Project Report

Yackandandah Microgrid Development Trial

October 2018 – May 2021

Thomas Edison to Henry Ford in 1931:

"We are like tenant farmers chopping down the fence around our house for fuel when we should be using Natures inexhaustible sources of energy – sun, wind and tide. …I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait until oil and coal run out before we tackle that." [1]

[1] J Newton (1987), *Uncommon Friends - Life with Thomas Edison, Henry Ford, Harvey Firestone, Alexis Carrel, and Charles Lindbergh*, 1st ed, Harcourt Brace Jovanovich

Acknowledgements

A special note of thanks to the participating residents of Yackandandah who invested in this program and withstood the testing and interruptions that resulted. This was made possible due to the State Government funding program, Microgrid Development Initiative.

Energy services specialist, Mondo, provided the needed hardware and software, project management and microgrid vision. And not forgetting the focused contributions of local installer partner, Solar Integrity.

Introduction

This document provides a snapshot of microgrid research works done in the northeast Victorian town of Yackandandah, with funding provided by the Department of Environment, Water, Land and Planning between October 2018 and May 2021. [2]

There is a broad and enduring question facing the energy sector in Australia,[3] and for our community energy group, Totally Renewable Yackandandah (TRY). Just how can we use innovative, smart and efficient management of renewable energy and electricity storage to adapt the electricity system to be more focused on an affordable, cleaner, more localised and resilient supply?

People in Yackandandah and across Australia are tackling this question in a myriad of ways, but TRY has adopted a target of transitioning to 100% renewable energy by the year 2022, and doing so by helping people use less power, and then generating, storing and using power at a local level. In this way, we seek to reduce the risks of the worst effects of climate change, save people money, and create a more resilient local supply.

This report examines efforts by TRY to resolve specific challenges in the electricity network and to do so in a way that directly benefits both the end user, and the chain of entities with responsibility to deliver safe electricity and move to a lower carbon future.

Specifically, this report considers five key questions:

1. Why complete a microgrid trial?
2. What did the microgrid trial do?
3. What was the participant experience?
4. What was learnt through the trial?
5. What do we do next?

The microgrid trial conducted in Yackandandah considers pathways to improve a particular type of electricity network – a 'single wire earth return' (SWER) which is common in rural and end-of-grid locations across Australia. A SWER uses a single conductor to connect properties to the network and completes a circuit through an earth connection.[4]

Solar Panels now appear on the roof tops of nearly 60% of buildings in Yackandandah. ***Photo Credit – Solar Integrity***

Why complete a microgrid trial?

Totally Renewable Yackandandah have identified microgrids as an important factor to reach 100% renewable energy. In our context, a microgrid is described as a group of

[2] DELWP (Website May 2021) https://www.energy.vic.gov.au/__data/assets/pdf_file/0026/441566/Microgrids_Factsheet.pdf

[3] AEMO (Website May 2021) Integrated Systems Plan. https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp

[4] ENA (Website May 2021) https://www.energynetworks.com.au/assets/uploads/ENA-Customer-Guide-to-Electricity-Supply1.pdf

properties cooperating with energy usage, renewable generation, storage and orchestrated management of electricity in a defined geographic location. The ability for a group of properties to operate during mains grid supply outages, or 'islandability,' is also an important performance measure. Islanding capability is a crucial consideration to achieve robust electricity supplies in future emergency events and unplanned outages, though a function currently unusual in the Australian National Energy Market.[5] Recently, using a network-scale battery (500kW/1MWh) Distribution Network Service Provider (DNSP), AusNet Services are now able to island the remote Victorian seaside town of Mallacoota, representing a very positive outcome for that fire-affected community.[6] This represents an important step change in achieving a locally resilient service.

Yackandandah had already trialled two microgrids, one starting in 2017 supported by Mondo, the second in 2018 funded by ARENA, via the University of Technology, Sydney. Both these programs focused on groups of houses bound by a single 'feeder' transformer. Though SWER lines are both common and a highly successful way of connecting isolated properties to the National Energy Market, they are challenging to adapt modern electricity supply demands and to accommodate increasing penetrations of renewable energy. Microgrid capabilities represent an important opportunity to improve the performance of SWERs by more successfully adjusting property demand (best done with loads that can be time shifted without consequence to user, eg hot water), orchestrating export from the property and considered discharge of battery charge to achieve strong outcomes for the property owner and the network.

Yackandandah's third microgrid, and the focus of this report, examines how SWER line performance can be improved with coordinated management of:

- Solar exports to the grid to manage voltage spikes, due to too much power being generated for the property to use,
- Strategic release of power from the battery to reduce the peak demand on the SWER,
- Reduced overnight hot water heating load by shifting to efficient hot water production using CO_2 heat pumps – typically timed to come on during solar generation hours.

Success with these outcomes can inform future planning of the electricity supply, and therefore affect costs for all electricity users. If we can get existing network assets to perform in a new way, it both improves the quality of electricity supply for users and avoids the need for costly network upgrades – in effect working smarter rather than bigger.

Microgrids in effect work smarter rather than bigger

What did the microgrid trial do?

The microgrid was focused on a single SWER line in Yackandandah with 32 metered households. The hardware to allow the establishment and operation of the trial are:

Nine subsidised batteries with appropriately sized solar systems including

- Batteries – LG Chem Resu or BYD,
- Selectronic SP Pro off-grid battery Inverter,
- Fronius Primo solar inverter,
- Panel types – resident choice ,

[5] Australian Energy Market Operator Website (June 2021) https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/about-the-national-electricity-market-nem

[6] AusNet Services (June 2021) https://www.ausnetservices.com.au/en/About/News-Room/News-Room-2021/Mallacoota-power-supply-strengthened-as-AusNet-installs-Gippslands-first-community-battery

- 17 Smart energy control devices – Mondo Ubi's, with CT's on inverter, supply, and various household circuits (all battery residents had an Ubi)
- 5 ReClaim Energy CO_2 hot water heat pumps

Typical Install, showing solar inverter (top left), battery inverter (top right), Ubi (bottom left) and battery (bottom right)

Efficient CO^2 heat pump

A Mondo Ubi smart energy controller, (or more technically the 'nano-grid controller'), provides the critical capability to transition the group of households from individual network-connected energy systems operating independently, to a unified group able to respond dynamically as a system. The Ubi computer is connected to the internet via either home Wi-Fi or 3G/4G, thus allowing that household's demand, generation and storage status to be shared with the microgrid operator (Mondo), and instructions issued via the 'cloud' back to the household to perform trial tasks. The Mondo Ubi also provides a web portal to view real-time performance information, both for the household and the microgrid as one whole.

TRY provided the community engagement function through the program, acting as an intermediary and facilitator between DELWP, Mondo and residents. This took the form of hosting information evenings in the start-up phase, and occasional sessions during the trial, though this later shifted to online and email communications due to COVID restrictions.

Mondo provided project management and hardware selection functions and working with a local installer Solar Integrity. The hardware was then used in the trial with schedules developed, managed and adjusted by Mondo.

Mondo Ubi Portal – Home screen

Trial activities were divided in to four key activities:

1) **Voltage control capability;**
   a. Using active and reactive power from the solar inverter to alter or improve network voltage (reducing excessive fluctuations).
2) **Reducing SWER peak demand,**
   a. Using battery discharge to reduce localised peak demand from the larger network (reducing extreme voltage peaks).
3) **Coordination of energy systems to test electricity network service capability,**
   a. Using solar inverters and battery discharge to dynamically support the network.
4) **Smart Exports,**
   a. Adjusting household exports to respond to network conditions and improve network voltage.

Originally it was anticipated the new hot water systems would also be integrated in to the microgrid functionality, but it was realised that the units were so efficient, it was more prudent to run them during the warmer part of the day. Doing this meant the load would almost always be covered by solar generation on the site, thus keeping the system simple and using energy that would otherwise be exported an low financial value.

Permission was sought from residents to adopt these interventions and a generous $7000+ financial incentive was given to both encourage purchase of the energy system, and then participate in the trial. This subsidy could not be applied in conjunction with the Solar Homes Battery subsidy.

It is worth noting at this point that the site selected was the second Yackandandah SWER line – TRY was unable to gather sufficient support on the first SWER focus area, mainly due to a combination of: existing solar residents with Victorian Premium Feed-in-Tariffs (which they would lose by joining the trial), residents preparing to sell their homes within the next 5 years, or the price of participation was considered too great.

The trial tested smart energy controllers with local generation and storage to provide benefits to households and the network

TRY Committee Reps

Mondo Ubi Chart – showing individual circuits.

What was the participant experience?

Each of the properties had different experiences and expectations of the microgrid trial, but overall people are very thankful of the ability to participate in a Government supported cooperative effort – a sentiment across the community of Yackandandah.

It has been highlighted how important the incentive payment was in helping people make a decision to purchase a battery. Most people love the idea of a battery to both reduce their reliance on fossil-fuel powered electricity but also to have a sense of resilience when the power goes out. This is particularly poignant for this group of residents as they live on small land holdings and thus use electricity to pump water for domestic, stock and firefighting purposes.

One participating resident described this resilience capability thus:

The battery resilience "…has quite frankly been gold for us in terms of how secure we feel during an emergency."

There were recurring themes shared by all residents during one-on-one interviews:

- Residents are protective of the reserve power in their battery, particularly if there is outage threats – during storm events or fire weather.
- Clear communication from the microgrid operator is critical, so the resident knows what is happening with their energy system – and this also communicated as reports (perhaps monthly) or via the (Ubi) web portal. Some residents felt TRY and Mondo were slow in communicating planned trial activities, and more importantly progressively reporting on learnings. This point underscores how important an open platform is between a microgrid operator and participants – trial activities must be available, clear and up to date.
- Mobile phone text messages were considered the most reliable means of communicating time-critical or important messages. Mondo uses a text platform called *Whispir.*
- Residents did not want to be bothered with regular messaging, but would rather know they have somewhere to go to find out how their energy system was being used during microgrid trial activities.

Overall, residents were comfortable with the trial regime, but were most sensitive to one part of the trial where batteries were fully discharged late afternoon (as part of peak load management activities). Once it was understood this was deliberate there was a higher acceptance, noting it was only for two weeks.

This final point identifies a clear creative tension in the development of systems to use privately owned energy systems for the benefit of the network and market systems. People understand the value of cooperation, but equally are cautious to see their expensive asset utilised for external benefit, especially when an outage threatens.

Having said that, most of the trial customers have elected to participate in an expansion of this coordination of private energy systems (referred to as aggregation by the energy industry). This follow-up program, titled Project EDGE, will use much of the learning from the microgrid trial to create a Hume Region (Victoria) wide Virtual Power Plant. This program seeks to establish mechanisms to create a more dynamic two-way energy network and marketplace – taking care that everyone who participates is appropriately rewarded.[7]

Participants were appreciative of the trial but were protective of their system's functions for providing them with resilience during unplanned network disruptions

What was learnt through the trial?

A key learning from the trial is that residents save the greatest amount by the addition of the solar system, even given the presence of lower export limits (3.5kW typical on a SWER line). The table below provides averages for the 9 solar battery sites, plus one solar and heat pump only resident. This finding is consistent with the larger group of customers in the Yackandandah area with Ubi's, where it is found that most savings are obtained from solar generation.

	Total Savings from Solar	**Total Savings from Battery**	**Total Savings**
Total	$12,752	$3240	$15,992

Table showing 12 months of savings comparing solar and battery values.

Predictably there was significant variance between properties due to differing energy use habits. The biggest savings were obtained by the biggest energy users and favoured those who could use daytime generation for heating water, water pumps, and room conditioning.

[7] Mondo (May 2021) https://mondo.com.au/edge

The greatest savings were also made by those who had a combination of solar panels, a hot water heat pump and a battery. An interesting finding is that where a resident had a 5kW solar system they would save more money installing a heat pump than a 11kWh battery (saving $640 for a heat pump, versus $365 for the battery).

Considering an 11kWh battery system can cost approx. $15,000 and a heat pump costs approx. $2,500 to $5,000, a heat pump will offer customers a much better return on investment compared to a battery. It must be noted a battery offers a much greater flexibility, since you can do a wide range of things with stored electricity as compared to a hot water system. And of especial note is the ability to have an islanded property to withstand outages and emergencies, something highlighted as a critical value.

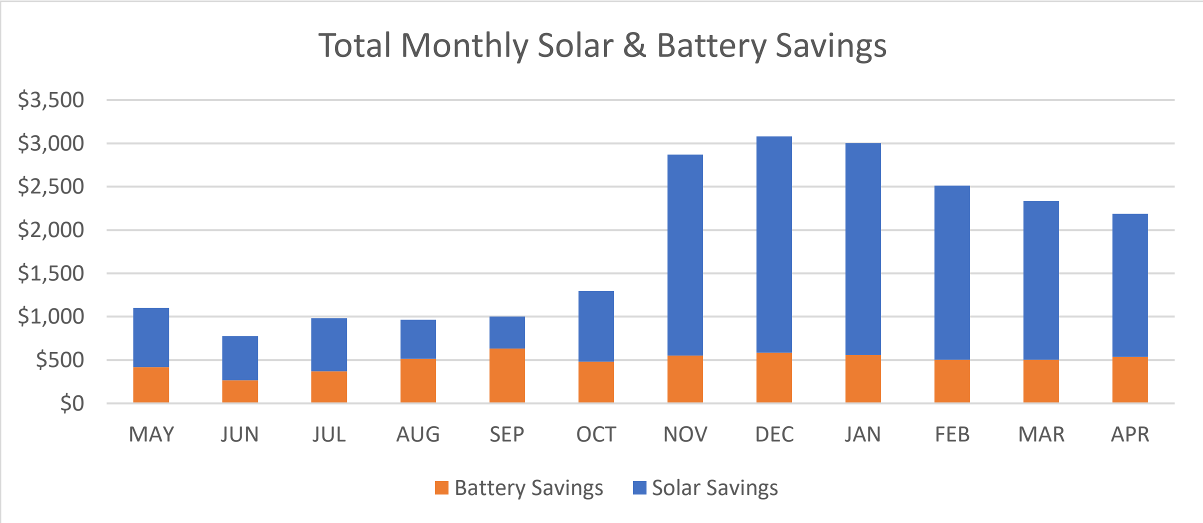
The program also provided a detailed technical analysis of microgrid trial findings. This has been provided to DELWP, and to participants upon request. In short, the Mondo Ubi proved highly successful in each of the trial settings;

1. Inverter active and reactive power release (voltage control),
2. Battery charge and discharge scheduling (reducing SWER line peaks),
3. Scheduling that can respond to network signals (DNSP service capability),
4. Flexible export control (smart exports).

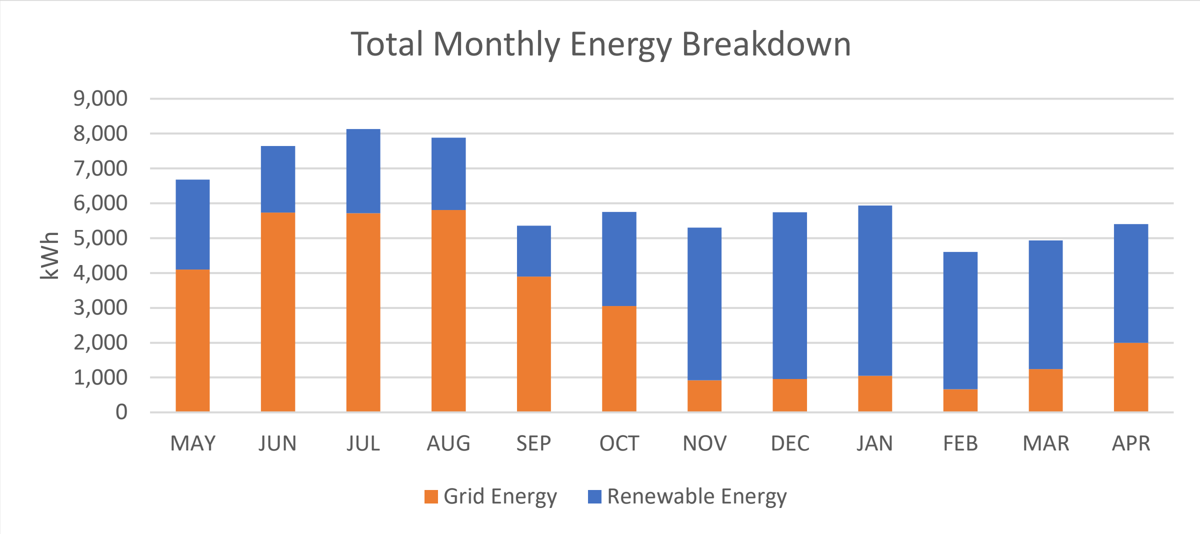
Each of these are critical capabilities as we activate new smart ways of managing the grid. Our learning was that this capability is best managed in cooperation with the DNSP (in network-connected microgrids), where they can provide real-time insights and responses to network performance – something still requiring regulatory and confidentiality fine tuning. Clearly the scope for a new dynamic energy system is before us, and could be leveraged in virtual power plant programs across Australia.

Smart management of household systems is possible and beneficial to our electricity network

Monthly Savings for 10 properties, showing proportion between solar versus batteries. (May 2020 to April 2021)



Monthly demand breakdown (Comparing power from the grid, versus power generated/stored onsite) 10 sites (May 2020 to April 2021)



What do we do next?

It is hard to say the learnings on the microgrid trial have started and finished. Rather the energy sector is on a continuing learning trajectory as it progressively migrates from an energy system based on centralised generation, with a focus on coal and gas, to one where renewable energy, with storage dominates the electricity grid – along with smart management of performance and data between users, the electricity network and the electricity market.

As referenced previously, Project EDGE is a next major step for the people of Yackandandah (and Beechworth). The first phase of the ARENA funded program is now underway in these two towns and will soon expand right across the Hume region. Quite directly, the learning from the microgrid trial is feeding in to the EDGE program which includes the Australian Energy Market Operator and AusNet Services as project partners. This includes the ability to manage inverter outputs and using scripted, centralised and mutually beneficial control.

Critically, learning from residents in this trial, all contributors to the microgrid control must ensure they clearly and openly communicate activities, learnings and changes. In this way confidence is built that a shared energy system can operate fairly for all those participating.

More generally in Yackandandah, we now enjoy solar installation densities at almost 60% of all network connections. Grant funds have been received by Totally Renewable Yackandandah, via the Federal Regional and Remote Community Reliability Fund – Microgrids[8] for a feasibility study. This analysis will determine the sizing and siting requirements to achieve 100% renewable energy in Yackandandah, with a critical focus on scaled generation and storage. This will also examine the expansion of microgrid programs, since they offer such direct strength to each individual property, particularly noting the cost saving from solar and hot water installations, and the flexibility and resilience offered by batteries – plus the performance enhancement for the electricity network.

In early July 2021, Yackandandah-born community energy service provider, Indigo Power, with Totally Renewable Yackandandah is preparing to install a community owned, retail battery on to an old sawmill. An exciting expansion as TRY drives toward a 100% renewable energy future – and made possible through substantial contributions from private donors, DELWPs New Energy Jobs Fund and Sustainability Victoria.

[8] Australian Government (May 2021) https://www.energy.gov.au/government-priorities/energy-programs/regional-and-remote-communities-reliability-fund

Exciting times indeed!

Onwards to 100% renewable energy using microgrids and community-scale generation and storage!

Yackandandah Main Street. Photo Credit: Grigg Media