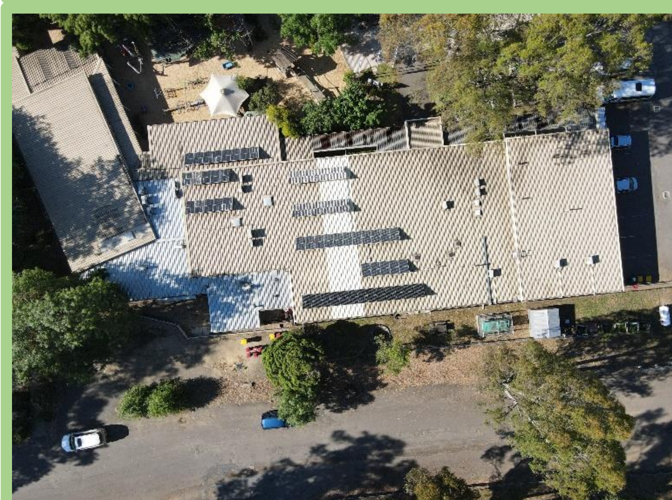
2030Yea Community Batteries Report



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Cover image credits: Yasin Gulec, Drone Surveyor, Strath Creek, Vic

Top row L to R: Yea & District Memorial Hospital (Y&DMH), Yea Community Shed (Men's Shed & Pottery Studio), Yea Wetlands Discovery Centre

Bottom row L to R: Yea Library and Customer Service, with Yea and District Children's Centre (Murrindindi shire Council)

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1. Project context

Yea is a regional town of more than 1600 residents (ABS), postcode 3717. It is situated in the Murrindindi Shire, within the Hume region, around 100 km to the north-east of Melbourne. Yea supports a vibrant tourism and service industries.

The 2030Yea Community Energy Group formed in 2020 with the goal of ensuring Yea has totally renewable energy sources by 2030 by encouraging energy efficiency, increasing solar PV and battery uptake and planning for community energy. Community interest reflected a high uptake of residential and commercial solar PV in the district. As of December 2021, 40.9% of buildings in the 3717 postcode have solar PV installed.

There has already been work done at a local and regional level exploring options to meet these goals. In its 2021 report, Opportunities for Community Energy in Yea, the Community Power Agency assessed the benefits of solar over other renewable resources and the benefits of a community battery over household batteries. The report concluded that a community battery presented a moderately feasible technology option that warranted further exploration. The Hume Renewable Energy Roadmap outlined opportunities for community energy groups to develop distributed energy resources. The push for community energy is also supported by the Federal Member for Indi's Local Power Plan. 2030Yea has also noted that it is part of a regional movement travelling down the community energy path.

Report goals

- Assess the compatibility of community batteries with respect to 2030Yea's stated goals
- Provide an estimate of Yea's current solar capacity and electricity demand requirements
- Support 2030Yea in deciding whether to pursue community batteries further

Community batteries and their Benefits

Community batteries provide storage for excess locally generated solar (and theoretically wind or biomass) electricity, making renewable energy more flexible and economically viable especially where the costs of individual household storage are prohibitive. Community batteries typically provide storage for around 100 customers, with the batteries ranging from 100kW to 5MW in size. Studies have shown that community batteries can reduce the total storage required to meet the same levels of aggregate demand by around one third.

A community battery is also a distributed energy resource (DER) – that is an energy generation or storage system, such as rooftop solar, installed close to the usage location. This is distinct from traditional, centralised generation which currently produces electricity mostly from fossil fuels. In a centralised grid, energy flows from the generators to the consumers. With DER, energy can flow both ways, providing in some circumstances the possibility of income as well as savings.

Community batteries can also manage the export of excess, local electricity generation to the grid better than household battery systems. This results in fewer voltage and frequency control issues that result from load-generation imbalances. Grid management becomes easier i.e. cheaper for the managing/owning party.

Literature review and summary of community battery projects

With the rapid increase in decentralised solar generation and the associated demand for storage to better utilise this energy, there has been considerable funding for community battery research and projects from government agencies such as the Australian Renewable Energy Agency (ARENA) and distribution network service providers (DNSP). There have also been several successful community scale batteries already developed in Australia.

Research and projects relevant to a community battery in Yea include:

ANU Battery Integration and Storage Program (BSGIP)

This program has produced research across all areas relevant to implementing a community scale battery. Their work is summarised in the Implementing community-scale batteries report. Key work relevant to this project includes the algorithm developed to design batteries which will be utilised in this project. There is also research exploring regulatory, technical and logistical considerations, stakeholder views and cost/benefit analysis which is referenced in this report.

Grid vs Garage

This report produced by AECOM, provides a comparison of battery deployment models providing low voltage network support and other services. The report separates the services a battery can provide by the connection point. The battery services discussed are:

- Load shifting
- Consumer bill management
- Frequency stability
- Voltage support
- Reliability and backup power

Their findings when comparing different battery deployment options were:

1. There is a diversity of market and commercial benefits from battery deployment. This refers to the wide range of services that a battery can provide depending on how it is deployed.
2. Batteries deployed on the low voltage network provide greatest benefit. As the most cost effective services can be provided in this configuration.
3. Controlled batteries create additional value for the system and asset owners. A controlled battery means that it is able to respond to market signals. This can provide benefit in a number of ways. If energy prices are high, the battery can sell energy and generate income. In this situation the battery can also discharge and prevent the electricity user from having to purchase energy at high prices.

Implemented Projects

- Totally Renewable Yackandandah has developed Yack01. This is a behind-the-meter, retail facing battery. This means it is managed by an electricity retailer so only their customers will receive benefit from the battery. It is defined as behind-the-meter as it is installed on private property rather than through a separate connection to the electricity network.

- Mallacoota Battery, installed by AusNet is island-able and can provide power to the community even if the area becomes disconnected from the grid due to faults or natural disasters. This has demonstrated the technical feasibility of an island-able battery and provided AusNet with the relevant technical expertise. This is extremely beneficial to the Mallacoota community due to the vulnerability of their location at the end of the line. It is unclear whether these same benefits will be as pronounced in Yea and can outweigh the additional capital and maintenance costs.

- In Western Australia 13 community batteries have been developed in a partnership between ARENA and Synergy (electricity retailer). These batteries have reduced peak demand by up to 85%. Reports from the project indicate the importance of early community engagement. The report also noted that the findings of the project should be leveraged to develop new tariff structures and market reform.

Future Projects/Feasibility Studies

- Hepburn Shire has received funding as part of the Neighbourhood Battery Initiative (NBI) to assess the feasibility of batteries in five locations and develop a decision-making tool. This initiative may be useful for further feasibility studies and decision making regarding a community battery.

- Powercor, Citipower and United Energy are installing 40 pole-top batteries and partnering with 12 council and community energy groups working on battery feasibility studies. This is an example of a Distribution Network Service Provider (DNSP) working with community groups to explore the mutual benefits available. The DNSP can benefit through upgrade deferral. This is because batteries can manage surplus solar generation and are cheaper than network upgrades which would otherwise be required. Consumers also benefit as their solar exports do not have to be curtailed in the future. This could be a useful case study to review for negotiations with AusNet to develop a similar partnership. The network operator has also explored different tariff options to avoid the issues associated with distribution use of service (DUOS) charges

- Philip Island has a proposed battery development from Mondo and AusNet to increase reliability and the opportunity for renewables. This battery was part of AusNet's non-network solutions and can provide similar benefits in Yea through increased reliability and enabling further renewable energy uptake.

- Yarra Energy Foundation (YEF) has partnered with CitiPower to develop a "solar sponge" community battery network in Melbourne's inner suburbs. This project is another community group led project designed to demonstrate the benefits of community batteries. The project recently received funding from the Victorian Government under the NBI to determine a scalable, commercially viable model to deploy community batteries. This project has already attracted interest from private investors with additional private capital. This project will provide valuable insights into the commercial viability of community batteries to store rooftop solar and related regulatory requirements.

2. Solar Output & Energy Demand Audit

This audit provides a snapshot of the current energy requirements and resources in the Yea Region. This will assist in the investigation of the case for a community battery. This audit will outline how energy demand changes over daily to annual timescales and discuss the impact that solar is having on this. The data used was provided by AusNet Services who operate the electricity network in Yea.

Data Sources

Load Data

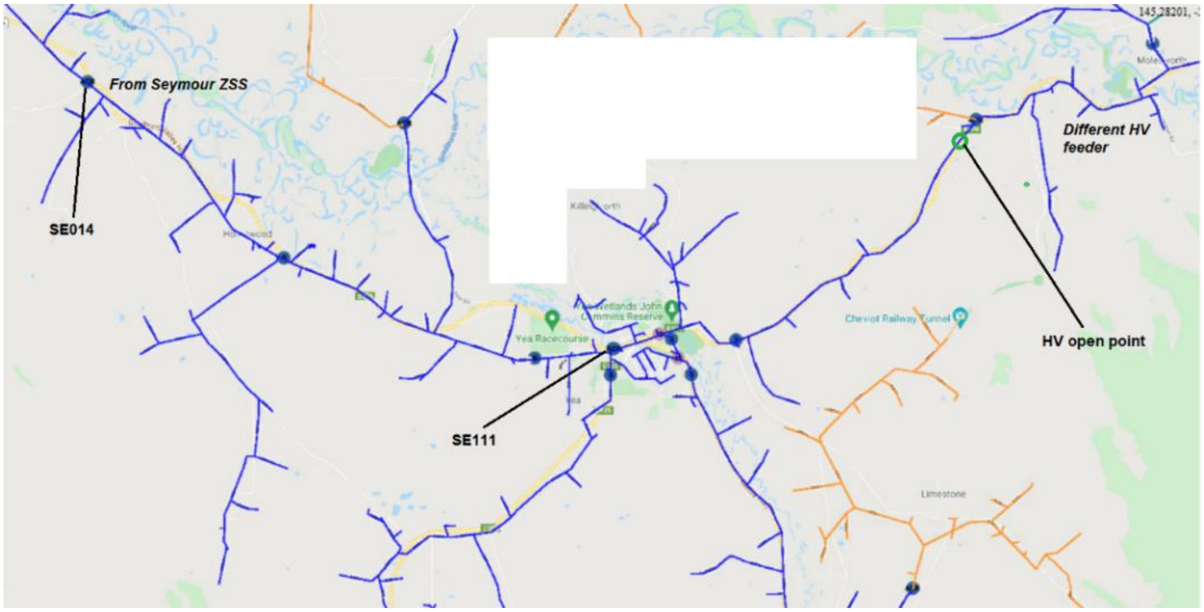

Figure 1: *Map of load data collection points*

There were two separate sites where data of the load was collected between 01/01/2018 and 30/09/2021 in 15 minute intervals. The load is the amount of power flowing through the grid at a point in time. A positive load represents a net import of energy through the switching device. Conversely a negative load means the energy produced in the area is greater than the demand resulting in a net export through the switching device. The point where load was measured was at the SE111 switching device in the centre of Yea (figure 1). The SE111 device is on the 22kV medium voltage network. The medium voltage network is typically used to transport energy over distances less than 100km between population centres. The load through the SE111 device provides an indication of the energy requirements of the entire Yea community. As the energy use must exactly match the energy generated, the load fluctuates with demand. This data is inclusive of the solar generation so as more solar is generated less energy needs to flow into Yea to meet demand and the load decreases.

In this report only 2018 load data was used. This was the only full year of data without unexplained variations or shifts. The most recent 2020 and 2021 data was impacted by a significant shift upwards of load in March 2020. From this point the load does not go negative and is consistently higher. As the cause of this could not be explained it was excluded from the analysis.

Solar Data

Figure 2: *Map of solar data collection points*

The area in Figure 2 is the area deemed to be the immediate town centre. Data for aggregated solar exports and load was provided for this area from 01/01/2019 till 31/08/2021 in 30 minute intervals. This smaller area was chosen as it represents the essential services in Yea such as the hospital, emergency services, supermarket and other main street shops. It also enables the analysis to be simplified by choosing a smaller area with the possibility to expand the area in future and apply a similar analysis procedure. Many of these building also have installed large solar arrays or plan to in the future.

Daily solar

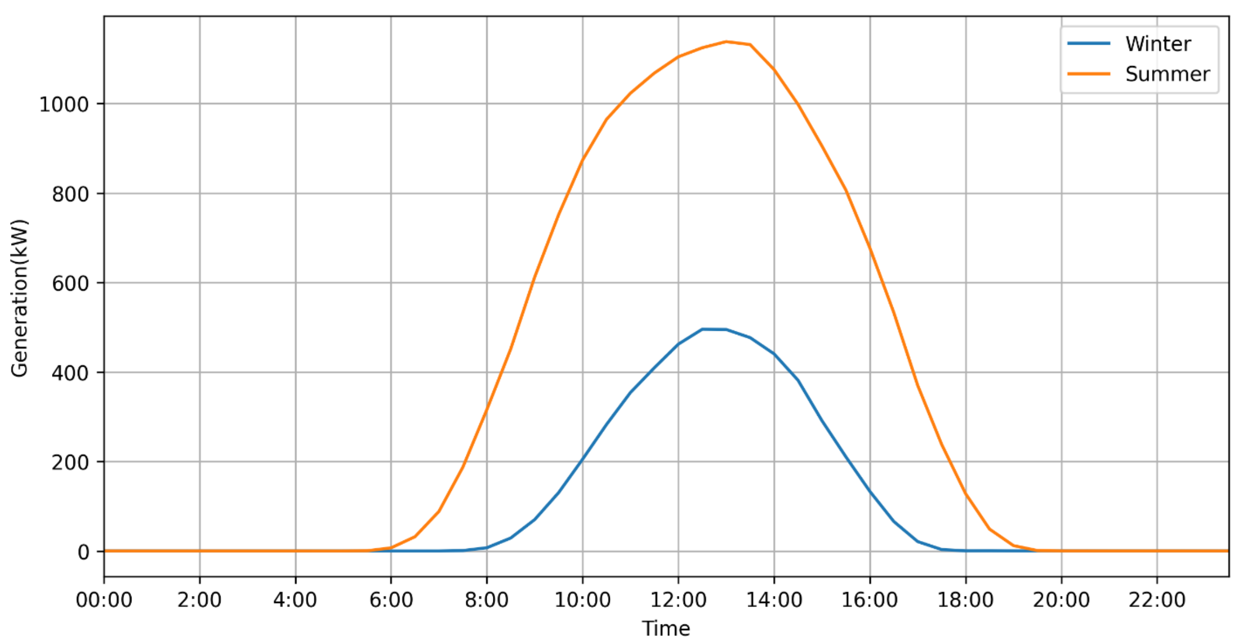

Figure 3: *The average daily solar generation produced in summer and winter months*

Figure 3 shows that peak solar generation is much larger and occurs for a much longer period in summer rather than winter. Peak solar generation occurs just after midday reaching 1150 kW in summer and 500 kW in winter.

Annual Solar

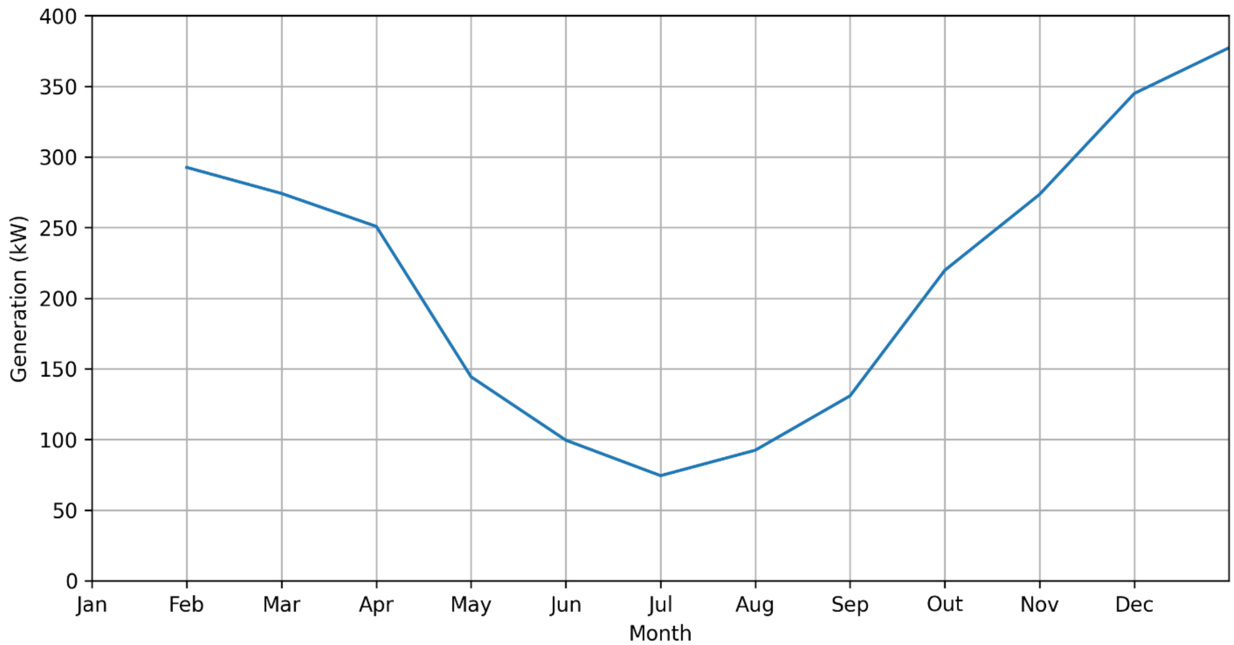

Figure 4: *Average monthly solar generation over for 2020*

Figure 4 shows the average solar generation occurring over a monthly period. This again demonstrates the differential between winter and summer generation. It is important to note that spring and autumn months still provide much greater solar generation than winter.

Solar Trends

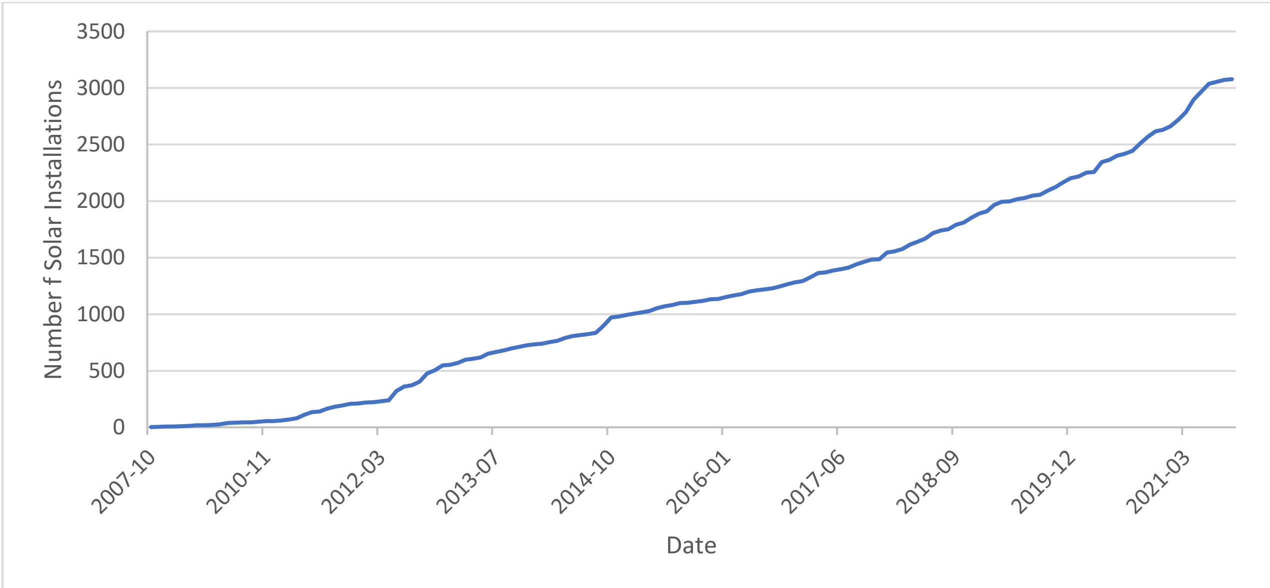

Figure 5: *The cumulative number of solar installations in the 3717 postcode since 2007.*

Figure 5 shows increasing solar installation in the Yea area. In the 12 months between August 2020 and August 2021 there were over 600 new solar installations.

Daily Load

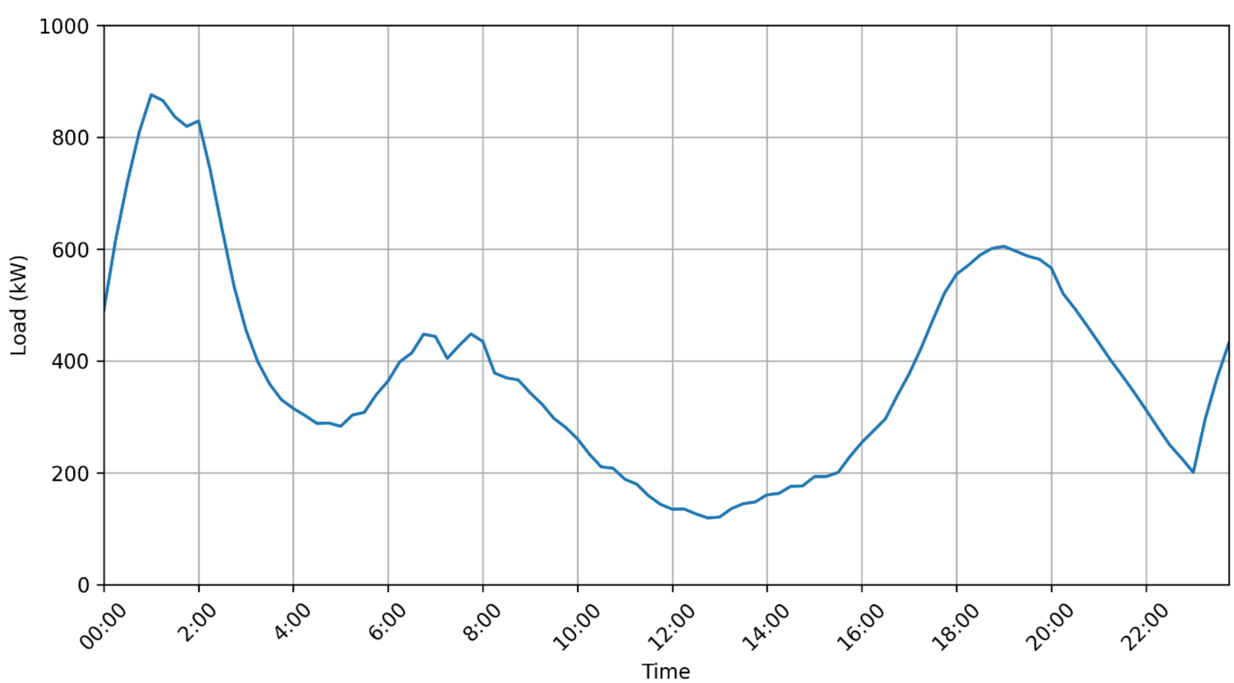

Figure 6: *The average daily load for 2018*

Figure 6 shows 3 distinct energy peaks. The largest peak is in the early hours of the morning. This peak is caused by electric hot water systems which operate on a timer to operate during off-peak electricity pricing periods. This system was designed so that the energy-intensive activity of heating water occurred during the off-peak electricity tariff periods and hot water was available for use the following morning. Due to the absence of solar generation in the evenings a larger proportion of non-renewable energy sources are used to provide energy overnight. Due to changes to network tariff structures, peak periods now only occur between 3pm and 9pm. This provides the opportunity for consumers with hot water systems to shift heating times closer to midday where they can utilise renewable solar generation to do much of the heating whilst still taking advantage of off-peak tariffs. Consumers who do not have solar installed can provide an environmental benefit by heating their water during the day. The grid is powered by a higher proportion of renewable energy during the day so transferring large energy uses during the day will result in decreased emissions.

As the hot water peak is the period of the highest energy demand, moving hot water heating to during the day would reduce the peak energy demand. If a community battery was used to provide power during an outage, reducing the peak energy demand would reduce the size of the battery necessary to meet demand.

A battery could provide benefit in this situation by charging between 12pm and 2pm and discharging between 6pm and 8pm. This would provide an environmental benefit aligned with the mission of 2030Yea as the solar energy could be utilised later in the day when there is normally a higher proportion of fossil fuel generation being used. Figure 7 demonstrates how the proportion of coal used in the grid changes diurnally. A battery can provide the ability to reduce the usage of energy generated from coal.

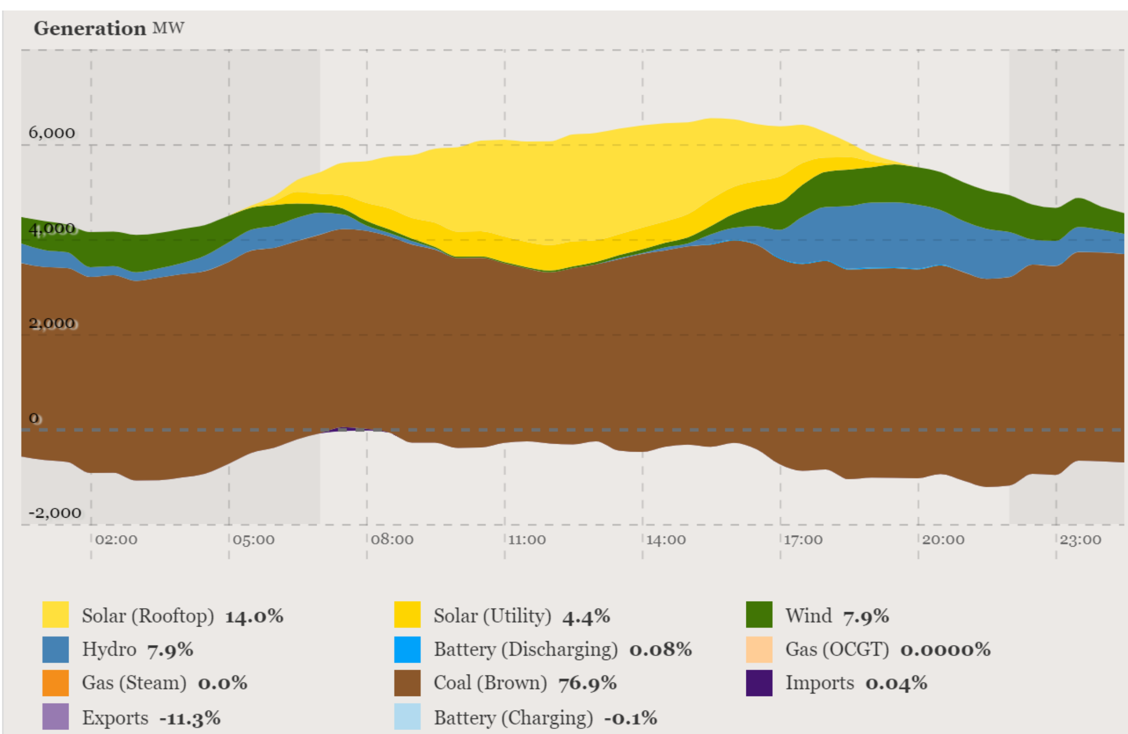

Figure 7: *Electricity generation sources over 24 hours for Victoria on 14/12/2021 (OpenNEM)*

Seasonal load

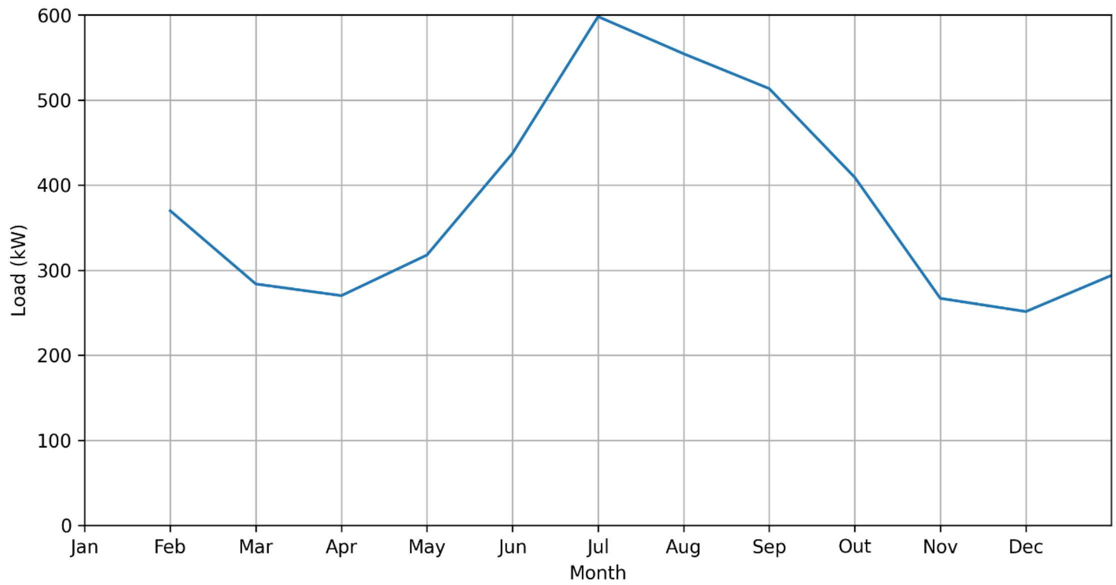

Figure 8: *The average monthly load during 2018*

From Figure 8, it is clear the highest energy loads occur in winter months. This coincides with the lowest solar outputs and increased energy consumption from heating. During the winter there is less excess solar load than in the summer months. The winter load is consistently higher than in summer so there is little use in using a battery to shift the load. The largest difference between winter and summer occurs during the early morning hot water peak. The increased energy consumption is likely due to the cooler water temperatures which have been shown to be almost 10 degrees cooler in winter. Batteries cannot provide long duration storage to balance seasonal difference is solar resources. While the average load in the winter months is higher, there can be large peaks in summer because of heatwaves and the resultant use of air conditioning. Batteries can provide benefits in both winter and summer seasons. In winter, the evening peak is higher. Batteries can be used in this situation to better utilise the solar energy that is generated during the day by storing it for use later in the evening. Stored energy in batteries can reduce the peak load. In summer, heatwaves and the increase in air-conditioning can put massive strain on the grid as the demand far exceeds normal conditions. This may become an increasing issue due to an increased contribution from solar generation which has reduced capacity under extreme heat. Batteries can alleviate some of the strain on the grid by providing spare generation capacity during peak demand periods.

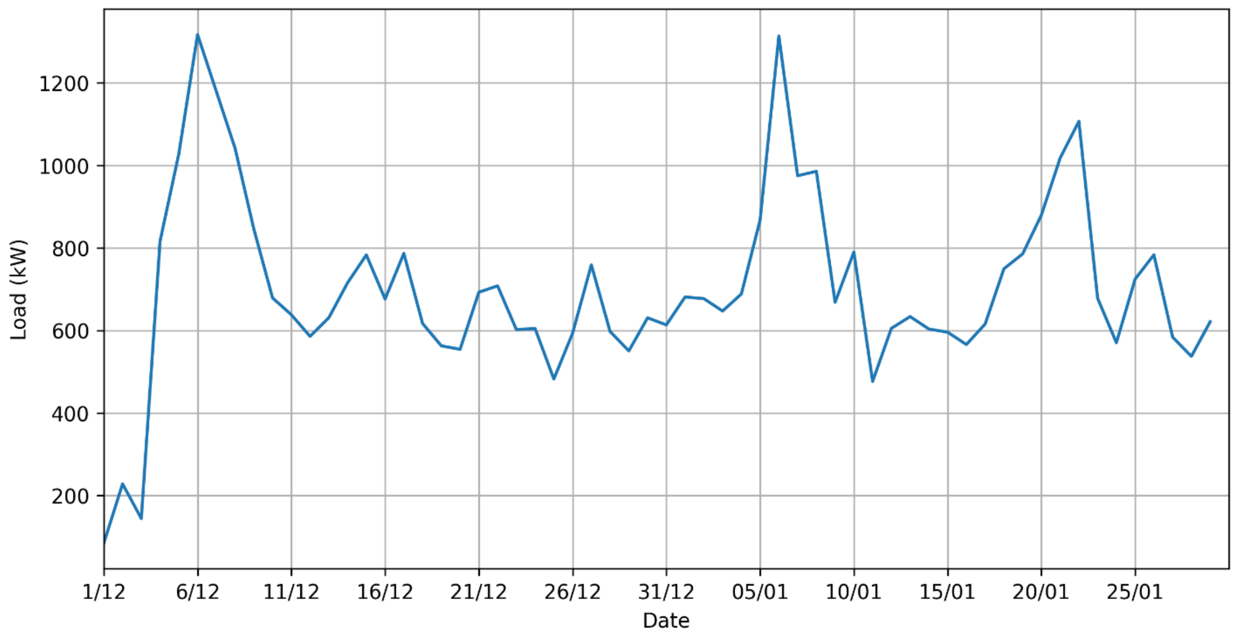

Figure 9: *The average daily load over the 2020 summer period which featured extreme heatwaves*

Annual load

Trends in annual load could not be analysed due to a shift in the data in March 2020. The source of the shift is unknown. As this may be due to changes in measuring equipment, only the data before this shift will be used in the analysis.

Maximum and minimum loads

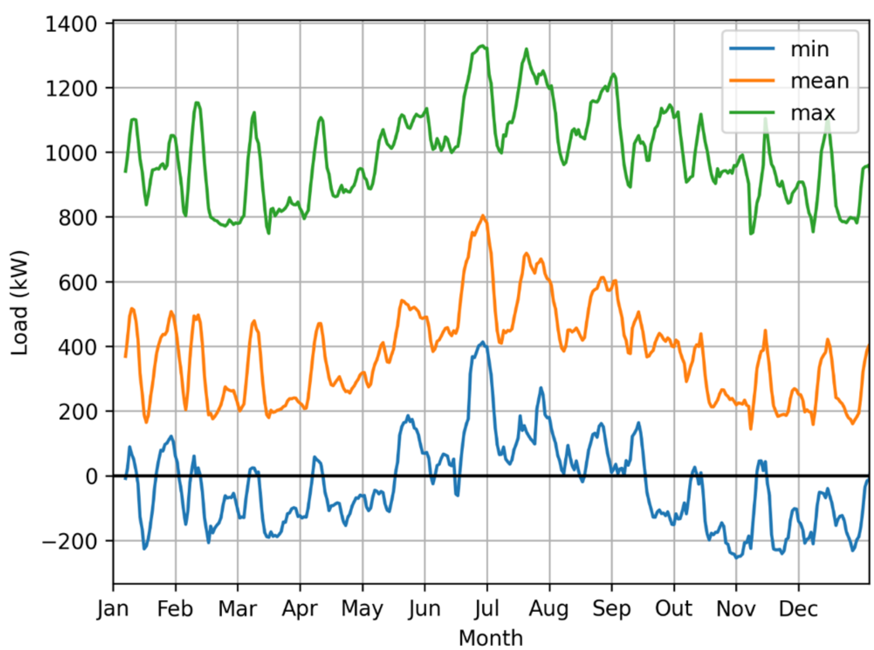

Figure 10: *A 7-day rolling average of minimum, mean and maximum loads over 2018*

Figure 9 shows the maximum, minimum and mean load over a rolling 7 day average. The rolling average means that the load is averaged over a 7 day period with the period shifting by a day for each interval. This smooths the data and minimises the impact of anomalies. This chart shows that for many of the months outside of winter the load is negative for part of the day because of exports from solar. This provides evidence to support the installation of a community battery to manage solar exports and better utilise solar generation.

Over 2018 there was 102,092 kWh of excess solar generation which averages to approximately 280 kWh per day. This is a significant amount of solar generation that the community is currently exporting which they could be storing and using locally. In winter months the daily average is only 30 kWh. In other months outside winter the daily average is over 360 kWh. Due to the lower generation in winter, it is unlikely a battery could be charged from solar alone during these months. Although it should also be noted that there has been further solar installations since 2018 and the solar generation would now be greater in all months.

LV Transformer Limits

Transformers between the low voltage (LV) and medium voltage (MV) networks have a maximum amount of power which can flow through them. In areas with a large amount of rooftop solar installed in the LV network there is the potential for the capacity of transformers to be reached. This occurs on days with high insolation and minimal demand. Ratings for each transformer in the area defined in Figure 2 (denoted by the green squares) and the corresponding amount of solar installed for each was analysed. This showed that there is no risk of capacity being reached in this area of Yea. This cannot be confirmed for residential areas as only the data for the main street area was accessed.

3. Battery Options

To provide further detail on the wide range of benefits community batteries can provide, three different ways of operating a battery will be explored.

Scenario 1: Minimise imports (emissions)

This scenario will maximise the use of locally generated energy. Locally generated energy is assumed to be all from solar and create no emissions. Energy generated from the grid comes from a greater proportion of fossil fuel generation. Over the past year only 33.6% of energy in Victoria came from renewables, with the rest produced by fossil fuels. To reduce energy emissions in Yea, imports from the grid must be minimized. To do so, the battery will store all solar energy that is surplus to the local demand so it can be utilized at times of lower generation and minimise the need for export.

Scenario 2: Maximise cost savings or profits

There are a number of ways that a battery can produce a financial benefit to the community.

1. Utilise more solar energy

As the feed-in-tariff is less than the energy price, it is cheaper to use the community's own rooftop solar than export it to the grid. A battery can increase the utilisation of solar by storing any energy that exceeds demand and would be exported. This energy could then be used in the evening when the demand for energy is higher than solar generation. This will result in cost savings as consumers will be able to utilise cheap solar energy for longer.

2. Energy arbitrage

On the east coast of Australia, energy is bought and sold on the National Electricity Market (NEM). As prices fluctuate throughout the day, batteries can buy energy at low prices and sell it at high prices. This is known as arbitrage and generally will mean that batteries will charge from solar during the day when energy prices are cheaper and discharge in the evening when demand and prices are higher. This requires the battery to register as a market participant which can be costly and requires strict regulations to be met.

3. Frequency Control and Ancillary Services (FCAS)

Due to faults and outages on the network sudden changes in the load or generation can occur. This can cause a mismatch between generation and demand which can cause outages and in the worst case an entire network blackout. To mitigate the impacts of this, electricity generators can provide FCAS. For a battery FCAS takes the form of rapid discharging to provide additional generation and stabilise the grid. Generators are paid for being available to provide these services which are administered through the NEM. Connecting to the NEM is costly with strict regulations but provides the best opportunity to generate income.

4. Network Support Services

There are a number of other services that the battery can deliver which provides value to network operators yet cannot yet be monetised under current electricity rules and agreements. These include:

a. Upgrade deferral: A battery can delay or avoid the need for upgrades to transmission and distribution infrastructure by discharging during peak demand periods to provide additional capacity.
b. Congestion relief: As demand grows it can be difficult for transmission networks to keep pace and provide enough reserve capacity to meet peaks. Batteries can provide additional capacity and reduce the need for load shedding in these situations.
c. Adequacy of supply: This may be an increasing factor as more fossil fuel generators are retired and replaced with intermittent renewables. When supply cannot meet demand batteries can discharge and provide additional generation to meet this.

As a result of the uncertainty associated with income from these services, they cannot yet be relied upon in a business case.

Scenario 3: Islanding (continued operation during power outages)

To enable the battery to provide as much backup energy as possible in a power outage scenario, the amount of energy discharged must be limited so it is always ready to provide backup. This situation will significantly limit the other services a battery can provide.

One question from 2030Yea was whether the potential community battery could function as a backup power source for essential services the main street area during extended power outage scenarios during emergencies.

Community batteries provide most of their benefit through allowing daily solar generation to be used at night. However, this requires frequently discharging the battery and therefore negates the batteries usefulness as a backup for longer unpredictable outages. Significantly larger battery capacities would be required to provide power to the town for periods greater than the 12 hour night time usage required under normal conditions.

To act as an island-able battery, a battery needs to be capable of providing electricity for the town for a suitable amount of time after the initial power loss. To cut down on the capacity requirements of the battery (i.e. save on upfront costs) select services could be chosen for which backup power is exclusively provided. This automatic exclusion of non-essential services may require infrastructural upgrades which may be expensive. Unlike the other scenarios, the minimum necessary capacity of the island-able battery would be determined by Yea’s emergency energy needs instead of the towns capacity to generate/ export solar.

To provide 24 hours of backup power to the recreational reserve (the emergency staging ground), an additional capacity of 100-200kWh on top of the community battery’s capacity would be sufficient. The maximum daily usage at the recreation reserve is 88kWh in May 2019, and an emergency energy usage is expected to be higher due to gathering. This additional capacity must remain charged throughout the battery's lifetime in case of emergency and the community battery needs to stay above this level under normal operation in case the attached solar arrays fail to provide power during the power outage.

5. Key findings

- Figure 10 shows that for most of the year there are solar exports for some of the day indicating that there is excess solar to charge a community battery. Across the year the average excess solar produced per day is 280 kWh. This is based on 2018 data and the exports have likely increased since then due to increased solar installations (Figure 5).
- Yea's daily load profile shows that peak electricity demand is at 1am. This demand could easily be shifted with a community engagement campaign to change pre-set hot water heating times. As most of the electricity at 1am currently comes from fossil fuels, reducing this demand would provide easy and fast reduction in GHG emissions in line with community net zero goals.
- In winter, based on 2018 solar generation, there would not be enough excess solar generation to charge a community battery in Yea. However, solar generation in Yea is increasing (Figure 5), so excess solar generation would be expected year-round in the future.
- Peak solar generation in Yea town centre is 1150kW in summer and 500kW in winter.
- The recreation reserve has a maximum daily usage of 88kWh. A community battery of moderate capacity (100-300kWh) could supply the power requirements of the recreation reserve in the case of emergency for several days.
- Using the community battery as backup power, islanded from the main grid, would require special technical support from the DNSP, Ausnet.

Glossary

Aggregated solar exports: The sum of all excess solar from a group of homes of businesses.

Arbitrage Trading: The purchase of energy at one price and sale at another to produce a profit.

ANU BSGIP: Australian National University Battery Storage and Grid Integration Program

Distributed Energy Resources (DER): These are a name given to the group of renewable resources that can be installed at the point of use.

Distribution Network Service Provider (DNSP): This is the company that operates LV networks and provides energy directly to consumers

Distribution Use of Service (DUOS): The tariff charges for energy distribution

Feed-in-Tariff: The price per kWh that consumers receive for excess solar energy produced that they feed back into the grid.

Gen-tailer: portmanteau of generator and retailer, referring to a company that generates and sells electricity. Many of the large electricity retailers in Australia such as AGL and Origin Energy also generate electricity.

Grid: When mentioning the grid this generally refers to the wider Victorian electricity grid.

Insolation: The energy from the sun incident on a surface.

Intermittent renewables: This refers to the variability in the output of renewable energy sources. The generation is intermittent as it will change depending on the sun and wind conditions at any given time.

Islanding: Allowing Yea's electrical services to operate when disconnected from the larger grid.

Load: The amount of energy flowing through a reference point in an electricity network. The generation going into the reference point must be equal to the demand on the other side.

Load shifting: When the peak load is moved to a different time of day to reduce strain on the network or reduce energy costs. This can be achieved by moving the time that a load occurs or discharging energy storage to reduce the net load.

Load shedding: When the demand is higher than the generation and electricity users must stop using power to avoid a blackout.

Local Energy System: This refers to energy produced in the Yea area.

LV Network: The low voltage network is used to distribute electricity to consumers operating at 400V.

Microgrid: A small self-sufficient energy network which can operate disconnected from the NEM. They are typically used in remote locations where the cost of interconnection is far greater than construction the necessary local infrastructure.

NEM: The National Electricity Market (NEM) is the interconnected grid on the East Coast of Australia where electricity is traded.

NER: The National Electricity Rules govern the operation of the NEM and define the rights and responsibilities of participants.

Network: Operated by AusNet in Victoria

Low Voltage (LV): This part of the network distributes energy to consumers

Medium Voltage (MV): This part of the network transmits energy over shorter distances such as between suburbs.

High Voltage (HV): This part of the network transmits energy over long distances greater than

100km

Peak shaving: When energy storage is discharged during peak electricity demand to effectively reduce the size of the peak.

Seasonal load: The load changes from season to season depending on consumer behaviour generally in response to changes in weather.

Transmission Use of Service (TUOS): The tariff charged for energy transmission

Top: Yea recreation reserve footy and cricket grounds

Middle: Yea recreation reserve netball court

Bottom: Yea recreation reserve existing 47kWh backup battery

Image credits: Yasin Gulec, Drone Surveyors, Strath Creek, Victoria