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COMMUNITY ENERGY:

Hope and Headwinds

Acknowledgements

We acknowledge the Traditional Custodians of the land. We pay our respects to their Elders, past and present.

Pollination extends that respect to Aboriginal and Torres Strait Islander peoples who contributed their experience and insights to this paper, to those engaging with its contents, and to all those improving energy access, reliability and resilience across Country.

Nature as a shared resource is central to the culture of Aboriginal and Torres Strait Islander peoples and its use in the provision of energy is the most recent iteration of a relationship that spans millennia.

We acknowledge that for more than 60,000 years Aboriginal and Torres Strait Islander people sustainably cared for Country, and that all Australians benefit from their continuing role in protecting the nature and biodiversity of our lands and seas.

We recognise that this always was, and always will be, Aboriginal land.

POLLINATION

Pollination is a specialist climate and nature advisory and investment firm focused on accelerating the transition to a net zero, nature positive future. We work with governments, corporates, and financial institutions, to understand and manage the risks and opportunities presented by the net zero transition and build long-term resilience for economies and businesses. Pollination has 8 offices across Oceania, Asia, North America and EMEA.

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Cover: The township of Dunkeld, nestled at the foot of Wurgarri (Mount Sturgeon), Victoria.

Contents

Executive Summary

This paper engages with community energy, a category of energy assets and projects that can take many forms, each sharing a common relevance to the local community. Projects can be as humble as the group purchase of energy efficient lighting, or as sophisticated as major infrastructure that unlocks local equity ownership. Increasingly, there is an interest in a class of assets that is many times larger than household energy technologies but orders of magnitude smaller than utility-scale assets; a mid-scale that serves a small neighbourhood. These are often economically awkward and deserve specific exploration.

The nature of community involvement in collective energy investments, and the economic and social implications of community participation, are as varied as the communities involved. Some can readily tap energy sector expertise to make technoeconomic decisions, where others can't. Different communities might seek to deliver emissions reductions, to pursue community engagement, or to target economic uplift as the primary inspiration for their efforts. Some project proponents are motivated by a desire for energy access, reliability, and resilience to climate-charged natural disasters, and seek outcomes that could be addressed by other parties either with or without community ownership. With such variation in the configuration of community energy projects, this paper necessarily draws more than one conclusion on the productivity and potential of the sector.

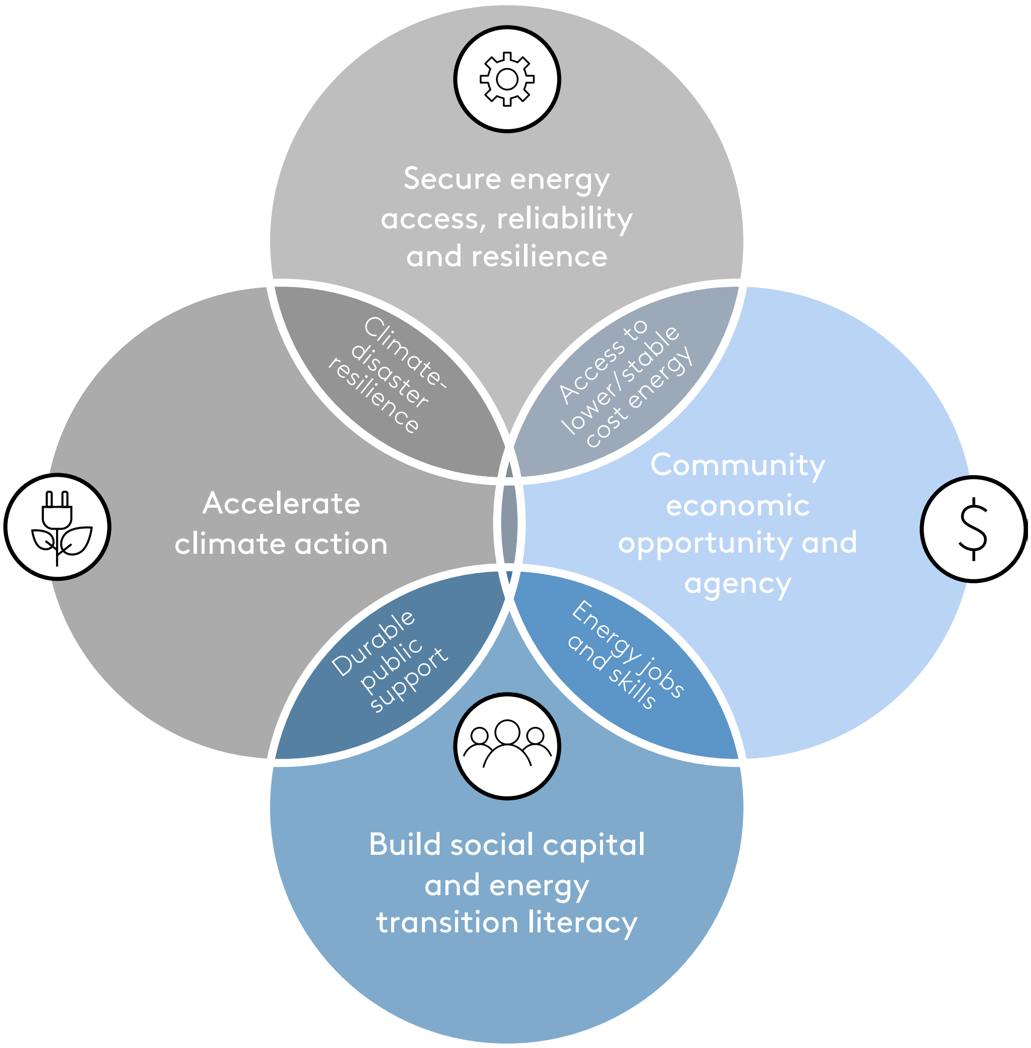
There is an extraordinary gift of community enthusiasm for local participation in the energy transition. There are hard-working communities motivated to contribute, and examples of gains when their enthusiasm is harnessed through projects that respond strategically to power system parameters. There also appears to be a perspective that community energy projects are the natural extension of Australia's rooftop solar success story. The economic reality, however, is more complex, and risks disenfranchising some community groups.

Energy projects of all scales interact with energy market fundamentals and interface with other participants in the adjoining transmission and distribution system, often to the point of interdependence. By connecting to the local grid, community energy projects are inescapably connected to the volatility of electricity pricing, including the growing prevalence of negative market pricing. This can suppress earnings, which projects may or may not be able to de-risk through offtake agreements. They may also be limited by the hosting capacity and voltage constraints that can apply in local grids, which in turn may be positively or negatively impacted by hosting local energy projects depending on their attributes. While some community projects may aspire to higher self-reliance, community energy projects that connect to the grid are best understood as blending into a larger system of formidable complexity, where collaboration with incumbent participants is central to success.

In this paper, we engage squarely with the economic context for these projects and find that some project types and configurations are much simpler to advance than others. Projects that aggregate more than one site, that involve more experienced actors, that overlay FCAS participation and associated revenues, and that are co-designed to achieve grid-complementary results typically have the strongest business case. In this context, grid-facing, community-led batteries can be particularly challenged, as shown in quantitative analysis in Section 4.1. Some projects in more remote settings contribute strongly to local reliability and resilience, adding to their economic logic, and assets that are located behind-the-meter continue to enjoy replicable success.

To explore the value of community energy projects, whether financial, non-financial or a combination of both, it is helpful to understand the driving objectives of those that initiate them. With an understanding of the problems that proponents are looking to solve, it's possible to reflect on how successfully these projects perform.

We identified four driving motivations, with crossovers common across projects: Accelerating climate action; Securing energy access, reliability and resilience; Building community economic opportunity and agency, and; Building social capital and energy transition literacy.



For communities in remote locations served by frail sections of transmission, and for First Nations people living on Country with high reliance on diesel generators, projects that improve energy reliability and resilience have particular significance. Further, growth in climate-fuelled disasters is heightening the need for more local supply resilience. Communities are seeing this growing need, and some are mobilising projects in response. For those with access to technical knowledge, dedicated volunteers and funding, outcomes can be transformative. For others, it is not clear that the responsibility to solve access, reliability and resilience shortcomings should fall to them.

Communities that are working to contribute positively to decarbonisation can have the greatest impact if they ultimately displace fossil fuel use, whether gas in the home, diesel in power generators, petrol in cars or adding rooftop solar or other renewables to their energy mix. Different project configurations will come with a different cost for every tonne of greenhouse gas effectively displaced. Naturally, there is a sound logic for pursuing those projects with the most sound economic logic so that decarbonisation dollars can go further. As already noted, diseconomies of scale and other development overheads can be significant for mid-sized assets, and particularly for those that are grid-facing. Where economic outcomes fall below the levels needed to inspire their replication at scale, their ability to promote high-volume, efficient decarbonisation is similarly constrained. In this economic context, it is often preferable to focus investments on behind-the-meter installations, particularly those promoting energy efficiency, electrification and rooftop solar and storage.

Communities may be looking to access a share of the wider energy transition economy by pursuing community batteries. While they may seek a figurative 'share of the pie', however, the economics of mid-scale battery units, in particular, tends to mean that there is very little pie to share.

There is evidence of some communities seeking to build social capital and energy transition literacy, at times intersecting with the needs of those communities acting as brokers and hosts to larger energy infrastructure developers in their region.

As people encounter changes relating to the energy transition, and particularly the opportunities enabled by newer forms of electrification, energy efficiency and behind-the-meter energy technology, there is an appetite for trusted, peer-to-peer explanations and rapport built one cup of coffee at a time. While this level of local support and engagement can involve collective projects that build energy efficiency and behind-the-meter participation, such as rooftop solar and batteries, it doesn't follow that these communities should necessarily invest in more complex local energy assets. There is space for approaches that build from the important role of local knowledge brokers to build community support and literacy for the energy transition, without stepping into outright project investment and interaction with the energy market.

Grid-connected community energy projects in Australia face significant challenges that innovative approaches to behind-the-meter asset investment can avoid. Where dedicated communities endeavour to step into grid-connected asset deployment, however, they do better in some locations than others, with some project designs than others, and where they can secure access to FCAS, technical expertise, mentoring, and even the partnership of an aggregator.

Despite the immense complexity and market risk, there are projects delivering the right mix of positive outcomes sought by their communities. Community projects so often involve generous people doing good work, but not all project configurations are equal. There is no shortcut for energy market knowledge. Caveat emptor.

About this Report

The energy transition occurring in Australia is not limited to large, utility-scale renewable energy deployment and the rooftops of Australia's housing stock. There is discernible interest in the role that mid-scale category of projects could deliver for communities that are deeply engaged in their design and deployment.

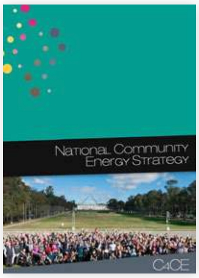
This paper has been commissioned by the Australian Renewable Energy Agency (ARENA) to explore the benefits of such projects in the context of the problems they are seeking to solve, which must be understood in terms that extend beyond the bounds of traditional financial returns.

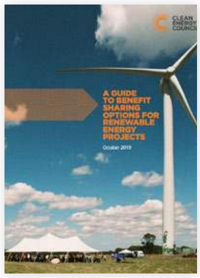
This decade has seen a rising awareness across Australia of the importance of social licence to the wider build-out of renewable energy and associated infrastructure. Expectations are crystallising around threshold levels of respectful consultation and benefit sharing, and community needs are increasingly in focus. In this context, we observe a level of proliferation in thinking and writing on topics relevant to community energy.

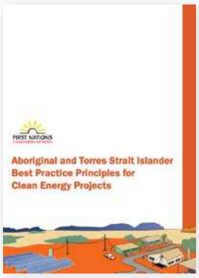
The conclusions in this paper reflect the literature, practitioner experience, and insights available to us at the time of writing and make extensive use of important publications, including those pictured. The sector will continue to see innovation and evolution of thought.

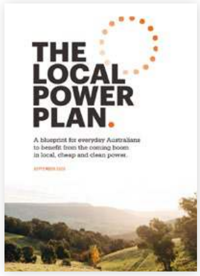
Modelling conclusions are subject to today's equipment costs and energy markets. Looking back, it is clear that change is almost certain.

KEY REPORTS AND GUIDANCE LEVERAGED THROUGHOUT OUR WORK[1]





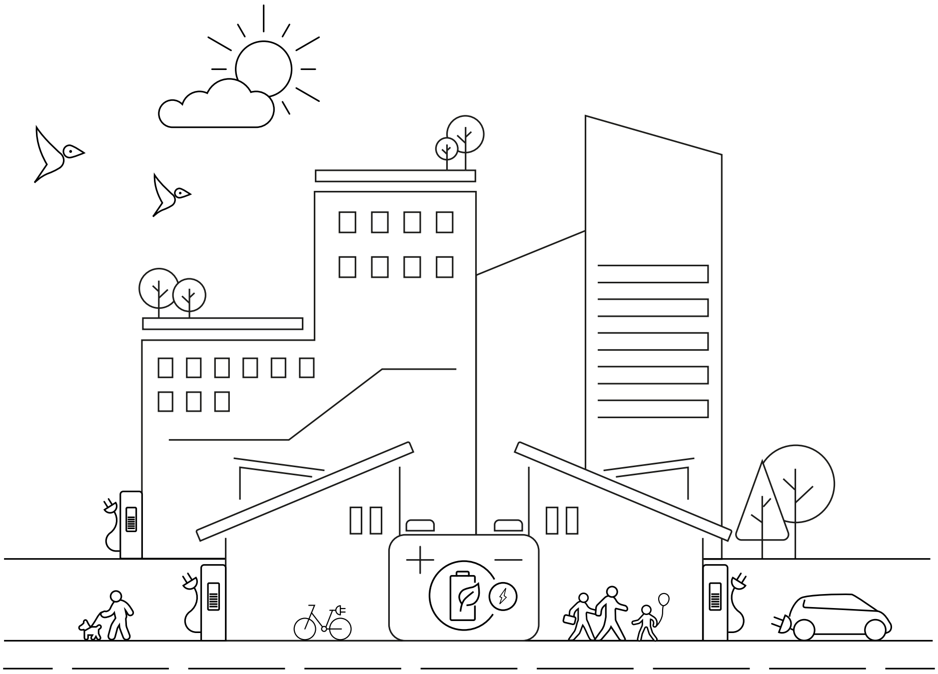




Produced in July 2024

1. Please see (Helene Haines 2020; UTS Institute for Sustainable Futures et al. 2015; Victorian Government 2015; Lane and Hicks 2017; Buckley et al. 2023; First Nations Clean Energy Network 2024)

1. Background



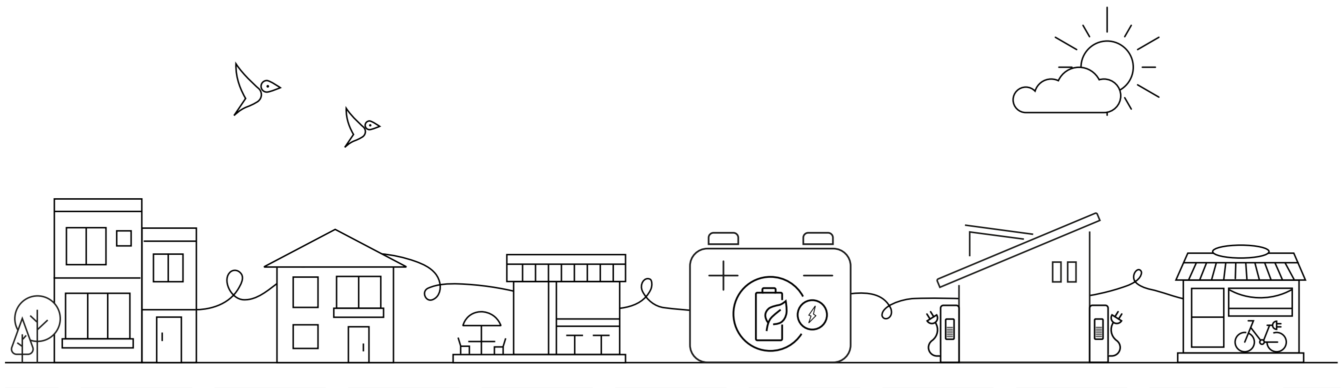
Community energy first came to life in Australia championed by communities with a desire to accelerate climate action. The Denmark Community Windfarm, first conceptualised in 2003 and profiled on page 51, and the Hepburn Wind Farm, established in 2007, demonstrated that community-led project development was possible, and each iconic project contributed positively to confidence in the wider energy transition.

As other projects have followed their example, however, the collective experience has shown community energy projects to be highly complex undertakings and very hard work..

As of 2023, the number of community energy projects in Australia has expanded to over 126, with over 37,500 supporters (Buckley et al. 2023). Over the course of 2023, $86.9 million was raised by community energy groups, resulting in approximately 12 MW of new renewable energy generation and 13,947 tCO_2-e in avoided emissions (Buckley et al. 2023). This achievement reflects tremendous community efforts but is a small fraction of the 3,100 MW of rooftop solar installed over the same period and tends to reflect less efficient abatement per dollar spent (Clean Energy Council 2024).

Today, while climate action remains a focal point for many community energy projects, emphasis appears to be expanding to projects intended to build energy supply reliability and resilience.

2. A broad definition of community energy



Community energy has a sprawling definition that allows for differences in interpretation. At its heart, the word 'community' resonates differently with different groups faced with varied needs and constraints.

Some of the most influential definitions have centred on the role of community groups, whether formal or informal collectives, as proponents. Examples include the Victorian Government's 2019 guide, which defined community energy as "projects where a community group initiates, develops, operates and benefits from a renewable energy resource or energy efficiency initiative" (p.7, Victorian Government 2015). The *Australian Local Power Agency Bill*, tabled as a Private Member's Bill in 2021 and not taken forward, similarly defined community energy projects as "carried out mainly by the community or by community organisations"[2], amongst other attributes.

Many others build their definitions for community energy around the concept of ownership, perhaps reasoning that ownership corresponds to carriage of decision rights and that decision rights confer secure access to benefits. The lived experience can be more varied.

2. *Australian Local Power Agency Bill 2021*, Section 5, Meaning of community energy project, p.6.

In this paper, we have applied a wider definition that allows space for movement that may become useful as we see evolution in technologies of relevance, and the advent of new partnership and commercial models. This provides for the exploration of projects initiated by distributors and aggregators of different types that can offer technical, power systems, and financial skills. We find that it is helpful to first explore the economic implications, and the efficiency of emissions reduction, for different classes of assets before turning to the extent of local ownership and leadership.

This paper engages mostly with energy assets that are either connected behind the meter, or involve a microgrid or off-grid solution, or are 'community-scale', by which we mean assets below 5 MW, and often significantly smaller, often connected to low-voltage, distribution poles and wires.

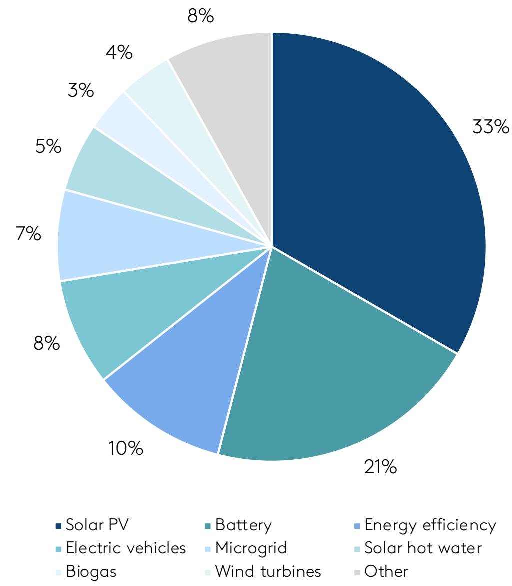
This paper does not engage at length with utility-scale or export-orientated assets as these are typically outside the definition of community energy. In a small number of cases, such as that exemplified by the Aboriginal Clean Energy Partnership in the East Kimberley[3], profiled on page 24, major assets can be conceived through true co-design, co-development and the division of equity to local land holders and custodians. This project and others that follow its model set the benchmark for community leadership and impact.

We note that social licence issues relating to the development of utility-scale projects are the source of considerable rumination across Australia. Project developers and infrastructure companies' approach to consultation, construction, and benefit sharing crucially shapes the experiences of surrounding communities and stakeholders. Their engagement in these processes directly influences community outcomes. This relevance to communities does not, however, place this thematic within our definition of community energy. Rather, these are very normal considerations in developer-led utility-scale projects, and much has already been written on the need for sincere and collaborative consultation and the importance of deeper forms of co-design and benefit sharing. We do not seek to duplicate this existing guidance here.[4]

We have taken a similarly expansive approach to defining 'energy': It relates to generating renewable electricity, storing electricity, and enhancing energy and greenhouse gas emissions efficiency, including through electrification. The mix of relevant technologies under this definition will continue expanding as new solutions become feasible.

Figure 1 provides a breakdown of community energy technology types in Australia over 12 months from 2022 to 2023 (Buckley et al. 2023).[5]

FIGURE 1. COMMUNITY ENERGY PROJECTS BY TECHNOLOGY TYPE, 2022-23



3. Please see https://aboriginalcleanenergy.com/

4. For more information please see the Dyer Report and First Nations Clean Energy Network's (FNCEN) 10 best practice principles.

5. Note that the data provided in the primary source only adds to 99%.

2.1 Definition categories

Figure 2 summarises the broad categories of community energy projects that we have applied, referencing scale and connection attributes and indicating the lead proponents. As acknowledged above, developer-led projects are not uniformly accepted as examples of community projects but can confer benefits: Those that manage to prioritise community objectives and engage deeply in co-design and co-delivery are more readily identified and supported as community projects.

FIGURE 2. COMMUNITY ENERGY DEFINITION CATEGORIES

SCALE AND CONNECTION TYPE	LEADERSHIP AND/OR OWNERSHIP: COMMUNITY PROPONENTS		LEADERSHIP AND/OR OWNERSHIP: DEVELOPER PROPONENTS
BEHIND-THE-METER	**Local proponents for behind-the-meter and off-grid assets:** • Behind-the-meter and microgrid assets brought forward for collective benefit by local groups, co-operatives and councils. This can include community-led projects involving government-owned properties. • Assets typically include rooftop solar and batteries for community premises and the collective roll-out of electrification.		**Developer-led behind-the-meter and off-grid assets:** • Behind-the-meter and microgrid assets brought forward by network providers, energy companies and other developers. • Assets can include microgrids and the regional roll-out of electrification, as with the Esperance Electrification Project.
COMMUNITY-SCALE distribution-connected	**Local proponents for mid-scale assets:** • Distribution-connected assets, typically sized well-below 5MW, brought forward by local groups, co-operatives and councils. • Assets typically include community batteries, small solar collectives and pairings of wind turbines.		**Developer-led mid-scale assets:** • Distribution-connected assets brought forward by network providers and other developers and aggregators. • The level of community participation and benefit varies. • Assets typically include local batteries.
UTILITY-SCALE and EXPORT transmission-connected	*	**Equity share:** • Utility-scale assets brought forward by developers with local shareholders gaining equity and active in co-design.	**Developer-led utility-scale assets (not community energy):** • Utility-scale assets brought forward by developers, with the local community hosting without material equity or co-design. • Assets typically include transmission, utility-scale wind and solar farms.

* This report does not explore community-owned and initiated, large-scale projects in detail, as they occur infrequently in Australia. However, international examples exist that use structures that pool capital across multiple communities, such as 3Cenergy in California.

3. Objectives and local outcomes

Community energy initiatives are often motivated by diverse and interrelated drivers, with community groups typically mobilising around projects that can achieve positive changes within their community. These motivations are often different to those of an archetypal private business venture, characterised as seeking profits that cover the funds invested and achieve, at a minimum, a hurdle rate of financial return. It is helpful to consider the broader motivations of community energy proponents, as these typically reflect a broader set of problems that those proponents are seeking to resolve.

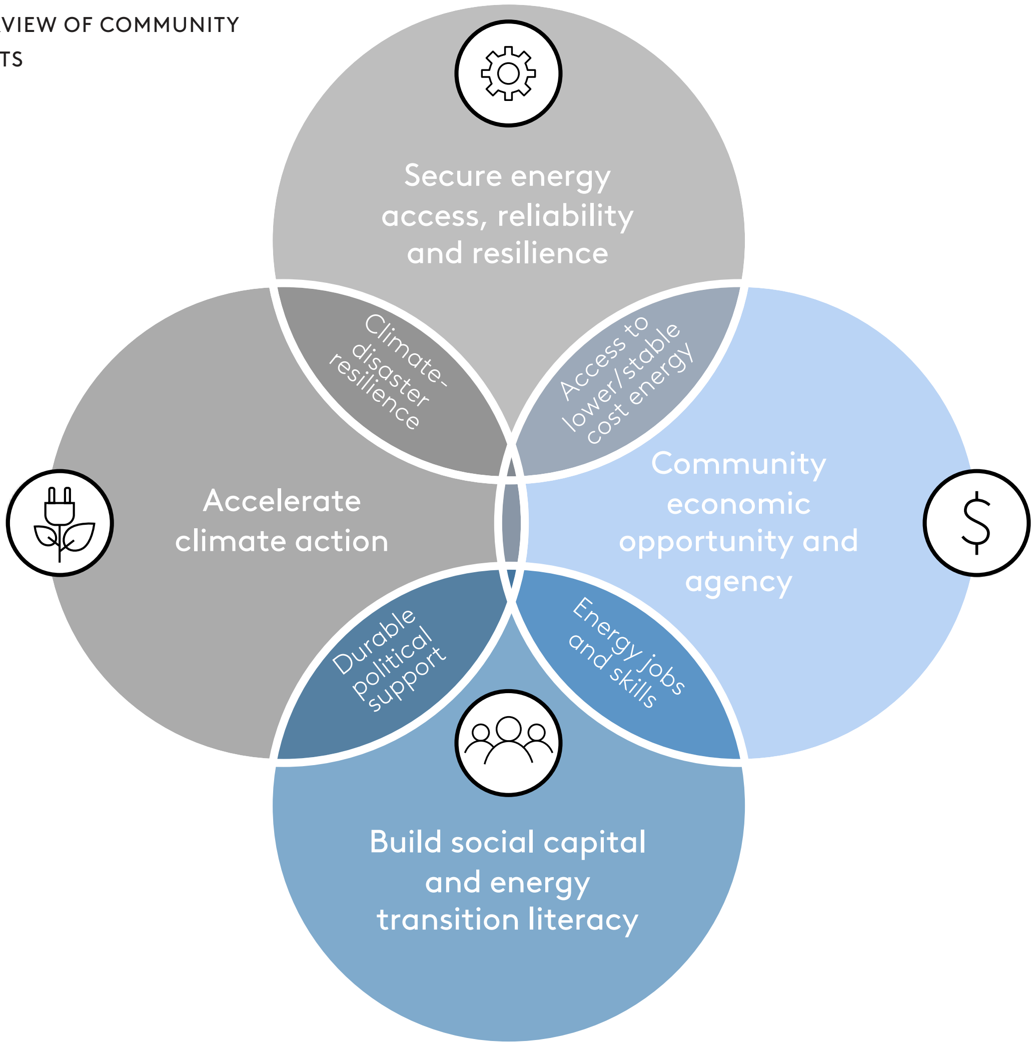
It is also critically important to consider the specific outcomes being sought in each community, and whether they might be better addressed through actions other than community energy investment projects.

Hopes commonly held for community energy projects include boosting power supply security and resilience (Buckley et al. 2023), creating value for the community (Feldhoff 2016), lowering energy costs (Norbu et al. 2021), fostering community cohesion (Hargreaves et al. 2013; Rogers et al. 2012), creating jobs (Helen Haines 2020a), facilitating skills and capacity development (Briggs et al. 2022), and reducing emissions (Soeiro and Ferreira Dias 2020). The objectives pursued by each community will reflect a different mix of priorities. The ability of each project to meet those objectives will be similarly varied.

In this paper, we have distilled the potential benefits of community energy into four overlapping categories of objectives, as shown in Figure 3, building from a wide-ranging literature review and stakeholder consultations.[6]

6. Over 30 expert and practitioner interviews from around Australia and globally.

FIGURE 3: OVERVIEW OF COMMUNITY ENERGY BENEFITS



In this section, we find that community energy assets, irrespective of the party initiating them, can be beneficial in addressing local issues relating to secure, reliable, and resilient energy access. We find the case for resilience-building growing with the increasing occurrence of climate disasters and the need for reasonable access to high voltage infrastructure, such as electric vehicle fast chargers, even in frail sections of grid.

We consider the importance of social capital and the benefits of conferring energy literacy in a trusted peer-to-peer setting that can be characteristic of community-led energy. We find these benefits compelling, particularly as communities navigate incoming technology change and a need to interact with energy in a more active way through the transition. We suggest, however, that literacy-related objectives can be targeted without the community necessarily having to lead local energy investment projects.

With reference to Section 4 and the exposure of energy projects to challenging market fundamentals, we find that not all community-led energy projects can achieve positive economic outcomes and cost-efficient decarbonisation. Project proponents seeking to maximise their impact and minimise their economic risk might alternatively consider co-design avenues with their local distributor, aggregation models, and other innovative partnerships and technology-led solutions that grow participation behind the meter.

3.1 Secure energy access, reliability, and resilience

In rural, remote, and isolated communities where levels of energy insecurity persist, improvements in energy access, reliability, security, and resilience are self-evidently beneficial. Communities with substandard energy supply can suffer impacts to quality of life, impacts to health, social disadvantage and the economic burden of interrupted business, interrupted internet and payment systems, and spoiled products. In some locations, dependence upon energy to pump and treat water can deepen the adverse implications of energy insecurity and underscore the benefits of actions that strengthen electricity supply and resilience.

Typical reasons for energy insecurity include reliance on ageing electricity infrastructure or dependence upon single transmission lines with stability issues and little contingency. The importance of secure and resilient access in vulnerable parts of Australia's grids will grow as the nation converts to electric vehicles and more regions seek to connect rooftop solar. Access to fast charging and rooftop connections depend upon the strength of intra-region electricity supply. Locations with weak supply risk being left behind.

Local technologies can potentially contribute, project by project, to reducing problems relating to remote energy reliability and resilience. Where the grid infrastructure is frail, it can make sense to consider place-based solutions that bring forward community-scale electricity generation or storage assets as an alternative to traditional grid investments. For example, microgrids, small batteries, and other technologies can provide supply contingency and resolve voltage issues in remote communities, irrespective of different ownership models. We profile this opportunity on page 32 with reference to research by Cutler Merz (2020).

The potential suitability of local technologies does not imply that projects must be community-led. While some motivated communities with access to energy expertise can contribute to the evolution of local energy assets, for many communities the task is too great. There is no suggestion that they should be held responsible for fixing weak points in rural and remote energy supply. Safe, reliable, and efficient delivery of electricity remains the responsibility of the regulated distribution and transmission system operators.

More broadly, the opportunity to build energy supply resilience through the deployment of local electricity technologies intersects with responses aimed at improving resilience to climate-charged natural disasters, discussed in Section 3.4.1 further below.

Even areas that are not exposed to climate-related interruptions today may face pressure from the physically changing climate and accompanying growth in climate disasters such as fires and floods. Climate change modelling indicates that the frequency, intensity and duration of extreme weather events are expected to increase in the coming decades (CSIRO, Bureau of Meteorology 2022; Pepler and Dowdy 2022; Canadell et al. 2021; Abram et al. 2021). Growth in climate-charged disasters may not yet be fully reflected in distribution network plans and may come to feature more prominently. Further, the National Energy Objective now includes an Environmental objective, which promotes efficient investment to achieve greenhouse gas reduction targets set by the Commonwealth and states, amongst other objectives, which will similarly become more of a feature in the distribution investment cycle.

BENEFITS TO LOCAL PROPONENTS

Many Australians suffer from energy disadvantage. Depending on the definitions used, 0.41% to 8.1% of Australians suffer from a level of energy poverty (Vera-Toscano and Brown 2022). Remote communities are 18% more likely to be underserved by energy service standards relating to eligibility to connect rooftop solar, guaranteed protections for powered equipment used for life support, and other protections (White et al. 2024).

Under such conditions, proponents may initiate community energy projects as a remedy. The development of microgrids and community-scale battery storage systems, if configured to ride-through grid events, can provide communities with a supply of energy that can bridge short-duration outages.

While community-scale and community-led energy is not the only model of response to energy insecurity, it can bolster the benefits case for such projects and counter some of the economic disincentives and other headwinds to community project development. This is further explored in Section 3.4.1.

The resilience benefits community energy can provide can have important practical outcomes for communities, such as enabling the provision of essential services during climate-fuelled natural disasters. This can be particularly important for small or regional communities that have limited access to critical infrastructure and services during such events.

The Community Power Agency has developed the concept of Resilient Energy Centres – buildings that have been equipped with a backup energy system so they can be energy independent in the event of a broader network outage (Hancock and Walters 2022). For example, the coastal township of Venus Bay in Victoria has installed a solar and battery system at the local community centre, with support from the Victorian government's Community Power Hubs program which has since concluded. The system provides for a safe place for residents to go to access water, kitchen facilities, and information in the event of a crisis. Such projects go further than more general notions of increased energy reliability and self-sufficiency (Buckley et al. 2023).

CASE STUDY

Totally Renewable Yackandandah – Building resilience

Totally Renewable Yackandandah, or TRY, is a volunteer-run community energy group in the northern Victorian town of Yackandandah. The town's approximately 2,000 residents depend upon a robust single 22kV 3-phase contingency feeder (common in country areas) to supply the valley, with no mains gas and many properties reliant upon electricity to pump water and septics.

TRY was originally conceived a decade ago to progressively deliver 100% renewable energy to act on climate change. More recently, its focus has expanded to respond to the physical effects of climate change. Energy resilience to climate-fuelled disasters is now a near-term priority, and TRY's leadership has overseen local power assets and contingency that provides a leading example of resilience in energy systems.

In a narrow valley surrounded by forest, Yackandandah has been threatened by bushfire three times in the last 18 years. During the 2019-20 Black Summer bushfires, teams involved in fighting fires in the Upper Murray used Yackandandah as a base, reinforced by strong access to electricity to power critical radio communications and other essential facilities. This period underscored to residents the importance of power resilience in times of crisis.

The growing focus on resilience is also readying the town for higher rates of electrification. As towns like Yackandandah integrate higher volumes of rooftop solar, electric appliances and transportation, and respond to the need for fast EV charging and growing peaks in power usage and voltage, system resilience, contingency and reliability come under increasing pressure. Proactive efforts that build local resilience and strength in turn provide for deeper local access to the clean energy and electrification transition.

The volunteer team behind TRY includes individuals with familiarity with energy markets, key power system participants and technical elements of the power grid, and knowledge of where to source expertise. This literacy has allowed TRY to pursue achievable, well-resolved projects with local relevance, and to build up to increasing complexity. Even starting with modest projects, the volunteer workload has been heavy and remains substantial ten years into the project. The TRY volunteers continue to give their time generously, wanting to share their knowledge of local energy technologies that enable higher penetration and usage of rooftop solar, lower energy-related emissions, and higher resilience.

Opening with a demand-side, behind the meter project, TRY raised $5,000 for the replacement of 276 light fittings with low maintenance LED lights for the then community-owned Yackandandah Health in 2017. The $5,000 was provided as a loan, to be repaid through energy cost savings and redeployed to other TRY projects, and so was the first step in funding a larger vision. TRY also offered thought leadership to Yackandandah Health, that helped realise the installation of a 90kW rooftop solar system. The local supermarket, post office and other buildings have followed this example.

Since this first project, TRY's achievements include the delivery of rooftop solar and battery systems at the Country Fire Authority and State Emergency Commission offices, rooftop solar and battery systems at the Town Hall, and a 274 kWh community battery coupled with a 65 kW rooftop solar system behind-the-meter, leveraging a pre-existing transformer.

With support from Mondo, AusNet and the Victorian Government's Microgrid Development Initiative three trial microgrids were installed between 2017-19. These microgrids have now been absorbed into a broader Virtual Power Plant encompassing more than 210 local properties and all integrating a smart energy control device, the Mondo Ubi.

Between 2021 and 2022 ARENA, AEMO, AusNet and Mondo funded a program titled Project EDGE, which examined the ways in which existing network assets could be integrated with controlled distributed energy resources to deliver more productive and dynamic management of local power. Settings and trials were configured to harness Consumer Energy Resources, for a two-way grid that integrates local network requirements and wholesale market opportunities.

Importantly, the microgrids were configured to isolate and supply energy if there was a wider blackout, and to interact with local grid fluctuations to assist grid stability and allow for higher levels of local rooftop solar connection. While the trial microgrids are no longer active, many homes, businesses and community buildings remain individually islandable.

Over the last year, with around $275,000 funding support from Emergency Recovery Victoria, Yackandandah purchased a 28 kVA and a 44 kVA generator for deployment in the event of a sustained power outage or emergency. These trailer-mounted generators can be connected to combinations of the Yackandandah Community Centre, Primary School, Senior Citizens Centre or the Town Hall, each with air conditioning, kitchen and bathroom facilities that would allow residents to congregate especially during times of recovery. The use of the diesel generators can be activated by the emergency Incident Command mechanism for incidents where it is deemed safe to stay in Yackandandah and deployed after an event to reduce recovery times. A small group of locals, including electricians, have been trained in the deployment of the trailers. Two Starlink satellite connections have also been added to aid communications should power be cut to mobile phone towers – a common event in many recent Australian emergency events.

The Yackandandah Emergency Readiness Project has also included the installation of an extra 13 kWh battery at the Town Hall, and a 13 kWh and 16 kWh battery system at the Yackandandah Community Centre, which also hosts the local radio station.

As described in the February-March 2024 edition of local paper Yackity Yak, the project and participation of a town-wide Community Reference Group "raised awareness about emergency readiness as a whole and drew together key decision makers to build an enhanced community-wide emergency preparedness framework".

Visitors to Yackandandah will not see any single large and visible change in the energy system. Instead, property by property and mostly behind the meter, change is underway that is increasing self-reliance and building resilience. Each project is the result of evaluating what can be achieved with the resources available that will fit within the local power network, to strengthen and accelerate the much broader electricity system retooling.

As the TRY team has gained experience through the delivery of each project and built knowledge of the relative costs of different technologies, the initial objective of isolating the town from the main grid and establishing a whole-of-town microgrid has given way to a more nuanced understanding of interdependence, incremental improvement, and energy solutions that strengthen and complement the local grid. There is an emphasis on using 'off the shelf' parts to contain costs, and on maximising behind-the-meter opportunities to minimise demands on the grid and build integrated system strength.

Outside the community centre entrance, YCC committee member Chantelle McConchie with TRY committee members, left to right, Neil, Juliette, Bernard, Matt and Kim, with Clare and Katie kneeling at the front. Both Clare and Katie are newer committee members, with Clare joining in 2020 and Katie joining last year.

BENEFITS FOR LOW-VOLTAGE GRIDS

There is potential for community-scale energy assets to address needs and opportunities in local distribution network systems. Assets of various types can benefit local electricity supply reliability, security and resilience, can result in deferred or diminished distribution asset costs and, in some circumstances, can unlock higher levels of rooftop solar participation to accelerate climate action. They can therefore be understood as blending into three of the benefit driver categories used in this paper.

We explore the intersection of local assets with energy supply resilience, under Section 3.4.1 on Climate Disaster Resilience. We also consider the potential for local community-scale assets to reduce demand peaks and in turn allow for more efficient use of existing poles and wires infrastructure, and hosting for increasing numbers of electrified assets in Section 3.4 on Accelerating Climate Action.

Community-energy projects are well placed to offer distribution-level solutions, combining surplus energy absorption, time-shifted dispatch and various technical network support services. Where community-energy projects are brought forward by parties other than the local distribution operator, these benefits are best unlocked through genuine co-design. Additional grid management benefits of community energy are summarised in Appendix B.

3.1.1 ACCESS TO LOWER-COST ENERGY

Community energy projects are often initiated in pursuit of lower energy usage costs for participants or other local community members that they subsidise.

Access to lower-cost energy, however, is not certain for community energy projects, and depends very much on their design, where they connect whether behind-the-meter or front-of-meter, and the transfer of benefits between participant parties, as explored in Section 4.

While numerous studies have profiled cost savings, they often reference times and locations with different energy-price dynamics, rather than taking forward looking positions responding to today's market-price outlook. Indications of lower energy costs should, therefore, be understood in concert with the economic observations made in Section 4.[7]

Subject to this economic framing, well-designed, well-located renewable and battery projects that manage their exposures to cost and revenue risks can have the potential to save energy users money. Naturally reduced energy costs can have broader economic benefits, as households enjoy energy cost relief on cost-of-living pressure and local businesses enjoy a source of relative stability and even advantage (Soeiro and Ferreira Dias 2020).

Energy assets installed behind-the-meter are most frequently associated with positive economic outcomes. Akan (2023) finds that scaling the adoption of renewable energy could help shield consumers from external inflationary pressures, with recent trends in headline inflation partially attributed to escalating global fossil fuel prices for non-renewable energy (Australian Bureau of Statistics 2024; RBA 2022; Rubene and Koester 2021). For those who can afford the up-front costs, the savings effect is particularly present in assets, such as rooftop solar, that are located behind-the-meter.

Since the value of behind-the-meter solar, batteries and other assets is most evident in the reduced cost of imported grid electricity, these projects provide a unique opportunity for one group of proponents and finance providers to bring forward the installation of assets that achieve lower energy costs for other members of the community and typically those in economic vulnerability. This can have a high social value. In this way, philanthropically minded communities can contribute to the costs of installing assets for the benefit of another section of the community, for example through rooftop solar for an assisted living facility so that residents can enjoy lower spend on energy purchases.

Technologies and funding arrangements that enable community investment in behind-the-meter assets can also achieve outcomes relevant to energy cost containment. Technology solutions, such as Allume's (profiled on the following page), provide for other models of collective purchase that reduce exposure to the cost of grid-supplied energy.

7. Barbour et al. (2018) found that community batteries can reduce total storage needs by 35% compared to individual household storage solutions, suggesting cost efficiency. Norbu et al. (2021) found that community-scale renewable energy and battery storage can lead to 10-18% savings on energy bills for communities. Furthermore, a study by Uddin et al. (2023) held that community-sized microgrids in Australia not only offer cost savings but also contribute to reductions in operating costs. In their review of Victoria's Community Power Hubs program, Hicks and Lane (2019) found that the 15 projects incubated produced savings of $365,000 from electricity costs each year, or a total net present value of $9.1 Million in savings over 25 years. Community Energy England (2021) reported that community energy initiatives in the UK saved customers £2.9 Million in 2020. Each of these should be read subject to their unique economic circumstances.

CASE STUDY

Allume - Unlocking rooftop solar for apartments

Apartment residents have had frustratingly few opportunities to connect rooftop solar and enjoy the corresponding reduction in grid electricity bills. If a community within a shared property works together and decides that it wants to use a shared roof space for solar panels, it is difficult to wire the solar output so that it displaces grid energy consumption for every dwelling and in turn pays back the initial investment from each resident. Unfortunately, the complexity of connecting solar generation to multiple dwellings with separate electricity meters is typically enough to short-circuit any project. As a result, we see underutilised roofs, suboptimal decarbonisation, and households disadvantaged in their access to low-cost electricity, which in turn impedes their electrification.

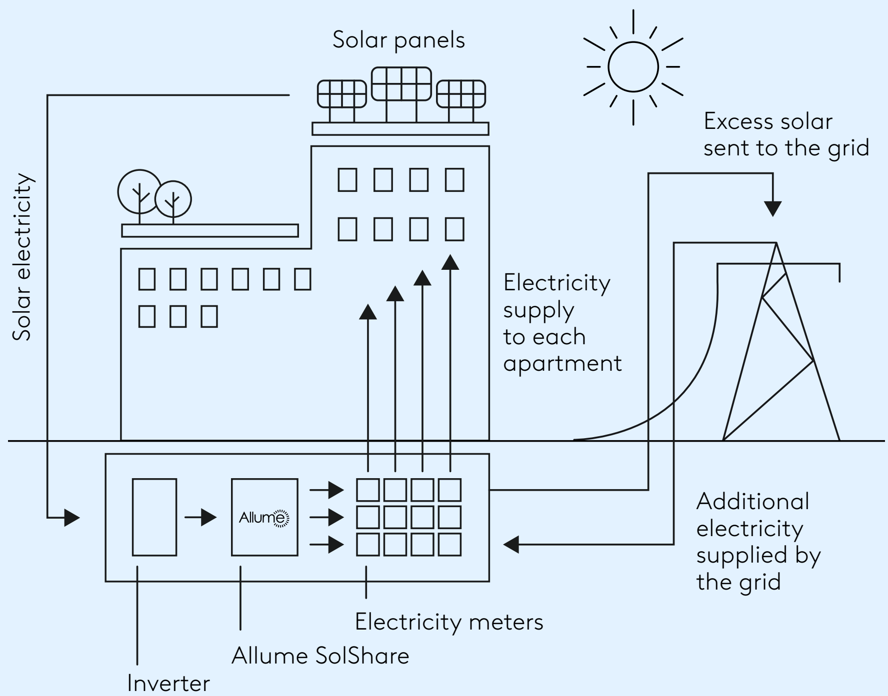
This is a shame, not just for the decarbonisation transition and the residents who miss out, but because behind-the-meter Consumer Energy Resources are some of the most efficient to deploy. With access to rooftop solar denied, we instead see some apartment residents considering other, more market-exposed investment vehicles under different community energy constructs in other parts of the electricity system.

There may, however, be hardware/software solutions that begin to solve the inherent complexity of rooftop solar for apartments, unlocking shared rooftop solar as a category of community energy.

One such solution, with application to mid-rise apartment buildings with fewer than 40 residencies, is Allume's SolShare technology. This Australian-made technology connects a single rooftop solar system to multiple apartments and shares it fairly between each resident via an algorithm to maximise self-consumption and minimise the total electricity exported back into the grid. It has so far been deployed in private apartments and social housing blocks, with demonstrated energy cost savings.

As shown in the figure below, SolShare takes the alternating current (AC) from a single supplementary power source, such as rooftop solar, and divides the current into multiple loads. The technology optimises its allocation so that all apartments consume an equal amount of shared solar energy efficiently throughout the day, by polling each apartments' energy demand five times a second and directing power to units based on the total solar power available and each unit's demand from the grid. Systems can be easily integrated with battery storage to increase energy savings and reduce exposure to retail pricing for grid electricity pricing.

FIGURE 4: OVERVIEW OF ALLUME SOLSHARE MODEL



3.2 Community economic opportunity and agency

Some proponents of community energy projects hold an expectation that such projects create economic opportunity and even wealth creation for those invested, and the opportunity for greater self-determination within the wider community. To this end, they often put a great deal of thought into how project earnings can be spent within the community. With a multi-trillion-dollar energy transition underway, many reason that they should be able to benefit through participation.

The reality for most community projects is far more muted, although we note that projects located behind-the-meter and projects involving equity and co-development of utility-scale and export-orientated renewable assets tend to be at a relative economic advantage to community-scale assets (Wallin et al. 2023) and as discussed in Section 4 and in discussion of First Nations community energy in Section 3.2. In these asset classes there are recent examples of strong economic opportunity. Naturally their success is determined by many factors and participants must always seek the financial advice they need.

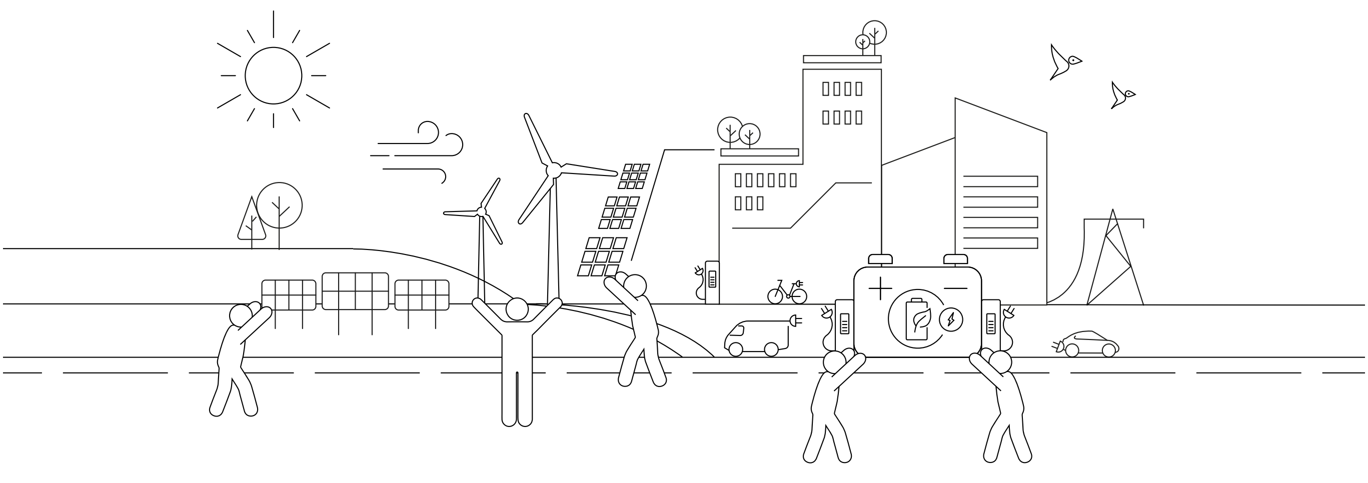
One-third of respondents to the Australian Community Energy Collective Impact Assessment survey in 2023 identified local economic development as a key motivational driver of their projects (Buckley et al. 2023). Other surveys of community energy participants have confirmed that stimulating local economic development is an important objective (Soeiro and Ferreira Dias 2020; Walker 2008).

In many cases, if the community's central objective is to lift their income diversification and economic performance, there may be more direct pathways than through the pursuit of community energy investments, particularly those connected to the distribution grid.

In general terms, renewable energy and energy storage projects are associated with very limited employment opportunities. Construction is often completed by technology experts from out of the area, and maintenance and operation are typically managed with minimal staffing.

There are examples, however, in which a small number of community members, particularly those engaged in project leadership and advocacy, gain skills that are transferrable, and a subset achieve related employment (see section 4.2.1) (Hicks and Lane 2019; Shaw et al. 2020). In remote locations, these opportunities can be highly prized. In addition to human resources, community-scale battery projects have been shown to help in retaining financial resources within the community (Shaw et al. 2020).

Job opportunities from utility-scale assets tend to be larger than those associated with community-scale projects, and so co-development and job development with equity holdings in larger projects can become a powerful enabler of local economic opportunity.



CASE STUDY:

ClearSky Solar Investments – Funding solar on other people's roofs

People without rooftop solar are excluded from investment in an successful asset class. They are also excluded, in all practicality, from investing in behind-the-meter assets at premises other than their own. This is because investments in rooftop solar and other Consumer Energy Resource assets are typically repaid over time through lower grid electricity import and retail costs, with a site-specific payback model that effectively locks out non-residents. That is, benefits are typically realised as operational cost savings to the tenant, rather than an explicit revenue stream.

Some of those excluded from rooftop solar and other behind-the-meter opportunities might reason that their only alternative is to organise around mid-scale community energy investments in front of the meter. In some cases, however, it may still be possible to participate in behind-the-meter investments through providers such as ClearSky Solar Investments.

ClearSky allows small-scale investors to help fund rooftop solar projects on top of businesses and other premises that operate 7 days per week, with an innovative payback model that promotes reinvestment and growth in rooftop solar deployment.

ClearSky, a not-for-profit social enterprise, emerged from an initiative by the Northern Beaches Chapter of Clean Energy for Eternity[8], with support from a NSW Government environmental and community energy grant. It operates an investment platform, through which small-scale investors can collectively fund rooftop solar projects ranging between $0.2 to $1.5 million in development costs. Through the platform, investors are notified of potential projects, along with information on forecast energy output and performance. Investments are made into a trust that finances the projects and pays investors a quarterly dividend, split between capital return and investment, based on the previous 3 month's generation, over 7-10 years.

ClearSky facilitates installation with the for-profit company Smart Commercial Solar. ClearSky conducts the pre-feasibility studies and manages the risks of the projects, while Smart Commercial Solar owns, installs, implements, and maintains the systems. Smart Commercial Solar also contracts the energy off-take and pays a specified rate per kWh to the Trust. After the 7-10 year term is complete, ownership is transferred to the end-user who receives free electricity for the remaining life of the asset.

This investment vehicle has enabled the completion of 86 projects representing 18 MW of installed capacity. ClearSky has connected $24.5 million of funding to community-based projects, providing investors with an average project internal rate of return of 7.1% and $2.35 million in dividend payments.

It is an interesting solution because it allows individuals to come together to participate in the energy transition, it supports community-scale projects that the building's occupants might otherwise struggle to fund up front, although we note several alternative funding solutions, and because it allows the building occupants pay for the energy used as an operational expense, absent up-front CAPEX, streamlining their participation.

8. CEFE Northern Beaches, a chapter of Clean Energy for Eternity Inc., a non-profit dedicated to combating climate change, was initiated by Dr. Matthew Nott in 2006. Originally focused on raising awareness via human signs, public forums, and the notable 50/50 by 2020 campaign, CEFE has evolved over time. The period 2007 to 2013 was a period of great expansion with chapters established across Southeast NSW and on Sydney's Northern Beaches. Fundraising efforts through swimming and mountain biking events enabled the installation of solar panels on numerous community buildings. Since 2013 the major initiatives have been solar bulk buys the IMAGINE solar (a joint initiative with Bega Valley Shire Council), ClearSky, and equipping Rural Fire Service sheds with solar and battery systems. ClearSky received three awards at the NSW Green Globe Awards in 2018 including the Premier's Award for Environmental Excellence.

First Nations community energy in Australia

Access to reliable and stable energy can be central to the opportunity to live and thrive on Country, to protect Country and culture, and to operate local services, payment methods and other economic infrastructure. Regrettably, access to reliable, future-ready energy is not yet assured. Particularly for those not served by a utility, such as communities living on Country with disaggregated funding models for essential services, energy insecurity persists at detrimental levels.

Research looking at the electricity supply reliability needed to power devices used for life support, and the rules for unplanned interruptions, mandatory electricity disconnection reporting, complaints process clarity and independence, and clear guidelines for rooftop solar connection, found that Indigenous communities in Australia are 15% more likely than non-Indigenous communities to be underserved by energy supply protections (White et al. 2024). For First Nations communities that are impacted by disconnections, energy use curtailments and poor energy resilience, including those reliant upon expensive, noisy and polluting diesel generators, access to renewable energy is seen as a circuit breaker (Australian Energy Infrastructure Commissioner 2023).

First Nations communities have indicated a desire to actively participate in the energy transition (DCCEEW 2023).

Remote communities are often particularly vulnerable to the physically changing climate, suffering more extreme weather, including floods, fires and heat waves that are dangerous to human health. The local build-out of local energy assets, such as rooftop solar on community facilities or robust, well-designed renewable and battery microgrids may, in appropriate cases, lessen this exposure.

Under traditional configurations of large-scale electricity generation and long-distance transmission, the per capita cost of delivering electricity to remote communities is generally high. Even where a uniform tariff is applied, regardless of the high cost to supply, poor communities can experience pricing that remains burdensome at the household and small business level. In a survey of public-housing tenants in the Kimberley region, 78% of respondents said that power prices are a barrier to their use of air conditioning, despite temperatures reaching 35 degrees or above for long periods of the year (Kimberley Community Legal Services 2022). In these settings, the benefits of implementing local energy solutions that are designed and integrated in a manner that achieves lower prices can deliver real benefits to quality of life.

The Commonwealth Government's successful and relatively long-running Bushlight program, which focussed on remote communities on Country, supported the installation of over 150 renewable energy systems between 2002 and 2013 across Western Australia, Queensland, and the Northern Territory. Today, ARENA allocates $75 million in microgrid funding to support First Nations communities and the National Indigenous Australians Agency's Outback Power program provides support to legacy Bushlight systems, delivering maintenance, repair and minor upgrade services for solar power systems in 180 remote First Nations communities in the Northern Territory, WA and Queensland. More work is needed to fully address the energy opportunity gap.

Photo: The township of Dunkeld, nestled at the foot of Wurgarri (Mount Sturgeon), Victoria.

CASE STUDY:

Original Power - Energy supply in remote First Nations communities

In the Northern Territory, two pioneering projects led by First Nations are working to address the high incidence of supply blackouts and cost-related disconnections, and to more broadly reduce reliance on high-cost diesel generation for two communities living on Country.

Marlinja Community Solar Project

In Marlinja, a community with around 60 residents located roughly halfway between Darwin and Alice Springs, a partnership between Original Power and community members has delivered Phase One of the Marlinja Community Solar Project. Phase Two is currently in construction.

Both phases respond to energy insecurity challenges and a desire for residents to access cleaner electricity and lower household power costs. The economic value of both projects builds fundamentally from the savings available from avoiding the high cost of diesel that otherwise powers local generators.

Assessment of the economic benefits of local renewable energy projects by utilities in remote areas may be distorted by comparing against the subsidised cost of diesel that is seen by the utility. Corporations are currently able to claim a fuel tax credit for diesel use of 49.6 cents per litre (other than for use in heavy vehicles, to which a different rate is applied). This equates to more than 25% of the wholesale diesel cost under current prices.[9]

Irrespective of retail electricity prices being subsidised in the Northern Territory, the high cost of operating diesel-fired generators in remote locations means that energy users are exposed to high overall energy use costs. Solutions that reduce costs for energy users create value, whether the solution reduces costs directly behind the meter, or by reducing the costs borne by the Northern Territory's Power and Water Corporation and providing for benefit sharing.

In Phase One of the project, 10.75 kW of solar panels and a 10 kWh battery, were installed on the local Community Centre roof. Use of this solar energy has allowed the Community Centre to purchase lower volumes of high-cost grid energy and enjoy lower energy costs overall. The installation behind the meter avoids the connection costs and use-of-grid charges typical of energy assets that are connected to the distribution system, and the system is configured to supply the Community Centre reliably during grid outages.

The project is also noteworthy for Its strong focus on community empowerment, capacity-building, co-design, and environmentally responsible care for Country.

DIESEL ECONOMICS:

For parts of Australia with electricity supplied from diesel power generators, the high cost of supplying diesel brings forward the tipping point at which renewable investments become economically positive, making them a more compelling proposition.

The cost of diesel power generation has four components:

- The cost of diesel power generation sets, which well-designed renewable energy projects may be able to avoid, minimize or defer,
- The price of diesel,
- The cost born by taxpayers for diesel excise tax exemption,
- The cost of delivering the diesel to remote locations, including cost surges when wet seasons and climate-fuelled disasters mean that higher cost transportation, such as barges, is required.

9. https://www.aip.com.au/pricing/terminal-gate-prices

Commissioned in July 2024, Phase Two of the project enables a more material shift away from reliance on diesel power through the installation of a 100KW solar array and 136 kWh battery storage system within a microgrid. Local households will receive direct financial credits on their pre-paid meters proportional to the microgrid's output each day.

The project makes intelligent use of existing metering infrastructure and unlocks participation in rooftop solar, where traditional approaches are frustrated by low rates of home ownership and grid-level constraints. It is the first grid-connected Indigenous community-owned renewable energy project in the Northern Territory.

Ngardara 'Sun' Project

Borroloola, a Northern Territory township with roughly one thousand residents, currently relies on diesel-generated electricity supplied by the Power and Water Corporation to meet 88% of its power needs. The remaining electricity is provided by a relatively small solar PV system, which currently faces round 25% export curtailment on average due to poor integration with the existing diesel system. The Ngardara 'Sun' Project aims to change this.

Supported by Original Power, the Project proposes to increase local renewable energy generation and storage capacity using a control system that will integrate with the existing diesel generator. The proposed system includes 2.1 MW of solar PV generation and a 6.2 MWh battery storage system, sized to allow the community to source over 70% of its electricity from renewable energy.

The project leaders are working closely with the Power and Water Corporation, envisaging that it will purchase electricity generated from the project. This would provide income to be shared with residents through the same pre-paid meter crediting model being piloted in Marlinja.

Original Power estimates that the Project would reduce diesel purchases by the Northern Territory Government by 1.2 million litres every year, corresponding to around 70,000 tCO_2e saved over the life of the project.

The town of Windorah, located within the Shire of Barcoo in Central West Queensland.

FIRST NATIONS LARGE-SCALE PROJECT PARTNERSHIPS

There is an understanding emerging, belatedly, of the critical role of First Nations in Australia's wider energy transition. Major build programs in locations with strong solar, wind or pumped hydro profiles or relevance to transmission pathways and other infrastructure interact with First Nations land entitlements and knowledge of Country, environmental and cultural heritage.

For utility-scale and export-orientated projects, First Nations economic participation can bring new, more durable commercial and economic development opportunities for Indigenous groups and agency on energy supply arrangements for community (Thorburn et al. 2019). Calls for sincere consultation and co-design are particularly poignant in light of findings that many First Nations communities are not consulted in decision-making processes relating to renewable energy developments on their land (White et al. 2024). We profile some leading examples below.

The Aboriginal Clean Energy (ACE) Partnership:

ACE is developing Australia's first Traditional Owner-led clean energy, green hydrogen, and green ammonia export project in the East Kimberley Region of Western Australia. ACE has four partners, each with a 25% stake, during the current project development phase: MG Corporation, Balanggarra Ventures Limited and the Kimberley Land Council, and Pollination, led by colleagues of this paper's authors.

The project will see a circa 1,000MW solar farm developed on 2,000 hectares of MG Corporation freehold land near Kununurra. This solar energy will be combined with water and hydro energy from the existing Ord Hydro Power Plant at Lake Argyle to produce green hydrogen. The green hydrogen will be transported by pipeline to Balanggarra Country in Wyndham where it will be converted to green ammonia, for use both locally as a fertiliser for irrigated agriculture, and for export.

The ACE Partnership has created an opportunity for Traditional Owner groups to co-develop, co-decide, and self-determine the project as appropriate for their Country and economic independence. This ownership model places Traditional Owners as shareholders, not just stakeholders, of the physical layout and commercial architecture design phase of the project.

Yindjibarndi Aboriginal Corporation (YAC):

YAC formed the Yindjibarndi Energy Corporation with Philippines-listed renewable developer ACEN in 2023. The partnership involves plans to develop 3 GW of renewable energy generation with a view to supplying energy to mining companies in the Pilbara. YAC will hold equity participation of 25 to 50% in all projects and will have approval rights for site selection for projects, along with preferred contractor status for Yindjibarndi-owned businesses.

The East Kimberley Region of Western Australia.

Where projects achieve positive economic outcomes, appropriate sharing of benefits can reinforce their success and social acceptance. Well-planned, well-governed, and collaborative models of benefit-sharing can promote the acceptance of renewable energy, empower communities with knowledge, and provide money for other needs within the community. The specific needs and values of each community should inform their approach to benefit-sharing.[10]

For instance, a community in Wales, UK was able to use income generated from renewable-energy production and export to install electric-vehicle charging stations at the community hall and establish a communal car-sharing program (O'Sullivan, Golubchikov, and Mehmood 2020). Many community energy projects reinvest a share of their profits into local development projects, such as facility enhancements and community events, which can generate additional jobs in the community. In 2020, Haines (2020a) cited 51 active benefit sharing funds associated with wind projects in Australia, which delivered $9.1 million to local communities.[11]

In Australia[12], the Victorian Government's $900,000 Community Power Hubs program was reported to have delivered a 13-to-1 return on Government investment and generated more than $14.5 million in value for three regional towns (Hicks and Lane 2019). Given the exposure of community energy projects to energy markets and distribution charges, however, these past experiences must not be understood as predictive of future.

3.2.1 ENERGY JOBS AND SKILLS

In evaluating employment impacts of community energy, it is helpful to distinguish between job creation metrics for different project phases. Operation and maintenance generally offer fewer jobs than manufacturing, construction, and installation. Meyer and Sommer (2016) highlight this distinction, showing that solar and onshore wind farms generate 11 and 2.5 job-years per MW during construction and installation, respectively, but only 0.3 and 0.2 jobs per MW for operation and maintenance.

Similar patterns apply across different jurisdictions globally (Moriizumi, Hondo, and Nakano 2017; O'Sullivan and Edler 2020). In Australia, the Community Power Hubs pilot program, which included battery and solar, among other projects, created 16 jobs resulting in an employment factor of 11.85 jobs[13] per MW whilst increasing local community capacity to deliver community energy projects (Hicks and Lane 2019).

10. Lane and Hicks set out a detailed guideline for evaluating and instituting benefit sharing for communities for the Victorian Renewable Energy Target that include; outlining early engagement, integrating local landscapes and values, completing social-feasibility analysis, equitable benefits-sharing, trust-building, complaints management, and managing of project legacy (Lane and Hicks 2017; 2019).

11. Building Stronger Communities, Australian Wind Alliance, 2019, p. 30.

12. In the USA, an estimate of the economic impact from wind and solar, including utility-scale, built between 2020 and 2030, could provide $10.9 billion in direct benefits to rural communities through operation and maintenance wages, land-lease payments, construction wages, and local taxes (Siegner, Brehm, and Dyson 2021).

13. This number is calculated using Hicks and Lane's (2019) report and does not distinguish between O&M and MCI jobs.

3.3 Build social capital and energy transition literacy

Simon Holmes à Court, the founder of Climate 200 and founding chair of Hepburn Wind, has described community energy as a "social technology" for its ability to build more durable forms of community support and active and multidirectional engagement in accelerating the energy transition. Community energy initiatives can produce social benefits, contributing to technology dispersion and enhanced social license for the energy transition (Helen Haines 2020a). Stakeholders have noted that community energy projects provide a particularly tangible touch point for community members to engage with, and experience direct benefits from, the energy transition, which may not be delivered by traditional education-focused measures. Such projects can also provide a focus for knowledge transfer across a wide variety of energy-related interests, and broader growth in civic engagement skills.

While the social ripple effects of community energy might be strongest in communities that are already motivated to reduce their impacts on the environment, other communities have a more direct motivation to seek transition literacy and greater social capital. For communities that are being asked to host utility-scale energy infrastructure on their land or within their region, the need for energy transition literacy and coaching can be acute. In communities with access to community energy practitioners or volunteers with relevant skills, this literacy can build one cup of tea at a time.

There appears to be a preference for local coaching, relying on trusted information sources, local understanding, and covering a wide range of energy interests, from home upgrades to engagement with proximate major developers. Communities may be able to access benefits from related forms of place-based energy mentoring without necessarily embarking on community energy projects that require sophisticated investments and market interactions.

Community energy groups have pointed to social benefits such as democratic empowerment and self-determination as key advantages of community energy projects (Soeiro and Ferreira Dias 2020; Community Power Agency 2014). Some communities seek stronger community cohesion, local empowerment, and reduced alienation from the political process. A 2022 study in the Eurobodalla region of NSW conducted 40 interviews with households and analysed 140 submissions to the 2020 Bushfires Royal Commission to provide an overview of community attitudes towards energy projects and microgrids (Chalaye and Ransan-Cooper 2023). The most prominent sentiment shared by respondents in the study was a lack of trust in energy companies, and especially large companies. For some communities the motivation for self-determination might be sufficient to justify their investment of time and money into community energy.

It has been suggested that participation in community energy projects can build stronger social connections amongst community members. This in turn may contribute to an enhanced ability to collaborate on community issues and an increased focus on looking after vulnerable members of the community (UTS Institute for Sustainable Futures 2023). It may also enhance resilience and connectedness both in emergency situations. Naturally, good will can dissipate in less successful projects and where volunteer goodwill is exhausted in pursuit of deeply complex community energy projects.

3.3.1 DURABLE PUBLIC SUPPORT

Community energy can play a role in accelerating the adoption of 'green' technologies. The term 'peer effects' is widely used to describe the ways in which individual behaviours and attitudes can be influenced by the wider social environment. These peer effects seem to be growing stronger over time with respect to renewable energy technologies, both for larger projects and at the community level. It is well documented that the global proliferation of rooftop solar worldwide has been influenced by social dynamics, including peer effects and social contagion (Wang et al. 2023; Qamar et al. 2022; Curtius et al. 2018; Graziano and Gillingham 2015; Linder 2012; Bollinger and Gillingham 2012; Rai and Robinson 2013).

Building from the strong economic case for rooftop solar, proliferation has been encouraged through information sharing that alleviates financial uncertainties associated with its adoption (Curtius et al. 2018; Wang et al. 2023; Bollinger and Gillingham 2012). It has also been shown that communities with robust interpersonal communication networks tend to adopt new technologies more swiftly (Wolske, Gillingham, and Schultz 2020). The essence of community energy lies in engaging communities and directly sharing information about projects and technologies. In Denmark, Scandinavia, where community ownership extends to 11% of installed wind capacity as a result of schemes relating to utility-scale asset development[14], community projects have increased public acceptance for renewables (Gorroño-Albizu, Sperling, and Djørup 2019; Skotte 2009).

14. Denmark has seen success with wind-power generation in large part due to promotion of community ownership of wind farms. Since 2009 the Danish Renewable Energy Act has required that any new wind project comprises of at least 20% ownership.

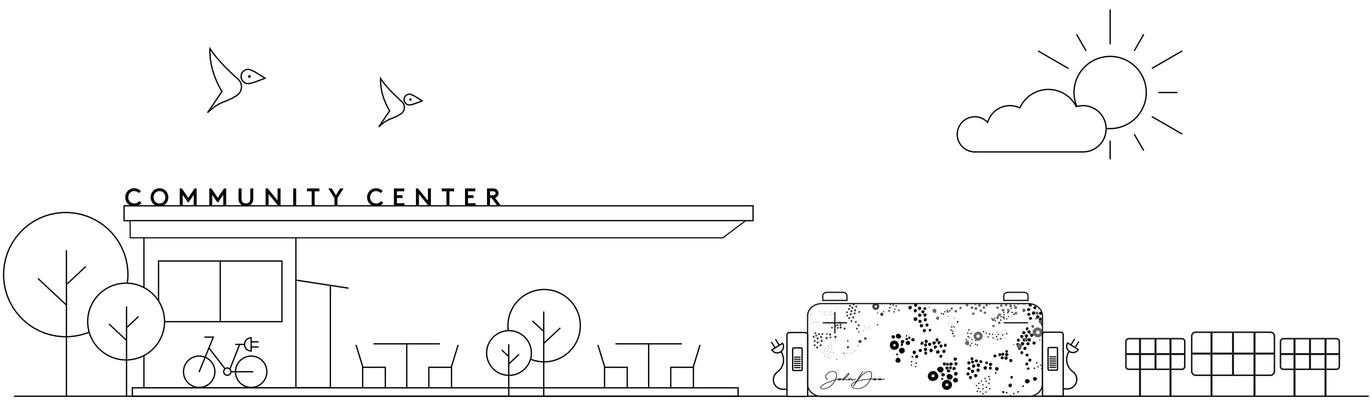
It is possible that growth in community energy could aid in the broader adoption of other clean energy technologies, such as electric vehicles. It may also build greater understanding and acceptance of the wider energy transition and build a more solid support base for policies that reinforce the decarbonisation transition.

Once nurtured through community energy projects, however, community support for unrelated utility-scale renewable energy projects is not assured and can be shaped by local interfaces with nature, politics, and the conduct of developers as it relates to consultation and benefit-sharing. These factors can outweigh the influence of peer effects and positive contagion with respect to the adoption of new energy technologies.

Brummer (2018) suggests that active involvement in civic engagement bolsters climate protection efforts. Participants in civic engagement were found to be more open to considering ethical and environmental concerns, prompting a re-evaluation of their energy consumption and a stronger acknowledgment of anthropogenic climate change.

Community energy projects that pioneered a new technology or configuration and demonstrated its feasibility, or that completed successfully at a time when climate-minded Australians were looking for iconic and hopeful examples of progress, no doubt had massive ripple effects. Looking ahead to future community energy project opportunities, however, it is difficult to conclude whether community energy projects can deliver positive peer effects or whether another form of trusted, place-based community support focused on energy literacy could achieve something similar.

The successful deployment of community energy projects, particularly in rural and remote locations and within poor communities, could help bridge potential rural/urban divides with respect to climate policy, renewable energy, and economic transition. Again, this flow-on effect is difficult to evidence and is subject to variation in practice.



3.4 Accelerate climate action

Community energy projects provide an avenue for climate-motivated community members to contribute directly to energy decarbonisation.

The opportunity to reduce emissions from their own energy usage and/or contribute to the decarbonisation of other parts of the energy system has been a key driver in the development of the community energy movement and remains an important motivation for many groups. Soeiro and Ferreira Dias (2020) write that environmental considerations and climate action are consistently ranked as the most important drivers for community energy globally.

The Victorian Government's consultation process for its Neighbourhood Battery Initiative found that 80% of respondents identified carbon emissions reductions and supporting the integration of more rooftop solar in the energy grid as expected benefits of the program (DELWP 2022). In a 2023 survey of community energy groups conducted by the Community Power Agency, 94% of respondents specified climate change and emissions reductions as motivating their activities (Buckley et al. 2023). In a virtuous impact cycle, a survey by Buckley et al. (2023), found that 73% of respondents indicated that their community energy projects substantially increased climate change awareness and the urgency of reducing carbon emissions.

The strong associative feeling of being able to decarbonise one's own energy needs is seen as extremely empowering by communities seeking to reduce their adverse environmental impacts. For community members motivated to reduce their energy-use emissions but unable to install rooftop solar and batteries behind their meters, whether as a result of the associated costs or by virtue of living in a multi-dwelling residency, community-scale batteries and solar gardens may bridge the gap between those with and without decarbonised electricity (Shaw et al. 2020). As profiled earlier, there are models for investment in energy installations for others' roofs and some technologies that share solar resources and can similarly provide the opportunity to participate.

As noted in this paper's introduction, community energy projects have delivered a small fraction of the installed capacity achieved through the deployment of rooftop solar. A (2015) Coalition for Community Energy (C4CE) report notes that, up until 2015, community energy projects in Australia had generated over 50,350 MWh of clean energy, avoiding more than 43,000 tonnes of carbon emissions (0.01% of Australia's gross emissions in 2015). The exposure of community energy projects to energy market fundamentals, as outlined in Section 4, may mean that there any opportunity to scale the deployment of community-scale assets interacts with certain economic constraints.

The decarbonisation value of energy technologies is determined by the total capacity deployed. A dispassionate analysis will confirm that the contribution of community energy projects to broader decarbonisation efforts will be poor if only a small number of small projects are commissioned, or if the high costs of community projects diverts capital from more deserving asset classes. The decarbonisation of the power system is primarily a volume game.

Certain financing mechanisms can build the emissions reduction impacts of investments in community energy projects. Revolving community funds enable repayments from loans provided to community energy projects to be reinvested in future projects, thereby offering emissions reduction multipliers for each dollar invested.

ANALYSIS

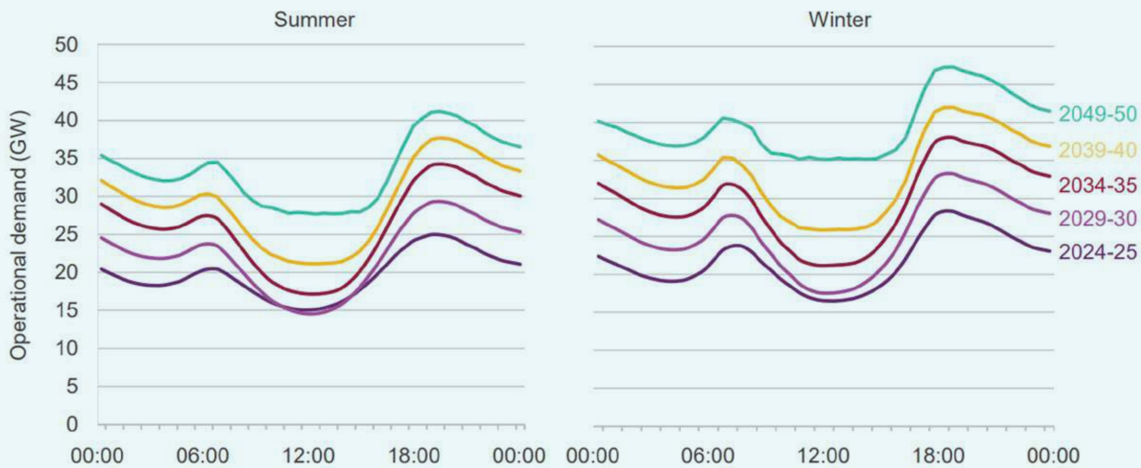
Distribution network utilisation to enable decarbonisation

Commonwealth and state energy ministers have committed to develop a National Consumer Energy Resources (CER) Roadmap, anticipated early in 2025, and organisations including the Clean Energy Council are raising awareness of the opportunity. Shifts in demand behaviours to better utilise rooftop solar and CER behind-the-meter can do more heavy lifting to reduce Australia's energy use emissions.

Different combinations of certain behind-the-meter energy assets and usage patterns place varying levels of stress on the grid. Coordinated CER solutions including dynamic resource management and orchestration can contribute solutions to efficiently manage the peaks and troughs of high generation or consumption times in a manner that improves outcomes for all energy consumers. Higher levels of rooftop solar generation have concomitant implications for grid voltage stability in scenarios where energy supply exceeds energy demand – limiting both the amount of renewable energy being exported and utilised. Contrarily, significant growth in energy demand, for example from electric vehicle charging if it is not accompanied by sophisticated charging behaviours[15], exacerbates existing energy infrastructure capacity constraints. The interactions of different assets and behaviours are a case study in complexity, but many anticipate that there will be increasing pressure on local power grids as the household-level opportunity is taken forward.

Figure 5 illustrates the increase in operational demand forecast under the Step Change scenario in AEMO's draft 2024 Integrated System Plan, which suggests an increase in peak evening demand of more than 60% from 2024-25 levels by 2050. We note that this metric, by averaging outcomes across locations, removes the extremes that may be experienced at some substations. Neighbourhood by neighbourhood, subject to local conditions, this growth in demand may trigger more investment in low-voltage grids with costs recovered from consumers on the grid.

FIGURE 5: AVERAGE OPERATIONAL DEMAND BY TIME OF DAY AND SEASON, NEM (GW, STEP CHANGE)



Source: AEMO, draft 2024 Integrated System Plan

15. Energy demand for charging electric vehicles will impact peak demand, and potentially interact with local distribution network constraints differently depending on the speed of charging, the time of charging, the speed of vehicle uptake and how quickly vehicle-to-load, vehicle-to-home or even vehicle-to-grid bidirectional charging becomes feasible. ENx Consulting's report for ARENA 'V2X.au Summary Report – Opportunities and Challenges for Bidirectional Charging in Australia' found that by 2050, the usable storage in Australia's EV fleet at that time will be nearly four times total NEM storage requirements. https://arena.gov.au/assets/2023/06/v2x-au-summary-report-opportunities-and-challenges-for-bidirectional-charger-in-australia.pdf p.3.

In this context, the capacity and system security of the local grid will make a critical contribution to local decarbonisation over and above the important augmentation of major transmission and interconnection assets.

There are three primary means of responding to growing needs in the low-voltage network, with different combinations needed to promote the most efficient cost and decarbonisation outcomes:

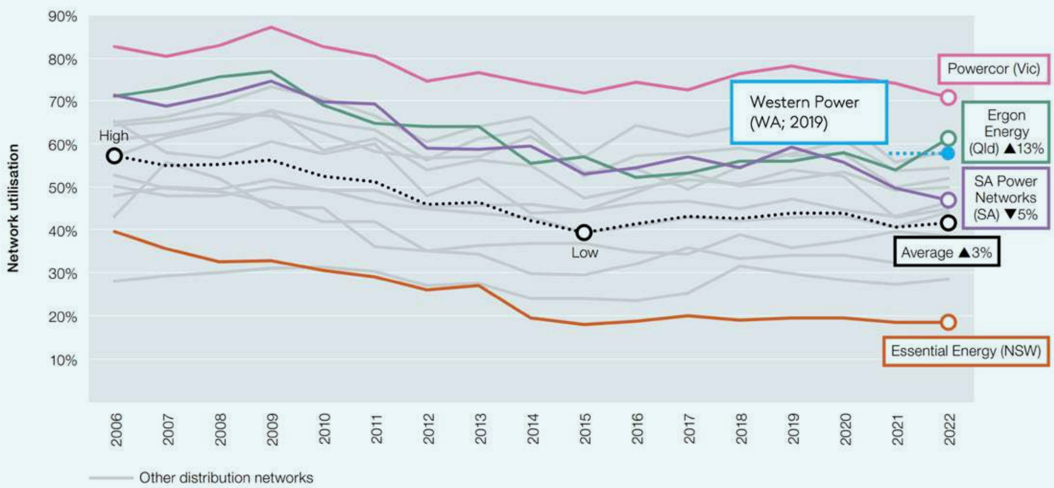
1. More sophisticated CER management and load shifting behind-the-meter,
2. More poles and wires infrastructure, or
3. More use of local energy assets to address community and network needs.

While each specific neighbourhood connected to a distribution system will have different needs and attributes, there may be a choice between extending the current pattern of assets or backing combinations of local assets, behaviours and energy efficiency behind the meter and embedded within the distribution zone.

If the behind-the-meter assets and behaviours and local energy assets outside of traditional grid expansion can shave peak demand and address any voltage and frequency issues, growth in electrification can be supported with high overall average utilisation of the existing low-voltage system.

Peak utilisation rates vary substantially between distribution network service providers, but are low and have generally trended downward in the National Electricity Market from 2006 to 2015 and remained relatively flat from 2015 to 2022 (as illustrated in Figure 7) (Australian Energy Regulator 2023). In 2022, average peak distribution network utilisation was 42% - a slight increase from 2021. Utilisation rates in the South West Interconnected System also only reached 58.4% in 2019 (Western Power 2020).

FIGURE 6: ELECTRICITY DISTRIBUTION NETWORK UTILISATION, 2006-2022



Note: Network utilisation is the non-coincident, summated raw system annual peak demand divided by total zone substation transformer capacity.

Source: AER, State of the Energy Market 2023

Despite limited utilisation, distribution network charges make up a signification portion of consumer electricity bills. Electricity network charges accounted for approximately 40% of a residential customer's energy bill in 2022 (Australian Energy Regulator 2023). Of this, the largest cost component related to distribution network services (73% to 78%), with some variation between costs to serve metropolitan, urban and rural areas. This underscores the importance of cost efficiency between the solutions available to host greater levels of electrification and distributed energy assets.

The concept of After Diversity Maximum Demand is central to sizing and managing traditional grid infrastructure. Put simply, if assets and actions can be used in combination to provide diversity, or smoothing, there is less reliance on growing poles and wires. While the selection of the best assets for each location cannot be generalised and will be subject to different costs, this may support greater decarbonisation and lower cost outcomes.

3.4.1 CLIMATE DISASTER RESILIENCE

As noted under Section 3.1 above, community energy can play a role in building the resilience of power systems to the physical impacts of the changing climate. Resilience can be defined as the ability of a power system to withstand high-impact-low probability events, rapidly recover from such disruptive events and adapt its operation and structure to prevent or mitigate the impact of similar events in the future (Panteli and Mancarella 2015). Ways in which community energy can strengthen power system resilience include:

- Local assets that reduce the community's reliance upon long-distance transmission lines.
- Increased use of distributed and consumer-electricity resources, with more interactive energy management systems to provide distributors greater flexibility in how they manage the distribution system.
- Microgrids that can separate from the network during an extreme weather event and automatically reconnect once the event has passed.
- Small to medium-sized battery storage systems installed in the distribution network, which can, subject to design, support local use through interruptions..

There is also research that suggests that community energy storage systems have advantages over household batteries when it comes to resilience and energy self-sufficiency at the community level. This is because residential battery systems typically operate according to the needs of individual households, thereby storing excess solar generated by houses with rooftop solar systems when that energy could otherwise be used by neighbouring households (Edward Barbour et al. 2018).

The township of Monash, South Australia.

ANALYSIS

An opportunity for end-of-line energy resilience

Across Australia there are remote communities served by exposed sections of the grid and single line wire that are vulnerable to disruption. Natural disasters, supercharged by climate change, compound this frailty.

The ramifications of power outages are pronounced in remote areas. The cessation of electrical supply deprives these communities not only of refrigeration and air conditioning but also severs mobile communications, disrupts transportation, and renders it impossible to charge telephones or computers. For some, the lack of electricity hinders the ability to pump essential resources such as fuel and water, whether for consumption, sanitation, or fire suppression.

The use of microgrids, including local energy assets connected through a microgrid to the local grid and Stand-Alone Power Systems (SAPS) comprising community-sized assets, could help build energy resilience for these communities.

Currently, however, these systems might be confronted by economic headwinds. A 2020 study led by Cutler Merz for Energy Networks Australia (Cutler Merz 2020) found limited economic benefits of SAPS across the NEM.

The study found that both islanded SAPS[16] and islandable SAPS[17] had negative Net Present Values even after considering avoided unserved energy, consistent with regulated valuation, and post hazard rebuild. Individual SAPS[18], however, showed a positive Net Present Value, indicating that they may contribute to the growing needs for resilience.

While the study offers interesting insights, it also exposes the difficulty in estimating benefits given the wide range of geographically heterogeneous cases, shifting cost basis of new technology, and impacts on human life. Estimating the effects on quality of life or impact on life support systems is not straight forward.

In addition, the changing climate may expose limits in traditional cost-benefit analysis.

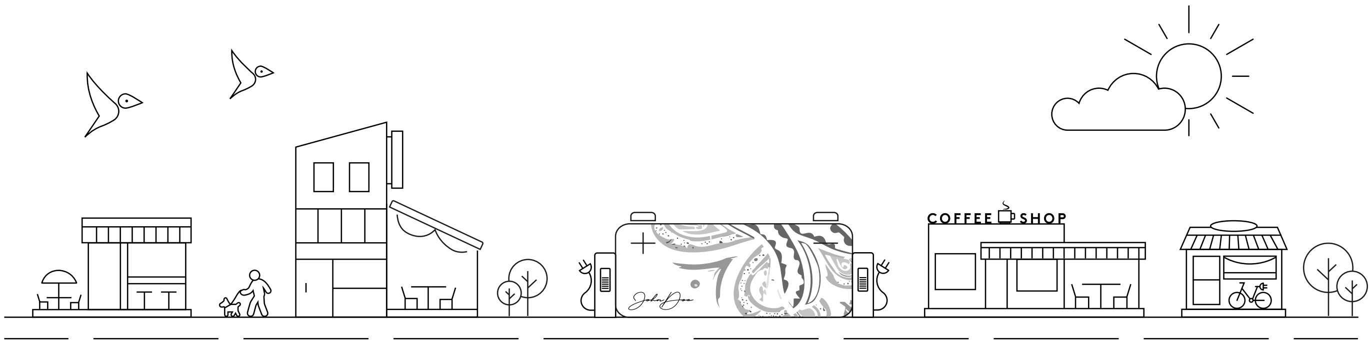
As we progress into this novel state, SAPS and microgrids are likely to become increasingly important. Further research that incorporates future-looking uncertainty under climate change is required, emphasising the importance of precaution and the high stakes involved. We must ensure that our strategies are robust against the wide spectrum of possible future scenarios, recognising that the cost of inaction or insufficient action could be extraordinarily high.

16. Islanded SAPS in this case study are 500 person energy systems not connected to the grid system able to independently provide power. Energy attributes consist of 6MW solar, 10MWh battery, 1.5MW diesel generator.

17. Islandable SAPS in the case study are 500 person energy systems that can partially provide energy for the community (45%) yet continue to maintain grid connection. Energy attributes consist of 2.7MW solar, 4.5MWh battery, 0.7MW diesel generator.

18. Individual SAPS in the case study are small stand alone SAPS for small amount of connections within communities with a size of 60 households. Energy attributes consist of 40 individual residential SAPS (20kW solar, 33kWh battery, 5kW diesel generator), 10 residential cluster SAPS (60kW solar, 100kWh battery, 15kW diesel generator) connected by a small LV network, and 10 light commercial SAPS (100kW solar, 166kWh battery, 25kW diesel generator).

4. Diseconomies and headwinds for community energy in Australia



In our exploration of literature and community energy project experiences, we have found that community-scale and community-led energy groups and projects in Australia face a range of challenges, which can be divided into three categories:

- Direct diseconomies, coupled with divergent economic incentives,
- Access to finance and funding support, and
- Access to technical expertise and wider participation in projects.

This section provides an overview of the key energy market dynamics that influence the economics of community energy projects, followed by an exploration of the barriers to community energy in each of the above categories.

The economic outlook for community energy projects varies materially and is subject to highly local differences that determine whether the project is an economic success or is something less. Some projects can be exposed to material headwinds and significant risk. Through this section, we seek to highlight the economic implications of different configurations, finding it best to engage with headwinds frankly and pragmatically.

4.1 Energy market and participant dynamics

All energy projects unavoidably interact with energy market fundamentals in some way.

At a project level, the economic return on a community energy project will reflect the component costs and the characteristics of the energy markets with which they interact. While there are differences in the costs outlaid to develop and connect energy assets of different classes and sizes, the interaction with energy market pricing dynamics is relevant across asset classes when evaluating the economic payback and opportunity for upside earnings.

An understanding of wholesale price dynamics is therefore central to understanding the economic payback of community energy asset costs. For this reason, we include a market overview below that familiar parties might skip.

Wholesale electricity pricing for grid-connected assets interacts with wholesale energy market pricing in one or more of the following ways:

- Direct revenues from the sale of electricity into the wholesale market,
- The value of avoided electricity supply costs (themselves built up from wholesale market pricing) by supplying one's own electricity use needs, and
- Being paid by a third party such as an electricity retailer, for the electricity produced or the remainder exported to the grid. Third parties will typically reflect wholesale market pricing dynamics in the payments that they offer.

There are other potential value lines related to services to the grid, but these are addressed separately.

Australia's grid-connected power systems, linking electricity production, storage, transmission, and end-user premises, are characterised by highly dynamic wholesale pricing and a degree of forecasting opacity. For electricity traded on the spot market, the price is set by matching supply and demand in each 5 minute dispatch interval. Periods of high demand and constrained supply result in peak pricing. Periods of supply abundance, often corresponding with high renewable energy output and lower consumption needs, see prices crashing to the point at which producers that continue to export electricity must pay the market to take it. In the largest connected power system, the National Electricity Market, prices per MWh currently vary between minus $1,000 and a Market Price Cap of $17,500.

Within each day, high prices are most common in the early evening when demand is higher and solar output recedes. Within each year, prices can fluctuate within each region depending on solar resources and patterns in electricity-based heating and cooling needs.

Batteries can extract value by arbitraging differences between lower-priced periods for charging and higher-priced periods for discharging, in addition to other potential earnings described below. This pattern of battery charge-and-discharge typically occurs within an intraday cycle.

Ancillary markets are used by the AEMO to control key technical characteristics of the power system, such as frequency and voltage. Ancillary services are split into two sub-categories, Frequency Control Ancillary Services (FCAS), and Network Support and Control Ancillary Services (NSCAS). FCAS is an important market for battery revenues, whereas NSCAS is a small, highly technical, niche market.[19]

Importantly, for community-energy projects, FCAS revenue is only available to actively managed assets above 1MW in size, subject to a site test, or 5MW on an aggregated basis.

19. FCAS markets are used to maintain the frequency of the power system within a prescribed operating window of 50Hz±0.15. Stability is achieved through both regulation and contingency control. 'Raise' services increase frequency via injection of power (or removal or load). 'Lower' services decrease frequency via removal of power (or injection of load). Regulation control works by continually adding/removing power to balance fluctuations in the supply/demand balance, whereas contingency control services are only called-upon when fluctuations are large enough to breach the normal operating window.

The 10 FCAS markets in the NEM:

Regulation		Contingency							
Continuous		Very fast (<1s)		Fast (<6s)		Slow (<60s)		Delayed (<300s)	
Raise	Lower	Raise	Lower	Raise	Lower	Raise	Lower	Raise	Lower

There are defined roles for different sets of participants in the energy market. Electricity generators and those dispatching electricity into the power system from storage facilities are prevented from operating poles and wires. Their output is sold into their region's collective 'pool' of energy, with financial hedging contracts overlaid. From dispatch into the grid, the electricity is moved through high voltage transmission infrastructure, into low-voltage distribution 'poles and wires' and then to the point of use. Electricity retailers buy electricity from the pool and manage customer billing for consumption. Electricity generators can also retail, with sale into the pool and purchase from the pool on respective sides of the market separated by transmission.

The ownership of transmission and distribution networks is naturally monopolistic, with the Australian Energy Regulator overseeing the governance on behalf of all market participants and end consumers. As regulated monopolies, transmission and distribution network service providers are prevented from participating in any 'contestable market', with specific waivers to allow the use of community-scale batteries to provide contestable services, such as FCAS (AER 2021). Distributors must assure the AER that their use will not result in cross-subsidisation of the asset, whereby guaranteed regulated revenues are used to fund the cost of using the battery to participate in contestable markets.

Taken together, market price dynamics, access to ancillary revenue, and the separation of market participant roles, profoundly shape the economic envelope of community energy projects.

4.2 Diseconomies of community energy projects

Each community energy project is subject to economic strengths and detractions that combine in different formations based on the specific attributes of each project. It is useful to understand the direction of these economic factors before overlaying the wider benefits that such projects can contribute to gain a sense of their overall impact, whether advantageous or economically inefficient.

As indicated above, most projects connect to a power grid and necessarily interface with other parties associated with that grid, including transmission and distribution companies, energy retailers and other energy users. Projects can deliver benefits to others connected to the same grid but can equally trigger costs by creating frequency or capacity issues for the local grid. As a result, projects can face higher costs and lower returns if genuine co-design with adjacent parties is lacking.

As described in Section 2, this paper considers community energy projects organised into three classes of scale and connection type. These are used to explore the different economic contexts that apply to each class of assets.

The three scales considered are:

- Behind-the-meter, including microgrids and technologies on the demand-side, relevant to energy efficiency, peak smoothing and electrification,
- Community-scale, distribution-connected assets, and
- Utility-scale, transmission-connected assets with community co-design and partial equity.

4.2.1 ECONOMICS BEHIND-THE-METER

Solar panels, batteries, and other energy technologies that influence electricity production and consumption and connect behind the meter, including those connecting from microgrids and commercial-scale premises, are not typically exposed to wholesale energy costs.[20] Their value centres on reducing or removing the cost of imported grid-supplied electricity, with accompanying opportunities to grow resilience to supply interruptions and to bundle assets to access Virtual Power Plant and wholesale-exposed income. The strongest economic signal is therefore to size such assets to optimise the self-consumption of self-produced energy, rather than to maximise exports to the grid.

Noting that grid-delivered electricity prices are charged by retailers in different time blocks, a well-sized installation behind-the-meter with battery storage can allow the energy user to avoid importing electricity at times when they would be exposed to high retail pricing. This can increase the value of reduced energy costs. For sites with high energy use, energy projects behind-the-meter can also help reduce exposure to demand charges, which apply higher prices for each kWh of electricity used based on a maximum amount of electricity consumed in a defined period and are effectively a peak usage cost loading during periods of high grid energy demand.

Behind-the-meter projects face scale limitations that may or may not impact their ambition. By connecting behind-the-meter, these assets don't have the luxury of choosing their connection location into the grid and can be constrained in size and output based on the adjoining transmission and distribution limitations. The proximate network voltage (e.g. 1kV), in combination with their own behind-the-meter consumption, will determine the asset that they can install. This means that the assets tend to be small and exposed to a higher unit cost base than a utility-scale equivalent.

Projects behind-the-meter, subject to configuration, can enjoy resilience to network interruptions and outages. As already discussed, this can be particularly valuable in communities with lower grid reliability or relatively high exposure to fires and other forms of climate-related natural disasters.

For batteries installed behind-the-meter, there is a high unit cost relative to larger projects, however this is somewhat alleviated by mass manufacturing which is lowering the cost of household batteries in the 5-15 kWh battery size range which is lowering the upfront costs for household batteries. For communities with co-benefits from local energy solutions such as those explored in Section 3.1 on secure energy access, reliability, and resilience, larger, more costly batteries or battery-microgrids that enable the site to go off-grid avoid connection charges of roughly $1.50 per day per connection point.

When considering behind-the-meter batteries coupled with behind-the-meter rooftop solar or some other form of generation, we note that the economic case is uncomplicated by distribution-level use of service fees to charge or discharge from the grid. Depending on the network provider's fees, this can make behind-the-meter installation relatively lower cost to operate. We also observe that behind-the-meter installations avoid the sometimes-tedious planning and approval processes. Since they are installed on private property, these projects can be deployed in a more streamlined manner compared to distribution-, or transmission-facing assets, depending on their level of grid export.

20. Some retailers such as Amber Electric and Flow Power offer pass-through wholesale import and export prices for a monthly subscription fee.

There are a wide variety of technologies and appliances that can be considered for behind-the-meter community energy action, each with slightly different economic profiles. We note that behind-the-meter community energy projects relating to electrification interact with the displacement of higher gas usage costs, and in some cases, removal of the gas connection charges altogether, typically unlocking close to of $300 in annual savings.

Outside of technology and investment solution providers such as ClearSky and Allume, profiled earlier, developers face higher obstacles to instigating behind-the-meter community energy projects as the payback tends to be shaped by energy cost savings rather than direct revenue. Developers may, however, lead on slightly larger off-grid, or embedded-network design, with earnings recovered via service contracts, contributing valuable expertise and expediting shifts in renewable asset deployment.

While not applicable to batteries, rooftop solar and heat-pump hot water installations have access to Small-scale (renewable) Technology Certificate value, which effectively subsidises their installation cost. While the subsidy is currently ratcheted down each year out to 2030, the subsidy supports the economics of community energy projects in these categories. In addition, the Commonwealth Government has consulted on the introduction of a new certificate scheme called the Renewable Electricity Guarantee of Origin (REGO), which may contain a replacement support mechanism and include revenue for output from renewably charged batteries when implemented.

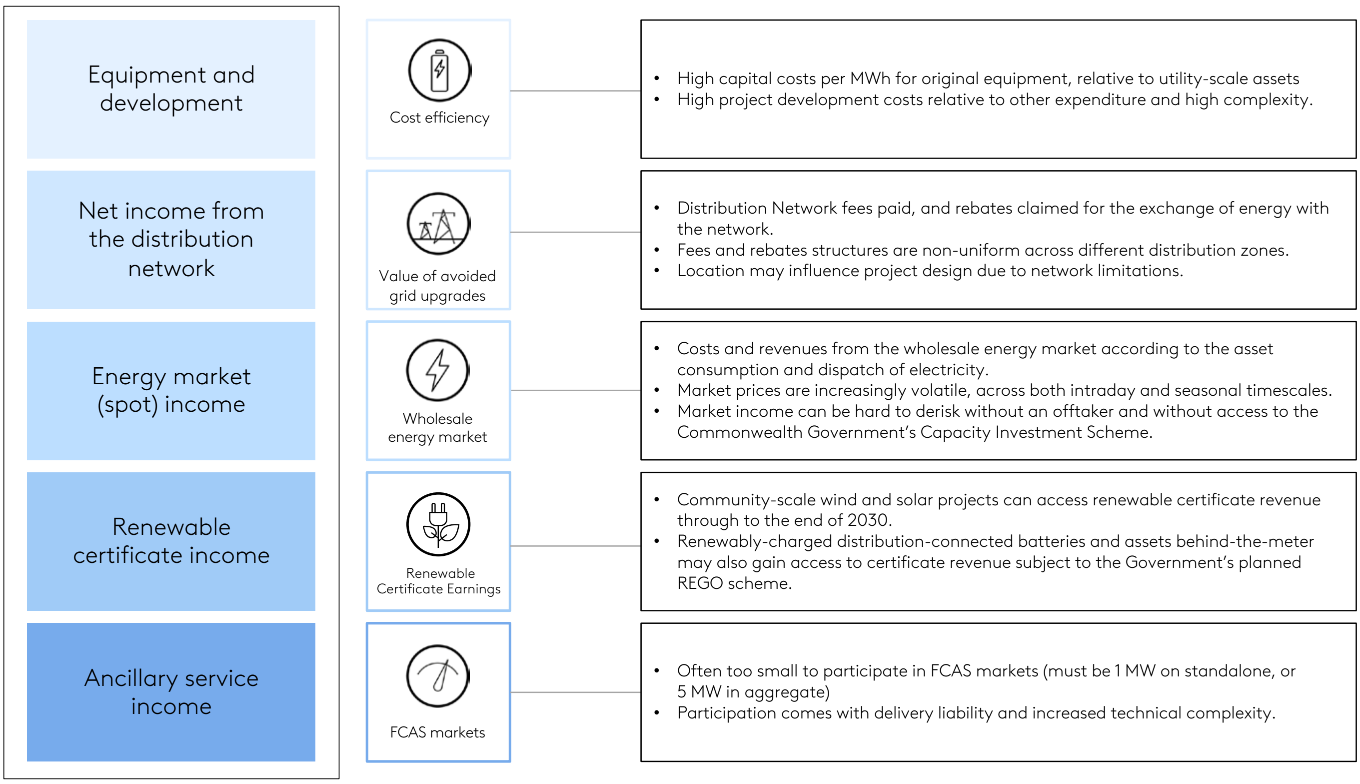
There is additional complexity when considering the potential to lower the costs payable by energy users through the installation of renewable and energy storage assets in isolated and remote communities. It is important to first understand the extent to which electricity usage prices are already regulated, for example with uniform residential electricity pricing subsidised across the Northern Territory and opacity around the actual underlying costs of electricity supply in different regions and communities. With the costs to resolve energy solutions for isolated communities typically higher than urban equivalents, the difference between system cost and energy user prices requires intentional thought and negotiation.

4.2.2 DISECONOMIES OF COMMUNITY-SCALE, DISTRIBUTION-CONNECTED ASSETS

The economics of community-scale, distribution-connected assets is dominated by five economic parameters.

The location of a community-scale asset within a distribution network will set the size constraints that correspond to the adjoining grid's limitations. Specifically, the network voltage can be used a proxy for the hosting capacity of a connected

FIGURE 7. FIVE ECONOMIC PARAMETERS FOR COMMUNITY-SCALE, DISTRIBUTION-CONNECTED ASSETS



community energy assets, with more flexibility in locations immediately adjacent to a transformer or zone substation. Operators of batteries below 5MW and electricity generation assets below 30MW are exempt from the requirement to register as a generator, with accompanying scheduling and other obligations, in accordance with section 2.2.1(c) of the National Electricity Rules and guidelines issued by AEMO, and more standard connection services apply to these assets.

This size of assets has strong scale diseconomies. Investment bank Lazard estimated in its 2023 levelised cost of energy (LCOE) analysis that utility-scale solar farms had an LCOE of USD24/MWh – USD96/MWh. In contrast, it found that community-scale solar faced an LCOE of USD49/MWh – USD185/MWh (Lazard 2023). The increasing size gap as more typical utility-scale projects grow bigger exacerbates the equipment cost diseconomies faced by community energy projects.

Diseconomies also stem from the practice of projects making disparate technology choices, reflecting their various constraints and needs, rather than driving down market-wide costs through economies of scale.

While there are exceptions, community-scale assets tend to be too small to secure offtake agreements from energy retailers and other parties and don't qualify for de-risking under the Commonwealth Capacity Investment Scheme, which encompasses assets over 30MW. This can leave them unable to hedge and exposed to the volatile energy market for their electricity export earnings. This can mean missing out on profits and wealth that had been anticipated for the community's benefit and in the worst case can present high levels of risk to community groups that can't afford losses.

4.2.3 SPECIFIC OBSERVATIONS ABOUT COMMUNITY-SCALE BATTERIES

There are different possible community battery configurations that have different levels of complexity and economic potential. Under Section 4.3, Quantitative analysis of community batteries, below, we present an economic analysis of community-scale battery returns. This section brings to life the economic challenges that such projects can face if they are connected front-of-meter and taken forward by parties without access to technical experience, FCAS revenue or consideration of co-optimisation of market and grid value.

Before progressing to this integrated analysis, however, it is important to explore access to distribution system value as another determinant or project costs and potential earnings.

Community-scale batteries, as a specific class of community-scale asset, can, depending on their location, solve problems for low-voltage distribution-level network provider businesses that can have an economic value measured by the avoidance of grid augmentation costs that would otherwise be incurred.

In general terms, the value of avoided investment can be augmented through the co-location with well-planned loads, such as electric vehicle charging. Savings from community-scale batteries as an alternative to distribution capacity expansion are particularly high for regions with high peak energy needs at one time of year and relatively low usage at other times. Batteries offer very efficient load smoothing.

As noted in Bjorn Sturmberg's discussion paper on Community Batteries (2023), community-scale batteries can improve distribution network conditions by:

- Contributing to peak-smoothing and voltage stability in local grids day-to-day, to facilitate higher presence of rooftop solar and large loads, like electric vehicle charging,
- Providing power to reduce outages, depending on the design of the battery installation, and
- Building resilience to events like floods and fires.

As Sturmberg notes, "these roles are all currently the responsibility of distribution network service providers" (Sturmberg 2023), and so interact with existing regulations and processes that determine the level of service and the costs incurred.

Community-scale batteries brought forward by distribution firms can be located at a site that optimises benefit to the distribution system, whether by resolving voltage issues at the end of the line, addressing peak load capacity constraints close to substations or addressing other forecast constraints. Depending on the parties involved, however, such projects may not unlock all the community benefits sought by proponents of community-led energy.

The 16 main electricity Distribution Network Service Providers that operate in Australia are engaging with local, or community batteries as a relatively new asset class, both in the case of batteries they bring forward themselves and those initiated by community groups and developers. So too are energy retailers who may or may not apportion value to customers. All parties are trying to assess the value of battery capacity and other services, with differing rates of experience and capability. This creates an uneven experience across distribution zones. Under the most supportive distributor settings, distribution level fees to charge and discharge a community-scale battery can enhance the project's economics, by paying the battery owner for the ways in which the battery delivers benefits such as voltage support, peak smoothing, and avoidance of capacity expansion. In some distribution zones, however, batteries may not yet be fully compensated for the value they provide.

The distribution operator must be confident that a community-led battery will be operated in a manner consistent with technical grid constraints in order for it to assign the full value of avoided grid investment through payments to a project. Unless there is sophistication in their design, some community energy projects exacerbate grid voltage challenges through high solar exports and may add cost to local distribution systems.

Importantly, the economic signals for automatically-dispatched community-scale batteries to optimise their wholesale electricity market revenue by charging or discharging at certain times often sits at odds with the optimal time for distribution system use, and so distributor and proponent objectives can be directly at odds.

The need to optimise asset charging and discharge times for both market and distribution system objectives is complex. We are hopeful that this complexity will spur new models of collaboration and asset override agreements, where needed.

For community-scale batteries with community proponents, many distribution companies are trialling and offering two-way pricing, with location-specific terms for the delivery of electricity to charge and the use of the distribution infrastructure to discharge and export electricity. The pricing structures can be complex and difficult to build into cost and revenue forecasts and can be exposed to change after a handful of years, which adds uncertainty to projects in development. It can also mean that one location will be better off than another. Many distribution businesses are working actively to provide community energy projects with more cost-reflective connection fees and service use charges, but the experience for project proponents is currently uneven.

Community proponents of battery projects can face further economic constraints in the form of practical distribution-level limitations on how quickly their asset is charged and discharged. This can mean that they are unable to access and take full advantage of periods with the lowest energy market pricing for charging and periods of high pricing by which to gain income from electricity dispatched. Such constraints must be carefully considered in financial forecasts and project planning.

For community groups and developers initiating front-of-meter local batteries, information asymmetries that see distributors retain valuable information on where different battery configurations could reduce grid spend, and differences in location preferences between distributors and other proponents, may leave some of the distribution benefit value unrealised where it could otherwise be allocated to their project. This information asymmetry was a key topic of feedback to the recent Ring-Fencing Waiver decision which allowed distributors to own and operate distribution connected batteries

Community-led projects are not always invited:

Where a proposed community-led energy project provides an efficient alternative to distribution system expansion, it can be ruled out by infrequent openings to participate.

The distributor is only required to run a public request for proposal when their expansion expenditure is forecast to be over $6 million. This process is known as the distribution regulatory test for investment, or the RIT-D. Community energy assets are typically an order of magnitude smaller. While they can deliver network benefits, and possibly help avoid or defer network expenditure, they typically offer solutions below the RIT-D threshold.

The proposal window tends not to be open for long, typically requiring proponents to act very quickly to identify and propose a solution, which is then evaluated against other network options, further reducing the number of parties able to respond.

4.2.4 CONSTRAINTS RELEVANT TO COMMUNITY CO-DESIGN AND EQUITY IN UTILITY-SCALE ASSETS

As described in Section 3.2 profiling First Nations community energy in Australia there are some leading examples of local equity stakes in major infrastructure projects, with more in development.

More broadly, the opportunity for project proponents to offer neighbouring communities equity stakes and co-development is, in part, an economic outcome of the prevailing wholesale electricity market pricing, ancillary service revenues and other development cost economics. With high development costs and complexity, the economic opportunity to share earnings must be understood in the context of the wider economic signal to invest in project development. Over the last year, and notably prior to the launch of the Commonwealth Government's first Capacity Investment Scheme auction, the economic signal was enough to see just 1,236 MW of utility-scale wind and solar projects reach Final Investment Decision[21]. This indicates that there may be less economic pie to share than communities might have hoped. We hope to see successful partnerships overcome any remaining headwinds.

21. https://cleanenergyregulator.gov.au/markets/reports-and-data/large-scale-renewable-energy-data

4.2.5 ADMINISTRATIVE INEFFICIENCIES ACROSS ALL COMMUNITY ASSET CLASSES

Community groups must contend with a range of cost drivers that are either specific to, or more material for, community energy projects relative to large-scale renewable energy developments. Key cost drivers identified by community groups that can substantially impact the development cost of projects include:

- **Less efficiency in market analysis:** The ability for community energy projects to identify and forecast different revenue streams is critical when assessing the feasibility of projects and attempting to secure financing. This complex and technical work is particularly subject to uncertainty and inefficiency for community energy projects unable to access the best skills and models without significant expense.
- **Less efficiency in project planning:** Lower access to the skills and technical knowledge necessary to move efficiently through the stages of design and project development, resulting in slower progress, more rework and, in some cases, sub-optimal project design.
- **Less efficiency in grid connection:** The process for connecting to the electricity grid (where applicable) can impose a significant burden on community energy projects. The challenge is two-fold based on feedback from community groups: (1) significant costs and tight timeframes associated with the grid connection process; and (2) difficulties in developing productive working relationships and transparent information sharing with network operators. Grid connection is critical for projects to be able to access revenue streams for the provision of market services. In terms of the financial implications of grid connection for projects, the National Community Energy Strategy notes that (UTS Institute for Sustainable Futures et al. 2015):
    - for New England Wind, grid connection accounted for approximately 18% of the upfront capital costs of the project; and
    - for Hepburn Wind, which was the first wind farm to connect to the distribution network, complications arising from this process resulted in an additional unforeseen $300,000 in costs and $600,000 in lost revenue resulting from constraints during the initial months of operation.
- **Scale inefficiency, with administration of small projects as demanding as larger projects:** Project overheads and operating costs are applied over a small project base and become relatively more onerous per unit of energy supplied. The costs of project administration and compliance with regulatory requirements can significantly erode potential returns on investment for community energy projects when compared to utility-scale projects (UTS Institute for Sustainable Futures et al. 2015)
- **Developing and testing new project models:** The landscape for community energy is continuing to evolve along with changes in technology and the development of new ownership and operational structures. This requires some community groups to take on a pioneering role with community energy projects, testing and iterating different project models to enable learning by doing and lay the groundwork for future projects. Through this process, some community energy projects will necessarily experience duplication of efforts and inefficiencies, which usually translate to higher costs than would be the case if the sector were more mature.

4.3 Quantitative analysis of community batteries

INTRODUCTION

Literature and information from community-scale battery projects (100 kWh - 5000 kWh) have indicated the potential for diseconomies. We explore the economics of community projects from a pure investment lens, by modelling the cash flows of a simple representative community battery connected to the distribution network by parties other than the local distributor, who are therefore subject to use of system fees. We acknowledge that such projects may contribute value in other ways, including growth in social capital and energy transition literacy, depending on the objectives of each project. We find that these and other forms of benefit may be available at lower cost through other project types.

The results from our modelling indicate that batteries frequently, but not always, provide challenging financial returns, particularly when understood in the context of the cost of debt and the opportunity cost of communities failing to invest in projects with higher returns. More sophisticated developers in key locations for market arbitrage and distribution, particularly those accessing FCAS, may be able to access higher rates of profit.

It is important to reiterate that this conclusion relates to low-voltage-grid-connected batteries that are typically sized well below 5MW. Batteries located behind the meter and in utility-scale applications enjoy stronger economics. Further, the conclusion does not consider projects initiated to solve specific grid needs, such as building local reliability, contributing resilience to climate-charged disasters, building grid capacity and voltage stability to accommodate higher levels of rooftop solar and rapid EV charging. These are discussed separately.

The profitability of community-scale battery projects is contingent on both the jurisdiction of the community battery and the avenues for revenue generation, whether including or excluding FCAS, recalling that FCAS revenue is only available to actively managed assets above 1MW in size, subject to a site test, or 5MW on an aggregated basis.

APPROACH

We modelled a simplified[22] cash flow analysis[23], taking into account revenues (wholesale energy market arbitrage, network tariffs, and FCAS, modelled in Orkestra[24]), operation costs (OPEX), capital cost (CAPEX), and additional development costs (see Appendix A).

In selecting modelling parameters, we intentionally sampled more favourable values wherever we were faced with choice. This has resulted in mildly optimistic projections.

We observed the internal rate of return (IRR) across five states (NSW, SA, VIC, QLD, TAS) and two revenue generation scenarios (FCAS and no FCAS). Project will inevitably have differing CAPEX costs and batteries have different capabilities with different cost structures. For example, Yarra Energy Foundation estimate their battery costs to be around $1,100/kWh[25] whilst a feasibility study by the Phillip Island Neighbourhood Battery project estimates that their CAPEX will fall between $2,100 and $4,900[26]. In their annual Gen Cost report the CSIRO estimated the average storage capital costs for 2023/2024 to be ~$1,000/kWh (Graham, Hayward, and Foster 2024). To account for these differences, we conducted a sensitivity analysis looking at the change in IRR given differences in CAPEX costs in $/kWh.

SCENARIOS

The cash flow analysis was conducted under a total of 10 different scenarios, which were differentiated by the jurisdiction, or state, and type of revenue generation. The scenarios were run using Orkestra's precision simulation. Variability across scenarios was constrained to revenues, and costs were held fixed for simplicity and transparency.

22. A simplified analysis was used to ensure transparency and flexibility in the analysis as additional complexities would impact the representative nature of the exercise.

23. Cash flow analysis consist of taking the sum of discounted cash flows over an investment's life (see equation below).

$$\sum_0^t \frac{CF_t}{(1+r)^t} = \sum_0^t \frac{(Revenue - Costs)_t}{(1+r)^t}$$

It is the conventional industry tool for analysing the value of investments and projects.

24. Orkestra is energy project feasibility software designed to forecast revenues for energy systems. Please see https://app.orkestra.energy

25. Please see https://www.yef.org.au/app/uploads/2022/11/Yarra-Energy-Foundation-NBI1-Final-Report.pdf

26. Please see https://www.energy.vic.gov.au/__data/assets/pdf_file/0021/620067/energy-innovation-co-operative-phillip-island-neighbourhood-battery-feasibility-study.pdf

PRICES

Each simulation used 2023 AEMO state-level data to forecast wholesale and FCAS prices in Orkestra. Wholesale price forecasts were adjusted using a Consumer Price Index (CPI) escalator. FCAS prices were given a conservative -10% de-escalator to account for increased competition and dilution over time.

Fees and revenues attached to use of the distribution network during periods of charging and discharging vary considerably across regions operated by different distributors but play a limited role in revenue generation (5-10% across scenarios). We surveyed distributor tariff structures and applied Endeavour Energy's tariff as indicative of a favourable structure.

A representative community battery

A representative 1-hour battery of 1000 KW was used in the simulations. The battery was based on a 2024 Tesla modified Megapack with a roundtrip efficiency of 88%, standby losses of 5% per month, and a maximum depth of discharge of 98%. The battery followed a non-linear degradation curve, dropping 20% over the first 8000 cycles and then to zero over the subsequent 2000 cycles, with an approximate life of between 15 and 20 years.

FINDINGS

Our modelling indicates that the economic opportunity from community battery projects is extremely sensitive to both CAPEX and development costs and varies considerably across different states, with access to FCAS revenue being very important.

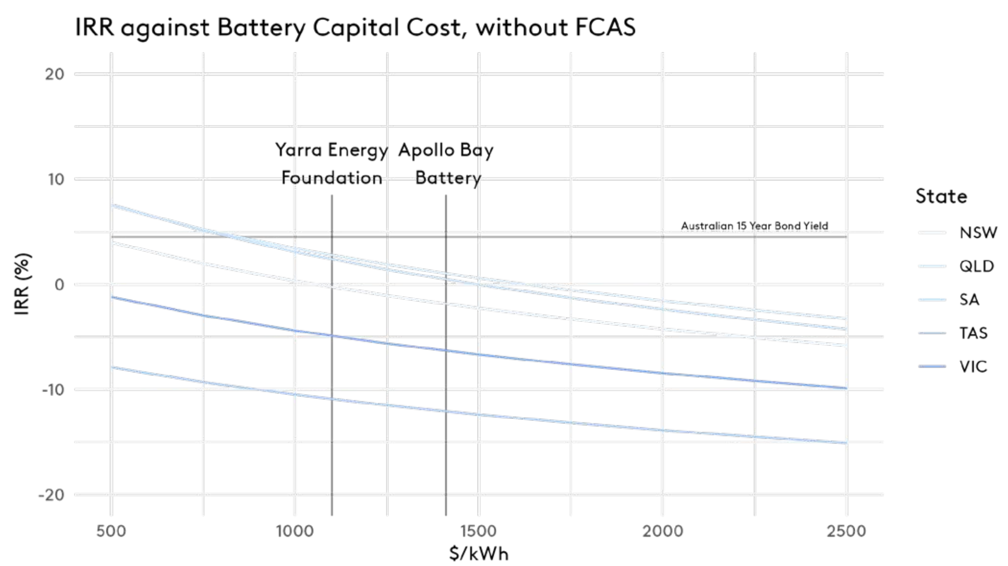
Figure 8 indicates the IRR for low-voltage-grid-connected batteries in different states and for different initial capital investment costs. Australian 15-year bond yields, 4.47%[27], are provided as an indication of the risk free return rate.

In many states and at battery costs consistent with published existing project costs, this modelling indicates that returns are negative. As battery costs fall, naturally the investment return improves. Positive returns shown above zero mostly indicate returns below interest rate thresholds.

Naturally, the ability to access lower development and connection costs corresponds to stronger project economics, as indicated in Figure 9. In many cases, development costs might be substantially reduced by volunteer hours and legal, energy markets, and grid connection expertise granted pro bono. However, we urge that these hours be incorporated into the analysis as they represent an opportunity cost for hours spent contributing to other civic ventures. Given light development cost and low CAPEX cost certain jurisdictions could have more economical community battery projects (see Appendix A.4).

FIGURE 8: INTERNAL RATE OF RETURN CURVES AGAINST BATTERY COSTS

Change in IRR of a reference community battery project given different battery capital costs. Development costs are fixed at $800,000. Revenues do **not** include FCAS participation.

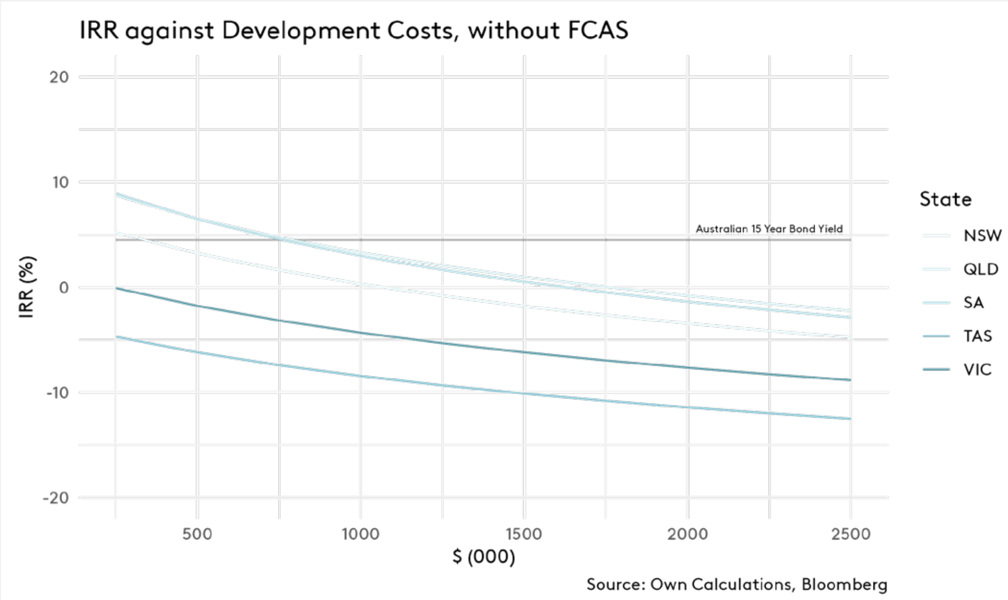


Source: Own Calculations, YEF Final Report, Apollo Bay Battery Feasibility Study Report, Bloomberg

27. Please see https://www.bloomberg.com/markets/rates-bonds/government-bonds/australia, taken 27/05/2024 at 11:17 AEST.

FIGURE 9: INTERNAL RATE OF RETURN CURVES AGAINST DEVELOPMENT COSTS

Change in IRR of a reference community battery project given different development cost. Battery capital costs are fixed at 1100 $/Kwh. Revenues do **not** include FCAS participation.

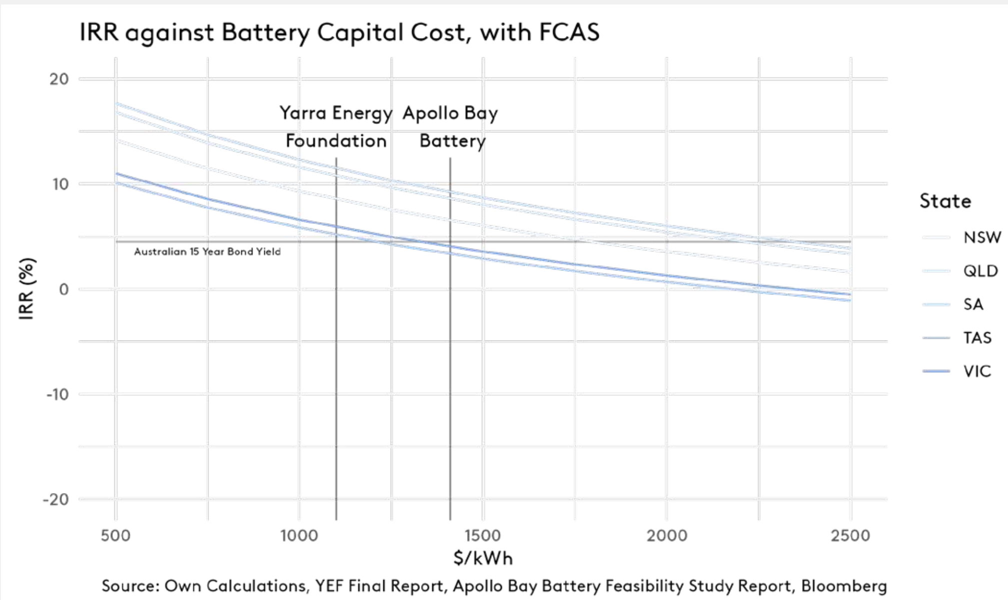


Project returns are notably strengthened for operators that are able to access FCAS revenue. Scenario returns are indicated in Figure 10.

FCAS is an important revenue stream, underscoring the importance of aggregation across more than one battery unit where scale constraints exist, and the value of technical knowledge in day-to-day optimisation. Accessing FCAS revenue will also require additional development costs and expertise to ensure the project meets distributor requirements. However, as more projects compete for FCAS revenue, the pool of revenues becomes increasingly diluted, and the economic benefits substantially reduced.

FIGURE 10: INTERNAL RATE OF RETURN CURVES WITH FREQUENCY CONTROL ANCILLARY SERVICES REVENUE

Change in IRR of a reference community battery project given different battery capital costs. Development costs are fixed at $800,000. Revenues **include** FCAS participation.



4.4 Access to funding support

4.4.1 FINANCING COMMUNITY ENERGY PROJECTS

Community energy projects can experience difficulty in accessing capital, even after configuring their system's design to solve for scale diseconomies and other challenges to market earnings and distribution level use of system fees.

Depending on the scale of the project, it may be necessary for proponents to secure some form of debt financing or equity from institutional investors to progress the project to construction. The National Community Energy Strategy suggests an approximate capital requirement of $1 million as the threshold beyond which projects are likely to require some form of additional financing or external investment (UTS Institute for Sustainable Futures et al. 2015). Those projects with significant debt can be particularly exposed in the event of poor project revenues during periods of unfavourable energy market conditions and may take their investors into distress.

Table 4 summarises some of the most common potential funding sources for community energy projects, along with the barriers community groups may encounter for each category (Patterson and Campbell 2016; Victorian Government 2015).

OVERVIEW OF FUNDING SOURCES FOR COMMUNITY ENERGY PROJECTS

SOURCE	OVERVIEW	BARRIERS/CHALLENGES
Government grants	Grant funding is commonly utilised by applicants for the early stages of community energy projects, such as feasibility studies. Given the smaller scale of most community energy projects and the limited resources of community energy groups, grant funding plays a critical role in helping projects progress to construction.	Since the early 2000s, Australia's community energy projects have received funding from several Commonwealth and state-led packages targeting specific project types for different reasons, each at a point in time. Today, only a small number of community energy project types, such as aggregated community batteries, are eligible for ongoing support. Community energy projects are typically ineligible for grants or revenue relief that may be available to larger renewable projects, such as the Commonwealth Capacity Investment Scheme.
Donations	Project proponents can seek charitable donations from the community to support the development of small-scale community energy projects.	Donations typically require a significant amount of effort to coordinate and do not provide certainty regarding the amount of funds that can be secured. In addition, it can be difficult to raise a material amount of funds through donations to support sizeable projects, limiting the application of this approach to smaller projects.
Equity investments	As the scale of community energy projects increases, it generally becomes more likely that the proponents would seek investment in the project in exchange for an equity stake. Investors may also receive associated benefits such as access to cheaper renewable energy or project revenue streams. Typical classes of potential investors may include: • Wholesale investors – sophisticated or professional investors • Retail investors – usually capture most members of the community who invest in the project but are not considered wholesale investors • Institutional investors – superannuation funds, financial institutions, credit unions, etc. • Social impact investors – specialist funds whose managers have a mandate of investing in socially responsible projects • Angel investors – may come from any of the above categories but typically provide funding in the early stages before the project has been de-risked (and may require a higher return on investment) • Sweat equity – providing equity in the project in exchange for labour.	Proponents may be required to comply with requirements set out in the *Corporations Act 2001* to raise capital through the issue of equity in a project. This depends on the business structure adopted by the project. The process for offering, issuing and managing shares in the project also requires a material commitment of time and resources. Project proponents may also face challenges in navigating the interests of a diverse range of shareholders.

Debt financing	Lending of funds by a financier is typically less common for smaller-scale community energy projects. However, debt financing may be necessary for larger projects or if the debt can be sourced more competitively than equity for a smaller project. Debt financing can take a number of forms, including: • Corporate finance – shorter-term debt (5 years or less) usually secured by a business based on its assets • Project finance – long-term debt (i.e. 5-10 years or longer) where repayments come from the cash flows of the project and the debt is secured against project assets • Asset finance – borrowing money against a specific asset (e.g. a wind turbine or solar installation) • Construction finance – funding for a community energy project whilst it is being constructed.	Minimum threshold requirements are likely to apply for certain types of debt financing, such as project size cut offs and requirements for revenue de-risking, such as offtake agreements or non-market revenue streams. If a community group decides to pursue debt financing, administrative and legal costs are associated with this process. Most communities do not have an adequate form of security to offer banks in exchange for a loan, apart from the earning potential of the project itself (Victorian Government 2015). This may be addressed by an individual, organisation or business agreeing to provide security for the loan on the project's behalf.

For First Nations groups, access to capital can be particularly challenging, especially in early-stage development for energy projects of all sizes. First Nations were broadly excluded from participating in the economy until the 1970s, with practical exclusion persisting for some communities. Asset accumulation and transfers of intergenerational wealth have therefore been very limited, meaning limited capital from which to self-fund investments. First Nations communities often face lower access to the incentives that support the installation of distributed Consumer Energy Resource technologies, and some are ruled out through access restrictions relating to social housing or their local energy company. First Nations people living in remote communities also feel they are 'locked out' of the energy transition benefits available to households connected to the main electricity grid (DCCEEW 2023). Access to capital challenges include:

- **Government capital:** First Nations communities are not accessing renewable finance in significant quantities. While branches of government and agencies have provided financial stimulus for renewable energy technologies, including ARENA's $75 million First Nations Microgrid stream and other streams identified on the First Nations Clean Energy Network website, there are not many funding programs that are specifically for First Nations.
- **Institutional capital:** Indigenous land rights can vary by location and are atypical assets that for financial counterparties such as banks and superannuation funds can find difficult to value.
- **Energy offtake and corporate capital:** As a solution to the capital and valuation challenges, innovative business models have arisen, including equity ownership of renewable projects.

The 2023 Australian Community Energy Collective Impact Assessment collected data on the funding sources for community energy projects undertaken from 2022-23, which is summarised in Figure 12 (Buckley et al. 2023).

The projects captured in this survey raised over $86.8 million in funding during the reporting period, supporting over 12MW of new renewable energy generation capacity.

Figure 12 provides an overview of how different funding sources may apply at different stages of a community energy project (Victorian Government 2015). Depending on the project model and size, the funding sources will typically shift from donations and grants in the early stages of the project to equity and debt as the project proceeds to construction.

In addition to challenges in securing funding, community energy projects can encounter difficulties in accessing insurance.

FIGURE 11. FUNDING SOURCES FOR COMMUNITY ENERGY PROJECTS, 2022-23

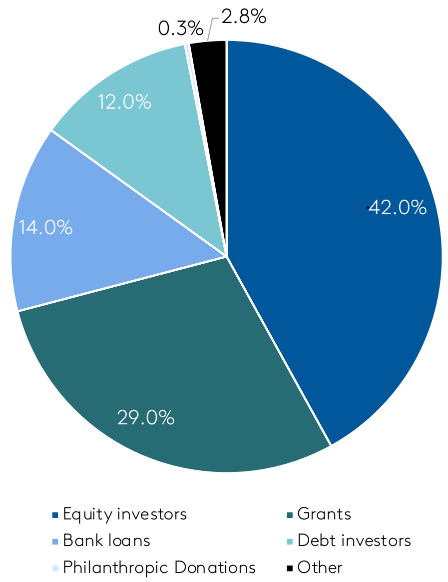
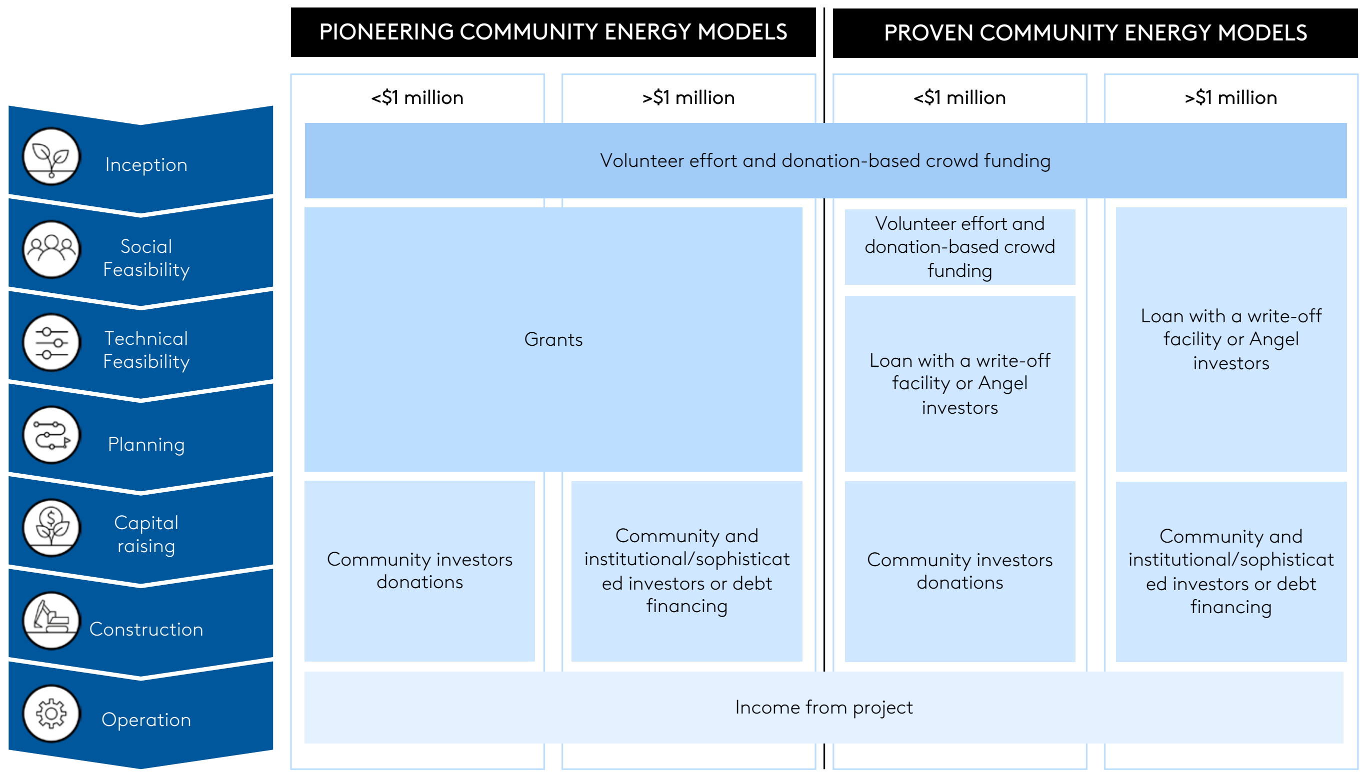


FIGURE 12. FUNDING SOURCES FOR COMMUNITY ENERGY PROJECTS BY SIZE, PROJECT STAGE AND PROJECT MODEL



Source: (Victorian Government 2015)

4.4.2 POLICY CONTEXT FOR COMMUNITY ENERGY

For projects that resolve community needs in an efficient manner, government grant programs have a particularly important role to play in supporting projects. This is particularly so through the pre-feasibility, feasibility and planning approval stages. While there are some policy schemes at the state and federal level designed to support community energy projects, community groups maintain that they face challenges in accessing the type and volume of funding needed. They also encounter difficulties in responding to funding openings with sufficient speed and in accessing support over the many years it can take to complete a project.

In particular, where policy-backed grants are available for community energy projects, challenges can persist where those funds lack:

- **Sufficient longevity and duration:** funding schemes that have an ad hoc or short-term focus are unlikely to align with lengthy project-development cycles;
- **Recognition of project benefits/objectives:** decision criteria for funding schemes do not always adequately recognise the full spectrum of benefits provided by community energy projects, consider the value of the specific community needs to be addressed through the project, or
- **Benefit sharing assurances:** beyond providing funding, programs that are characterised as supporting community energy should include some guardrails to ensure that benefits of projects are adequately shared with the community (e.g. for distributor-owned community batteries).

Factoring these considerations into the design of community energy funding schemes can help ensure they are fit for purpose and provide viable development pathways and sustained support for community energy projects.

An overview of current and historical public funding programs for community energy in Australia is provided in the table below. The policy landscape is dynamic, and funds can cease or be created.

The township of Hawker, located in the Flinders Ranges area of South Australia.

OVERVIEW OF PUBLIC FUNDING PROGRAMS

The scope of public funding programs in Australia that have been specifically targeted towards community energy has been relatively limited relative to other renewable energy support schemes. Currently active programs that are relevant to, or may be accessed by, community energy proponents are summarised in the table below.

OVERVIEW OF CURRENTLY OPEN PUBLIC FUNDING PROGRAMS FOR COMMUNITY ENERGY:

PROGRAM	AGENCY	FUNDING AVAILABLE	PURPOSE
Community Energy Upgrades Fund (CEUF)	Australian Department of Industry, Science and Resources	\$100M	The CEUF is a targeted, competitive grant program that provides co-funding for energy upgrades at existing local government facilities. Grants between \$25,000 and \$2.5 million will be awarded on a merit basis. The program aims to help local governments to: • make their facilities more energy efficient • lower their greenhouse emissions and energy bills
Long Duration Energy Storage trials	ARENA; WA Department of Energy, Mines, Industry Regulation and Safety	\$5.7M	This program will support trials of long-duration batteries to help Australians living in off-grid communities store solar energy. Horizon Power will pilot two new battery technologies powered by regional microgrids in remote communities. If successful, the trials will help Horizon Power roll out Distributed Energy Resource Management Systems across 34 regional areas by the end of 2024.
Neighbourhood Batteries Program	QLD Department of Energy and Climate	\$179M	Stages three and four of this program will see 12 new local network-connected batteries installed across the state. The package will also enable the installation of two flow batteries from Queensland manufacturers. These batteries are in areas with high solar penetration and will be used to support the energy network during times of peak demand.
Community Solar Banks	Australian Department of Climate Change, Energy, the Environment and Water, in partnership with state and territory governments	\$100M (additional funding provided by states/ territories)	The program will support apartment residents, including renters, to access solar by funding the installation of shared rooftop solar on apartment buildings and subsidised plots in solar gardens.
Regional Microgrids Program	ARENA	\$125M	Funding will support the development and deployment of microgrid technologies across regional and remote communities. \$75M of this is available for First Nations projects only.

There are also a number of seminal examples of community energy funding programs that are no longer open to applicants but have had an important impact on accelerating the deployment of community energy in Australia. The learnings available from these programs can be leveraged to inform the design of future funding schemes. These include:

- **ARENA Community Batteries Funding Round 1:** On 29 June 2024, ARENA announced that it had conditionally approved \$143 million to support the roll out of up to 370 community batteries, subject to contracts being finalised with each recipient group. The funding has been awarded to 20 applicants across 21 application submissions, with 10 applications for \$67.3 million under Stream A Distribution Network Service Providers (DNSPs), and 11 applications requesting \$75.7 million under Stream B Non-DNSPs, with projects covering every state and the Northern Territory. Successful applicants must install a minimum of five community batteries, between 50 kW and 5 MW in size each, and must be connected to the distribution network. ARENA intends to allocate further funding to a second round with at least \$28 million to accommodate projects that have longer development times.

- **NSW Regional Community Energy Fund:** The Regional Community Energy Fund provides grants to community energy projects that create innovative and/or dispatchable renewable energy and benefit the local community. The program awarded grants to seven projects, worth approximately $15.4 million, in the first round of funding. These projects will unlock nearly 17.2MW in electricity generation and up to 17.9MW/39.3MWh of energy storage, leveraging around $36 million in private investment.

- **Victorian Community Power Hubs:** The Community Power Hubs program has funded the establishment and operation of hubs to support communities in the development and delivery of locally-owned, cost-effective renewable energy projects, including by facilitating knowledge sharing and providing advice on clean energy solutions and project development. The program empowered communities to be active participants in planning and decisions around the transition to renewable energy and enabled local environmental, social and economic benefits to be realised, including cost savings for local communities.

- **Victorian Neighbourhood Battery Initiative:** This $10.92 million initiative supports a range of neighbourhood battery models in Victoria, from feasibility to implementation. The initiative supports a deeper understanding of what role neighbourhood-scale batteries can play in Victoria's transitioning electricity system and demonstrates a range of benefits for Victorian communities, energy users, and electricity networks. The government is also investing a further $42 million to install 100 more neighbourhood batteries across Victoria through the separate but related 100 Neighbourhood Batteries (100NB) Program, tripling the number of homes with access to renewable energy storage.

The bulk of the funding identified for community energy over the past five years has been delivered by the Australian Government, followed by the New South Wales and Victorian governments. Most of this funding has been for community-scale solar and/or battery systems. It appears that in many cases these have offered limited funding certainty through a lack of detailed information about the timing and quantum of future funding rounds.

4.5 Access to expertise and unpaid labour

There is agreement among community energy groups and researchers that energy projects draw deeply on technical expertise, particularly across stages of work that involve system design, income modelling referencing energy markets, planning, connection approvals and financing. These skills are vital to the success of energy projects and tend to be in very limited supply.

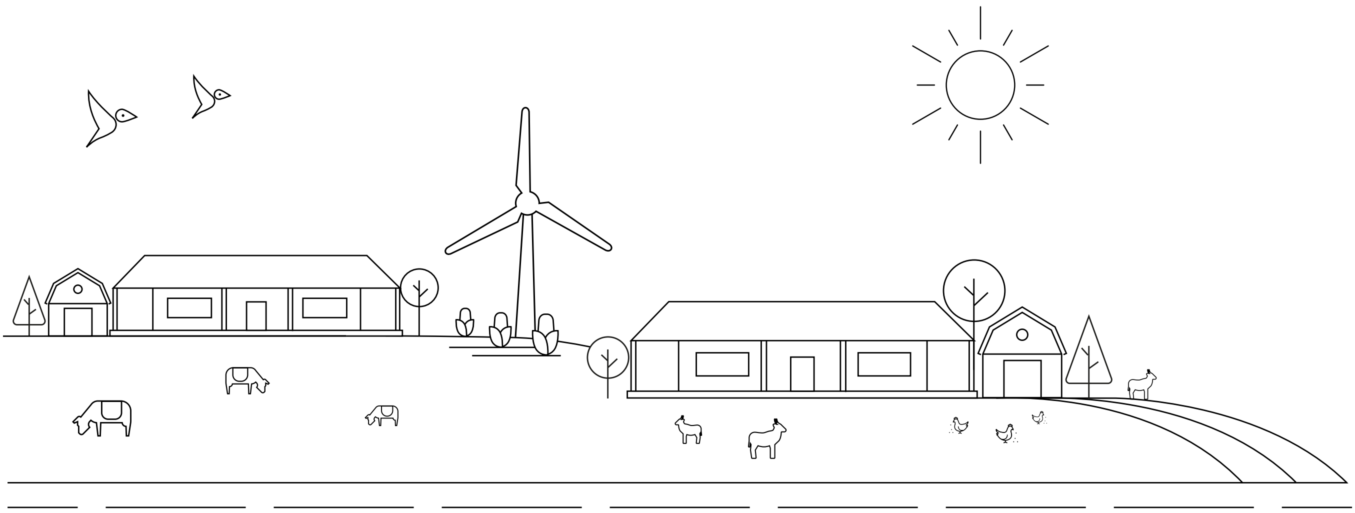
Without deep technical skills already resident within the volunteer group supporting the community project, community projects encounter significantly greater difficulty than larger energy developers and corporate proponents with access to technical teams. The dearth of skills tends to be felt in direct economic terms as much as in frustrated processes: community energy groups often have to pay for technical services or work through with lower-quality information and suffer higher costs associated with rework and suboptimal funding outcomes and configuration that can curtail asset cost recovery and income.

More generally, community energy projects have a heavy and, at times, onerous reliance upon volunteers. Responses to the 2023 Community Energy Collective Impact Assessment suggested that nearly 20,000 volunteer hours were contributed to community energy projects over the 12 month reporting period, estimated at almost $900,000 of in-kind value (Buckley et al. 2023).[28] This heavy reliance upon the efforts of passionate volunteers has been cited as a key area of challenge and risk.

Volunteering Australia has reported that "Volunteering participation in Australia generally declined from 2001 to 2020" (Zhu 2022). The 2021 Census reported a 19% decline in the number of Australians volunteering since 2016 (ABS 2022), with the decline likely heightened at that time by the COVID pandemic. "Volunteer fatigue" was identified in the literature as a key impediment to the volunteer hours required over the course of many years to successfully deliver a community energy project (Buckley et al. 2023). The oversight of operating projects and the administration of associated cooperative or business structures can demand significant volunteer time extending over two decades.

28. Based on a costing of $45 per hour.

5. Enablers and success supports for community energy



While community energy projects face headwinds in the form of high costs, complexity and other constraints, there are three key project attributes and enablers that are associated with higher rates of success. These include secure access to:

- Technical expertise through the design of the community energy asset project and through grid connection planning, where required,
- Access to mentoring, knowledge sharing, and process stewardship across the project life cycle, and
- De-risking of income volatility, often by securing an energy off-taker and often combined with outsourced asset operation and market participation.

While some projects have been able to leverage and maintain the momentum created by passionate individuals and groups within the community, many falter. We have observed that project teams with succession plans and durable corporate structures tend to do best. For others, phased divestment to an asset operator, where feasible, can be a sensible approach.

CASE STUDY

Denmark Community Windfarm – Right time and place for community wind

On a headland along WA's windy southern coastline overlooking the Indian Ocean, the blades of two wind turbines turn. The turbines, located in the coastal town of Denmark, have become an iconic example of community energy in Australia.

Following a series of public workshops in 2003, a steering group was formed to build a locally-scaled, locally-owned, grid-connected wind energy facility to provide up to 100% of the community's annual electricity consumption. While the Denmark community has historically been environmentally active, the project was from the outset framed as a commercial enterprise, to underpin its intended lifespan and help secure buy-in from key stakeholders.

In 2006, having won funding through the federal government's now closed Remote & Regional Power Generation Program (RRPGP), the community set about putting its plan into action. As the first project of its type in WA, the wind farm faced some unforeseeable challenges and delays for a decade between inception and connection but, in March 2013, the two 800 kW turbines commenced operation, supplying 5 GWh of renewable energy annually, meeting approximately 40% of Denmark's then energy needs. The project secured a buyer, Synergy, under a long-term Power Purchase Agreement (PPA), with profits distributed to shareholders, who began to receive dividends in the first year of commissioning. The project completed repayment of its financial debts in 2022.

At completion, the not-for-profit steering group transferred the project to an operating entity named Denmark Community Windfarm Ltd (DCW), a public company established to own and operate the windfarm. In return, the steering group received shares in the company that reflected a nominal dollar value applied to the hours of voluntary input. These shares pay annual dividends, which are invested in funding local community enterprises, thus keeping money earned by the windfarm circulating in the community.

One of the two turbines of the Denmark Community Wind Farm, Western Australia.

Diseconomies and headwinds

The project is located on Crown land, which required a statutory excision process that took approximately three years. Delays to the RRPGP funding and technical studies required for Western Power to approve connection to the State-owned grid again drew heavily on volunteer time and dedication. In all, some 11,600 hours of volunteer time were contributed to take the project through to technical and financial feasibility. Volunteer contributions have now been sustained over 20 years.

The community had originally secured EPA approval to install four wind turbines on the site, which would have supplied all the energy needs of the town at the time. However, Western Power determined that the transmission line could not support the required load and constrained the project to two turbines.

In 2007, after a major blackout left parts of the region without power for several days, the WA government instructed Western Power to upgrade the line's capacity to what the project was originally designed for. However, by then the project was too advanced to justify reworking the feasibility study and bearing the unbudgeted costs that would have been involved to return to the design of four turbines.

Today the company is considering several expansion options, including adding more turbines, using the site for other energy assets such as batteries, and wider energy transition-aligned projects such as local truck fleet electrification. The economic opportunity of each asset type and configuration is necessarily connected to energy market dynamics and the cost of procuring assets (e.g. two additional turbines are estimated to cost roughly double the price paid for the existing assets).

Enablers and success supports

The community was fortunate that local residents with relevant technical and commercial skills, including backgrounds in environmental science, law, commerce and communications, joined the initial steering group. This breadth of skills and generosity in assigning time and effort have been key enablers of the project.

While the project faced difficult delays and scale restrictions in its development phase, it enjoyed certain enablers that new projects today would likely find difficult to secure:

- $2.48m under a then federal government RRPGP grant;
- a highly favourable Power Purchase Agreement: it is unlikely that a similar Agreement could be negotiated today given the current penetration of renewables and market pricing dynamics;
- relatively low capital costs: development costs have increased significantly over the past decade, as standard utility-scale wind projects have grown progressively larger, making small-scale installations less commercially viable.

The architects of the project created a public company to own and operate the project because a profit-making entity with no limit on the number of shareholders created access to a wider group of investors than other organisational structures. This model supported benefit-sharing that was underpinned by the economic fundamentals of the project, across the original cost base, inclusive of the Commonwealth grant, and the offtake agreement.

While DCW provides an iconic example of the potential benefits and longevity of community energy, the project's economic success is difficult if not impossible to replicate under today's market and capital-cost conditions.

5.1 Technical leadership in the project planning phase

A consistent insight from community energy groups in Australia is the immense value of having a sophisticated third party involved early in the project lifecycle to provide technical support on the key areas that are critical to the project reaching a final investment decision. This may include, for example, taking responsibility for:

- project sizing and technical design;
- energy market and revenue modelling;
- aggregation with other small to mid-scale renewable energy projects for the purposes of participation in the market;
- interfacing with the planning system to obtain relevant approvals; and
- engaging with distributors in relation to the grid connection process.

The above elements of project planning can involve significant technical complexity and often require a level of understanding of the energy market structure and dynamics that is unlikely to be held by community groups. Accessing this skill set may, therefore, require a partnership with an energy project developer and/or market participant who has experience in these areas and can advise the community on the optimal approach. Several community groups have commented that trust, and alignment between the expectations and objectives of the community and the relevant partner, are critical to the success of such partnerships.

5.2 Access to mentoring, knowledge sharing and stewardship

Beyond project-level technical support, community groups benefit from being able to access information and guidance on:

- the potential challenges and benefits associated with community energy projects;
- the viable project models that could be employed in their community;
- key elements of the project development process, including how to navigate regulatory frameworks and access funding;
- the learnings and knowledge gained from the experiences of other community groups developing similar projects in the region (and more broadly); and
- engaging with potential project partners.

The establishment of community power hubs is often cited as a way to deliver the above support to community energy groups. The Yarra Energy Foundation offers services akin to that of an advice hub to support higher success rates for other communities approaching community energy. Hubs more broadly were a key focus of the Local Power Plan – developed by Dr Helen Haines MP and targeted at accelerating community energy in Australia – which specifically proposes the establishment of 50 “Local Power Hubs” across Australia to support regional communities to develop their own energy projects (Helen Haines 2020b).

The Victorian Government’s Community Power Hubs program also demonstrated the impact a hub model can have in practice. The program, administered by Sustainability Victoria, provided funding over 2 years to establish three Community Power Hubs in the state. These supported the delivery of 15 community energy projects and 1.35MW of renewable energy. The evaluation report for the program suggests that these projects save communities $364,000 in electricity bills each year (Hicks and Lane 2019).

Returning to the categories of project benefit outlined in Section 3, where the community’s central motivation is to build social capital and energy transition literacy, community energy projects may not be the only possible approach. Hubs that seek to enable direct community engagement with small- and large-scale energy assets and boost energy literacy may contribute meaningfully even in the absence of community energy projects. Benefits may include:

- Higher levels of individual action to reduce emissions and higher motivation to participate in collective community energy initiatives (Burch 2010).
- Reduced pushback to the development of energy infrastructure. For example, in responses to the Victorian Government's consultation on its Neighbourhood Battery Initiative (DELWP 2022), community members identified the following concerns regarding the presence of a community battery system in their neighbourhood:
    - cost of the battery system and potential to lead to higher energy bills,
    - visual impacts and noise,
    - lack of community benefits or difficulties in effectively communicating those benefits to the community,
    - safety, environmental and health impacts, including fire risk,
    - inequalities in the costs and benefits of a community battery for customers with residential solar systems and those without,
    - potential for vandalism, and
    - potential for privatisation and monopolisation of services provided by the battery.

Some of the above barriers may be related to the perception amongst community groups that there is a lack of a national overarching narrative to engage communities in the energy transition and clearly explain their role in this process and the critical need for energy infrastructure to support it (Australian Energy Infrastructure Commissioner 2023). Community energy hubs could help to shape and communicate this narrative at a grassroots level.

5.3 De-risking of income volatility and asset operation

Community groups are often not well equipped to take on the risk associated with unpredictable project revenue streams and ongoing operation of energy assets. Utilising the resulting asset to participate in the energy market involves exposure to the volatility of wholesale electricity prices, which introduces uncertainty that can impact on the ability to secure financing for a project. Projects are typically exposed to the full volatility of the market, where utility-scale assets are expected to access earnings protections under the Expanded Capacity Investment Scheme. Trading 'merchant' also requires registration with AEMO as a market participant, which carries with it a host of financial and legal obligations. It is therefore beneficial to partner with an entity with an understanding of the market and experience managing the associated commercial risk administering the operation of the asset. If the community wants to relinquish any risk associated with the project, it can offer full ownership to a commercial partner in exchange for the opportunity to realise benefits from the project in other ways (e.g. the model adopted by Renewable Newstead through its partnership with Flow Power).

Securing an off-taker for electricity generated by the project through a PPA is another way of providing a greater degree of revenue certainty to assist with securing financing. However, as discussed above, this option is generally more limited for community scale projects as it would likely require co-location with a consumer that has an appropriate electricity demand profile and who is willing to accept an adequately high electricity price to make the project viable.

First Nations energy ownership in Canada

Canada's First Nations, Métis, and Inuit have achieved world-leading rates of energy asset ownership. Clean energy projects with levels of Indigenous community partnership boast a total capacity of 19,516 MW accounting for almost 20% of Canadian power production infrastructure (Henderson and Sanders 2017). In Canada, Indigenous ownership occurs across all energy technology types, including transmission, with projects comprising hydro (57%), wind (23%), solar (12%), bioenergy (7%), and a small number of other sources (ICE 2020). Projects span all asset sizes but are more commonly utility-scale rather than community-scale projects.

While these successes are naturally a beacon for what Australia might hope to achieve over time, they build from foundational land rights and other enablers that are manifestly less available to First Nations in Australia. Canadian native title was first recognised in 1888, and Federal and Provincial policies over decades have sought to strengthen First Nations, Métis, and Inuit economic opportunity and participation. This context is relevant as we seek to understand what can be readily transferred and achieved at scale in Australia under today's legal and policy settings. We are eager to see Australia make up for lost time.

Indigenous Clean Energy, Canada

The Indigenous Clean Energy (ICE) Social Enterprise has overseen the proliferation of projects taken forward with Indigenous equity holders since 2000.

After the first groundbreaking projects demonstrated the opportunity, emphasis shifted from 2005 to 2015 to capacity building and the development of the 20/20 Catalyst Program, a knowledge and capacity building program, fostering grassroots technical, business, and managerial competencies within communities. This program, combined with government grants for renewable projects, has supported around 30% growth in Indigenous community energy projects in Canada since 2017. Around 200 renewable projects, sized 1 MW and larger are now in operation, alongside 1,700-and 2,100 'micro or small renewable energy systems' below 1 MW (ICE 2020). ICE has more recently focussed its considerable capability on the expansion of large-scale renewable projects as well as the development of renewable projects in remote and Northern communities (ICE 2022).

A 2022 ICE report[29] found that the 2107-2507 Indigenous-led clean energy projects across Canada led to CAD 1.492 billion in estimated Indigenous employment and contracting income over 10 years and CAD 295 million in annual returns to the communities in 2020 (ICE 2020).

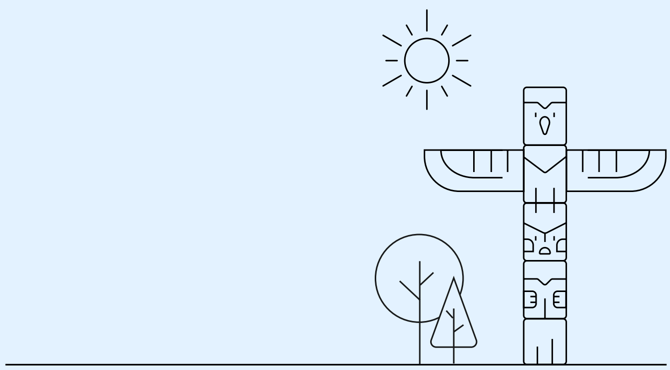
Henderson and Sanders (2017) found that the average return on investment (ROI) for Indigenous renewable energy projects in Canada was 14% for projects completed before 2014. For projects undertaken from 2014 to the current period, the average ROI has decreased to 12%, with an outlook closer to 10%. Today, Indigenous developers typically contribute between 10-15% of the total capital needed for projects, with other participants and capital providers making up the remainder. It is common for Indigenous communities to own about 25% of clean energy projects. According to a report by Henderson and Sanders (2017), Indigenous communities have made energy equity investments totalling CAD 1.8 billion.

Key enabling conditions:

The success of Canadian Indigenous energy groups builds from broader economic and social empowerment. This level of empowerment, while incomplete, is the sum of positive historical and legal recognition and coordinated action by policy makers and Indigenous groups and is self-reinforcing.

Historical and Legal Precedent for empowerment:

Indigenous communities in Canada have held native title for over a century, strengthened by legal precedents established over the past three decades. In the early 2000s, several landmark cases, including the settlement between the Northern Cree Nation and the province of Quebec, established that Indigenous communities would receive compensation for projects on their land. Accordingly, project developers have been motivated to involve Canadian Indigenous groups, which has strengthened community access to economic participation, growth in skills and wealth for further community-driven investment. Today there is broad and enduring political and social will for supporting policies.



29. The report did not take into account the economic impact of early-stage development or the multiplier effects associated with increased economic activity in consumption expenditure and investment due to higher employment and investment income, household saving and community energy and efficiency savings, and social reinvestment of project earnings.

Multifaceted Government Policy:

Federal and Provincial policies have been comprehensive in alleviating frictions in the development of Indigenous energy projects. The federal government has provided consistent support throughout the development chain through capacity building programs, small and medium-sized grants for project pre-feasibility[30], de-risking loans for project equity[31], and directed grant programs to provide energy security for remote communities.[32] Provincial governments have followed suit with complementary grant and credit de-risking programs[33], and equity arrangements to encourage the participation of Indigenous communities.[34] Several provincial utilities have either explicit or implicit requirements and programs that grant preferential generation network access through PPAs to partially Indigenous-owned projects[35].

These arrangements de-risk project income and enhance capital accumulation for Indigenous groups. Along with Federal programs, these efforts have not only advanced capacity building but also contributed to self-determination, and the social and economic empowerment of Indigenous energy sectors in Canada.

Place-based capacity building and wider knowledge sharing:

ICE has been instrumental in rolling-out training, preparing trusted reference materials and taking a network-based, community-driven approach to capacity building. Additionally, ICE has developed an online hub[36] that hosts thousands of entries and examples as well as a lively community of experts, mentors and community members engaged in active information exchange. This capacity building effort is often coordinated with government support, as exemplified by the Catalyst 20/20 program. In this program, members, after acquiring project development skills, gain access to project grants for stage-gated implementation.[37]

Inuit Village of Salluit, the second northernmost Inuit community in Quebec, Canada.

30. NRCan's Clean Energy for Rural and Remote Communities (CERRC) has been an important policy replacing Indigenous communities' reliance on diesel. The CERRC program was allocated $220 Million over 8 years to reduce diesel reliance for heat and power in Indigenous and remote communities. The program has supported 111 projects nationally, including capacity building initiatives, large capital projects, innovation projects, and bioheat projects.

31. The Canada Infrastructure Bank, established in 2017, provides loan guarantees and loans (marginally above sovereign rate), to Indigenous communities to cover equity positions in new projects. Please see https://cib-bic.ca/en/work-with-us/indigenous-infra/.

32. See https://natural-resources.canada.ca/reducingdiesel.

33. Canadian Indigenous communities who are land rich but sometimes collateral-poor due to the Indian Act have benefited from increased access to capital due to provincial government de-risking mechanisms such as loan guarantees (Ontario Financing Authority 2024), funds, and capital grant programs.

34. BC has set up the First Nations Clean Energy Business Fund to encourage participation from Indigenous communities in the clean energy industry. This initiative offers capacity and equity funding through agreements between the B.C. Government and selected applicants. Moreover, it includes revenue-sharing arrangements with eligible First Nations groups, detailing the share of income from developments that will be allocated to the respective Indigenous group (Thorburn et al. 2019).

35. Provincial procurement programs for independent power production, which provided returns for Indigenous participation, have led to a high number of medium-large Indigenous renewable power projects being established across British Columbia (BC), Ontario, and Quebec. Ontario's Green Energy and Green Economy Act incorporated measures to support procurement, such as an Aboriginal Price Adder for Power Purchase Agreements, financial mechanisms like the securitisation of Indigenous equity investments in renewable energy projects over several years and encouraged the development of small-scale renewable energy initiatives via feed-in tariff contracts.

36. See https://www.icenet.work/home

37. See https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/reduce-emissions/reducing-reliance-diesel/indigenous-off-diesel-initiative/iodi-cohort-1.html

6. Acronyms and definitions

AEMO	Australian Energy Market Operator
ACECIA	Australian Community Energy Collective Impact Assessment
ARENA	Australian Renewable Energy Agency
CAD	Canadian Dollar
CEUF	Community Energy Upgrades Fund
DER	Distributed Energy Resources
DNSP	Distributed Network Service Providers
FNCEN	First Nations Clean Energy Network
FCAS	Frequency Control Ancillary Services
ICE	Indigenous Clean Energy Social Enterprise
LCOE	Levelised Costs of energy
MCI	Manufacturing, Construction, and Installation
NSCAS	Network Support and Control Ancillary Services
O&M	Operation and Maintenance
PV	Photovoltaic
REGO	Renewable Electricity Guarantee of Origin
ROI	Return on Investment
VDO	Victorian Default Offer
VPP	Virtual Power Plants

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8. Appendix

Appendix A – Community battery cost estimation

A.1 - CAPEX ESTIMATION

In forming an estimation for CAPEX costs, we profiled 17 different community batteries from around the world across different sizes (108.94–10,000 kWh) and durations (1, 2, 4 hours). These cost estimates were taken from research papers, Bloomberg, CSIRO, and AMEO. The costs were split across 11 different dimensions (see below) and provided an estimate for turnkey community battery projects. For Australian-specific costs, we profiled three projects: the Yarra Community Energy Battery, and feasibility studies conducted by Totally Renewable Yackandandah[38], Phillip Island Neighbourhood Batteries[39], and Apollo Bay Community Battery.[40]

CATEGORY		DESCRIPTION	YARRA COMMUNITY	TRY - MICROGRID		PHILIPP ISLAND NEIGHBOURHOOD BATTERIES				APOLLO BAY COMMUNITY BATTERY
				Allans Flat Site	North East Water Site	Cape Woolamai	Ventnor	Smiths Beach	Cowes	
Energy storage project cost	Fully installed energy storage system cost	Battery Rack, Balance of System, Energy Management System, Power Conversion System, Transformer, Expenses, System Integrator Margin, Procurement and Construction, Grid Connection	$1,100/kWh	$432/kWh	$432/kWh	$2,100/kWh	$2,800/kWh	$3,100/kWh	$4,900/kWh	$993-1,830/kWh
		Developer Overhead								
		Developer Margin								

38. Please see https://totallyrenewableyack.org.au/kookaburra/wp-content/uploads/2022/02/211001_TRY.Yackandandah-Micro-Grid-Feas.Report.PUBLIC.1-Oct.2021.pdf
39. Please see https://www.energy.vic.gov.au/__data/assets/pdf_file/0021/620067/energy-innovation-co-operative-phillip-island-neighbourhood-battery-feasibility-study.pdf
40. Please see https://www.energy.vic.gov.au/__data/assets/pdf_file/0015/620061/apollo-bay-neighbourhood-battery-feasibility-study.pdf

A.2 – DNSP TARIFFS

A comparison of community and neighbourhood DNSP battery tariffs was undertaken. The most favourable, Endeavour, was use as a representative tariff to show the best case scenario.

DNSP		Fixed	Peak	Shoulder	Solar Soak	Off-Peak
	Units	c/day	c/kWh	c/kWh	c/kWh	c/kWh
Endeavour[41]	Time		16:00-20:00	NA	10:00-14:00	All other time
	Fixed	145				
	Import		12.611 (HS), 4.927 (LS)	0	0	1.54
	Export		-11.036 (HS), -3.37 (LS)	0	0	0
United Energy[42]	Time		16:00-21:00	NA	10:00-15:00	All other time
	Fixed	45				
	Import		-1.5		25	0
	Export		0		-1	0
Jemena[43]	Time		15:00-21:00	NA	10:00-15:00	
	Fixed		0.082537068			
	Import		4.502		-1.5	0
	Export		-1.5			
Essential Energy[44]	Time		7:00-9:00, 17:00-20:00	9:00-17:00, 20:00-22:00	NA	
	Fixed	0.165				
	Import		5.3527	4.3939		2.9049
	Export					
CitiPower, Powercor and United Energy[45]	Time		16:00-21:00	NA	10:00-15:00	
	Fixed		45			
	Import		25		-1.5	0
	Export		-1		0	0

41. Please see https://www.aer.gov.au/documents/endeavour-energy-revised-proposal-023-scs-main-indicative-price-schedule-november-2023-0
42. Please see https://media.powercor.com.au/wp-content/uploads/2022/07/04103342/220701_Community-Battery-Trial-Tariff-factsheet.pdf
43. Please see https://www.jemena.com.au/electricity/jemena-electricity-network/network-information/trial-tarrifs/
44. Please see https://ehq-production-australia.s3.ap-southeast-2.amazonaws.com/baad6178e0aa62050152da2bb4807c95c75930bb/original/1662080522/deb298f24905a7ebdcfaff3fc39dcb2d_Attachment_1_-_2024-29_TSS_-_Indicative_NUoS_Pricing_Schedule.pdf?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIA4KKNQAKIOR7VAOP4%2F20240516%2Fap-southeast-2%2Fs3%2Faws4_request&X-Amz-Date=20240516T064523Z&X-Amz-Expires=300&X-Amz-SignedHeaders=host&X-Amz-Signature=07cc79b7f20e88f6088cac638ced2dd2382c2b6b4a15d8f14b4282b9516b7ff2
45. Please see https://www.energy.vic.gov.au/__data/assets/pdf_file/0015/620070/apd-projects-clarkefield-zero-carbon-community-battery-feasibility-study.pdf

A.3 OPEX

We estimated operating costs in the simulation based on Yarra Energy Foundation's stated in their final report.[46]

As quoted from the report on page 29:

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

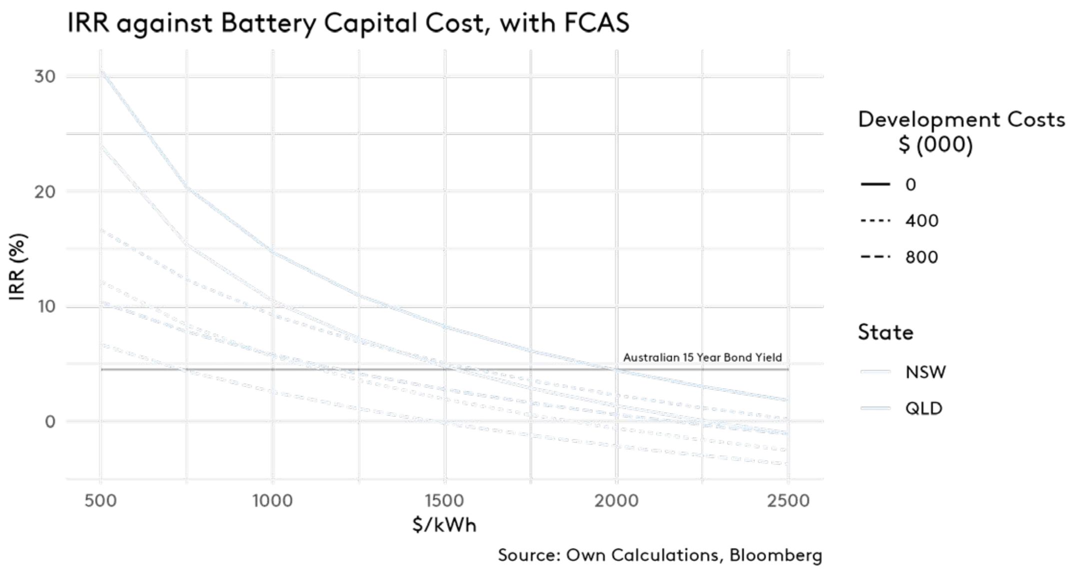
The estimate includes:

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

A.4 CHANGES IN DEVELOPMENT COST AND CAPEX

Simulations were run for different development costs and change CAPEX costs to see the economic potential in NSW and QLD.

FIGURE 13: CHANGE IN IRR OF A REFERENCE COMMUNITY BATTERY PROJECT GIVEN DIFFERENT BATTERY CAPITAL COSTS FOR NSW AND QLD. DEVELOPMENT COSTS VARY BETWEEN 0, 400,000, AND $800,000. REVENUES INCLUDE FCAS PARTICIPATION.



46. Please see https://www.yef.org.au/app/uploads/2022/11/Yarra-Energy-Foundation-NBI1-Final-Report.pdf

Apendix B - Overview of grid management benefits of community energy

SCALE	TECHNOLOGY	BENEFITS/IMPACTS
Behind-the-meter	Rooftop solar, home batteries, energy efficiency improvements, resource sharing and microgrids	The benefits of behind-the-meter generation, storage, and other peak shaving measures directly correlate with the extent of self-consumption and behavioural changes these technologies enable. When self-consumption levels are low and electricity exports are high, these technologies may have a limited beneficial impact, and in some cases a negative impact, on the operation of the adjoining grid. Conversely, high self-consumption levels can provide system benefits, for example, by reducing the level of demand needed to be met by grid-supplied electricity during peak periods. However, research suggests that this sort of behaviour is rarely co-optimised with network providers, as this requires network support agreements that network service providers can have low economic incentives to pursue (Domenech, De Corato, and Mancarella 2024).
Community-scale	Wind and venue rooftop solar	Community-scale projects might better align with electricity demand in a particular area and reduce or replace the need for costly improvements and expansions of the local network. Additionally, they can provide pockets of reliability during times when the grid is down and help maintain voltage stability (Hain et al. 2005).
	Community batteries	Community batteries can provide essential support for rooftop solar integration and enhance the flexibility of network management when well matched to local grid conditions. Through a combination of active and reactive power management, community batteries can address voltage regulation issues, mitigate power losses, and contribute to grid resilience. **Solar Hosting Support:** Community batteries significantly enhance network voltage management through their ability to adjust active or reactive power. This capability is vital as electricity typically flows from higher- to lower-voltage areas, necessitating power injection at varying voltages along a network. Batteries absorb active power, which is essential for charging, and reactive power, which balances rooftop solar output. **Load Shifting:** By storing excess energy for later use, community batteries help avoid potential curtailment due to voltage or transformer limitations, optimising energy distribution. **Grid Resilience:** In the face of sudden demand surges or supply drops, community batteries provide rapid response capacity, stabilising the grid during unforeseen events. **Virtual Transmission in Rural Areas:** Rural communities, often reliant on a single distribution or transmission line, face challenges with system voltage and thermal constraints. Strategically placing a battery at the user end of the transmission line can reinforce the line by storing excess energy, enabling a 'ride through' with a local energy source during low-capacity periods. Such batteries can also enhance management of power system constraints, making them less frequent.. **Peak Network Reduction:** Dispatching stored energy during periods of peak demand reduces the need for upgrades to transmission and distribution networks, highlighting the strategic economic and technical value of local batteries. Some research suggests that community batteries smooth peak power flows more effectively than individual residential batteries, as they can optimise for the most extreme collective demand and solar peaks rather than solving for household level patterns (Shaw et al. 2020; Fthenakis, Mason, and Zweibel 2009; Hain et al. 2005).

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