNCIL

VICTORIA State Government | Environment, Land, Water and Planning

orkestra

COMMUNITY POWER HUB GRAMPIANS

Contents

Section 1:

Who this booklet is for

This booklet offers information for community members and groups with interest in community-scale batteries. We've focused on the Hepburn Shire and some surrounding Local Government Areas (LGAs) but many of our insights may be applicable across the state.

We'd also like to acknowledge the huge interest in this area, with many community groups looking at community-scale batteries across central Victoria. We hope that this booklet helps these groups assess both the opportunities and barriers to implementing community-scale batteries in our region.

About this Guide

The Community-scale Battery Booklet is a resource to help community members across Central Victoria learn about community-scale batteries.

This booklet is just one of several outputs from a project called 'Community Sparks', funded by the Victorian Government's Neighbourhood Battery Initiative and led by the Central Victorian Greenhouse Alliance. As part of this project, our team engaged with over 300 community members in the Hepburn Shire and pulled together insights from technical experts and community organisations.

We found that community members wanted to learn more about community-scale batteries, specifically [1]:

- Cost and feasibility
- Amenity and timing
- Scalability, participation and meeting demand
- Any existing projects or examples
- Different models
- Different stakeholder roles and the risks associated with management
- Alternatives to community-scale batteries

The Community-scale Battery Booklet addresses the key areas of interest listed above while providing energy concepts needed to understand the potential and limitations of this technology.

Context

The Central Victorian Greenhouse Alliance (CVGA) investigated community-scale batteries across the Hepburn Shire, as part of the Victorian Government's Neighbourhood Battery Initiative. This project, called 'Community Sparks', has assessed the feasibility of community-scale battery sites in the Hepburn Shire and explored battery sites for other nearby Local Government Areas.

The Hepburn Shire Council and Hepburn Energy partnered with CVGA to deliver this project, with Hepburn Energy completing a social feasibility study for the Hepburn Shire.

The Hepburn Shire is a useful test case for community-scale batteries because of the area's renewable energy leadership. This is partly thanks to Hepburn Z-NET, a collaborative partnership seeking to achieve zero-net energy by 2025 and zero-net emissions by 2030. This partnership brings together community groups, experts and Council and is guided by a co-designed community transition plan which mapped out pathways to zero-net. This plan found that battery storage would be critical to help the Shire reach zero-net energy and to unlock the full potential of rooftop solar. It also highlighted how relatively low capacity on the distribution network was worsening grid reliability, particularly in towns such as Glenlyon, Trentham, Lyonville and Wheatsheaf [3].

But these issues do not only affect the Hepburn Shire. In a report from Orkestra (2022), they found that across a sample of Central Victorian towns the average outage time was 8 hours, far higher than Australian standards [2]. And extended grid outages were far longer in some instances, with Lyonville having a continual outage for three days over 2021.

Another issue facing some Central Victorian communities is that households cannot install solar, with the local distributor rejecting their applications. Orkestra's report showed that 14% of their sample of transformers were at or near capacity, limiting the potential for new solar installations which would feed back into the grid [2].

These opportunities and issues make Central Victoria a great case study to explore what community-scale batteries could or couldn't do to solve these challenges.

Section 2:

Cautions and guiding questions for community groups

We want to be really upfront with what we've found through the Community Sparks Project. Community-scale battery projects located at transformers at the street level are risky.

Orkestra looked at 11,640 project variations across many locations in Central Victoria, and none of these could earn enough to pay for the battery itself and its installation [2]. Even with substantial (up to 100%) grant funding, these projects don't make sense.

Considering alternatives to this type of community-scale batteries can unlock greater value and deliver more meaningful 'common good'. This includes models that are:
– Co-located behind-the-meter at a Commercial and Industrial (C&I) facility:
– Servicing a high-value community need (such as emergency shelter back up power)
– A virtual power plant led by the community
– Co-location at a community generator

See section 10 for more detail.

To give a sense of why low voltage batteries located at transformers at the street level might be risky for communities here are a few key findings.

- Batteries at this scale and location can't reliably deliver multiple services, i.e lowering your bills, stopping blackouts and increasing the use of renewables.
- Cheaper alternatives exist, such as upgrading transformers on low voltage lines (i.e the poles and wires connecting your home to the grid) and behind-the-meter projects.
- It is challenging for low voltage front-of-the meter batteries to reduce bills or reduce emissions.
- They're very expensive. The systems modelled ranged between close to $100,000 and $800,000 and not one project recouped even a tiny percentage of its capital over the life of the battery.
- There wouldn't be the funds to replace them at end of life.
- Over 70% of their capital cost (i.e the battery itself) would need to be covered by grant funding.
- Even with 100% grant funding, management and maintenance costs would be an ongoing expense that communities would need to cover. The battery would not earn enough to cover these costs and would be particularly risky after warranties expire (after year 5 is standard).
- We found that most projects would only service a small number of households, which makes it a high-risk and expensive project for a very small benefit.
- Costs such as insurance can't be reliably modeled over 10 years and again put the community group at risk for operating them.
- There is no financial pathway of covering project management and administration costs of the operating batteries.

For those community energy groups reading this booklet, we encourage you to consider these questions:

1. What problems are we trying to solve with community-scale batteries? Are there alternative solutions?
2. What models might work to solve these problems?
3. What are the key factors - to save money, save emissions or both?
4. Community-scale batteries are not by themselves economical, is grant funding available and what would it cover?
5. What is the ongoing and long-term financial risk associated with these projects? Could it result in a stranded asset i.e never deliver as expected? If there is going to be a community-scale battery built in your area how can your community group negotiate to have the up-side whilst not being exposed to long term risks. Can you secure benefits like bill discounts and community funds?
6. Is there a site available for the battery?
7. Who are the key stakeholders involved in delivering a community-scale battery project?
8. What are the key roles your community might play?
9. Is there a suitable partner to drive the project? Can they manage and afford the long term costs for administration, operations and maintenance if the battery is not self-sustaining?
10. Where community-scale batteries aren't viable what other solutions might work? For example, advocating for transformer upgrades? Or household batteries?
11. Have you weighed up community good versus community cost? Will the battery service an appropriate size of community to make the effort and spend worthwhile?

Section 3:

Energy Background

The following section outlines some key foundational concepts regarding the energy system needed to understand community-scale batteries and their potential.

A: Energy systems and the grid

The energy system is a broad term describing how energy services are provided [4]. This includes energy production, transportation and the use of various sources of energy including electricity and liquid fuels. The electricity system is a subset of the energy system, transmitting and distributing electricity through 'the grid'.

The grid is made up of [5]:
- Generators that produce electricity
- Transformers that change electricity voltage for distribution or use
- Transmission and distribution lines, that carry electricity.

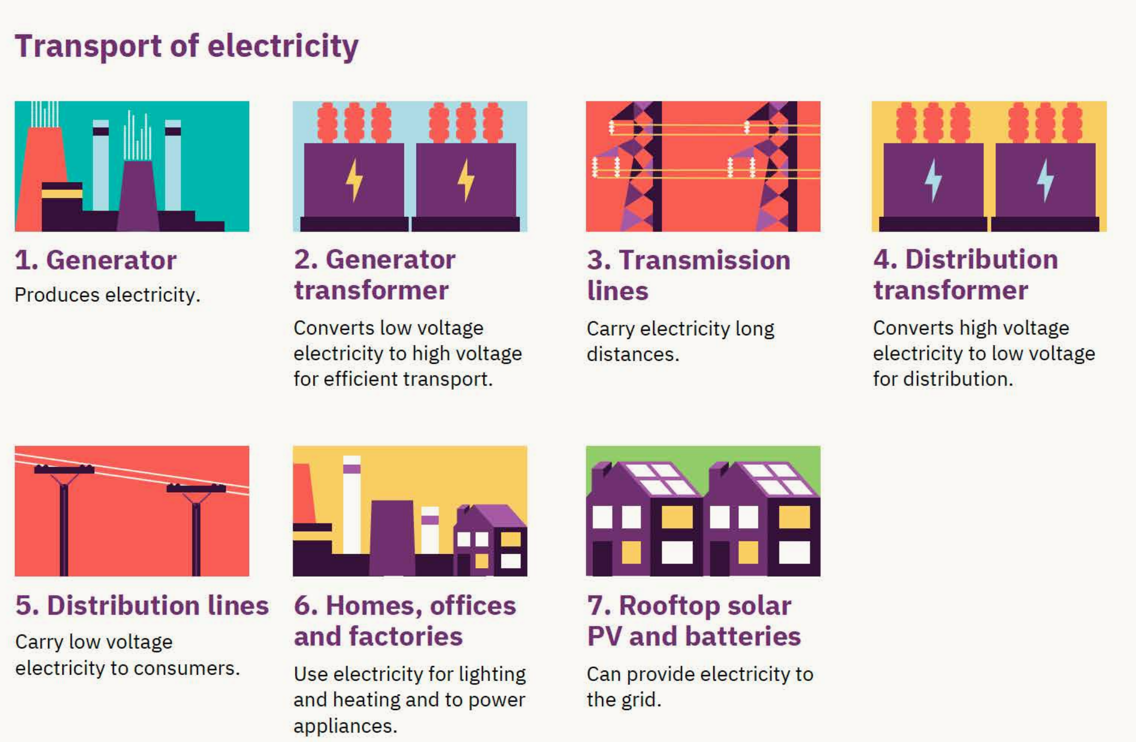


Figure 1. Image from AEMO, 2021, National Electricity Market Factsheet

Box 1.

Energy resources and the grid

Different energy resources sit on different parts of the grid:
- Large-scale generators (10MW+) sit on transmission networks i.e a large wind farm
- Mid-scale generators (100kW-10MW) typically sit on the distribution network i.e Hepburn Energy's wind farm
- Small scale generators (0-100kW) low voltage lines on distribution networks i.e residential solar

Broadly speaking in this model, large-scale generators produce electricity which is then transported via transmission lines, and then converted by transformers to circulate on distribution lines for use in homes and businesses.

But electricity systems across the globe are changing. In the past, generators were predominantly large-scale coal, gas or hydro. We're now moving to distributed energy resources, like household solar, electric vehicles and demand management technologies [6]. This shift means that generation is now coming from across the grid, presenting new opportunities and challenges.

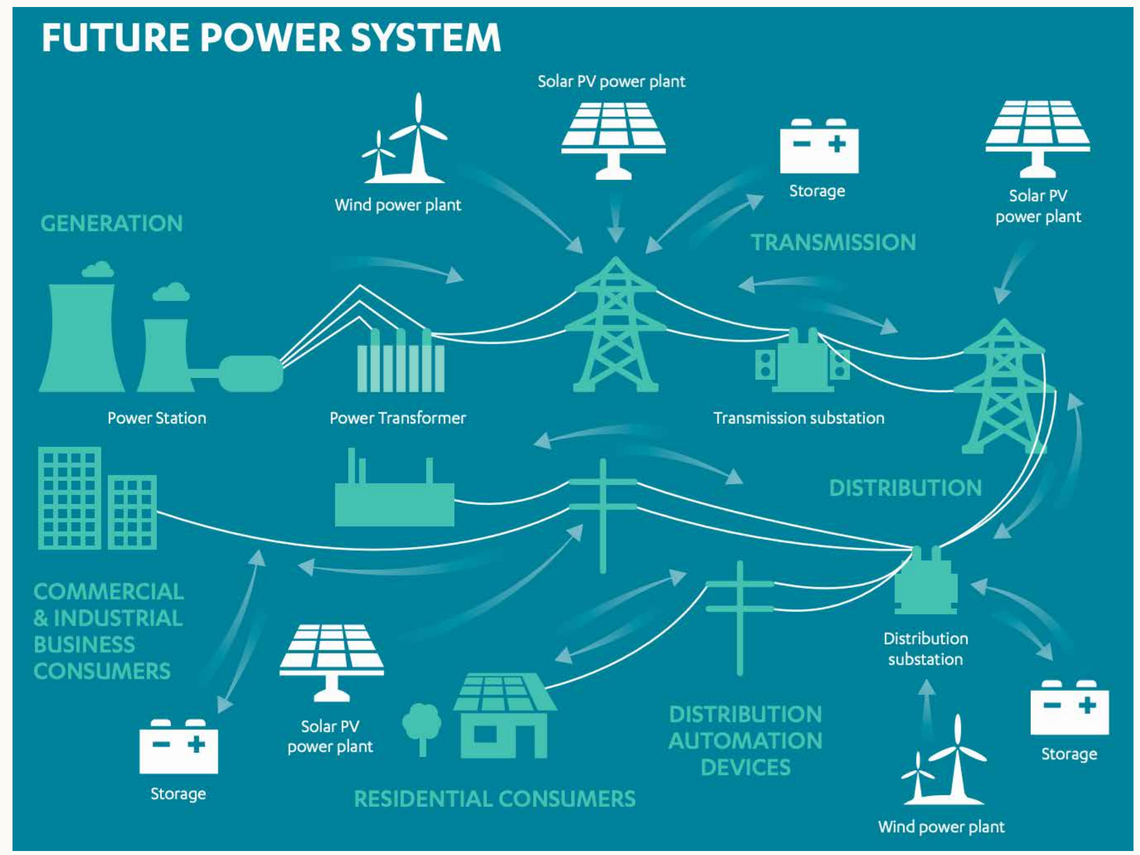


Figure 2. Image from National Infrastructure Commission, 2015, Smart Power, Future Power System

B: The National Electricity Market

In Australia, our energy system is coordinated with a combination of markets and regulation. In Central Victoria (and across the Eastern seaboard) the National Electricity Market (or the NEM) is the market that services electricity demand.

The NEM is managed by the Australian Energy Market Operator (AEMO). They oversee the electricity spot market, where 'the output from all generators is aggregated and scheduled at five-minute intervals to meet demand.' [5].

The market is pretty complicated! But in essence, there is a range of systems in place that signal to generators to produce so they meet consumer demands.

C: Generation and storage

Electricity generation can come from various technologies and resources. In Victoria, the main sources of electricity generation are [7]:

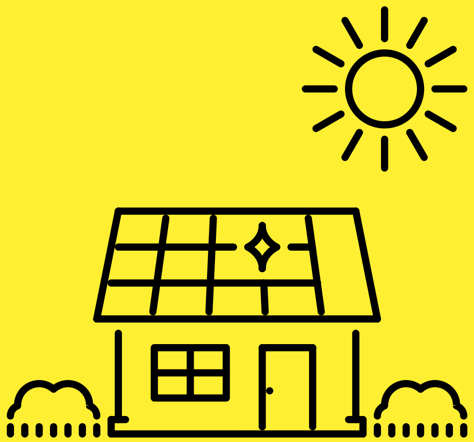
- Brown coal: 66.4%
- Wind: 20.4%
- Solar (Rooftop) 8.1%
- Hydro: 6.7%
- Gas: 4%
- Solar (Utility): 3.1%
- Battery: 0.3%

We've seen real growth in large-scale wind and residential solar but brown coal still represents the majority of our electricity capacity in Victoria [8]. To ensure our state is doing its part for climate action, we need more renewables to displace these polluting fossil fuels. Increasing this share of renewables will require changes to the grid and how we store, generate and share energy.

Batteries, rooftop solar, energy efficiency and mid-scale renewables can help our state tackle this challenge. By combining local generation and storage, we may reduce expensive grid upgrades while assisting communities to benefit from this energy shift [9].

Box 2.

Behind and in front-of-meter



In the following sections, we'll bring up 'behind' and in 'front-of-meter' energy projects. These terms refer to where an energy project sits in relation to the grid.

A project that is 'behind-the-meter' sits at a customer's property and isn't integrated into the electricity network. The focus here is on self-consumption and is managed within the property. This could be a residential or commercial property.

An in 'front-of-meter' project integrates into the electricity network and can be located on transmission or distribution lines.

Section 4:

Community-scale batteries

We have used 'community-scale battery' as a broad overarching term capturing all different battery models but implemented at the community level. Generally, we're discussing a small to mid-scale battery (between 40kWh to 5,000kWh) that sits on the distribution or low voltage network in front-of-meter or behind-the-meter.

Figure 3. Image from RenewEconomy, 2021, Hanging batts: 40 pole-mounted community batteries to boost grid reliability

There are many community-scale battery models. You can read about some of these in section 9 of this booklet.

Box 3. +–

Community-scale batteries vs community batteries

In this report a community-scale battery is the umbrella term for a battery located in a regional area on the low voltage or distribution network. For urban environments, the term neighbourhood battery is more common. Many of the batteries that have been piloted in the community space are owned by distributors or retailers. While these projects still seek to offer some benefit to community users we would not call these batteries 'community batteries'. This is because they're primarily operated for the benefit of the distributor or retailer, not community members. We consider a 'community battery' to be a subset of community-scale batteries that ensure some level of direct benefit, community ownership or control.

B. What makes a community-scale battery feasible and viable?

Feasibility is the possibility and ability for something to be done. Viability is that something's ability to survive. Both feasibility and viability are critical to consider before embarking on a project.

There are many different ways of assessing viability. Here we want to highlight that a viable project needs to meet certain criteria. These include financial, regulatory, environmental and social viability criteria. If they don't stack up across all these areas, then the project is probably not viable. We discuss these different points in detail in section 8.

C. Potential benefits of community-scale batteries

Community-scale batteries have the potential to provide a range of benefits [10] which broadly include:

- Network benefits: Helping to manage voltage, energy demand issues and avoid infrastructure upgrades.
- Solar integration: Enabling more solar panels by improving network conditions and soaking up excess solar.
- Wholesale energy and ancillary services: Participate in various markets for financial rewards. These include spot price arbitrage (see Box 4) in the wholesale electricity market and Frequency Control Ancillary Services (FCAS) (see Box 5).
- Reliability in outage-prone areas: Customers in remote, outage-prone areas may benefit from local neighbourhood scale batteries providing backup power and improving the reliability of supply.
- Virtual storage service for customers: They could offer virtual storage (i.e digitally linking household batteries for greater coordination and sharing), supporting households with solar and batteries to maximise their returns or participate in peer-to-peer trading.

Box 4. +−

What's price arbitrage?

Price arbitrage is where energy is stored during periods of low demand and released during periods of high demand. Not only does this help the battery earn more income, but it also improves energy reliability by supplying the grid when most needed

Box 5. +−

What are Frequency Control Ancillary Services?

The Australian Energy Market Operator (AEMO) manages several markets for energy services that help the grid function, including maintaining the right grid voltage [11]. These services are known as Frequency Control Ancillary Services (FCAS) or frequency control. This is particularly important when large generators experience a fault, which can cause voltage and frequency issues. FCAS markets help control the flow on impacts of such faults and ensure blackouts are avoided.

But while all these benefits are possible, a small-scale battery located on a transformer at the low voltage level can't deliver them all, or even more than one at a time. Determining what benefits a battery prioritises is a key question for that community. And some of these benefits might mean that the battery doesn't lead to cheaper bills or saved emissions (see section 5.D). Other models such as a larger battery at a mid-scale generator can provide multiple functions simultaneously such as: soaking up excess generation, network services, FCAS, etc.

In the Hepburn Shire, we found that local community members wanted to prioritise benefits like [1]:

- progressing zero-net emissions targets (Hepburn Z-NET)
- improving resilience
- increasing self-sufficiency
- increasing carbon savings
- reducing energy bills.

Our social feasibility study also found that respondents cared less about financial benefits and enabling more solar. When asked how financial benefits should be distributed, the focus was on supporting community members facing economic or social marginalisation. For instance, people on low incomes, older people or people with disabilities. We assess this potential to provide financial benefits in greater detail in section 8.C.

Possibilities

'There are many possibilities for community-scale batteries, but unlocking the right solution for the right context is key.'

D. Where could community-scale batteries be located?

Research conducted by Orkestra highlighted several places on the distribution network in Central Victoria where community-scale front-of-meter batteries could be located [2]. The terminal substation, zone substation, pole-mounted on transformers or at the end of the line.

Terminal substations
Transform high-voltage electricity running on large-scale transmission lines to a lower voltage on the distribution network.

Zone substations
Transform this electricity (66kV) to local distribution networks of a lower voltage (22kV).

Transformers
These are located on the neighbourhood level, usually located on a street transformer.

Orkestra found that pole-mounted transformers on the distribution network offered the most potential benefits to community members, including: [2]

- Voltage support
- Backup power
- Improving energy independence
- Reducing carbon emissions
- Can work as a shared battery (as a service)
- Wholesale market arbitrage
- Contingency FCAS markets participation
- Soft network capacity

For residents, this would look like a small additional box located on or close to an electricity pole. These installations are simple to implement and not very noticeable visually.

There are four potential locations of a neighbourhood battery in a distribution network.

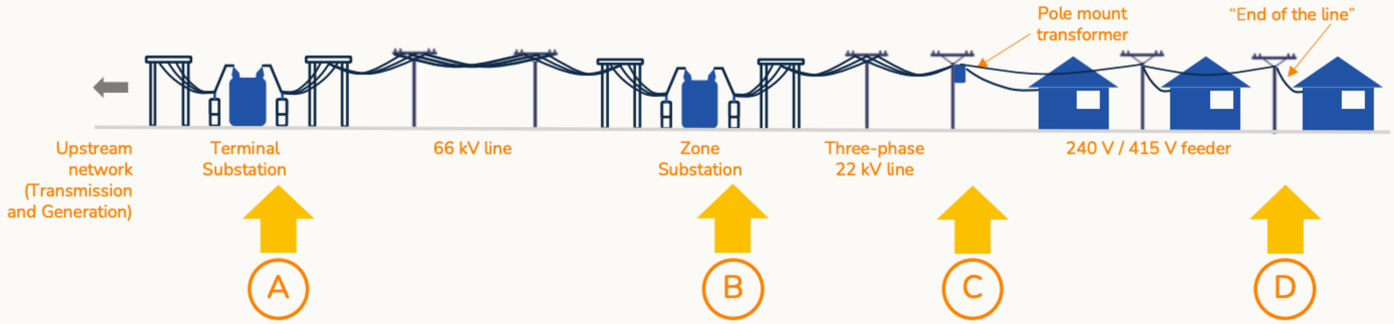


Figure 4. 'Where should neighbourhood batteries be located' from Orkestra, 2022, Neighbourhood Battery Initiative - Final Report, pg.79

E. Different control parameters

While community-scale batteries could provide a wide range of benefits, these come with trade-offs as one system won't be able to deliver on everything.

The benefits a battery system prioritises are determined by its 'control profile'. This control profile is an algorithm that seeks to optimise performance to a set of pre-defined parameters.

In Orkestra's study of Central Victoria's community-scale battery potential, they looked at different control profiles [2], including:

1. Solar charging: to optimise energy independence, i.e making the most of household solar generation
2. Delayed solar charging: to offer energy independence and soft network capacity i.e enabling more households to install solar
3. Delayed solar charging & market triggers: optimise energy independence, soft network capacity and provide better economic performance
4. Optimisation: maximum economic benefit

Box 6.

What is soft network capacity

At any given point in time the local grid will have capacity for only so much electricity to flow through it. Energy flows coming from household solar may mean that network capacity becomes constrained. Soft network capacity here refers to increasing that capacity through a solution that does not involve a 'hard' or physical change to the grid itself. So capacity is increased but not through standard network upgrades.

Orkestra's report ran thousands of simulations, highlighting several models for community-scale batteries across different transformers in Central Victoria. They produced case studies highlighting different models' potential benefits and costs.

Maximised energy independence ⟷ **Maximised economic return**

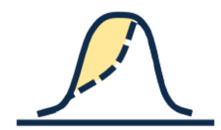
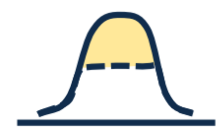
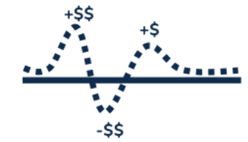
Control profile	1. Solar charging	2. Delayed solar charging	3. Delayed solar charging + market triggers	4. Optimization
Illustration				
Description	Battery attempts to store energy whenever there are negative energy flows at the transformer (i.e., generation of energy exceeds the load). Battery does not explicitly chase value capture. Any financial value capture is incidental.	Same as control profile 1 but charge only commences at a predefined time of day to increase the chance of charging during times of peak export. Battery does not explicitly chase value capture. Any financial value capture is incidental.	Same as control profile 2 but: • If the wholesale market price exceeds $1000 then force the battery to discharge. • If the wholesale market price dips below $0 then force the battery to charge. • If the FCAS price exceeds $100 then the battery should stop all activity in case of dispatch.	Linear optimization of charging and discharging of the battery over a forward 48-hour period as optimized to charge during times of low prices and discharge during times of high prices. The value stack for this control profile was wholesale market arbitrage and FCAS with capacity of the battery reserved to participate in the FCAS market.
Benefits	• Improve **energy independence** of the residents and businesses connected to a particular transformer.	• As per control profile 1 • **Potentially improved soft network capacity provision** by better aligning the battery charging with times of peak export.	• As per control profile 2 • **Potentially improved economic performance from wholesale market participation** but with tradeoffs against energy ind. and network support.	• **Optimal charging and discharging of the battery for maximum economic benefit** • **Optimal for back-up power as the battery tends to be fully charged all the time.**

Figure 5. 'Description and benefits of the control profiles considered in this report' from Orkestra, 2022, Neighbourhood Battery Initiative - Final Report, pg.24

Section 5:

Community-scale battery control models

Orkestra looked at several potential control models in real-life examples, with different objectives such as unlocking more solar, enabling energy independence and building grid reliability. These are some of the best-performing examples from Orkestra's analysis, described in the section below [2].

A. Model: Unlocking Solar

Context
Clunes is a small town in the Hepburn Shire that has high levels of solar and little grid capacity.

The problem
Many Clunes community members cannot install residential solar because there's too much already.

The solution
To help more households install solar, Orkestra assessed a community-scale battery optimising for solar self-consumption (the 'Delayed solar charging' control profile). They chose a transformer of 25kVA that served 10 residential customers, 5 of whom had solar. Looking at a 36kW/120kWh battery they found that the network capacity could be increased to 12kVA which could increase solar uptake from 50% to 70%.

Limitations
While great news for the five Clunes residents at that transformer who cannot currently install solar, the battery would come at a big cost. Orkestra calculated that over the full lifetime of the battery it would cost $118,000, with battery income unable to cover its initial capital ($96,000) and ongoing running costs. With this control profile, the battery wouldn't provide backup power in the case of a blackout.

Verdict
It would be unwise to deliver this battery, even with 100% grant funding, as community members would need to pay for the ongoing running and maintenance costs.

Box 7.

Solar finding

An important finding from Orkestra's report was that battery or transformer upgrades would be needed to unlock higher rates of solar. From a technical perspective, there is a sweet spot for batteries around 40% solar uptake. After this point, the impact of these batteries on solar capacity starts to decline as these batteries would be too small to manage higher solar rates of around 60 - 80% (see page 40-41 Orkestra report) [2].

Neighbourhood Battery:	Clunes					
Powercor Transformer ID	156944641-BAN006					
Transformer size	100 kVA					
Residential customers	33					
Commercial customers	5					
Resi. solar connections	14					
Comm. solar connections	Nil					
Technical specifications						
Battery size	36 kW / 120 kWh					
Control Profile	Optimisation					
Value stack description	Wholesale market arbitrage and contingency FCAS					
Financial summary						
15-year NPV Discount rate of 3%	($77k)					
Initial CAPEX	$96k					
Socials/environment benefits						
Solar connections enabled	Nil (Not at capacity)					
Est. soft network capacity	Before:	100kVA	After:	130kVA	**Uplift:**	**30kVA**
Est. solar hosting capacity	Before:	132kWp	After:	172kWp	**Uplift:**	**40kWp**
Est. energy independence at current solar uptake (36.4%)	Before:	31%	After:	31%	**Uplift:**	**0%**
Average percentage likelihood the battery can provide 8 hours of back up for any interval	**0%**					

Table 1. 'Case study of transformer benefitting from a neighbourhood battery improving solar hosting capacity at current solar uptake' from Orkestra, 2022 Neighbourhood Battery Initiative - Final Report, pg.32

B. Model: Energy Independence

Context
Energy independence means enabling households and businesses to make the most of their own local renewable capacity. So where the control model above is looking to enable more households to install solar, this model is helping local households use their solar. Many community members want this independence to reduce their consumption from the Victorian grid, which gets a lot of power from polluting brown coal [8].

The problem
In Ballan, Orkestra looked at a transformer where they found fairly limited self-consumption of solar i.e solar was flowing back into the grid and not being used by local residents.

The solution
They found that energy independence could be improved at this transformer with a community-scale battery. This 50kVA transformer serviced five residential customers, three of whom had solar. With a battery of 36kW/120kWh capacity and a self-consumption control profile, energy independence could be increased by 26% from current levels. Where they modelled a 100% solar scenario, this energy independence could increase to 50%.

Limitations
This battery would again be expensive, coming at a lifetime cost of $117,000 (with an initial capital cost of $96,000) and only servicing five households. Furthermore, it wouldn't be able to provide backup power during blackouts.

The verdict
Again, it would be unwise to deliver this battery. Even with 100% grant funding community members would need to pay for ongoing maintenance and running costs.

Box 8.

Energy Independence finding

At current solar rates across Central Victoria, installing community-scale batteries doesn't increase energy independence very much. This is because most solar households use the energy they produce. But some transformers with high solar rates can significantly benefit. As solar rates increase, relatively small community-scale batteries could increase energy independence. But these benefits tend to drop off when looking at larger batteries. Again, these benefits need to be balanced in terms of their capital and operating costs to ensure communities aren't left to foot the bill.

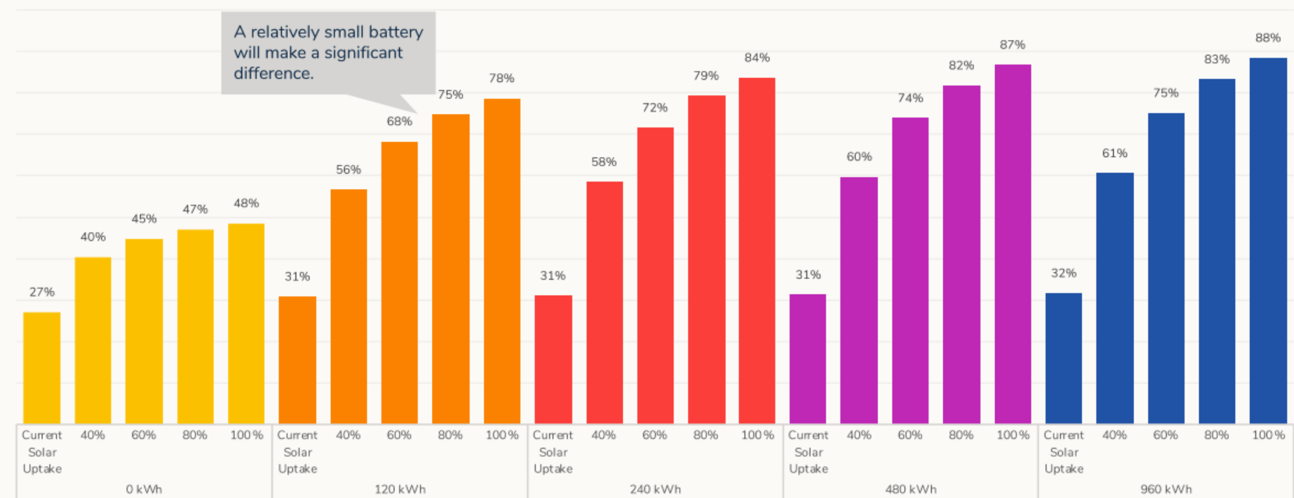


Figure 6. 'Average energy independence for all transformers by solar uptake and battery size' from Orkestra, 2022, Neighbourhood Battery Initiative - Final Report, pg.25

C. Model: Energy Reliability

Context
As mentioned throughout this report, Central Victoria has fairly low capacity on the distribution network and lots of grid reliability issues.

The problem
Community members of Wheatsheaf have reported that blackouts are very common in their township. This was backed up in Orkestra's technical report where they found that this town had ten outage events over 2021 and a blackout for 32 hours.

The solution
Orkestra looked at a transformer in Wheatsheaf that serves six customers, two of whom had solar, and modelled the installation of a 120kWh battery. Using an optimisation control profile they found the battery had a 52% chance of covering an eight-hour blackout.

Limitations
The battery would be costly but could recoup some of its initial costs during operation.

The verdict
Again, even when looking to maximise battery earnings with the optimisation control parameter, this battery would not stack up financially.

Box 9.

+ –

Energy Independence finding

Orkestra highlight some interesting findings regarding energy reliability in their report [2]. They show that small batteries could assist with energy independence, while larger batteries would be required to address energy reliability.

They also discovered that the optimisation control profile, which seeks to increase financial returns, co-incidentally performed best for energy reliability. They suggest this is because the battery would cycle infrequently and be fully charged more often, so it could be drawn on during blackouts.

C. Issues with community-scale batteries

Analysis from Orkestra highlights that these batteries face several issues, including their prohibitive cost and complexity to install and manage [2].

As part of their technical feasibility study, the smallest and cheapest batteries modelled cost $96,000, while the largest and most costly were $768,000. **Regardless of their size and control parameters, none of the batteries could recoup their initial capital** i.e they wouldn't earn as much as the cost. Most couldn't even cover their maintenance costs.

This poses a set of risks because community members seeking to benefit financially from these batteries would instead face an ongoing cost.

These projects could be funded with government grants, but in most cases, this would need to cover 70-100% of their capital outlay (i.e the battery and install process). But even with this funding, management and maintenance costs would be an ongoing issue that communities would need to cover, particularly past the 5-year typical warranty phase.

Increasing costs, such as insurance, would also be a huge risk for the future. For instance, community groups could find themselves in a position where they either need to cover increasing insurance costs or be exposed to environmental disasters.

Furthermore, there is an issue of scale. While the names 'community' or 'neighbourhood' imply that these batteries will look after a region or street, **Orkestra found that most projects in Hepburn Shire would cover less than 15 households (more often 6 or 8).** The transformers that are suited to hosting community-scale batteries only support a small number of households and businesses in regional areas. If these batteries receive grant funding, communities will need to develop frameworks to decide which locations are most suited and deserving, which is a difficult question to answer.

Section 6:

Stakeholders, management and ownership

The following section looks at the different stakeholders, potential owners and regulatory considerations relating to community-scale batteries.

A. Key stakeholders

If community-scale batteries are developed, a wide range of stakeholders would need to be involved. Broadly speaking these would include: Distributors (Powercor); Financially Responsible Market Participants and Market Ancillary Services Providers; Battery providers; Control providers; and Community members, all described in the table opposite.

Stakeholder	Description
Distribution Network Service Provider (Powercor)	Will be involved in enabling grid connection. They may request power system studies and this process could take up to six months. Should a proponent be seeking some kind of financial arrangement for services provided, they may request additional extensive power system studies.
FRMPs (retailer or small generation aggregator) and MASPs	Where the community-scale battery model involves the sale of electricity to an end customer, a retailer will be needed. If proponents need wholesale market access, they will need a Financially Responsible Market Participant (FRMP) which could be a retailer or Small Generation Aggregator. If the proponent wants to participate in FCAS markets then they will need to engage a retailer or Market Ancillary Services Provider (MASP).
Battery providers	Typically are system integrators or Original Equipment Manufacturers (OEMs) with the latter more interested in large projects, above 1MW.
Controls provider	This may come from the battery provider. Otherwise, support may be needed from one of the few control providers that exist.
Community members	Would help to determine the model, location and priorities of the community-scale battery.

B. Ownership

Different owners of a community-scale battery are possible including Councils, Community groups, Distributors, Retailers and Special project developers. These different owners all have their own pros and cons which are described below.

Table 1. From Orkestra, Neighbourhood Battery Initiative - Final Report, pg.32

Entity	Pros	Cons
Councils	– Have access to land needed to develop batteries – Councils and councillors view batteries as highly desirable	– Not core business, may hamper decision-making – Risk profile may be outside of comfort zone
Community group	– Would lead most benefit back to community – Community groups with experience in space could develop projects	– Significant administration – Decision making is complex and could challenge groups – Group members may not be the direct beneficiaries of a battery
Distribution Network Service Provider (Powercor)	– Could incorporate into regulated asset base – Can directly benefit from them and monetise improvements to capacity and grid reliability	– Have own investment priorities – AER rules mean they are locked out from certain value streams – Limited scope for community to participate
Retailer	– Can access most revenue streams from battery – Could potentially pass benefits to community via a retail plan	– Community would be locked into retailer – May be difficult to secure interest
Specialist project developer	– Best placed to deliver efficiently	– Complex projects with too many stakeholders, less value than large-scale – No incentive to involve community

C. Complexity in management and ownership

The tables above highlights the complexity in setting up and running a community-scale battery. Several stakeholders are needed to engage with the energy market, gain access to network information, and manage battery assets and their control parameters. Managers of the battery asset must be able to navigate these contractual relationships to ensure that these batteries deliver as intended and avoid risks.

Orkestra's technical feasibility report recommends that a community group with experience delivering energy projects would be an ideal developer should a project be undertaken [2]. This finding overlaps with Hepburn Energy's social feasibility study, which found that community members were most supportive of community organisations owning and being responsible for community-scale batteries [1].

However, many communities may not have the technical expertise and organisational capacity to do so [12]. In these contexts, it may be more appropriate to partner with a developer or retailer who could deliver or advocate to the local distributor to deploy them. But, many retailers and distributors may not find these projects desirable due to their high capital and operational costs.

Importantly, whoever owns the battery would still require private companies to deliver specific operational requirements including market access, maintenance and battery control provision [2].

Some of these regulatory themes and considerations are elaborated on in the section below.

Section 7:

Regulations around ownership

A. Community ownership

There are several considerations for communities that have decided to own these batteries. Batteries over 5MW must be owned by a registered generator [13]. Becoming a generator is a lengthy and complex process that community groups may wish to avoid. But batteries less than 5MW do not need to register as a generator if they are not buying or selling electricity in the grid. Should they wish to participate in the electricity market, they would need to either, contract out retail functions to an existing market participant (i.e a retailer) or register as a Small Generation Aggregator (SGA). The former is the easiest way for community groups to own these assets and access important income streams. Partnering with an existing market participant avoids the complexity and costs of registering and meeting regulatory requirements. Alternatively, community groups could seek to become a Small Generation Aggregator (SGA) [14].

What is a Small Generation Aggregator?
A Small Generation Aggregator (SGA) enables some exempt generators in the NEM to participate in the market despite being smaller than 5MW. To become an SGA a community group must go through the process of registration and then sell their electricity via the spot market [15]. As an SGA the group then needs to meet AEMO regulatory requirements. As a battery owner, the SGA could not participate in Frequency Control Ancillary Service (FCAS) markets and load management [16]. They would also face additional regulatory requirements which take time, resources and expertise to navigate. Should a community group successfully register as an SGA they would then need to establish a connection agreement with the distributor [17], another complex process requiring legal advice from an energy lawyer. Research from the University of Melbourne has also highlighted that SGAs might not be suitable in communities with distributed solar, as AEMO has previously advised that solar systems would need to be 'gross metered' [16].

B. Distributor ownership

Benefits of distributor ownership
Distributor ownership may be a more straightforward path for communities to access benefits from community-scale batteries. Distributors have oversite over local networks and have the data needed to assess where these batteries may be most appropriate [12].

Distributors could also implement different tariff structures that would help lower the network costs faced by community-scale batteries. Generators and battery storage facilities pay distributors network charges, covering the supply and transportation of energy flows between customers. But as battery facilities require energy to flow both from the customer to the battery and from the grid to the battery, the customer will be charged twice. This adds significant cost to the battery's operation. But distributors could implement alternative tariff structures that would address this issue [12].

Some academics are calling for the introduction of Local use of service (LUOS) tariffs that would be less costly than existing tariffs (TUOS and DUOS). These would apply for a small subregion of a local distribution network and would reduce costs for all customers in this area, incentivising local generation use and improving the efficiency of the grid [18].

Distributor owned batteries may be able to offer customers other benefits such as reduced network charges. While not the case for all distributors, Powercor is undertaking a community-scale battery tariff trial, which would give community-scale batteries more favourable charges [19].

Issues with distributor ownership
However, distributor owned batteries face regulatory hurdles. Distributors are not allowed to participate in the energy market under the Australian Energy Regulator (AER) Rules [18]. This means they cannot typically sell electricity or provide FCAS services, which are important income sources for community-scale batteries.

There are also limitations around how distributors differentiate between customers. All energy flows to and from a battery are considered to be 'virtual flows' [20]. Under the current system, there is no mechanism to recognise flows to and from the community-scale battery. These virtual flows are assumed to be settled in the energy market via a retailer, not a distributor. This means there isn't a clear pathway for distributors to pass on benefits to customers, although some trial projects have looked for alternatives. Some of these issues may be addressed by real-time smart meters, offering greater clarity on household use and generation.

Pathways for Distributors
Distributors may be able to obtain a full array of market and network benefits by leasing out a portion of the battery to a retailer, who can access the wholesale market and engage customers. Alternatively, they can seek a waiver from AER rules which prohibit them from providing these services themselves [21]. Community-scale batteries can apply for a more streamlined process for seeking this waiver than their large-scale counterparts. However, this pathway offers little incentive for distributors to engage with community members' interests and priorities.

C. Retailer ownership

Benefits of retail ownership
Retailer ownership also offers its own benefits for community-scale batteries, as these actors can participate in the wholesale market and provide several income generating services. They can access and participate in the wholesale energy market and obtain FCAS and price arbitrage income streams [22]. These streams represent a significant component of what's available to help community-scale batteries stack up financially. Retailers also have direct access to customers and can bill them appropriately for community-scale battery services.

Issues with retail ownership
As mentioned earlier, a key issue with community-scale batteries are that energy flows are not disaggregated, which means that retail customers are charged twice, once when the battery imports and again when it exports [23]. While distributors can to some extent lower these network charges, retailers will have to take these prices and pass them on to the customer.

Furthermore, under the current electricity framework, energy flows from the community-scale battery into the customer's property need to be recovered as though the customer was being supplied from the wholesale market [23]. This makes the electricity prices for retailer owned batteries far higher than distributor owned [24].

Other issues include land access and social license. While distributors have access to the poles and wires, where they can freely install batteries, retailers would need to enter into a contract with a third party to access land [25]. The third party would likely be local council or a community organisation. But retailers have very low trust in the community, so their ability to build relationships and a customer base may be limited [26].

Pathways to retailer ownership
Retailers who wish to own community-scale batteries need to register (as do other parties) but face less paperwork as they are already market participants. But because energy from the battery is both collected and distributed, they need to be registered as both a generator and a customer. Alternatively, they can register as an Integrated Resource Provider (IRP), a new category in the market [27].

Retailers will still need to form multiple contracts with different parties including: a connection agreement with their local distributor, battery operation and maintenance contracts, battery supply and install contracts, an offtake agreement, an agreement between the distributor and retailer, plus standard retail contracts with customers.

Section 8:

Viability

The next section describes some of the key considerations for community members interested in delivering community-scale batteries.

A. Social viability

Interest and appetite
There is considerable interest in community-scale batteries across Victoria. In Central Victoria, we surveyed local community members to understand their interests and priorities around community-scale batteries. Hepburn Energy found a high level of interest and locals were hopeful that this technology could help reduce emissions, improve resilience, increase self-sufficiency, and lower energy bills [1].

While there is a lot of interest, community members may not be aware of the full costs and complexity involved with community-scale batteries, which this booklet is attempting to address.

Amenity
How community-scale batteries look, sound and interact with their environment and social landscape is highly varied and depends on the design and consultation process. In terms of scale, different batteries can be of different sizes. For instance, the Yarra Energy Foundation community battery is roughly the size of three fridges with a 283kWh capacity [28]. Whereas the community battery from Totally Renewable Yackandandah and their local retailer, Indigo Power (Yack01) has a 274kWh capacity and is roughly the size of a car [29]. Similarly, noise would vary depending on the design of the system. Where noise or other amenity impacts are possible community consultation processes would be required to ensure the needs of local people are met.
One of the advantages of community-scale batteries is their potential for greater customisation. Yarra Energy Foundation contracted a Melbourne-based artist to cover their battery with a mural, demonstrating how these batteries can respond to their community and environment.

Safety
All batteries need to meet Australian standards to ensure that risks are minimised and they can be used safely [30]. The relevant standards for grid-scale battery storage systems are the 'AS/NZS 5139:2019 Electrical installations — Safety of battery systems for use with power conversion equipment'. Safety issues that can exist with battery systems include: fire, electric shocks and the production of hazardous chemicals [31]. Several of these issues arise from mismanagement or poor design. If the battery is not fit for the context and use, overheating or degradation can occur. The risk of these issues occurring can be mitigated through considered planning, development, careful management and maintenance [31].

Figure 7. Image from Yarra Energy Foundation website, available here.

B. Environmental viability

Emissions benefits

Community members have highlighted their interest in community-scale batteries' potential to lower emissions [1]. While this is possible, Orkestra's technical analysis highlighted that such emission reductions appear to be fairly minor from low voltage level transformer batteries, with many of the sites modelled demonstrating that local solar was mostly being self-consumed [2]. Community-scale batteries could enable more households to install solar in some areas, but similar improvements could be made by upgrading local transformers, at roughly 1/10th to 1/20th of the cost. So while these batteries can provide some emissions benefits, there may be more affordable tools to achieve the same outcome.

Sustainability

Different battery technologies exist, with their own specific characteristics in terms of performance and sustainability. Lithium-ion batteries are commonly deployed due to their high energy density and cycling stability [32]. Other battery technologies include nickel cobalt, nickel manganese cobalt and flow batteries [33]. Some environmental downsides of battery technology are that they increase mining for raw earth minerals, and pose issues around safe disposal [32]. But it is possible to recycle and make use of many components of these batteries [34]. In Australia, several organisations and companies exist that support the recycling and repurposing of battery storage units. For instance collaborations like the Australian Battery Recycling Initiative (ABRI) [35] seek to enable battery recycling of many scales and companies like Relectrify are extending the life cycle of battery storage systems [36]. Some battery technologies come with fewer environmental impacts such as the Redflow battery, which seeks to increase operating life and make use of readily available and non-toxic materials [37].

C. Financial viability

Battery costs and revenue

While community-scale batteries at the low voltage transformer level could provide a range of benefits, such as enabling solar, and improving energy independence and energy reliability, without significant government support for both the construction and then the operation of the asset, the business case is not viable [2]. Current grant funds only cover capital expenditure and can leave the owner exposed to unpredictable operations, maintenance, insurance and administrative costs into the future.

Orkestra looked at potential revenue streams for community-scale batteries, assessing income from network tariff arbitrage, wholesale spot arbitrage and contingency FCAS and found that with these alone, none of the projects modelled broke even [2].

In the future, new income streams may arise which could improve their financial viability such as; new markets to encourage storage, distributors paying for grid services from third parties and models where batteries are owned by one entity but leased to others who operate them for profit (battery-as-a-service). But in the current and near future, these systems struggle to stack up in Central Victoria.

A vital consideration is the concept of community good versus community cost. Will the battery service an appropriate size of community to make the effort and spend worthwhile and how will the operational risk be managed so as not to create stranded assets over time.

Indirect economic benefits

Orkestra found that various economic benefits from community-scale batteries can not be easily monetised these include (see page 22 in Orkestra) [2]:

- Soft network capacity value to the network
- Soft network capacity value to individuals serviced by a transformer (who can install solar due to increased solar hosting capacity)
- Energy independence value
- Grid reliability value

The table below gives an example of a transformer in Lyonville and the potential of accounting for both direct and indirect economic benefits.

Importantly, these projects are still operating at a loss even with these indirect financial benefits accounted for. This presents a huge challenge for both attracting government funding and seeking involvement from distributors or retailers.

Control profile	1. Solar charging	2. Delayed solar charging	3. Delayed solar charging with market triggers	4. Optimisation[13]
Upfront Cost	($96,000)	($96,000)	($96,000)	($96,000)
Wholesale Market Arb.	$663	$661	$3,215	$11,448
Contingency FCAS	Nil	Nil	$1,987	$30,788
O&M Costs	($22,921)	($22,921)	($22,921)	($22,921)
NPV (Subtotal)	($118,258)	($118,260)	($113,720)	($76,685)
SNC – Network Value	$8,137	$8,137	$1,948	Nil
SNC – Customer Value	$19,693	$19,693	$7,859	Nil
Energy Ind. Value	$3,002	$2,752	$2,808	Nil
Grid Reliability Value	Nil	Nil	Nil	$15,894
Adjusted NPV	($87,426)	($87,678)	($101,909)	($60,791)

Table 2. 'Comparison of key metrics for the various control profiles on a 120kWh battery installed on transformer 20485589-BAN003 in Lyonville with a name plate rating of 50kVA with 10 residential customers, 6 already with solar at current solar uptake (43%).' from Orkestra, 2022, Neighbourhood Battery Initiative - Final Report, pg.39

Generator/battery tariffs

Generators and battery storage facilities also pay distributors network charges, covering the supply and transportation of energy flows between customers. But as battery facilities require energy to flow both from the customer to the battery and from the grid to the battery, the storage facility will be charged twice. This adds significant costs to the battery's operation. But alternative tariff structures exist that could address this issue.

Local Use Of Service (LUOS) tariffs could be applied to a small subregion of the distribution network and be less costly than existing charges (TUOS and DUOS) [18].

D. Regulatory viability

While community-scale batteries can be delivered by a range of stakeholders, they all need to implement a complex array of contracts and registrations to meet regulatory requirements.

All participants considering operating a community-scale battery need to be registered under at least one National Electricity Market participant category [13]. Community groups registering with projects less than 5MW would most likely opt-in to be a Small Generator Aggregator (SGA) but would then be unable to participate in FCAS markets [16]. Retailers or existing market participants may look to become an Integrated Resource Provider (IRP). Distributor owned batteries would likely lease out a portion of the battery to an existing market participant to get access to wholesale market income [18].

Due to the scale and scope of these regulatory requirements, we have not been able to capture these in detail for this booklet. Community groups looking to deliver a community-scale battery would need legal advice from energy lawyers to navigate many of these processes. Distributors and retailers may be better placed to navigate these spaces, with greater expertise and knowledge. Community groups that wish to partner with these stakeholders to deliver these batteries will need to have clear contracts that define their respective roles, responsibilities and protections.

Section 9:

Alternatives to typical community-scale batteries

This booklet primarily focuses on small-scale in 'front-of-meter' projects that are connected to the low-voltage network at the transformer. This is based on the Victorian Government's Neighbourhood Battery Initiative criteria [10]. But alternative designs may be more viable and can unlock greater value. For instance, community-scale batteries could be:

- **Co-located behind-the-meter at a Commercial and Industrial (C&I) facility:**
  In some instances, commercial and industrial projects can install a battery behind-the-meter (i.e at that property) to make the most of available tariffs and potential energy arbitrage. For example, community members could fund the installation of an oversized solar system, backed up by a battery to make the most of demand-based tariffs. In this scenario, excess generation can be discharged when electricity prices are high, earning income for community investors.

- **Servicing a high-value community need:**
  This is where a community-scale battery is installed to meet an important need. For example, the battery could be deployed at an emergency shelter for fire preparedness. Powerlines often go down during significant fires, leaving people with limited electricity access which can be an issue for communication (i.e charging mobile phones). A community battery at a designated place of last resort could be helpful during these emergencies but may also offer some market and network benefits during normal operation.

- **A virtual power plant led by the community:**
  For residential users with lots of solar, and an appropriate tariff (time-of-use) and access to government subsidies residential batteries are starting to make financial sense. Battery households and small businesses could collaborate to create an alternative form of community storage, through a 'Virtual Power Plant'. This is where individual batteries are networked together through smart technology. They can then be calibrated to deliver for particular community interests, such as more stable and affordable power supply, increase solar hosting capacity or and back up power provision.

- **Co-location at a community generator:**
  This is where a community-scale battery is located at a community generator. These batteries can make the most of arbitrage opportunities and provide soft-network capacity to the generator whilst meeting community goals of energy independence. For more information, see our Case Study of Hepburn Energy's proposed community battery (see Case Study E).

A. Behind-the-meter batteries

The focus of this report is on community-scale batteries that sit in front-of-meter. These batteries are integrated into the electricity network and located on low voltage lines. A project which is 'behind-the-meter' sits at a facility or customer property and can be either integrated into the electricity network or not integrated, depending on the design. The focus of these projects is to enable greater self-consumption or storage of the facility's own energy resources, such as rooftop solar.

As part of the Community Sparks project Orkestra looked at the potential of three community facilities to host behind-the-meter batteries [38]. These batteries could unlock bill savings and potentially be a source of backup power during blackouts.

Orkestra modelled:
- three sites, the Daylesford Town Hall, Kerang Library and Creswick Hub
- five battery sizes ranging from 13-200kWh systems, and
- the impact of different value streams such as
  - tariff arbitrage,
  - wholesale arbitrage,
  - Frequency, Control and Ancillary Services
  - solar self-consumption
  - provision of backup power

How did they perform?
In terms of their financial performance, several characteristics influenced the behind-the-meter batteries' viability. All sites modelled had some solar, but when Orkestra looked at adding 'oversized' solar arrays i.e systems that provided over and above the consumption needs of the site, they performed much better. When these solar systems were paired with an appropriate tariff, like a 'Time of Use' or 'Wholesale exposed tariff' they earnt more income. With these tariffs, the battery could export energy during periods of high demand and receive a better price. If these characteristics were met Orkestra, found that both Daylesford Town Hall and Kerang Library could stack up.

Key findings:
- Oversized solar helped projects to financially stack up
- Time of Use* and wholesale price exposed tariffs* unlocked greater income
- Larger loads (>160MWh p.a) with an appropriate network tariff might benefit more
- Prioritising financial rewards may reduce back-up power or energy independence capacity

Box 10.

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Your bills and tariffs explained

Chances are if you're reading this booklet, you're pretty familiar with the electricity tariffs. But for those of you looking for a refresher, here's a recap!

Your electricity bill includes usage and supply charges and, if you have solar, a feed-in-tariff for your generation. Most households are on a flat or single tariff where all your usage is charged at the same rate. Some people are moving towards Time of Use tariffs, which have a peak, off-peak and sometimes a shoulder rate, representing times of the day when electricity has typically been in high or low demand.

New retailers are coming on board that offer 'wholesale price exposed' tariffs. This means that households and businesses are rewarded for responding to the wholesale market. This price is far more variable than standard tariffs, going far lower and higher than their non-exposed counterparts. This makes this tariff structure ideal for households and businesses with batteries as they can discharge when electricity is expensive and charge when it's cheap.

The other component of your bill is the supply charge. This goes to your distributor and is what we pay for access, maintenance and improving the electricity grid itself.

Behind-the-meter viability
These behind-the-meter projects are far simpler to deliver than front-of-meter, transformer located batteries. Located on a property, they avoid complex regulatory and procedural barriers that make delivering community-scale batteries challenging. They also face fewer transaction costs which come from having many stakeholders involved. These characteristics of behind-the-meter batteries make them more straightforward to deliver, and in some instances, more financially viable as community projects.

Section 10:

Addressing community needs

Community members have expressed their desire for community-scale batteries to help progress zero-net emissions targets (Hepburn Z-NET), improve resilience, increase self-sufficiency, increase carbon savings and reduce energy bills [1].

When looking at these batteries (front-of-meter, at the transformer, on the low voltage network) we've found that there is a clear conflict between delivering these benefits, if any at all. Projects that seek to reduce emissions are unlikely to in the short term as they charge from the grid, they're unable to improve blackout resilience (a household battery would better serve this purpose) and all projects will likely add billing costs, rather than reduce them.

Alternatives to these kinds of front-of-meter batteries exist and make more sense for community proponents. These alternatives such as behind-the-meter batteries, batteries as a service, Virtual Power Plants or batteries located at community generators, may be able to provide these benefits more directly or at lower cost than their counterparts.

But where we are looking at community-scale grid-connected batteries, several interventions could make these projects more viable, described here.

Improved participation from distributors
Distributors could support community-scale batteries by making payments in recognition of the network services they provide, such as delaying grid upgrades and enabling more solar. Another option for distributors is to release more attractive network tariffs that would reward energy customers for using locally produced energy (LUOS).

Market or regulator changes
A key area of uncertainty is around energy market prices. With recent price spikes, battery storage has become comparatively more viable. There is also the possibility that battery prices will come down as the technology gains traction. Government agencies have also considered potential new energy value streams that would reward batteries and make their value stack more appealing.

Government incentives
Another area that would make community-scale batteries more viable is through government incentives. Government initiatives frequently support new technologies to help their deployment and the establishment of new industries. In Victoria, we have several examples of this kind of investment, including the Solar Homes initiative and the Neighbourhood Battery Initiative (which funded this Community Sparks project).

In addition, we also have the Federal Government's Community Battery program. Such incentives can make these projects viable and help communities build solar access, energy independence and reliability. But with these projects, communities will need to carefully assess if the project can cover its long-term running costs, which will not be covered by grant funding.

In addition, we recommend that Government's create program criteria that include multiple forms of community-scale batteries and not preference one model.

Wider changes to improve the grid
While some community-scale batteries may offer benefits for reliability or solar access, cheaper grid-based solutions exist but would involve action from distributors.

Distributors have the capacity to upgrade transformers to improve solar access and reliability and reduce voltage issues and reliability. In fact, upgrading transformers would be 1/10th to 1/20th of the cost of installing a community-scale battery for the same effect. But distributors have their own investment priorities, so community members, organisations and businesses need to advocate for these network upgrades.

Another area for improvement is broader market reforms which could support local solar adoption. These reforms could include introducing dynamic operating envelopes and dynamic export limits, which would offer greater nuance when it comes to constraining solar installation in the future. Another example is enabling local energy trading or cost-reflective network charges, which would better account for the value of locally produced energy being consumed nearby.

Section 11:

Case Studies

A. Behind the meter

Daylesford Townhall 1.0

The Daylesford Townhall is a key facility for the Hepburn Shire community hosting a range of community events and a library, with 10kW of solar.

Modelling from Orkestra found that a 13kW battery (the smallest size analysed) with appropriate tariffs could break even when considering financial viability alone.

A larger battery (50kWh) would be needed to provide backup power but this capacity would drop if the battery prioritises back-up power provision over financial rewards.

The analysis also noted that a larger solar system would improve the viability of the battery by reducing imports from grid electricity.

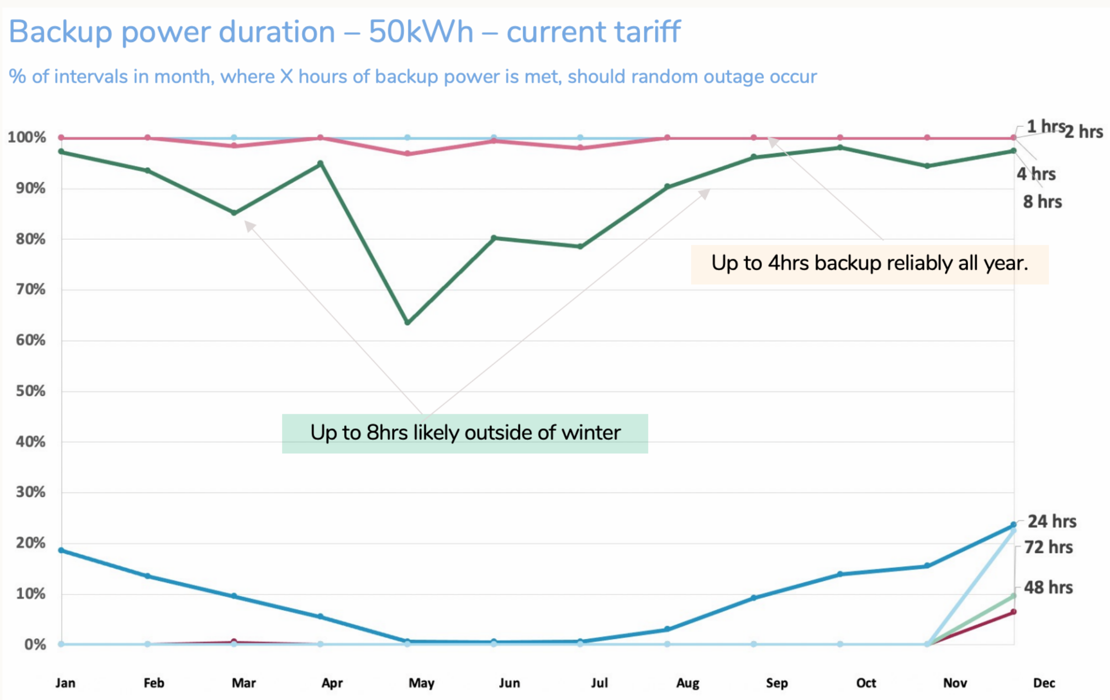

Figure 8. Image from Orkestra, 2022, Technical & Financial analysis, pg.21

Kerang Library 2.0

Kerang Library is an important community hub hosting events throughout the year with 10kW of solar.

Similar to the Daylesford Town Hall, only the 13kWh system stacked-up financially. But if a further 20kW of solar was added, both the 26kWh and 50kWh options would make financial sense with the appropriate tariffs.

The 50kWh battery could provide between 1-8 hours back-up power with the current solar system. But if this system was boosted with 20kW of additional solar, it would be able to meet longer durations of blackout throughout the year.

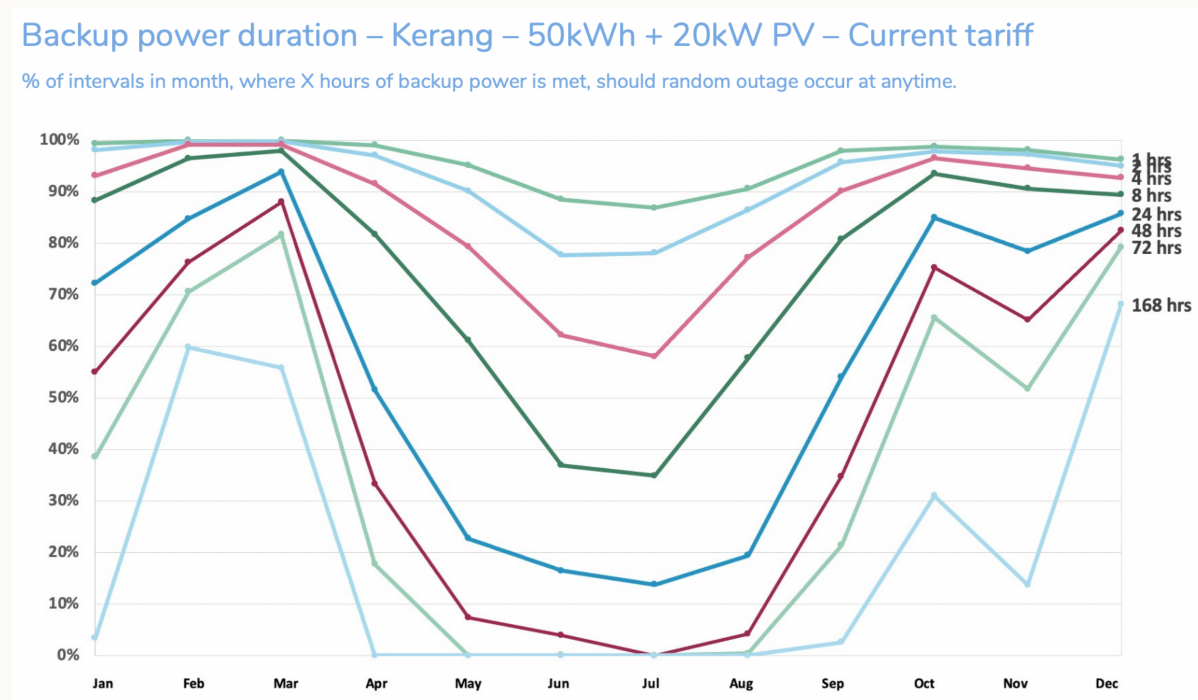

Figure 9. Image from Orkestra, 2022, Technical & Financial analysis, pg.37

B. Emergency Shelter

Another key opportunity for behind-the-meter battery systems is to provide back-up power in case of emergencies. Such facilities could play an important role during bushfires, storms or severe flood events, which can often lead to power outages. In these instances, the lack of access to power can make it difficult for community members to stay informed about the emergency and meet their basic needs. In these instances, battery-powered shelters can be a lifeline and provide a critical service.

Orkestra analysed the viability of a battery designed specifically to support community members in times of emergency [38]. They modelled a system that needed to cater for 100 people when in use as a shelter, consuming roughly 134kWh of electricity over the day, with slight variations for season.

They found that

- **20kW PV + 200kWh:** could reliably provide 24 hours of service even in the coldest months of the year and would cover as much as 168 hours in November.
- **40kW PV + 200kWh:** could reliability provide 42 hours of service in the coldest months and 168 hours throughout summer.

Box 11.

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Emergency service vs breaking even

As noticed with the front-of-meter batteries discussed throughout this booklet, Orkestra found a tension between providing financial rewards and back-up power [2, 38]. Where communities operate a battery as an emergency service, it may limit its potential to generate revenue. This is because during periods of elevated emergency risk, such as high fire danger, the battery would be storing capacity rather than exporting for profit. But during times of the year when emergency risks are lower, the battery could be optimised for financial benefits, although this is unlikely to surpass the initial battery investment. As with many of the community-scale batteries studied throughout this project, covering initial battery costs often requires optimising for financial rewards alone.

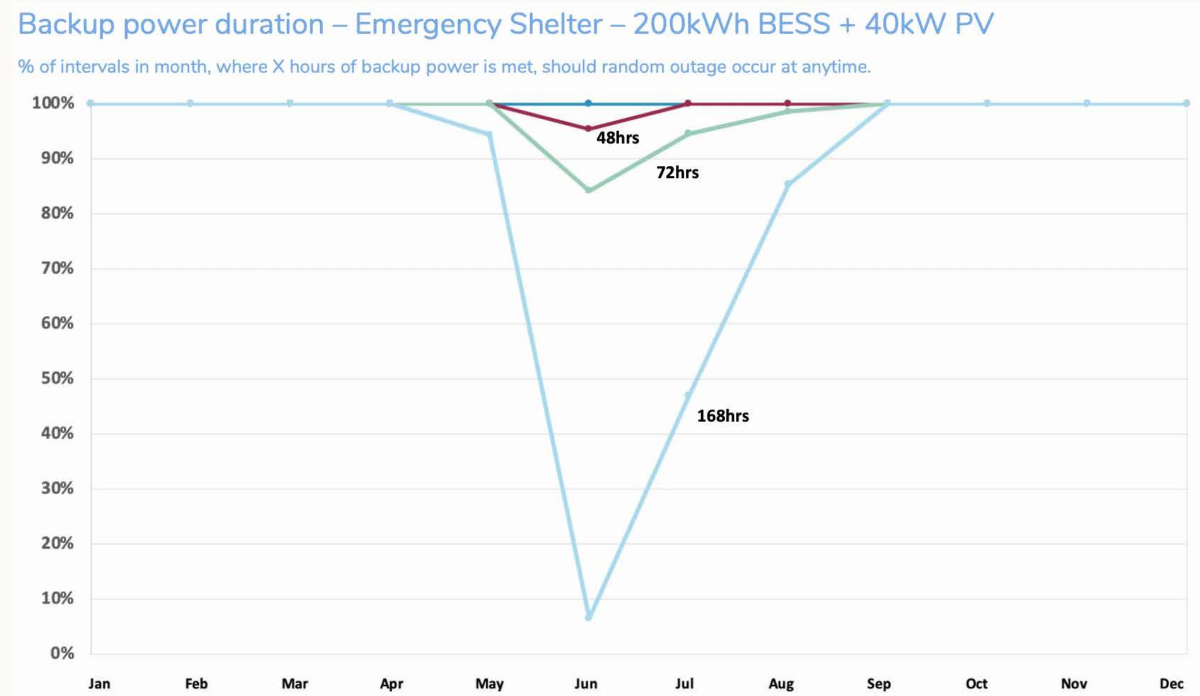

Figure 7. Image from Orkestra, 2022, Technical & Financial analysis, pg.54

C. Yarra Energy Foundation

The not-for-profit Yarra Energy Foundation delivered a 'third-party independently-owned' community battery in Fitzroy North, Melbourne. This 110kW/284kWh lithium-ion battery was delivered in a partnership with CitiPower, the local distributor, and the Australian National University (ANU) Battery Storage and Grid Integration Program (BSGIP), with the support of the Victorian Governments Neighbourhood Battery Initiative [39] .

This battery sits in front-of-meter and is designed to enable rooftop solar to be soaked up during periods of peak generation and then used during evening consumption peaks. It has one cycle a day - so it charges when the sun is out and then discharges when people return home and start using household appliances [19].

The battery is expected to serve roughly 200 homes and supports households connected to that part of the sub-network, even those without solar. The battery itself is a PowerShaper, from a Norwegian company called Pixi and is made of 95% recyclable battery cells that are produced with 100% renewable energy. The battery cost roughly $1 million, with $800,000 from the Neighbourhood Battery Initiative, and the remaining funds coming from CitiPower, the City of Yarra and the Yarra Energy Foundation [28].

D. Totally Renewable Yackandandah

Yack01 is a new project from the not-for-profit Totally Renewable Yackandandah and the community energy retailer Indigo Power.

The Yack01 is a 274kWh community battery used to make the most of a 65kW solar system located at a local sawmill serving close to 40 homes [29, 40]. This is a behind-the-meter project, meaning that the battery is connected at the property level and is managed by Indigo Power, a community energy retailer. This particular battery is also making the most of smart demand management technology provided by Mondo, with the 'Ubi' device [40]. This device will enable battery charge and discharge cycles to better respond to needs in the electricity network and maximise value for Indigo Power. The battery will also offer back up supply in the case of black outs, helping to run essential services for some time.

The project raised $200,000 and received $171,000 from the Victorian Government to deliver a 274kWh battery. The battery is expected to power roughly 30-40 homes in the evening [40].

E. Hepburn Energy

Hepburn Energy has a planning permit for up to 10MWh of battery storage. This battery would be 100% owned and operated by the co-operative, making it another great example of a community battery. This storage facility would be co-located with the existing 4.1MW wind generator and a 5MW AC solar farm in the future. This combination of generation and storage assets will help the co-operative reap rewards from various battery income streams.

This battery would be located on the distribution network on a 22kV line, unlike many of the front-of-meter, low-voltage connected batteries studied in this booklet.

To manage the regulatory requirements of the NEM, Hepburn Energy has partnered with the retailer Flow Power. Flow Power has a retailing license and acts as the co-operative's intermediary in the NEM. They also enable the co-operatives retailing offers. These retailing offers reward customers for the region's renewable energy transition and connect them with energy-saving tools.

Section 12:

Glossary & definitions

Arbitrage
Arbitrage involves the buying and selling of commodities or resources, such as energy, in order to take advantage of differing prices for the same asset.

Behind-the-meter
A project which is 'behind-the-meter' sits at a customer's property and may or may not be integrated into the electricity network itself. The focus here is on self-consumption and is managed within the property. This could be a residential or commercial property.

Community energy
Community energy is where communities are involved in developing, producing, distributing, selling and buying energy assets and their output.

Community battery
A community battery is any kind of battery storage technology deployed by or for direct community benefit, such as community ownership.

Community-scale battery
A community-scale battery is the umbrella term for a battery located in a regional area on the low voltage or distribution network. For urban environments the term neighbourhood battery is more commonly used.

Distributed Energy Resources
Distributed Energy Resources (DER) are energy resources on the distribution network which produce electricity and/or help to manage consumer demand. This could include solar PV, batteries, demand management at other technologies.

Distribution lines
Distributions lines are part of the electricity network, taking power from large scale transmission lines to lower voltage lines.

Distributor
A distributor owns the power lines poles and infrastructure involved in the transportation of electricity from the distribution network to homes.

Electricity
Refers to energy which can be distributed through electricity networks and used by homes, businesses and industry. This does not include heat or gas energy which are also important energy sources.

Energy
Is a broad term referring to the capacity for power from many sources, including mechanical, light, chemical and electrical. This includes electricity, gas and heat sources.

Energy independence
Energy independence means enabling households and businesses to make the most of their own local renewable capacity.

Energy reliability
Refers to the consistent provision of power for homes and businesses i.e avoiding or limiting blackouts and brownouts.

Energy system
The energy system is a broad term describing how energy services are provided.

Financial viability
Financial viability is where a project or organisation is able to meet operating or project objectives and fulfil its purpose over time. This requires consideration of various factors that may enable or inhibit this.

Frequency Control Ancillary Services (FCAS)
Frequency Control Ancillary Services help to ensure that grid voltage and frequency levels are balanced. AEMO manages markets designed to provide these services.

Front-of-meter
Front-of-meter energy systems are connected to the grid, and therefore not metered at a private property (see behind-the-meter).

Generator
An asset that produces electricity or gas. This can be produced through renewable sources such as wind or solar, or through fossil fuels such as coal or gas.

Low voltage lines
Are part of the distribution network but at a lower voltage than distribution lines. These low voltage lines transport energy to residential properties.

Metrics
- Kilojoule (KJ): a measure of energy equal to 1000 joules
- Kilowatt (kW) a measure of electricity equal to 1,000 watts
- Kilowatt hour (kWh): electricity equal to 1,000 watt hours
- Megawatt (MW): a measure of electricity equal to 1,000 kilojoules
- Megawatt hour (MWh): a measure of electricity equal to 1,000kilojoule hours

National Electricity Market
The National Electricity Market is a wholesale market through which generators and retailers trade electricity in Australia. It interconnects the six eastern and southern states and territories and delivers around 80% of all electricity consumption in Australia.

Renewable energy
Includes energy from the sun, water, wind and heat. Renewable energy technologies include wind turbines, solar photovoltaic cells, hydropower, wave power and geothermal.

Retailer
Retailers purchase electricity and gas from generators through the wholesale market, which they then sell to their own customers. Retailers also require authorisations through the Australian Energy Regulator.

Transformers
Transformers convert the voltage of electricity higher or lower to enable distribution to and from households or commercial properties.

Transmission lines
These are large scale networks that transport high voltage electricity across large areas of land. These typically service distribution lines but occasionally connect to large scale generators.

Voltage
Voltage is the electric potential between two points. Where voltage is higher, there is a greater current of electricity flowing through.

Virtual Power Plant
A Virtual Power Plant is where digital communication technology is used to connect distributed energy resources (like residential battery and solar) to deliver services or capabilities in aggregate.

Soft capacity
Soft network capacity refers to increasing total potential energy flows in part of the grid without delivering physical network upgrades i.e not a 'hard' change to the grid itself.

Substation
Substations transform voltage from high to low and low to high enabling distribution from transmission to distribution systems.

Section 13:

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