



Energy and Climate Resilient Trentham

October 2022





Client: Trentham Sustainability Group and Cool Country Community Enterprises Ltd
Revision: 0
Project: Energy and Climate Resilient Trentham
Doc no: P22027-G-RPT-0001

FINAL



Revision control

Revision	Date	Description	Prepared by	Reviewed by	Approved by
A	28.06.22	Initial revision	Vincent Wong	Roger Brown	Alex Low
B	01.08.22	Draft issue	Vincent Wong	Roger Brown	Alex Low
0	18.10.22	Final issue	Vincent Wong, Jason Gomes  Digitally signed by Vincent Wong Date: 2022.10.18 16:00:58 +11'00'	Roger Brown 	Alex Low

Disclaimer

This document has been prepared by Middleton Group Engineering Pty Ltd solely for the exclusive use of Trentham Sustainability Group and Cool Country Community Enterprises Ltd. This document is not intended to be and should not be used or relied upon by anyone else. Middleton Group Engineering Pty Ltd does not accept any duty of care or liability to any other person or entity other than Trentham Sustainability Group and Cool Country Community Enterprises Ltd. Users of this document should exercise their own skill and care or seek professional advice in the use of the document.

The opinions, conclusions and any recommendations in this report are necessarily based on assumptions made by Middleton Group Engineering Pty Ltd, as described in this report. To the extent the report makes assumptions, these can give rise to discrepancies to the extent that they may or may not represent actual existing circumstances or eventuate to be correct assumptions. Middleton Group Engineering Pty Ltd disclaims liability arising because of such discrepancies to the extent such assumptions are such that Middleton Group Engineering Pty Ltd can reasonably be expected to make in accordance with sound professional principles.

Executive Summary

Trentham Sustainability Group and Cool Country Community Enterprises Ltd have engaged Middleton Group to examine the feasibility of renewable energy supplies to provide improved power reliability for the community and essential sites. The work addressed four key areas to improve energy resilience and reduce the emissions associated with electricity supply in the town. These were conceived to address:

- Immediate concerns around energy supply for essential facilities in emergency situations and natural disasters
- Energy supply for individual households
- Broader questions of how the whole town might achieve a reliable, renewable energy supply; and
- A final element examining how retailers might be engaged to create partnership-based business models to help fund such projects.

Broadly the project was designed to support the community to take immediate action on the small scale and also look at the bigger picture relating to concepts of whole-of-town energy supply and a microgrid, with a view to building the case for an application to the Federal Government's RAMPP program and similar government-funded programs.

To improve energy resilience within Trentham, increase in solar and / or energy storage systems will be required. Energy storage systems may be addressed at each household or centralised with a community microgrid (with generator).

For essential sites, we recommend installing solar systems for the CFA, Community Hub, Sportsground Pavilion, and the Community Bank. Analysis of generators and/or batteries does not produce a "feasible" outcome on financial grounds of capital investment and payback periods. Other considerations for generators or batteries include security of supply, supporting renewable utilisation, as well as supporting increased uptake and utilisation of these technology options. Battery and solar systems would only be financially viable if the solar export price drops to 2c/kWh with battery prices reducing to \$960/kWh.

Essential sites such as the CFA, Community Hub and the IGA have already managed power resilience issues with backup generators. The Sportsground Pavilion and Community Bank does not have a generator to operate during outages. A battery and solar solution may be able to provide reasonable continuity of supply for these two sites for a designated period. This solution would be at cost to both sites as the return on investment is longer than the expected operational life of the battery.

Increase in small scale solar generation improves the feasibility of a microgrid or community battery and helps achieve Trentham's goal of reducing overall carbon emissions. Implementing further energy storage systems will improve the resilience within Trentham. Our recommendation is to maximise the adoption of solar within commercial and residential customers. Battery systems coupled with solar for residential customers are considered a breakeven investment. There are limits to the amount of power that can be generated from small scale solar. If the adoption of solar was doubled, it would export about 1.5 GWh per year to be used by other customers.

To achieve carbon neutral generation locally, larger systems such as the solar power station or wind generation would need to be considered with a total generation of 4.05 GWh. A 1.6 MWDC solar farm would be required to supplement 50% of the annual imported energy in 2021. These are a substantial investment and long-term commitment for the community. Finding partners interested in working with the community to develop such plants would be necessary to take it forward.

The recommended retailer for a white label partnership with TSG / CCCE is Diamond Energy. More than one retailer was able to provide services of interest to TSG / CCCE.

Abbreviations

Table 1: Abbreviations and definitions

Abbreviation / definition	Explanation
BESS	Battery energy storage system
C4NET	Centre for New Energy Technologies
CCCE	Cool Country Community Enterprises Ltd
CEC	Clean Energy Council
CEFC	Clean Energy Finance Corporation
CER	Clean Energy Regulator
DC	Direct current
DF	Domestic Farm
FCAS	Frequency Control Ancillary Services
HOMER	Hybrid Optimization of Multiple Energy Resources
IRR	Internal rate of return
NPC	Net present cost
NPV	Net present value
O&M	Operational and maintenance
PV	Photo-voltaic
PV-E	Existing PV
PV-R	New proposed residential PV
RAMPP	Regional Australia Microgrid Pilots Program
ROI	Return on investment
STC	Small-scale technology certificate
TOU	Time of use
TSG	Trentham Sustainability Group
VDO	Victorian Default Offer
VPP	Virtual power plant

Contents

1	Introduction	1
1.1	Vision	1
1.2	Purpose	1
1.3	Scope	2
1.4	Design inputs	2
2	Essential Sites – Secure and Local Energy Supply Feasibility	3
2.1	Country Fire Authority	3
2.2	Community Hub	4
2.3	Country Grocers IGA	4
2.4	Sportsground and Pavilion	5
2.5	Community Bank	5
2.6	Essential sites summary	6
3	Community Microgrid Feasibility	7
3.1	Trentham Community Power Usage	7
3.2	Community Energy Modelling	17
4	Community Energy Infrastructure Installation Feasibility	27
4.1	Existing Renewable Energy Technologies	27
4.2	Household Batteries	27
4.3	Community Batteries	28
4.4	Microgrid	31
4.5	Solar Power Station	32
4.6	Wind Power	33
5	Energy Retailer Review	34
5.1	Trentham Retailer Partnership Offers	34
6	Residential Study	35
7	Conclusion	38
Appendix A	Essential Site Modelling Assumptions	40
A.1	Country Fire Authority	41
A.2	Country Grocers – IGA Supermarket	43
A.3	Sportsground Pavilion	45
A.4	Community Hub	47
Appendix B	Retailer Engagement and Selection Process	49
B.1	Retailer Engagement	49
B.2	Selection of Retailer Partnership	50
Appendix C	Community Battery Model Assumptions	51
C.1	Existing Solar	51

C.2	Tariff Rates	51
C.3	System Architecture	51
C.4	System Costs	52
C.5	Operations and Maintenance (O&M) Costs	52
C.6	Model Limitations	52
C.7	Sensitivity Parameters	52
C.8	High Export Solar Case – Rahills Road	53

Appendix D Battery Revenue Streams 57

D.1	Summary of Revenue Streams	57
D.2	Energy Arbitrage	58
D.3	Frequency Control Ancillary Services (FCAS)	59
D.4	Other Services	61

Appendix E Technology prices 63

E.1	Rooftop solar PV systems	63
E.2	Battery storage	64
E.3	Inverters	65

Appendix F Additional Data and Graphs 66

Tables

Table 1: Abbreviations and definitions	iv
Table 2: Yearly Carbon Emissions - Country Fire Authority	3
Table 3: Yearly Carbon Emissions – Community Hub	4
Table 4: Yearly Carbon Emissions - Country Grocers IGA	4
Table 5: Yearly Carbon Emissions - Sportsground and Pavilion	5
Table 6: Yearly Carbon Emissions - Community Bank	5
Table 7: Essential Site Recommendations	6
Table 8: Percentage breakdown of total customers by type	8
Table 9: Energy Consumption and Solar Export Summary	9
Table 10: Change in Annual Consumption by Customer Type	10
Table 11: Percentage breakdown of solar customers by type	12
Table 12: Solar PV penetration based on Powercor Data	13
Table 13: Outages for Trentham in 2021	16
Table 14: HOMER model scenarios	17
Table 15: Trentham customer profile	18
Table 16: Winning system architecture for Case 1 – Market Street Transformer	20

Table 17: Economic feasibility for Case 1 – Market Street Transformer	20
Table 18: Estimated available solar capacity for high consumption case	22
Table 19: Economic feasibility for Microgrid	23
Table 20: Solar feed-in tariff rates for sensitivity analysis	24
Table 21: Battery capital cost multipliers for sensitivity analysis	25
Table 22: FCAS Inputs into Market Street Transformer	26
Table 23: Government fundings and grants	29
Table 24: Community battery and microgrid examples	30
Table 25: Retailer Response Table	34
Table 26: Annual Household Electricity Consumption - By Category	35
Table 27: Household Category Defined for Trentham	36
Table 28: Residential Study Payback Period for Solar and Batteries	37
Table 29: Modelling Parameters	40
Table 30: Solar and Generator Table Summary	42
Table 31: Solar and Generator - Predicted Electricity Monthly Bill Summary	42
Table 32: Solar and Generator Summary Table	44
Table 33: Predicted Electricity Bill - Solar and Generator	44
Table 34: Solar and Generator Table Summary	46
Table 35: 18 kW Solar - Predicted Electricity Monthly Bill Summary	46
Table 36: Solar and Generator Summary	48
Table 37: Solar and Generator Predicted Bill Summary	48
Table 38: Retailer Engagement Interest Summary	49
Table 39: Retailer Partnership Criteria	50
Table 40: Winning system architecture for Case 2 – 20614201-WND024 Rahills Road	55
Table 41: Economic feasibility for Case 2 – 20614201-WND024 Rahills Road	55
Table 42: Estimated available solar capacity for high export case	56
Table 43: Summary of all battery revenue streams	57
Table 44: Total retail price of solar systems for residential and commercial customers (June 2022)	63
Table 45: Average battery installation costs (May 2022)	65
Table 46: 2020 Monthly Data Table	67
Table 47: 2021 Monthly Data Table	68

Figures

Figure 1: Trentham suburb area used for census statistics	7
Figure 2: Total Customer Count by Type	8
Figure 3: Trentham Daily Energy Consumption	8
Figure 4: Trentham Total Energy Consumption by Month	9
Figure 5: Total energy contribution by customer type	10
Figure 6: Total Solar Export in Trentham	11
Figure 7: Total Solar Export Contribution by Customer Type	11
Figure 8: Solar Customer Count by Type	12
Figure 9: PV density by postcode 3458	13
Figure 10: Solar PV penetration by customer type	14
Figure 11: Customer Count by Transformer (where total customer > 5)	14
Figure 12: Total Consumption by Transformer ID (2021)	15
Figure 13: 500 kVA Market Street Transformer	18
Figure 14: Consumption and Solar Export from Market Street Transformer	19
Figure 15: 86620900-WND024 Market Street Transformer 2021 Load Profile	19
Figure 16: Market Street Transformer – Cumulative cashflow over 20 years	21
Figure 17: Potential Community Battery Location 1 (Yellow)	21
Figure 18: Potential Community Battery Location 2 (Yellow)	21
Figure 19: Annual diesel generator fuel consumption	23
Figure 20: Solar feed-in tariff sensitivity analysis in HOMER	24
Figure 21: Battery cost sensitivity analysis in HOMER	25
Figure 22: Typical microgrid architecture	31
Figure 23: Power Station in Trentham	32
Figure 24: Victorian average wind speed at 100m with Trentham indicated (Source Global Wind Atlas)	33
Figure 25: Wind speed index and wind rose (Global wind Atlas)	33
Figure 26: HOMER Model schematic	51
Figure 27: Consumption and Export Profile of 20614201-WND024, Rahills Road	54
Figure 28: 20614201-WND024 Rahills Road, Highest Export 2021 Load Profile	54
Figure 29: Case 2 – Cumulative cashflow over 20 years	56
Figure 30: Battery net market revenue from Q2 19 to Q1 21	57
Figure 31: Trend in negative daytime average prices in SA	58

Figure 32: Negative spot price occurrences in SA and VIC	58
Figure 33: Market ancillary services summary	59
Figure 34: Quarterly global FCAS costs by services	60
Figure 35: Projected FCAS requirements for increasing penetration of solar and wind generation	60
Figure 36: non-market ancillary services	61
Figure 37: Solar Choice price index	63
Figure 38: Solar Choice Battery Price Index – December 2017 – May 2022	64
Figure 39: Market St Transformer 86620900 Solar Export	66
Figure 40: Market St Transformer 86620900 Consumption Profile (includes outages and meter failures)	66

1 Introduction

Trentham Sustainability Group (TSG) and Cool Country Community Enterprises Ltd (CCCE) have partnered together for the Energy and Climate Resilient Trentham project as two key organisations in the Trentham community who can take leadership for climate action and are committed to developing projects that will contribute to the resilience of the Trentham and Districts community, located within Dja Dja Wurrung Country.

The Project Partners mutually recognise the challenges of climate change, the impact of these on our community and the responsibility of our community to act to mitigate and adapt to the impacts of climate change.

Middleton Group were engaged by TSG and CCCE to undertake the Feasibility Phase of the Project. This phase of the project is jointly funded by CCCE and Hepburn Shire Council (via a grant obtained through the Towards Zero Community Grants Program in 2021).

1.1 Vision

The vision for the Energy & Climate Resilient Trentham project is to provide secure and local back-up energy supply for the betterment of Trentham's community. This will both strengthen the Trentham community's resilience in response to climate change, as well as increase local emission-mitigation.

This document aims to provide a cohesive and comprehensive Feasibility Phase report with recommendations that support this vision.

1.2 Purpose

The purpose of this report is to deliver a comprehensive feasibility study that examines the feasibility of renewable energy supplies and storage for the Trentham community in the context of back-up electricity supply to essential services sites; a community scale microgrid for the wider community; to encourage an increase in the proportion of renewable energy produced in Trentham; and to consider provision of a "white label" retail energy product.

It is an aspiration of the project that it will in turn stimulate greater business and private take-up of solar, batteries and reliable energy supply through solutions like community energy microgrids.

1.2.1 Background

The devastating storm event in June 2021 saw power out for 3-6 days across Trentham and the wider surrounding districts. Communications, water supply and other services, usually reliable in such circumstances, went down, and road access to the town was cut off. Trentham's vulnerability is due to the township being uniquely positioned at the fringes of several distribution network supplies managed by Powercor as the Distributed Network Supply Provider.

This situation was over and above the difficulties the town faces with frequent planned and unplanned power outages. This is the first time that mobile communications had gone down. This was not the only time that the local supermarket, and other businesses, had to throw out chilled foods. It was not the first time that residents wondered how to cook and how to heat their homes in the middle of winter. Nor the first time that due to power outages the town sewer treatment plant backed up and flowed out around local houses and into water ways.

In a changing climate this scenario was a wake-up call highlighting the vulnerability of our community and essential services to extreme weather events and climate change. Given Trentham's status as a fire-prone town it was a chilling reminder of how reliant we are on grid-supplied power and mobile communications.

1.3 Scope

Middleton Group have undertaken and achieved the **target outcomes** for this project:

1. Examine the feasibility of secure and local backup-energy supply continuity at 5 key sites within the township of Trentham.
2. Assess whether a community microgrid is feasibly both technically and financially (at a high level) to address wider community power reliability issues.
3. Explore options for partnering with progressive energy retailers to deliver a 'white label' retail energy product.
4. Delivery of a final feasibility phase report with clear recommendation and findings.

1.4 Design inputs

As part of this project, C4Net was engaged to provide the following inputs required for this project:

- Daily aggregated power usage and solar export data for all transformers in Trentham from 2020 – 2021 (inclusive).
- 30-min interval power usage and solar export data for nominated transformers.

2 Essential Sites – Secure and Local Energy Supply Feasibility

As part of the scope, TSG / CCCE had requested a feasibility assessment of local backup supply for essential sites in Trentham. Such sites were the Country Grocers Supermarket (IGA), Country Fire Authority (CFA), Sports Ground / Pavilion, Community Hub, and the Community Bank.

A site visit was held on the 2nd of June to examine the constructability of the local energy supply for each site. Discussions were also held with each stakeholder to understand site-specific preferences.

The sites were modelled using HOMER Grid Energy. HOMER Grid can optimise multiple generation sources (PV, batteries, wind, diesel generators etc.) in a system based on input tariffs and loads. For simplicity of the assessment, scope feasibility was limited to solar and battery generation sources only. General model assumptions were summarised in Appendix A.

2.1 Country Fire Authority

The recommended 6.6 kW solar-only system has an initial capital of \$8,321 with a payback period of 7.3 years.

Reliability measures have been taken in response to past issues with long-term power outages. The CFA facility has been fitted with a generator able to supply the power needs of the site. The existing generator can support the site power needs and is quite likely oversized for the duty.

A solar and battery system could provide a more seamless transfer in event of grid failure without the noise and carbon emissions (and without manual change over). A battery system size of 10kWh can supply the CFA for a minimum of 2 hours (at peak load of 4.64kW). The CAPEX for this solution would be \$20,321. This is a more expensive option and at current power prices, does not provide a reasonable return. If an external source of funding can be found to support this outcome, then this may be deemed a desirable from a qualitative standpoint. A further detailed summary is provided in Appendix A.1.

Table 2: Yearly Carbon Emissions - Country Fire Authority

Scenario	Carbon Emissions (tonnes/yr)
Do Nothing (Generator)	5.2
Solar (6.6 kW) and Generator	3.5
Solar (6.6 kW), Batteries (13 kWh) and Generator	2.3

Reduction of carbon emissions is low for the recommended solar option as the energy consumption at CFA is low.

2.2 Community Hub

Reliability measures have been considered as a standby generator (110 kVA) has been included as part of the refurbishment. The standby generator will supply a limited load compared to the maximum estimated peak load of the Community Hub (182 kVA).

The estimated battery size is based on the solar system size and recorded peak load for 1 hour. If an external source of funding can be found to support battery installation and continuity of energy supply, then this may be deemed a desirable from a qualitative assessment standpoint. A further detailed summary is provided in Appendix A.4.

Table 3: Yearly Carbon Emissions – Community Hub

Scenario	Carbon Emissions (tonnes/yr)
Do Nothing (Generator Only)	86.6
Solar (32 kW) and Generator	62.7
Solar (32 kW), Batteries (43 kWh) and Generator	58.7

The estimated carbon emissions of the community hub are 86.6 tonnes per year. The solar generation would reduce this by 27.5% down to 62.7 tonnes/year. Based on limited runtime, generator operation during outages is estimated to contribute to less than 1% of the carbon emissions.

2.3 Country Grocers IGA

Based on discussion with Country Grocers (confidential), the preference for the site is to do nothing. The system with the least payback period is a 32 kW solar system with no batteries. This has a capital cost of \$28,527 and a payback period of 5.9 years. This option would reduce the carbon emissions by approximately 23.8 tonnes/year. Purchase of carbon offset energy or green power are also a valid mitigation strategy. A further detailed summary is provided in Appendix A.2.

Table 4: Yearly Carbon Emissions - Country Grocers IGA

Scenario	Carbon Emissions (tonnes/yr)
Do Nothing	175.5
Solar (30 kW) and Generator	151.3
Solar (30 kW), Batteries (42 kWh) and Generator	152.1

Power reliability measures for the supermarket have been taken as the facility has installed a standby generator that is sufficiently sized for an extended outage. A solar or battery system also could not be practically sized for the required load given the space available.

2.4 Sportsground and Pavilion

The existing load profile of the sportsground operates on a 68 kW peak load, 6 pm – 8pm during Autumn and Winter periods. Calculations show that the additional load from the upgrade would increase the peak load by 32 kW.

To improve energy resilience at the sports ground, battery systems may be installed at a cost to the sports ground facility as the payback period exceeds the operational lifetime of the battery. The battery would also have to be sufficiently sized to ensure loads continue running for an adequate period.

Another solution for power resilience would be to consider a generator that is sized based on the peak load of the Sportsground Pavilion. Our estimations show a 100 kW Generator is approximately \$30,000.

Carbon emissions between the 'Do Nothing' and recommended option only slightly decreased. This is because most of the solar generation is exported. A further detailed summary is provided in A.3.

Table 5: Yearly Carbon Emissions - Sportsground and Pavilion

Scenario	Carbon Emissions (tonnes/year)
Do Nothing (3 kW solar system)	33.2
Solar Only (18 kW total solar system)	30.7
Solar (30 kW) and Batteries (30kWh)	25.8

2.5 Community Bank

The recommended option (12 kW solar) has an initial capital of \$15,968 and a payback of 6.9 years. The solar only option reduces the carbon emissions of the community bank by 55% the solar generation is directly offsetting the energy consumption from the bank during office hours.

Table 6: Yearly Carbon Emissions - Community Bank

Scenario	Carbon Emissions (tonnes/year)
Do Nothing	7.4
Solar Only (12 kW solar system)	3.3
Solar (12 kW) and Batteries (5 kWh)	2.6
Solar (12 kW) and Batteries (10 kWh)	2.0
Solar (12 kW) and Batteries (30 kWh)	1.4

A potential resilience solution could be a 12-kW solar system with a 30 kWh battery supplying 3-5 hours of peak power. The payback period for this solution is above 15 years with an initial capital of \$51,968.

2.6 Essential sites summary

The essential site summary on the sole basis of financial viability for each site is shown in Table 7.

Table 7: Essential Site Recommendations

Site	Recommendation	System Size	Payback Period
Country Fire Authority	Solar only system	6.6 kW	7.3 years
Community Hub	Solar only system	32 kW	3.1 years
Country Grocers IGA	Do Nothing	30 kW	5.9 years
Sportsground Pavilion	Solar only system	15 kW	8.9 years
Community Bank	Solar only system	12 kW	6.9 years

Based on the current market conditions, battery systems coupled with solar is not economically viable. Batteries and solar begin to become viable if export tariffs fall between 1 to 2 c/kWh and battery prices reduce to \$840 – 960/kWh.

3 Community Microgrid Feasibility

3.1 Trentham Community Power Usage

As part of this project, we have acquired the community power meter data aggregated by distribution transformer from Powercor. The data includes daily consumption and solar export data from 126 distribution transformers in Trentham over the recent two calendar years (2020 and 2021).

3.1.1 Residential Dwellings

In the 2021 census, in the Trentham suburb shown in Figure 1, there were 760 private dwellings recorded with an average of 2.2 persons per household¹.



Figure 1: Trentham suburb area used for census statistics

¹ [Trentham 2021 Census Data – All Persons Quickstats](#)

3.1.2 Customer Type Analysis

Figure 2 shows the percentage breakdown of customer types in Trentham.

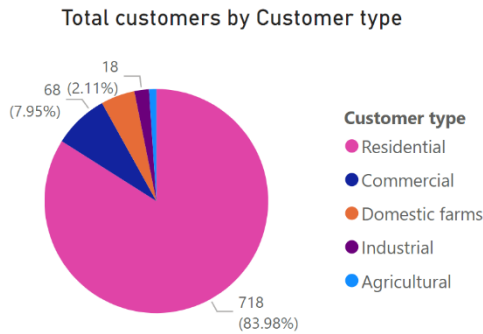


Figure 2: Total Customer Count by Type

Table 8: Percentage breakdown of total customers by type

Customer Type	Amount	% Of Total
Residential	718	83.98%
Commercial	68	7.95%
Domestic Farms	42	4.91%
Industrial	18	2.11%
Agricultural	9	1.05%
Total	855	100%

From the Powercor data, residential customers make up majority of Trentham’s electricity customer base at 84%. This is followed by commercial customers at approximately 8%. Domestic farms, industrial and agricultural customers combined constitute around 8% of the total customer base.

The 2021 census data (refer to Section 3.1.1) aligns and validates the sum of residential and domestic farm customers extracted from the Powercor data.

3.1.3 Community Energy Usage

Total Energy Consumption

Figure 3 shows the daily energy consumption in Trentham between January 2020 and December 2021.

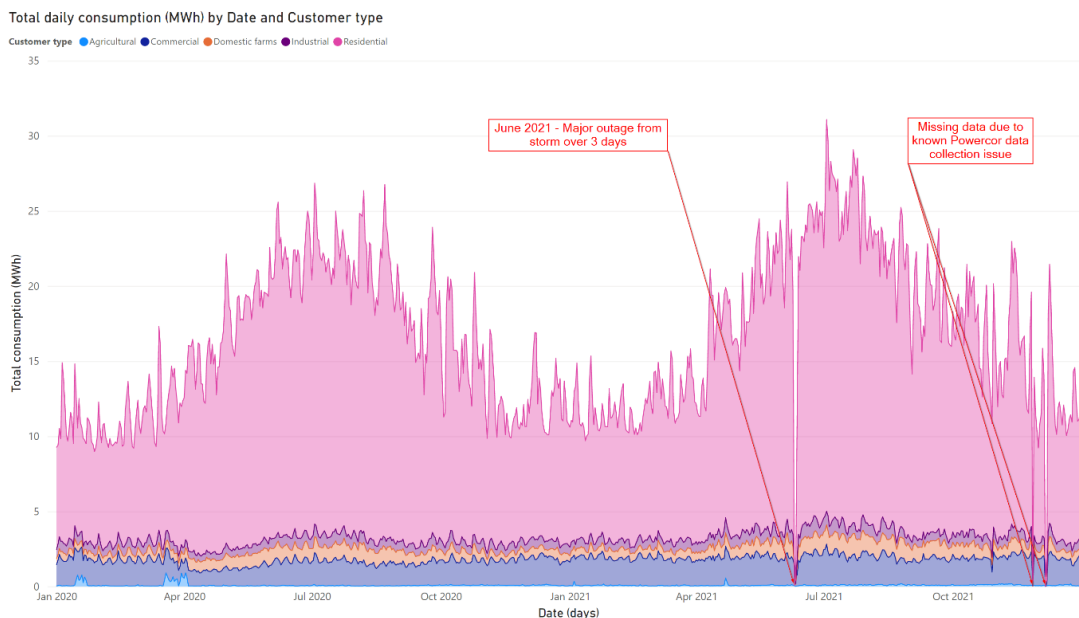


Figure 3: Trentham Daily Energy Consumption

Winter usage is significantly higher than in summer. The 2021 peak daily consumption occurs in July with approximately 31 MWh of energy purchased from the grid. This is a 15% increase from 2020 which had a peak daily consumption of 27MWh.

Table 9: Energy Consumption and Solar Export Summary

Year	Energy Consumption (GWh)	Consumption Increase (%)	Solar Export (GWh)	Solar Export Increase (%)
2020	5.849	-	0.663	-
2021	6.297	7.66	0.747	12.67%

The total annual energy consumption in 2021 is approximately 6.3 GWh with an average daily energy usage of 17.3 MWh. Overall consumption from 2020 to 2021 increased by 7.66%.

Locally generated solar export supports approximately 11.6% of total electricity usage.

Figure 4 shows the total monthly energy consumption in Trentham by five different customer types.

Total consumption (MWh) by Date and Customer type

Customer type: Agricultural Commercial Domestic farms Industrial Residential

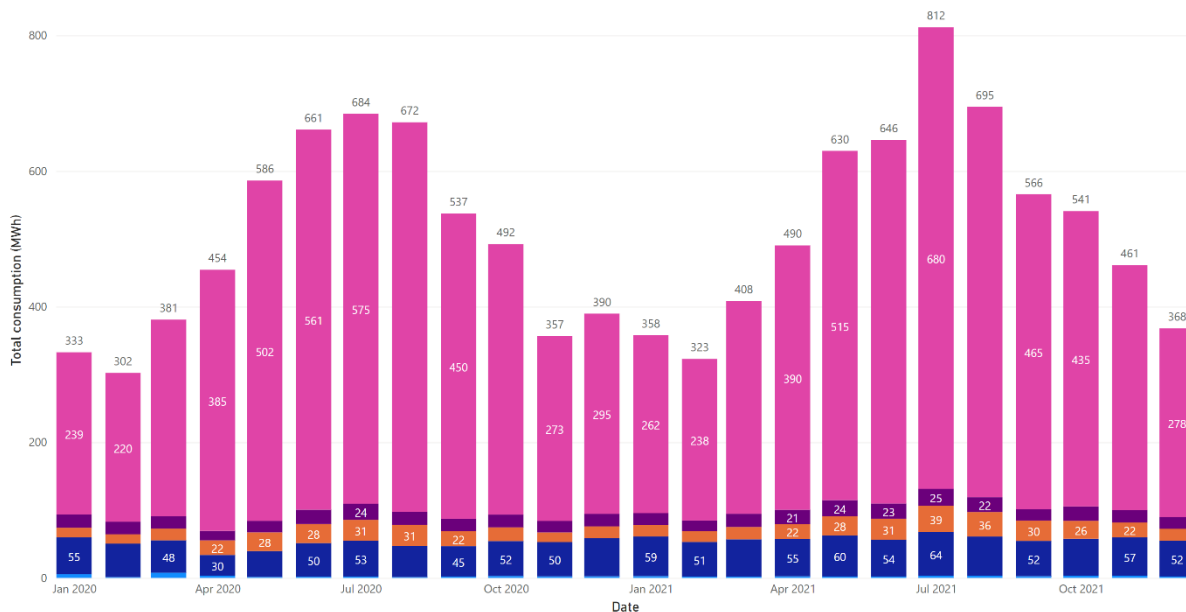


Figure 4: Trentham Total Energy Consumption by Month

Residential power use is the dominant power consumption in the Trentham area. In the last two years, the residential energy consumption has steadily grown at 6% per annum, whilst solar export has increased by 2.5 times the consumption rate at approximately 14.73%, as shown in Table 10.

This trend can be attributed to the rapid uptake in rooftop solar in Victoria. The consumption data only accounts for grid purchases in front of the meter and solar exports. It does not include behind the meter self-consumption of solar. Local solar adoption within Trentham will supplement the growth in demand as well as produce export.

Table 10: Change in Annual Consumption by Customer Type

Customer type	Consumption (kWh)			Solar export (kWh)		
	2021	2022	% Change	2021	2022	% Change
Agricultural	33,023	30,514	-7.60%	2,265	3,329	46.96%
Commercial	571,340	672,448	17.70%	2,549	2,620	2.79%
Domestic farms	259,539	302,288	16.47%	15,244	13,476	-11.59%
Industrial	222,658	240,682	8.09%	40,549	37,101	-8.50%
Residential	4,762,673	5,051,796	6.07%	602,041	690,701	14.73%
Grand Total	5,849,232	6,297,728	7.67%	662,647	747,226	12.76%

Figure 5 shows the same monthly consumption data, though represents the five customer types as a percentage of the total monthly usage.

Total consumption (MWh) by Date and Customer type

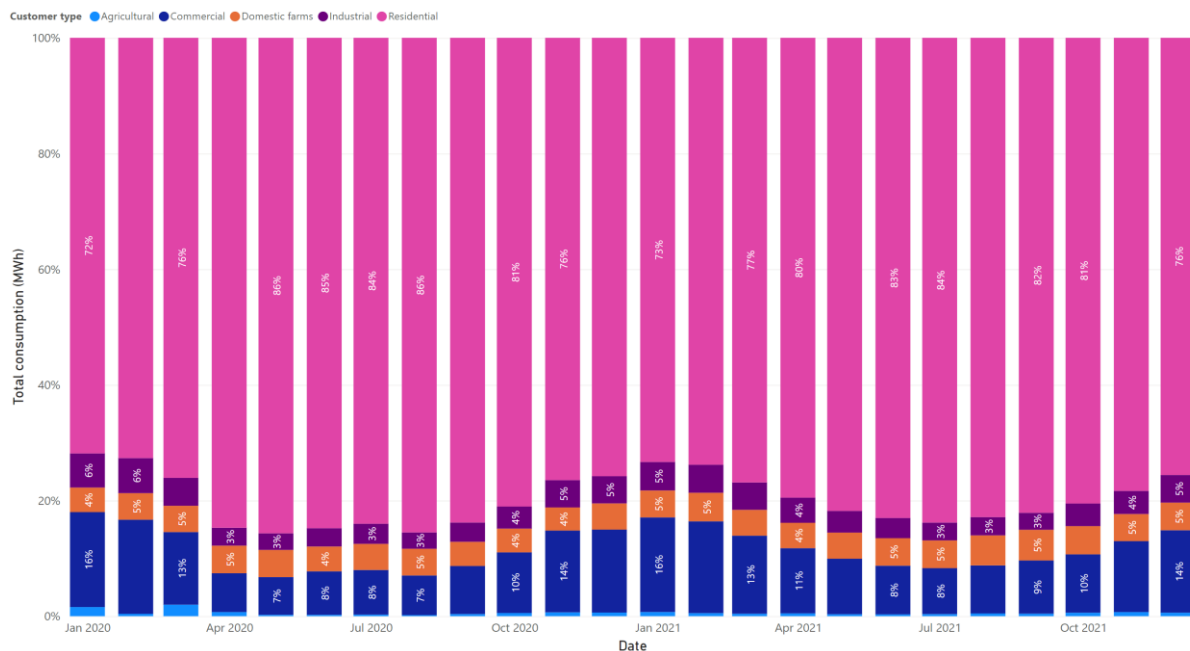


Figure 5: Total energy contribution by customer type

In the last two years, most of the energy consumption comprised of residential customers who contributed between 72-86%, followed by commercial customers at 8-16%. The industrial and domestic farm customers in Trentham contribute between 4-6% of the total energy consumption each month.

3.1.4 Community solar export

Figure 6 shows the total solar export in Trentham by customer type.

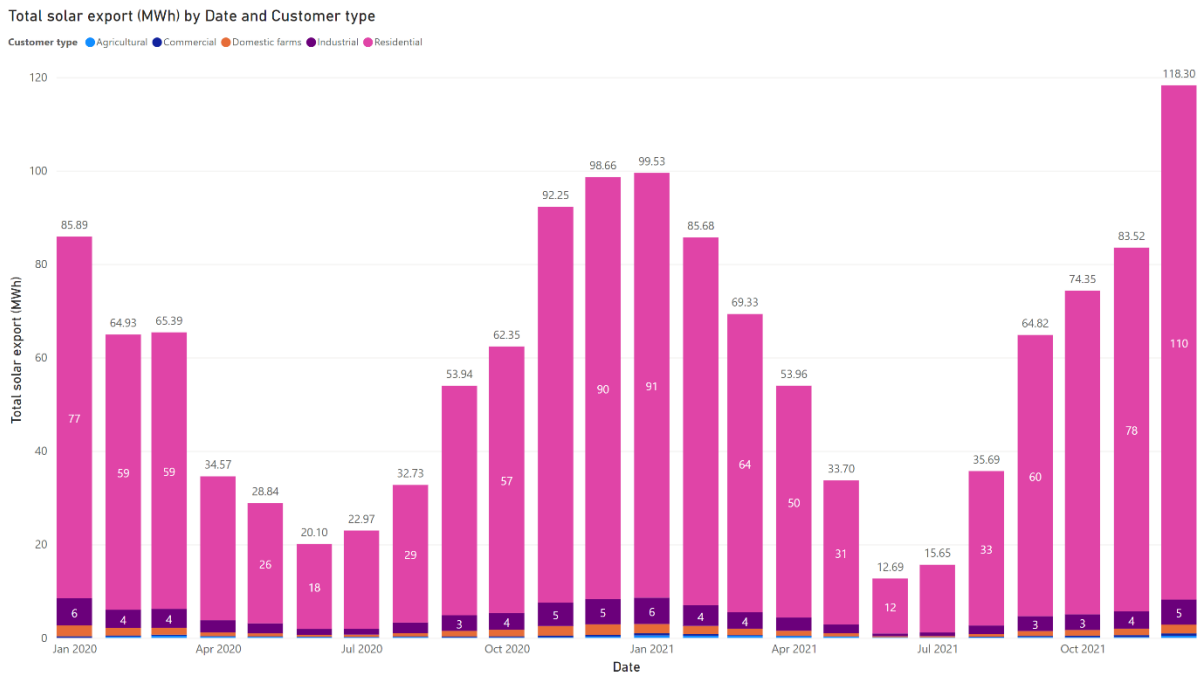


Figure 6: Total Solar Export in Trentham

Figure 7 shows the monthly solar export data, though represents the five customer types as a percentage of the total monthly output.

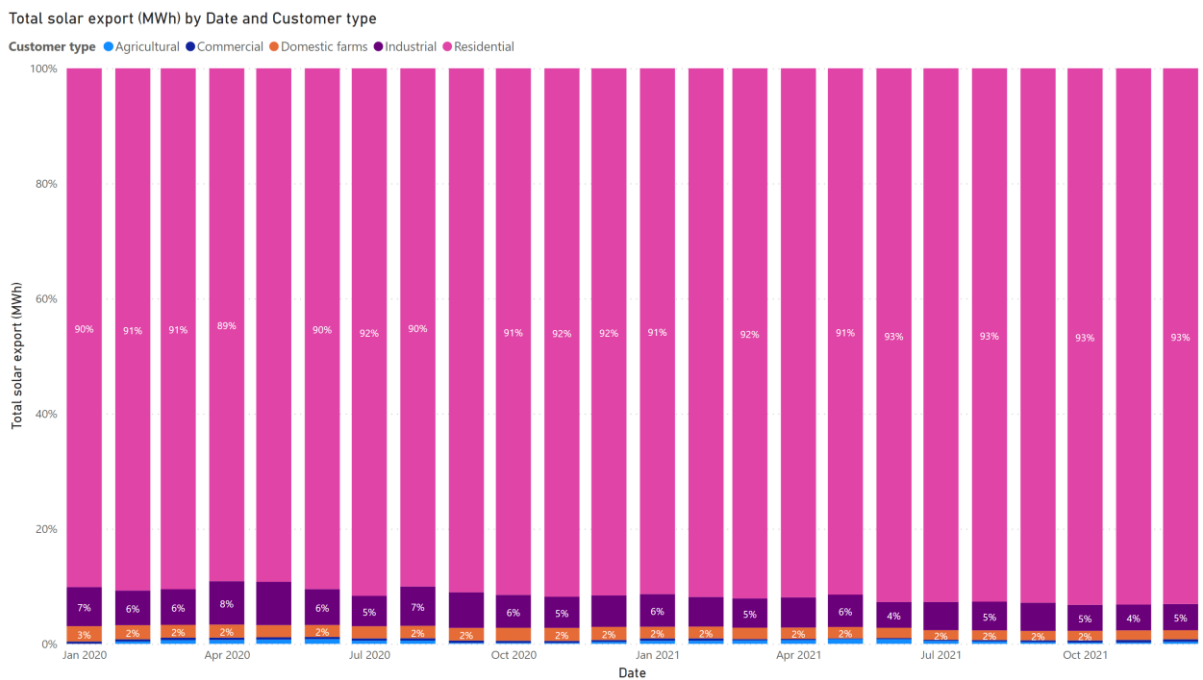


Figure 7: Total Solar Export Contribution by Customer Type

The key takeaways from the community solar export data are:

- In 2021, the peak solar export for Trentham is 5,622 kWh per day with an average of 1,928 kWh per day.
- The solar export increased by 12.6% from 0.663GWh in 2020, to 0.747GWh in 2021.
- In the last two years, most of the monthly solar export is contributed by residential customers ranging between 89-93%, followed by industrial customers at around 4-8%, depending on the season.
- Solar export supports approximately 12% of the electricity used in Trentham.

3.1.5 Solar Customer Type Analysis

Figure 8 shows the percentage breakdown of solar customer types in Trentham.

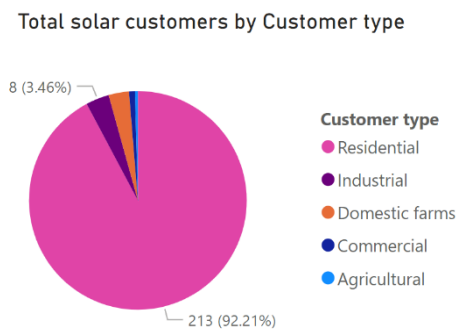


Figure 8: Solar Customer Count by Type

Table 11: Percentage breakdown of solar customers by type

Customer Type	Number	% Of Total Customer Type
Residential	213	92.21%
Industrial	8	3.46%
Domestic Farms	7	3.03%
Commercial	2	0.87%
Agricultural	1	0.43%
Total Solar Customers	231	100%

Most of the solar customers in Trentham are made up of residential customers at 92% (213 customers). The remaining 8% comprises of industrial, domestic farm, commercial and agricultural customers with a combined total of 18 solar customers.

3.1.6 Solar penetration

Based on the number of dwellings from 2016 census data and current Clean Energy Regulator (CER) data for the 3458 postcode² – there are approximately 30.8% of dwellings (426 installations) with solar PV installed. This aligns reasonably with the Powercor data. APVI has noted that number of systems installed may be understated due to the lag in system registrations.

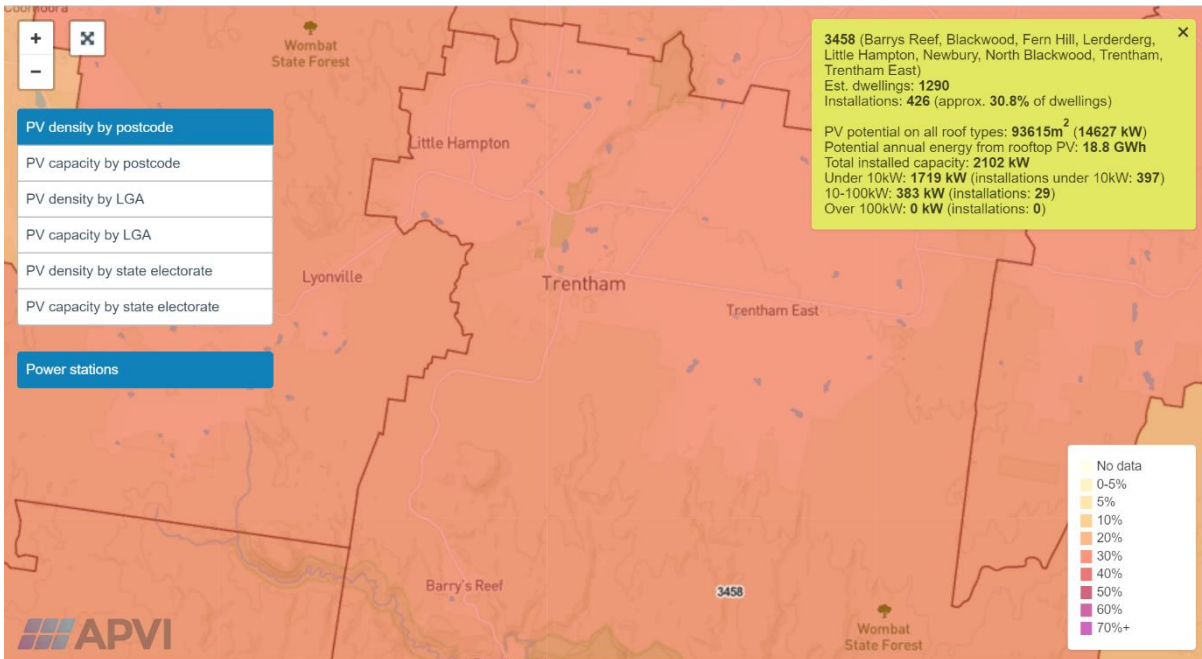


Figure 9: PV density by postcode 3458³

Table 12 shows the solar penetration by each customer type with respect to the total customers within Trentham. The Powercor data is a more accurate representation of solar penetration than the CER data, as it focuses on Trentham rather than the full postcode.

Table 12: Solar PV penetration based on Powercor Data

Customers	Agricultural	Commercial	Domestic farm	Industrial	Residential	Grand Total
Total customers	9	68	42	18	718	855
Solar customers	1	2	7	8	213	231
PV penetration %	11.11%	2.94%	16.67%	44.44%	29.67%	27.02%

The total solar penetration within Trentham from all customers is 27%. Based on CEC postcode data the average size of existing solar installations is 5kW. New small scale domestic installations are often about this size or larger. If solar take up was doubled, then one quarter of Trentham’s power could be locally supplied.

² Note that this includes suburbs other than Trentham and thus should only be indicative.

³ [Australian Photovoltaic Institute • Mapping Australian Photovoltaic installations \(apvi.org.au\)](http://www.apvi.org.au)

Figure 10 shows the solar penetration by the five different customer types.

Solar customers and Non-solar customers by Customer type

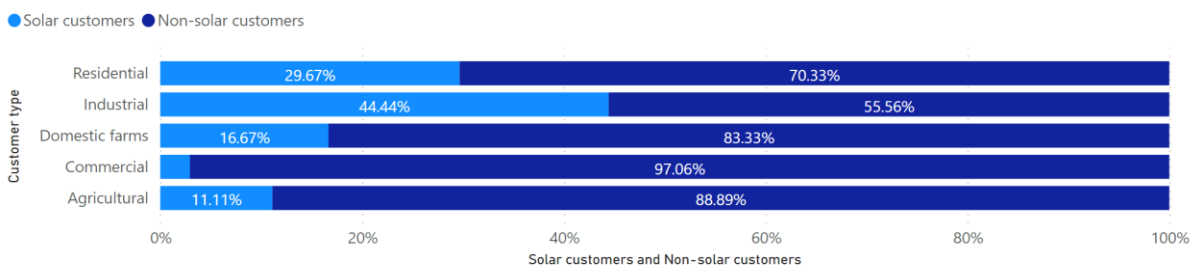


Figure 10: Solar PV penetration by customer type

The key takeaways are:

- Industrial customers currently have the highest solar penetration at 44.44% (8 out of 18 customers).
- Approximately 30% of residential customers, or 213 customers, have solar installations.
- There is opportunity for much more rooftop solar to be installed.

3.1.7 Data Analysis by Transformer

The Powercor data indicates there are a total of 126 distribution transformers within Trentham.

Figure 11 shows the estimated number of customers per transformer. Note, the chart only shows transformers with more than 5 connected customers.

Estimated total customers per transformer by Transformer ID and Customer type

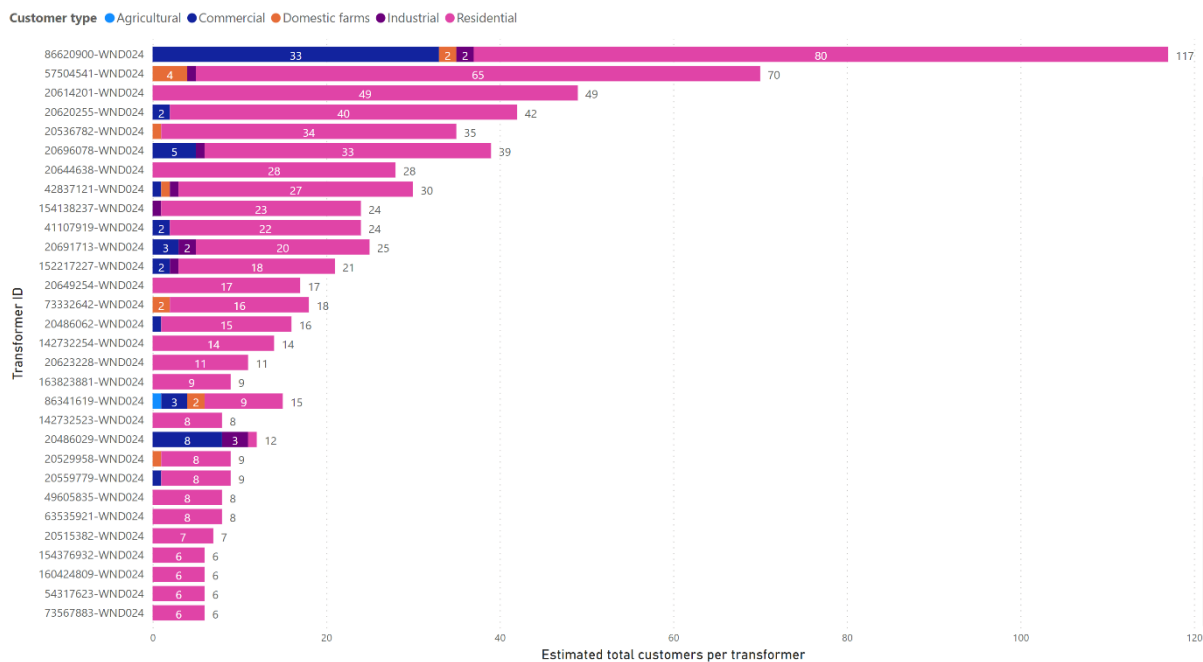


Figure 11: Customer Count by Transformer (where total customer > 5)

Figure 12 shows the total energy consumption in 2021 segmented by each transformer. A large proportion of Trentham is supplied by just a few transformers.

Total consumption (kWh) by Transformer ID

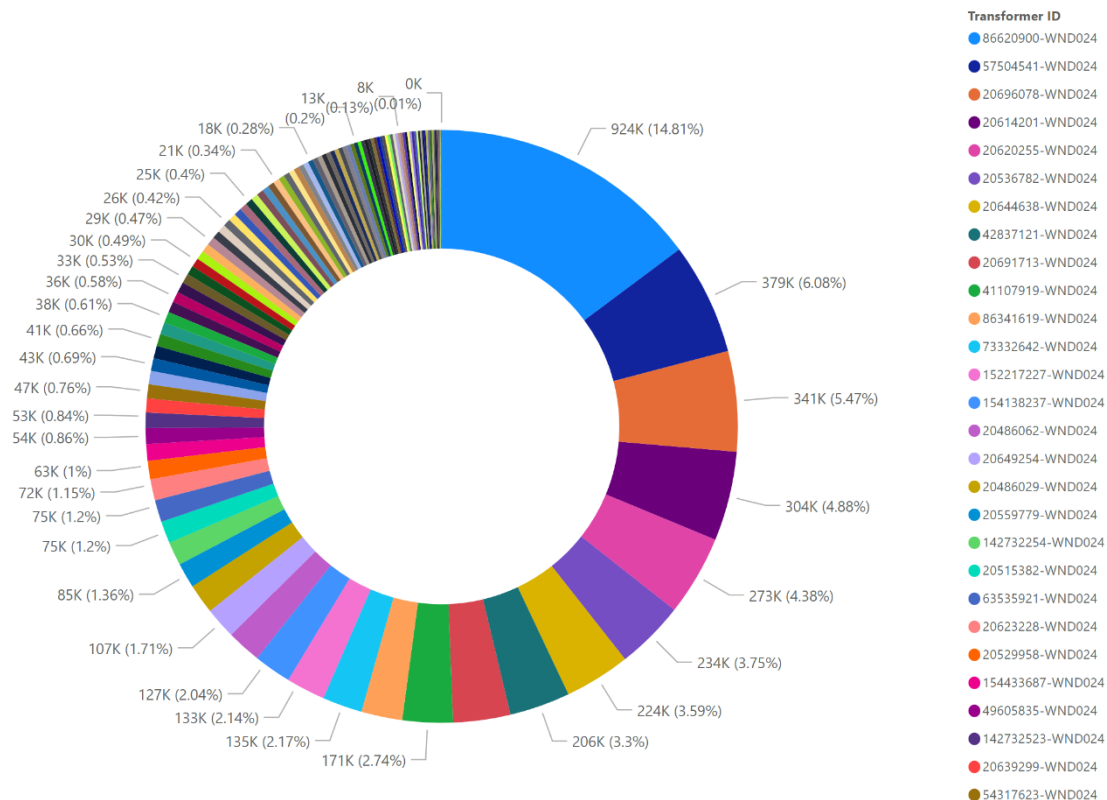


Figure 12: Total Consumption by Transformer ID (2021)

Based on the 2021 data (Powercor), the transformer with the highest proportion of energy consumption and total customers was the 86620900-WND024 Market Street transformer. The key findings from this transformer include:

- It distributed 924 MWh, or 14.81% of the total annual energy consumption, to 117 customers in Trentham.
- The rated transformer capacity is 500kVA, and as the highest consumption transformer is approximately 52% loaded respective to its total rated capacity.
- This transformer distributes power to 11.1% of residents in Trentham (80 customers). It also consists of the largest residential customer base supplied by a single transformer.
- It also supplies most of the commercial customers – 33 of the 68 customers, or 48.5% of the total commercial customer base.
- Overall, the transformer supplies 13.7% of the total customer base which is the highest proportion within Trentham.

The second highest consumption transformer is 57504541-WND024 Rahills Road which supplies 70 customers, or 6.08% of total customer base.

3.1.8 Outage Analysis

The outage analysis was based on 30-minute interval data from the three highest consumption transformers only. As the data is based on 30-minute intervals, shorter outages will be shown. To be detected in this data the outage must be at least 30 minutes.

The data indicates there were long sustained outages on the following dates:

Table 13: Outages for Trentham in 2021

Date	Duration	Outage period
Saturday, 23 January 2021	1.5hr	2 – 3:30pm
Wednesday, 9 June 2021 – Saturday 12th June 2021	0.5 hr 67hr	4:30 – 5pm 7:30pm (9/6) – 2:30pm (12/6)
Saturday, 14 August 2021	9.5hr	12am – 9:30am
Saturday, 14 August 2021	3.5hr	8pm – 11:30pm
Thursday, 30 September 2021	1.5hr	7 – 8:30pm
Friday, 29 October 2021	9.5hr	5am – 2:30pm
Wednesday, 1 December 2021	3.5hr	9:30pm (1/12) – 1am (2/12)
Thursday, 16 December 2021	0.5hr	5 – 5:30am

There interval data indicates there were at least 12 sustained outages in 2021:

- There was one significant outage, due to a severe storm, which lasted for 67 hours in June 2021.
- The eleven other sustained outages durations range roughly between 30 min and 9.5 hr.

It is not known whether any of these outages are planned outages, given Powercor does not publish any historical outage data. Also, there may be more frequent momentary outages (< 1 min) or short sustained outages (between 1 min and 30 min). However, such outages are not reflected in the 30-min interval dataset.

3.2 Community Energy Modelling

The energy options modelling was completed using HOMER Grid – an industry standard, hybrid power system modelling software package. The software assesses the local system and load requirements then optimises the distributed energy resource sizes based on existing tariffs, incentive programs, and capital costs for individual systems.

It generates several options based on a combination of renewable sources and sizing which then got ranked based on economics and the lowest net present cost (NPC) at the end of the project lifetime. This allows for easy comparison of design outcomes to assist with considering design options and to minimise financial risk to the project whilst reducing energy expenditure.

As part of this study, practical considerations for energy reliability included solar and batteries only.

3.2.1 Model Scenarios and Transformer Selection

To model different operating scenarios, only select transformers were chosen after analysing the Powercor data. The individual transformers were chosen to develop several different model cases, based on the following rationale:

1. 86620900 Market Street Transformer – Highest customer count, energy consumption and large solar export for residential customers.
2. 86620900 Market Street Transformer (with Generator)
3. 20614201 Rahills Road Transformer (see Appendix C.8) – Highest export ratio for residential customers.

Based on this rationale, two transformers were chosen as representative of the wider Trentham community for the following model cases:

Table 14: HOMER model scenarios

Model scenario	Transformer ID / Location	Transformer rating	Total Customers	Solar customers	Estimated existing solar
Highest Consumption	86620900-WND024 / Market Street, Trentham	500 kVA	117 total (80 Residential, 2 Industrial, 2 Domestic farms, and 33 Commercial)	19 total (1 industrial, 18 residential)	44 kW
Highest Solar Export (Refer to C.8.1)	20614201-WND024 / Rahills Road	200 kVA (assumed)	49 Residential	13 residential	78 kW

3.2.2 Case 1: Market Street Transformer (Highest Consumption)

This model is based on the Market Street transformer (86620900-WND024) rated at 500 kVA.

The transformer supplies the highest number of residential and commercial customers with the highest consumption.



Figure 13: 500 kVA Market Street Transformer

Existing customer profile

There are 117 customers and 19 solar customers connected to this transformer. Total customers supplied by this transformer is around 13.7% of the total Trentham community.

Table 15: Trentham customer profile

Customer type	Total customers	Solar customers	PV penetration
Residential	80	18	22.5%
Industrial	2	1	50%
Domestic farms	2	-	0%
Commercial	33	-	0%
Total	117	19	16.24%

Based on the solar export data and a conservative assumption that solar self-consumption is 30%, the estimated existing solar PV size is 44 kW (DC).

Transformer load profile

Figure 14 shows the consumption and solar trend from this transformer in the last two years.

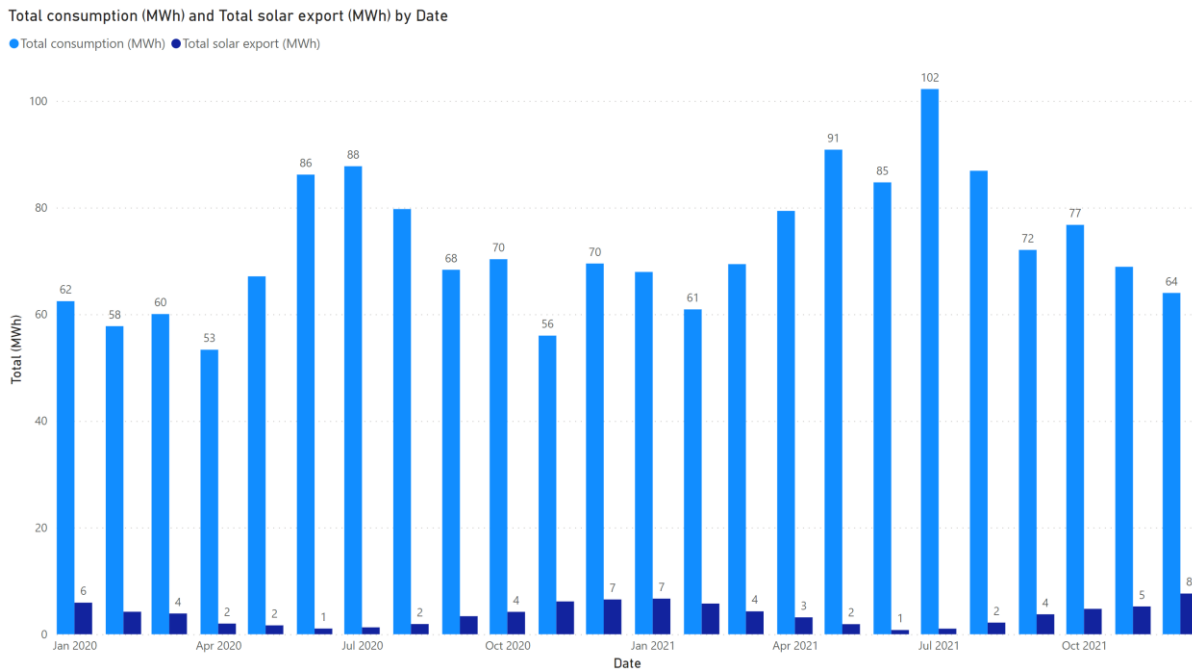


Figure 14: Consumption and Solar Export from Market Street Transformer

Figure 15 shows the transformer load profile in 2021, which was applied for this model.

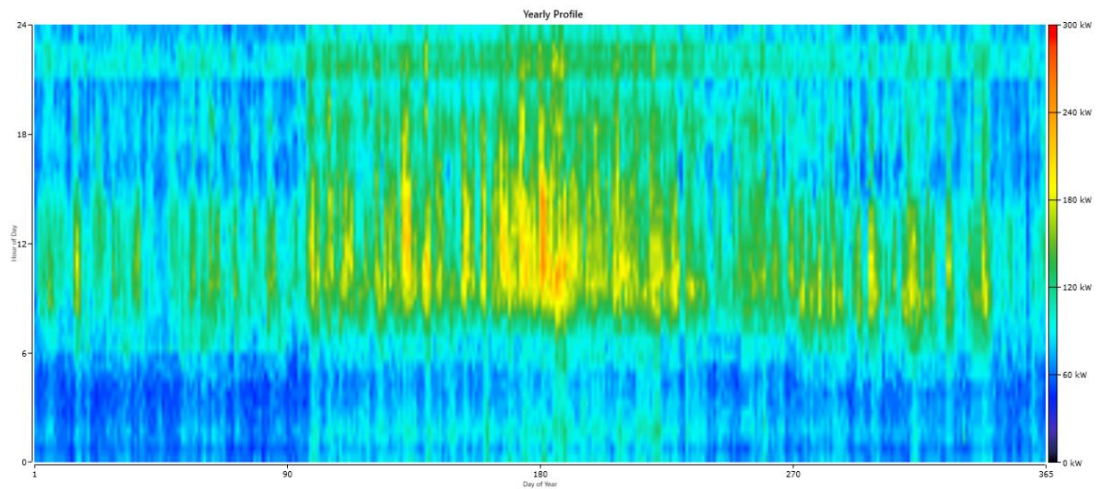


Figure 15: 86620900-WND024 Market Street Transformer 2021 Load Profile

The average load of this transformer is 2601.93 kWh per day. The peak load has been recorded at 265.43 kW which occurs during winter.

The outages from the 2021 load data were not considered in this model. The outage scenarios are included in Case 3 – Microgrid.

Simulation outcome

CURRENT SYSTEM



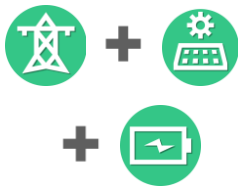
The electric needs of the area serviced by transformer 86620900-WND024, Trentham VIC 3458, Australia are met with a grid connection and 44 kW of PV. The customers currently spend \$196,572 p.a. in total on their utility bills.

Total Net Present Cost: \$3,247,025

Levelized Cost of Energy (\$/kWh): \$0.2079

Estimated Carbon Emissions (tonnes/year): 561.127

PROPOSED SYSTEM



We propose adding 706 kW (DC) of PV and 258 kWh of battery capacity. This would reduce the combined annual utility bill to \$73,777. Your investment has a payback of 8.71 years and an IRR of 9.67%.

Total Net Present Cost: \$2,297,508

Levelized Cost of Energy (\$/kWh): \$0.0958

Estimated Carbon Emissions (tonnes/year): 304.853

Winning system architecture

Table 16: Winning system architecture for Case 1 – Market Street Transformer

Component	Name	Size	Unit
PV #1	Additional PV	706	kW
PV #2	Existing solar PV	44	kW
Battery system	Li-ion BESS	258	kWh
System converter	Inverter	499	kW
Transformer load	86620900-WND024	2601.93	kWh/day
Utility	2 Period TOU – VDO (5.2c)		

Economic feasibility

Table 17: Economic feasibility for Case 1 – Market Street Transformer

Simple payback	8.71 yrs.
Return on Investment	6.48 %
Internal Rate of Return	9.67 %
Net Present Value	\$949,517
Capital Investment	\$1.07M
Annualized Savings	\$122,796

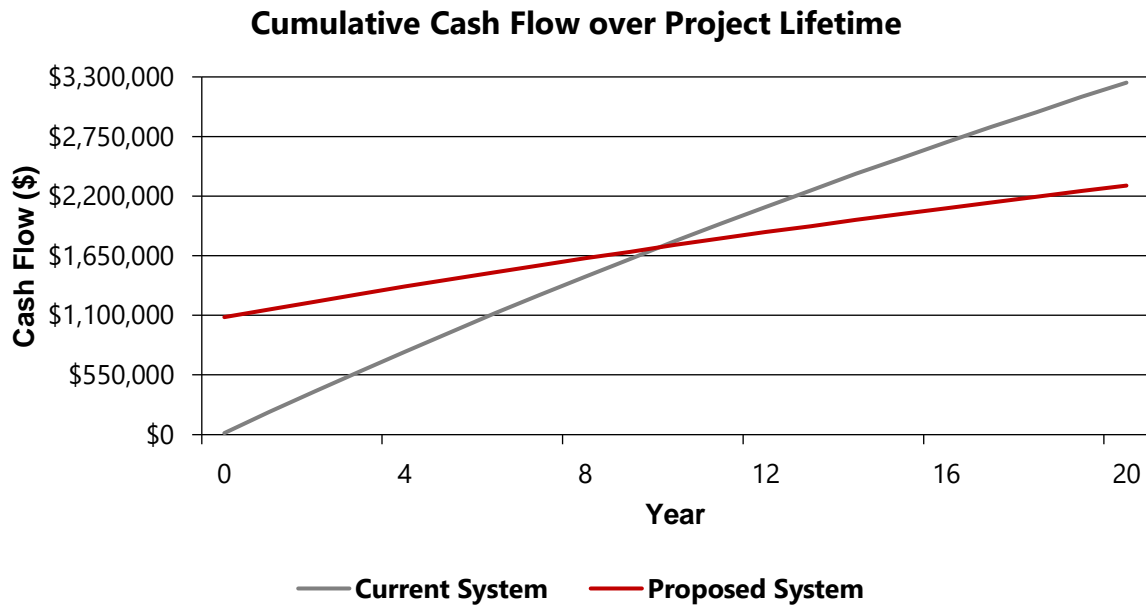


Figure 16: Market Street Transformer – Cumulative cashflow over 20 years

Market Street Transformer Site Constructability

The Market St transformer was observed during a site visit and was highlighted that this transformer was supplying majority of the commercial and residential customers on High Street. Potential space for a community battery was also noted.

Further investigation on constructability feasibility is recommended with council planning and existing services on the viability of the community battery highlighted in Figure 17 and Figure 18.



Figure 17: Potential Community Battery Location 1 (Yellow)



Figure 18: Potential Community Battery Location 2 (Yellow)

Analysis

For the high consumption model, the optimal solution for community is to install **more solar PV and battery storage**.

The model indicates the best NPC over 20 years would be achieved by installing 706 kW of DC solar in addition to the estimated 44 kW of existing solar, totalling to 750 kW of DC solar. The recommended total DC solar is based on a 1.5 DC/AC ratio and the upper limit of total inverter capacity, at 500 kW. The most effective way for the community to achieve this is by **increasing the amount of rooftop solar PV** in the area.

The 258 kWh batteries could be realised either through multiple residential batteries or a single community battery connected to the LV network. To achieve maximum benefits from the Powercor community battery tariff trial, the community battery can be no larger than 240 kVA.

Potential implementation scenarios

To achieve the proposed 500 kW solar inverter capacity from this model, the optimal solution for this transformer could be implemented by assuming customers adopt the following solar and battery configurations:

- Residential customers – to install 6.6 kW DC panels / 5 kW AC inverter, with a minimum 10 kWh battery.
- Industrial, commercial, and domestic farm customers – to install 20 kW DC panels / 15 kW AC inverter.

Table 18: Estimated available solar capacity for high consumption case

Customer type	Customers			Potential additional solar system	
	Total	Existing solar	New solar	DC panels (kW)	Inverter (kW)
Residential	80	18	32	211.2	160
Industrial	2	1	1	20	15
Domestic farms	2	-	2	40	30
Commercial	33	-	33	660	495
Total	117	19	68	931.2	700

This transformer has an estimated 700kW of potential new solar inverter capacity which means the community could very reasonably meet the 500kW solar capacity limit.

The 258 kWh battery capacity could also be achieved by installing:

- A 240 kWh community battery with two 10 kWh batteries on a residential or commercial site.
- At least 26 x 10 kWh batteries installed on any customer property.

3.2.3 Microgrid at Market Street

The microgrid model is based on the Market Street Transformer with the addition of a 300 kW generator. The generator will be able to operate the load on the Market St / High Street Transformer which supplies majority of the commercial customers within the town.

Assumptions

To accurately model the microgrid's response during power outages, this model assumed some artificial outages based on actual 2021 data:

Long outage – a continuous 72-hour outage occurring on 9th June, every year over the project lifetime. The date is based on the storm outage in 2021.

Short outages – a total of five random short outages (3.3 hours each), every year over the project lifetime.

The diesel fuel price was assumed to be \$2/L on average over the project lifetime.

A sensitivity analysis was completed varying the fuel price between \$1.50/L and \$2.50/L given the current increase in fuel prices due to recent world events. However, given the limited hours of operation, economic sensitivity to the fuel price is negligible.

Due to HOMER limitations, the "current system" model also includes generator in the base scenario which requires a capital investment of \$126,600.

Economic Feasibility and Results

Table 19: Economic feasibility for Microgrid

Simple payback	9.64 yrs.
Net Present Value	\$822,917
Capital Investment	\$1,196,600

Analysis

The microgrid model produces a similar system architecture of Market Street Case (refer to Table 17) with the addition of a 300-kW diesel generator. The total capital cost for the diesel generator is estimated to be \$126,600 (\$63,000 for a 300 kVA diesel generation plus \$63,000 for installation costs). There are also minor O&M costs and fuel during operation.

This diesel generator helps with community energy resilience, allowing the grid to operate during the 3-day continuous and five 3.3-hour artificial outages, as shown in Figure 19. The generator can be seen to only operate outside of solar generation hours.

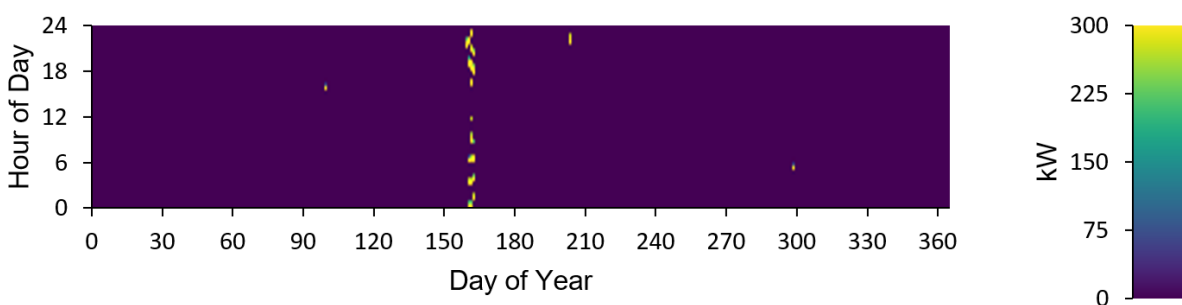


Figure 19: Annual diesel generator fuel consumption

The payback time for this system is approximately 9.64 years. In comparison to Case 1 Residential, which has a payback of 8.71 years – the capital investment of \$126,600 and slight increase of 0.93 years provides the community with greater energy security.

3.2.4 Sensitivity Analysis

Battery Prices and Export Tariff Fluctuations

Sensitivity checks were run by reducing battery prices to \$800/kWh and export tariffs to 4c/kWh. Results showed that declining tariff prices increased the economic viability of batteries but decreased the viability of solar. This is because excess solar generation would be used for energy arbitrage through the community battery instead of feeding into the grid.

The following section presents the findings from the sensitivity analysis was conducted on the solar feed-in tariff and battery costs for the residential base case:

Solar feed-in tariff rates

The final solar feed-in tariff used each case was the minimum feed-in tariff (effective 1st July 2022) of 5.2 c/kWh. The trend in recent years is for feed in rates to reduce and this is expected to continue as solar penetration increases. Reduced feed in rates make battery systems more attractive.

To demonstrate the impact of variable feed-in tariffs, a sensitivity analysis was conducted using various rates, as shown in Table 20.

Table 20: Solar feed-in tariff rates for sensitivity analysis

Solar feed-in tariff rates	Capital cost (c/kWh)
Current Powercor feed-in rate for FY21/22	6.7
Minimum feed-in tariff for FY22/23	5.2
Conservative estimate of future rates	4

		5.2c	4c	Architecture						Cost				Compare Economics			
		PV-R (kW)	PV-E (kW)	LI-Ion	VDO (5.2c)	VDO	Inverter (kW)	NPC (\$)	COE (\$)	Operating cost (\$/yr)	Initial capital (\$)	IRR (%)	Simple Payback (yr)	Utility Bill Savings (\$/yr)	Total Bill Savings (\$)	Demand Charge Savings (\$/yr)	Energy Charge Savings (\$/yr)
		706	44.0	258	1		499	\$2.30M	\$0.0958	\$73,777	\$1.08M	11	8.0	\$135,451	\$2.23M	\$0	\$135,451
		706	44.0		1		500	\$2.32M	\$0.0934	\$90,739	\$826,640	13	7.0	\$118,489	\$1.95M	\$0	\$118,489
		706		267	1		500	\$2.35M	\$0.101	\$76,424	\$1.09M	10	8.2	\$132,804	\$2.18M	\$0	\$132,804
		706			1		500	\$2.37M	\$0.0967	\$93,832	\$826,640	13	7.2	\$115,396	\$1.90M	\$0	\$115,396
		706	44.0	300		1	497	\$2.40M	\$0.101	\$77,315	\$1.13M	10	8.5	\$131,913	\$2.17M	\$0	\$131,913
		706	44.0			1	500	\$2.43M	\$0.0969	\$82,660	\$826,640	12	7.4	\$111,568	\$1.83M	\$0	\$111,568
		706		275		1	473	\$2.44M	\$0.106	\$82,216	\$1.09M	9.9	8.6	\$127,015	\$2.09M	\$0	\$127,015
		706				1	479	\$2.48M	\$0.102	\$100,798	\$818,273	12	7.5	\$108,430	\$1.78M	\$0	\$108,430

Figure 20: Solar feed-in tariff sensitivity analysis in HOMER

Figure 20 shows the impact of a smaller feed-in tariff on the NPC and proposed BESS size. Note, the battery capital cost assumed \$1,000 per kWh.

- Using a 5.2 c/kWh tariff, the proposed battery is **smaller** at 258 kWh resulting in a smaller and **better** NPC.
- Using a 4 c/kWh tariff, the proposed battery is **larger** at 300 kWh. The NPC benefit reduces due to the lower feed-in tariff – an external factor that would also reduce the NPC benefit of other solar-based systems. The larger battery size is attributed to greater economic benefit from consuming solar energy stored in the battery, rather than selling it back to the grid at a reduced rate.

Naturally, a higher feed-in tariff yields a better NPC given there is less capital investment in a smaller battery and there are more utility bill savings from the additional feed-in credits.

Battery Capital Costs

The proposed battery capacity for each case was based on a capital cost of \$1,000 per kWh.

To demonstrate the impact of variable battery costs, a sensitivity analysis was conducted by varying scaling the capital cost between 80% - 120% in 10% increments, as shown in Table 21.

Table 21: Battery capital cost multipliers for sensitivity analysis

Li-ion capital cost multiplier	Capital cost (\$/kWh)
0.8	800
0.9	900
1	1,000
1.1	1,100
1.2	1,200

Sensitivity	Architecture							Cost				Compare Economics				
	Li-Ion Capital Cost Multiplier (%)	PV-R (kW)	PV-E (kW)	Li-Ion (kWh)	VDO (5.2c)	Inverter (kW)	NPC (\$)	COE (\$)	Operating cost (\$/yr)	Initial capital (\$)	IRR (%)	Simple Payback (yr)	Utility Bill Savings (\$/yr)	Total Bill Savings (\$)	Demand Charge Savings (\$/yr)	Energy Charge Savings (\$/yr)
0.800		706	44.0	427	1	497	\$2.23M	\$0.0958	\$64,785	\$1.17M	9.6	8.7	\$131,787	\$2.17M	\$0	\$131,787
0.900		706	44.0	325	1	500	\$2.27M	\$0.0956	\$69,873	\$1.12M	9.7	8.7	\$126,699	\$2.08M	\$0	\$126,699
1.000		706	44.0	258	1	499	\$2.30M	\$0.0958	\$73,777	\$1.08M	9.7	8.7	\$122,796	\$2.02M	\$0	\$122,796
1.100		706	44.0	99	1	500	\$2.31M	\$0.0933	\$86,571	\$891,386	11	8.0	\$110,001	\$1.81M	\$0	\$110,001
1.200		706	44.0	1	1	500	\$2.32M	\$0.0924	\$90,739	\$626,640	12	7.7	\$105,833	\$1.74M	\$0	\$105,833

Figure 21: Battery cost sensitivity analysis in HOMER

Figure 21 shows the impact of varying the capital cost of the battery. Note, this only shows the impact when paired with the base solar feed-in tariff for FY22/23 of 5.2 c/kWh.

- The **lower battery costs yield a higher proposed battery size**. The proposed battery size is 427 kWh when capital cost is \$800/kWh. In comparison, when the capital cost is \$1200 per kWh, the most optimal solution is no battery at all.
- The larger battery size leads to an improved NPC.

FCAS Revenue Stream

Frequency Control Ancillary Services (FCAS) is as a potential revenue stream for the community battery. For requirements to participate in FCAS, systems must be at a minimum of 1MW and can be aggregated via market ancillary service providers.

The following assumptions were made in demand response participation:

Table 22: FCAS Inputs into Market Street Transformer

Input Parameter	Value
No. of DR Events per year	5
Event Duration Hours	1
Demand Reduction Incentive	\$35/kW

By applying the demand response inputs on the Market Street transformer as per Table 22, participation in FCAS reduces the payback period by 1.5 years (8.4 to 6.9 years). On a demand reduction incentive of \$35/kW (240kWh battery), it is estimated that each event produces ~\$3000 revenue.

Assuming 5 events per year, this would result in a revenue of ~\$15,000, and \$150,000 in revenue for 10 years considering a battery in operation for 10 years. Actual DR events are difficult to predict due to the number of variables involved (load, demand reduction incentive, event durations and capacity available).

Conclusions from this FCAS scenario show that FCAS participation for a community battery is recommended. For further information on FCAS, refer to D.3.

4 Community Energy Infrastructure Installation Feasibility

4.1 Existing Renewable Energy Technologies

The current existing renewable energy technologies to date include residential solar and batteries. The dataset provided by C4Net/Powercor does not include any information on the adoption of battery systems coupled with solar.

Small scale solar is increasing at approximately 12.7% p.a. Exported solar energy accounts for approximately 11.9% of consumption in 2021. At this rate of growth locally generated solar export could meet current demand in 2039, though this is not a realistic end point. Currently approximately one third of houses have solar. It is reasonable to forecast that this may double to cover two thirds of houses and new systems are typically slightly larger. At the current growth this would be achieved in 2025-2026 and solar export from the small systems could support approximately 25% of energy used.

There are current subsidy schemes to assist in solar installations⁴. It is recommended that small scale solar continue to be supported and encouraged.

Small scale solar is grid interactive and cannot operate when the grid fails. On its own is cannot significantly contribute to improving grid reliability, and with high solar export grid constraints may limit new solar export.

Local solar uptake is a key factor for other measures such as local and community batteries and microgrids.

4.1.1 Powercor Requirements for Solar Installations

Powercor requires all micro embedded generators to remain below the maximum export capability and export limit. For single phase customers, the maximum system capacity on the Powercor network is 10 kVA with a maximum export of 5 kW. For three phase customers, the maximum system capacity on the Powercor network is 30 kVA with a maximum export of 15 kW. Note, this depends on the transformer size and existing inverter connections.

The rough estimate for a 5 kW solar system consisting of a 6.6 kW DC solar panel and 5 kW battery-ready inverter is \$8,000⁵. The addition of a 14 kWh residential battery increases to cost to around \$16,750 (including installation costs).

4.2 Household Batteries

Household batteries can be installed on their own and charge from the grid, but they achieve their maximum potential when coupled with a local solar system. In this configuration low value solar export is stored locally and then returned to the household when power is needed instead of from the grid, avoiding higher peak power prices.

Household batteries often have enough supply capacity to provide all load for a house and when coupled with a grid change over switch can automatically take over in a grid failure to keep power seamlessly on to the house. If there is local solar that can generate enough for total daily usage, then the household could

⁴ <https://www.solar.vic.gov.au/solar-panel-rebate>

⁵ [Lithium-Ion Batteries and solar energy storage \(solarquotes.com.au\)](https://www.solarquotes.com.au)

operate independent of the grid for many days. This will be more achievable in the warmer months. In winter, some support from a small generator may be required depending on the household usage.

We recommend engaging local solar and battery distributors to reduce markup costs during installation. This markup may be quoted from suppliers as Trentham is a significant distance from Melbourne. A solar and batteries bulk buy program may assist in alleviating potential markup costs.

4.3 Community Batteries

4.3.1 Background

A community battery, or neighbourhood-scale battery, is an asset located in front of the meter on either private or public land. It is an energy storage system designed to charge and discharge electricity, which enables a more resilient grid. It also promotes the uptake of solar within the community given excess solar energy produced during the day can be stored, then used by the community at night.

The benefits of community batteries include:

- Providing access to local solar generation storage at a lower cost than individual household batteries.
- Increasing the capacity of solar that can be added to the network – in areas with high solar uptake where voltage limits or utility restrictions limit solar output.
- Providing access to cheaper local solar generated power for people without solar, or for whom the installation of solar is impractical.

Based on the analysis to date it does not appear that solar uptake is significantly limited. In some areas local export of solar at peak times of the year is up to one third of total usage. These areas may be an opportunity for a community battery. Initial modelling presented in section 3.2 indicates that at this stage the best cost outcome is to encourage more solar on its own. Greater solar uptake creates an immediate benefit with the shortest payback. Once solar uptake starts to create limitations for solar export then a battery starts to become viable to unleash more solar and to maximise the benefit of the solar being generated.

Key to the financial viability of a community battery is favourable network tariffs. Powercor is currently offering a community battery tariff trial which is a significant benefit for batteries no larger than 240 kVA. The evaluation does not currently include for the favourable network tariff, which is for a 2-year trial period.

From the data and analysis, we can identify the best candidates for a community battery. A detailed feasibility study would be required at these locations to take this further. A high-level assessment on the 3 best candidates is presented in Section 3.2.

4.3.2 Typical Barriers for Community Batteries

Some of the barriers for community batteries include the following:

1. Double up of costs from discharging and charging the community battery – If significant network charges apply for the community to charge and discharge battery, then the community battery becomes infeasible.
2. Identification of revenue streams – Ensuring which revenue stream would be appropriate for the community battery.

For more details on battery revenue streams, see Appendix D.

3. Identification of operational philosophies and ownership models – It should be noted that council planning for community batteries is now exempt across Victoria.

4.3.3 Government Funding and Grants

The following government funding opportunities may be applicable:

Table 23: Government fundings and grants

Funding opportunity	Description
<u>Towards Zero Community Grants Program</u>	<p>The Towards Zero Community Grants Program has opportunities of funding up to \$40,000.</p> <p>This supports community groups and organisations to reduce greenhouse gas emissions, through reduced energy consumption, carbon drawdown and/or increasing the use of renewable energy in community facilities. These include:</p> <ul style="list-style-type: none">○ Renewable energy systems, such as solar PV○ Energy efficient heating/cooling systems, lighting, etc.○ Carbon drawdown
<u>Small Grants for Rural Communities</u>	Grants to support your community before, during, and after a natural disaster or drought and build your community's climate resilience.
<u>Regional Australia Microgrid Pilots Program</u>	RAMPP is a \$50 million six-year program that aims to improve the resilience and reliability of power supply for regional and remote communities.
<u>Neighbourhood Battery Initiative Victorian Government (www.vic.gov.au)</u>	The Victorian Government's \$10.92 million Neighbourhood Battery Initiative (NBI) is providing grants to fund pilots and demonstrations of a range of neighbourhood-scale battery ownership and operational models, to unlock the role that neighbourhood scale batteries can play in Victoria's transitioning electricity system. The growth in renewables and electrification will continue to drive demand for batteries.
<u>New Energy Jobs Fund</u>	The New Energy Jobs Fund Round Six will provide \$1 million in grants for a broad range of renewable energy and energy efficiency feasibility studies, business cases and implementation-ready capital works projects.

4.3.4 Community Battery / Microgrid Examples

The following community battery examples are shown below:

Table 24: Community battery and microgrid examples

Microgrid / Community Battery	Summary of Findings
<p>Yarra Energy Foundation Community Battery (YEF) - (110 kW / 284 kWh)</p> <p>Source: Youtube Link</p>	<ul style="list-style-type: none"> • YEF Community Battery operated by Acacia Energy as the market operator. • 66% of total revenue stack from the battery via FCAS. One third of revenue stack from energy arbitrage (Daily saver tariff). • Operating philosophy of the community battery charges and discharges from renewable energy sources only (no charging / discharging from non-renewable sources). • Accessible to renters / apartment dwellers.
<p>Clean Energy Nillumbik Community Battery - Feasibility Study</p>	<ul style="list-style-type: none"> • Two sites being feasible with NPV between \$0 – \$35,000 over 12.5 years. • Feasibility was highly dependent on the ‘community battery tariff’ by Powercor (daily saver tariff). • Community engagement indicated significant support for these projects with input in operation of the battery to support the grid network (81% of community interested in selling energy to a neighbourhood battery).
<p>Community Sparks – Hepburn</p> <p>Community Sparks - Hepburn</p>	<ul style="list-style-type: none"> • Financial feasibility assessment of community batteries. • Survey findings with report to be produced (273 respondents). • Close to one third of residential respondents in the survey had solar. Business respondents had 38% of solar. • Lots of community members are vulnerable to impacts of climate change. • Different issues for different townships may affect their preferences for how and what a community battery addresses. • The most important benefit for most respondents were addressing climate change, followed by building resilience, then self-sufficiency, carbon saving, solar benefits, and lastly financial rewards. • Out of all benefits, personal financial rewards were not as important as others. • Many respondents wanted to see financial benefits targeted to those with the greatest need. • In focus groups, some participants felt projects needed to benefit them financially and others were happy with non-financial benefits such as improved resilience or less blackouts. • Community ownership was the most popular ownership arrangement (75%).

4.4 Microgrid

4.4.1 Microgrid Architecture

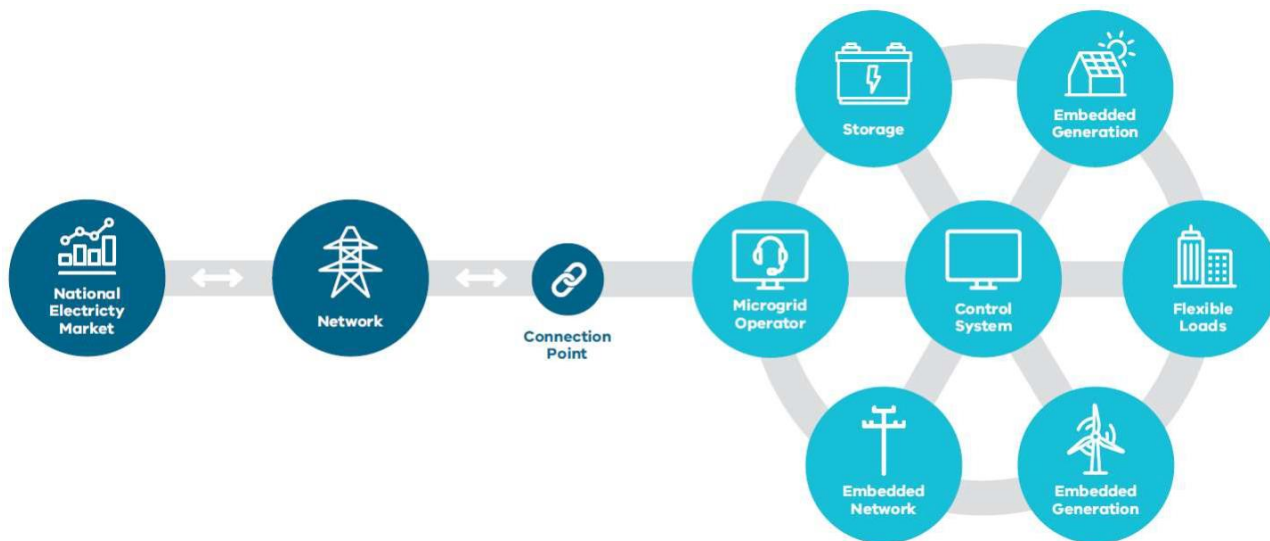


Figure 22: Typical microgrid architecture⁶

Microgrids are like a community battery which also include:

- Increasing the output rating to at least match the maximum demand,
- Adding a changeover switch to allow the battery to supply the area (typically a transformer's load/output area) when the grid supply is down, and
- Adding a generator that can support the average load when other generation such as solar is insufficient (e.g., a diesel backup for overnight and winter).

Financially, community batteries can be expected to outperform microgrids as they are sized for the optimum power transfer for financial benefit and not to support all load. They also do not need the changeover switching and additional control and generator support. Substantial benefit needs to be provided by a reliability requirement (e.g., many outages causing safety issues or economic loss) or cost saving by replacing network supply (such as remote areas where cost to support network supply is high). Neither of these benefits appear to be applicable to the general Trentham community. There may be benefit in providing outage support for specific facilities such as community buildings or support services (e.g., supermarket, community halls, CFA (Country Fire Authority), police).

The residential case study has been modelled for taking it to a microgrid that can be fully autonomous, and the results provided below to show the indicative size and cost of such a system.

⁶ [Microsoft Word - Microgrids Factsheet.docx \(energy.vic.gov.au\)](#)

4.5 Solar Power Station

Trentham currently generates up to one eighth of its power. The gap supplied by the grid is 5.55GWh annually. Half of this gap could be served by a 1.6MW DC/ 1.2MW AC solar power station. The solar field below contained 1.6MW of panels and would generate 2.63GWh of power each year – one half of the total usage drawn from the grid.



Figure 23: Power Station in Trentham

4.6 Wind Power

Trentham has some nearby areas with moderate wind resource but is not as windy as the better areas in Victoria.

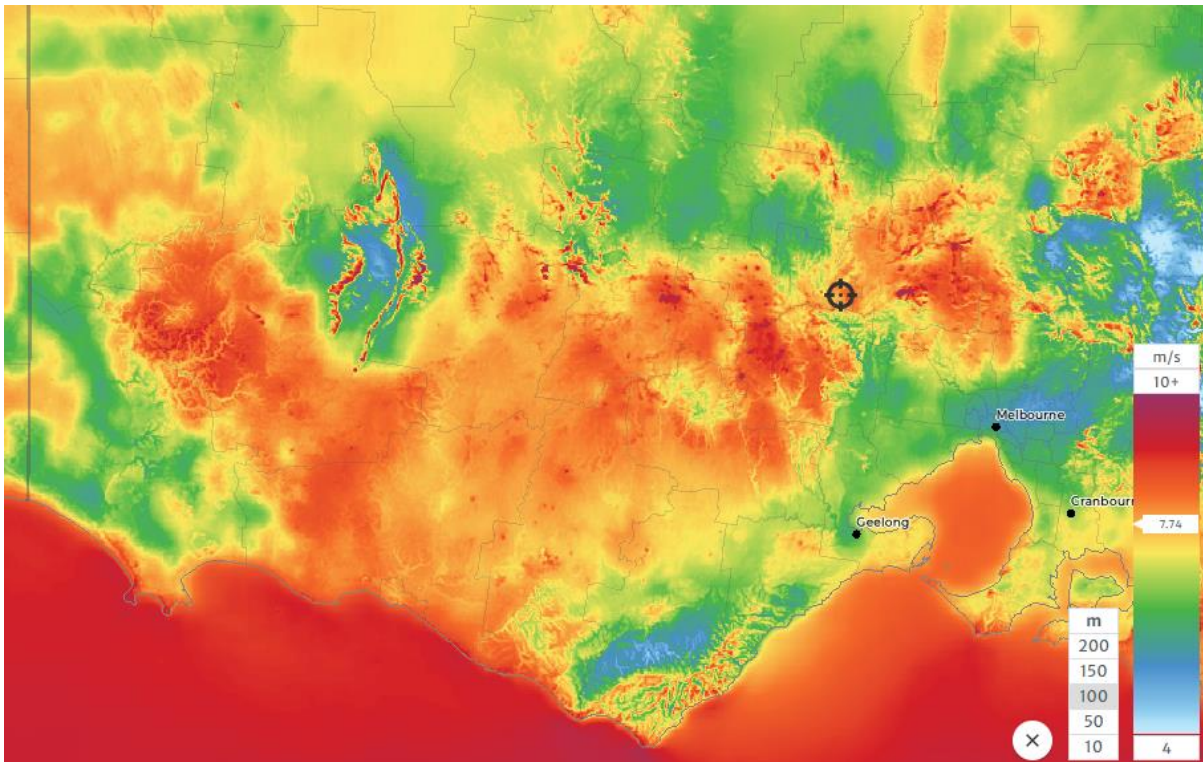


Figure 24: Victorian average wind speed at 100m with Trentham indicated (Source Global Wind Atlas)

Wind resources are generally higher in winter. Solar generation is lower in winter. Wind opportunity is higher in winter which aligns to the power needs of the community.

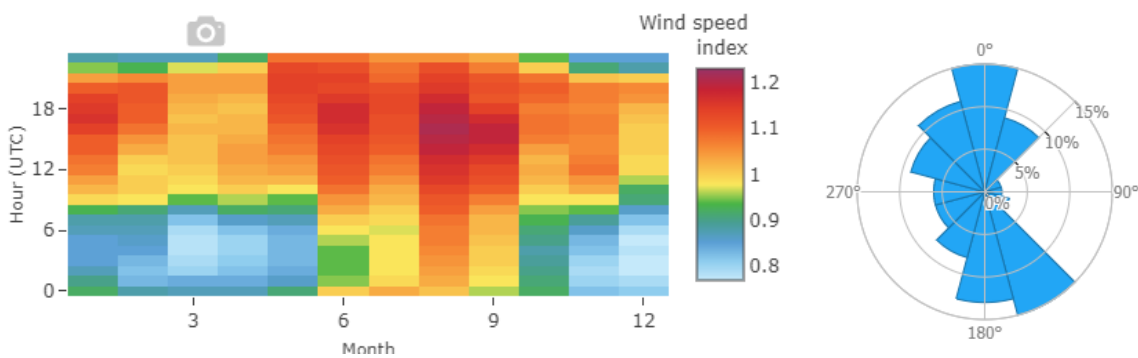


Figure 25: Wind speed index and wind rose (Global wind Atlas)

5 Energy Retailer Review

5.1 Trentham Retailer Partnership Offers

TSG/CCCE have requested Middleton Group to engage potential retailers to develop a 'white label' retailer partnership with TSG. The purpose of the retailer partnership was to develop into a model resulting in financial dividends. This would support ongoing energy and climate resilience projects in the Trentham community.

Further benefits of the partnership would be enabling energy to be more affordable for the town. Improving access to more affordable power would encourage the community to an uptake of renewable energy adoption (such as solar and VPP bulk buys).

The retailer engagement and selection process are further detailed in Appendix B. There was a total of 5 retailer responses for the weighting criteria and is shown in Table 25.

Table 25: Retailer Response Table

Query	Diamond Energy	Acacia Energy	Flow Power (Via Hepburn Energy)	Indigo Power	Shinehub
Retailer partnership experience	3	2	2	2	0
Powercor area of operation	3	3	3	0	0
Renewable initiatives	2	2	3	3	3
Solar bulk buy and VPP program	2	1	2	0	1
General low tariff offer	3	0	0	0	0
Community battery experience	1	3	1	3	2

Based on the weighting criteria, the recommended retailer for TSG / CCCE engagement would be Diamond Energy. It is important to note that TSG / CCCE is not limited to a single retailer for all portions of the scope. A single retailer may be engaged for a certain part of the scope based on their proven experience (e.g., Acacia Energy would be a suitable retailer for management of a community battery, whereas TSG / CCCE may engage Diamond Energy or Flow Power for a solar bulk buy / VPP program).

5.1.1 Recommendation

The recommendation is for TSG / CCCE to engage with Diamond energy to discuss a white label retailer partnership. TSG / CCCE would also be able to engage other retailers for any future projects based upon the weighting criteria.

6 Residential Study

A residential study for solar and batteries was held for households within Trentham to understand the payback period for households.

Residential loads were classified from the Victorian Energy Usage Profiles study⁷ (2016). Results of this study is indicative only, as the energy usage patterns for each household may have slightly changed from 2016.

The Victorian Energy Usage Profile considers Trentham in Climate Zone 6 and 7⁸. As part of this report, we have considered Trentham to be in Climate Zone 7. The township of Trentham is also supplied by the Powercor Network.

6.1.1 Household Energy Usage Trends

The report states that cooler climates in such as Trentham have a much higher gas heater ownership than warmer climates. The proportion of households that have ducted gas heating was estimated to be 67% in climate zone 7⁹. It is expected that a household with access to gas can be expected to use less electricity than a household without gas access¹⁰.

Observations from the analysis also show that the presence of a swimming pool or electrical underfloor heating showed had a significant impact in energy use. In climate zone 7, approximately 10% of the population had a swimming pool and 6% of the population had an underfloor heating system.

The average consumption categories were included in Table 26. The electricity consumption of the 'no solar' option was of interest to this study, as the purpose of this study was to identify the current payback period (and return) for households when purchasing a solar and battery system. The annual electricity consumption of the 'solar' category was of interest showing an approximate 600kWh reduction compared to the 'no solar' category.

Table 26: Annual Household Electricity Consumption - By Category

Category	Annual Electricity Consumption (kWh)
Powercor Network Average	5,413
No Solar (All DNSPs)	5,241
Solar (All DNSPs)	4,671

For simplicity, controlled or non-controlled loads were not considered as part of this study. Results showed that there are only minor differences in the general consumption profile of controlled loads to non-controlled load customers¹¹. Separate controlled load data for Powercor was also not available.

⁷ [Acil Allen Report \(esc.vic.gov.au\)](http://esc.vic.gov.au)

⁸ Climate Zone 7 is considered as a cool temperate climate zone (low humidity, high diurnal range, four distinct seasons, summer and winter exceed human comfort range, variable spring, and autumn conditions, cold to very cold winters with majority of rainfall, hot dry summers).

⁹ ACIL Allen Report (esc.vic.gov.au), Section 4.6.2.

¹⁰ ACIL Allen Report (esc.vic.gov.au), Section 3.1.5.

¹¹ ACIL Allen Report (esc.vic.gov.au), Section 4.4.2.

The Energy Consumption Benchmarks Report¹² was used to categorise household energy usage into low, medium, and high (refer to Table 27). No swimming pool loads, controlled loads or gas were included in any of the following categories.

A solar system was assigned to each household category, with low, medium, and high usage households having a 5, 7, and 10 kW system, respectively.

Table 27: Household Category Defined for Trentham

Category	Category Detail	Daily Estimated Usage (kWh)	Yearly Estimated Usage
Low	1 person No Slab Heating 5 kW Solar System	10.2	4,482
Medium	4-5 People No Slab Heating 7 kW Solar System	17.9	6,205
High	4-5 People Slab Heating included 10 kW Solar System	35.3	8,619

6.1.2 Residential Solar Payback Period

Based on the household categories defined in Table 27, results of the residential study showed that the payback period of a solar coupled battery system for households are marginal. Higher usage households would have a slightly higher return due to the offset of daily consumption from the solar system. Results of the payback period are summarised in the Table below.

The following assumptions were made to determine the payback period:

- Battery system size for all categories is 13.5 kWh. This is equivalent to a Tesla Powerwall 2.
- Assumed direct consumption / direct offset from solar system is 30%
- Assumed Solar VIC Rebate eligibility for all categories.
- Assumed STC price of \$40.

¹² [Energy Consumption Benchmarks Report](#), Section 5.12 and 5.13.

Table 28: Residential Study Payback Period for Solar and Batteries

Time of Use Tariff Type	Low Usage	Medium Usage	High Usage
Installation Cost	\$15,044	\$16,237	\$17,822
Return of Investment (%)	11.1%	11.1%	12.8%
Payback Period	9.0	9.0	7.8
Flat Rate Tariff Type	Low Usage	Medium Usage	High Usage
Installation Cost	\$15,044	\$16,237	\$17,822
Return of Investment (%)	6.7%	11.8%	10.8%
Payback Period	14.9	11.8	9.3
No Rebate from Solar Victoria	Low Usage	Medium Usage	High Usage
Installation Cost	\$18,544	\$19,737	\$21,322
Return of Investment (%)	9%	10.9%	10.7%
Payback Period	11.1	10.9	9.3
Solar Only	Low Usage	Medium Usage	High Usage
Installation Cost	\$2,649	\$3,842	\$5,427
Return of Investment (%)	15.2%	15.1%	19.6%
Payback Period	6.6	6.6	5.1

The key takeaways are:

- Time of use tariffs improve payback period of solar and battery investments compared to a flat rate tariff.
- Assuming a 5.2c/kWh feed-in tariff, the return of solar-only systems is still viable.
- Battery coupled solar systems are considered a break-even investment.

Although battery coupled solar systems are near break-even, they may be worth considering as a trade-off for a more reliable power supply.

7 Conclusion

Essential Sites

Our recommendation is that solar systems be installed for the Country Fire Authority, Community Hub, Sportsground, and the Community Bank and will provide a useful return.

At current market rates and conditions, battery systems coupled with solar are only marginally viable for residents, and not viable for commercial customers. Battery and solar systems would only be viable if the export price drops to 2c/kWh with battery prices reducing to \$960/kWh.

Power resilience through a generator has been installed for the CFA, Community Hub, and the IGA. The Sportsground Pavilion and Community Bank do not have generators to operate during long outages. For the community bank, a battery and solar resilience solution may be able to provide continuity of supply during office hours. This is the most green option but not the best financial return.

Microgrid Modelling and Feasibility

A Microgrid consists of an automatic switch, backup generator with several generation sources. In this case the proposed generation sources would be solar and batteries, with generator backup. Community batteries allow for power to be stored and supplied back to the grid when demand is high. The greatest benefit occurs when the power stored comes from locally generated solar exports, which can then be returned to the community at peak times.

More solar is needed in Trentham for the microgrid to be feasible. The recommended location for a microgrid would be under the High Street / Market Street Transformer. The market street transformer supplies most of the commercial customer base and a small portion (11%) of the residential customers in Trentham. Economic viability for a battery is a complex combination of the power flows, power rates, and cost of the battery. The viability of the Market St Transformer microgrid is best with 706 kW of local solar generation. This would enable a 258 kWh battery to be installed. The NPV for the community battery would be \$822,917 with a capital investment of \$1.196M with a payback period of 9.64 years. A 300 kW size diesel generator can supply the peak load of the transformer for backup supply adding an additional investment of \$126K.

A total of 126 transformers were investigated by solar export. The value of a community battery at the majority of the transformers was not as great as compared to the High Street Transformer. Feasibility would be increased if there was greater local solar generation, attractive tariffs for batteries, or battery prices reduced.

The energy consumption for Trentham in 2021 was 6.3 GWh. Solar export within Trentham is 0.747GWh leading to an annual import of 5.55 GWh. If solar generation by residential and commercial customers were to double, large scale generation would still be required to supplement peak demand. It was calculated that a 1.6 MWDC solar farm would be required to supplement 50% of the annual imported energy in 2021 (2.63 GWh). Solar generation is lowest in the winter months which is also when the power demand from the grid is highest. Wind resources were also assessed in Trentham showing moderate wind speeds. Higher wind speeds occur during winter which correlates with the power needs of the community. Wind generation could be considered as an option though it is more complicated as a project than solar power.

White Label Retailer Engagement

An assessment of retailers for a white label partnership was conducted based on a weighting criterion. The recommended retailer is Diamond Energy. It is important to note that TSG / CCCE is not limited to a single retailer for all portions of the scope and several had offerings of interest. A single retailer may be engaged for a certain part of the scope based on their proven experience and TSG / CCCE preferences (e.g., Acacia Energy would be a suitable retailer for management of a community battery, whereas Diamond Energy or Flow Power may be engaged for a solar bulk buy / VPP program.).

Residential Study

A residential study was conducted to determine the investment in solar and battery systems. Solar systems alone have a good return and are still good investments. Batteries have a marginal payback when coupled with rebates and may be worth considering for continuity of supply.

To address resilience within residential households, battery coupled solar systems are considered a break-even investment. Investment into such systems is worth considering as a trade-off for a more reliable power supply.

Summary Recommendation

Our recommendation is to maximise the adoption of solar within commercial and residential customers. 27% of electricity customers within Trentham have solar PV generating 0.747 GWh of export. This 27% breaks down as 3% of commercial customers and 30% of residential customers. Based on the current solar adoption rate in Trentham, solar export could double to 1.5 GWh per year within the next 3-4 years. An estimate of 4.05 GWh of generation would still be required from other sources for Trentham to be self-sufficient.

To improve energy resilience within Trentham, increase in solar and / or energy storage systems will be required. Energy storage systems may be addressed at each household or centralised with a community microgrid (with generator). Increase in solar generation improves the feasibility of a microgrid / community battery and helps achieve Trentham's goal of energy resilience and reducing overall carbon emissions.

There are limits to the amount of power that can be generated from small scale solar. To achieve carbon neutral generation locally, larger systems such as the solar power station or wind generation would need to be considered. These are a substantial investment and long-term commitment for the community. Finding partners interested in working with the community to develop such plants would be necessary to take it forward.

Appendix A Essential Site Modelling Assumptions

The energy options modelling was completed using HOMER Grid – an industry standard, hybrid power system modelling software package. The software assesses the local system and load requirements then optimises the distributed energy resource sizes based on existing tariffs, incentive programs, and capital costs for individual systems.

It generates several options based on a combination of renewable sources and sizing's then ranks them based on economics and the lowest net present cost (NPC). This allows for easy comparison of design outcomes to assist with considering design options and to minimise financial risk to the project whilst reducing energy expenditure.

As part of this study, practical considerations for energy reliability included solar and batteries only.

Individual sites were selected by Trentham Sustainability Group for consideration of a dedicated microgrid. Such sites were the Trentham IGA Supermarket (Country Grocers), Trentham Country Fire Authority, Trentham Sports Ground and Pavilion, and the Trentham Community Hub.

The sites were modelled using the recent 12 months of power data (2021 June – 2022 June).

To accurately determine the cash flows, the following assumptions model assumptions were made for all cases:

Table 29: Modelling Parameters

Parameter	Value
Project lifetime	20 years
Expected inflation rate	3%
Nominal discount rate	5%
Real interest rate	1.9%

A.1 Country Fire Authority

An energy economic assessment has been conducted based on historical power data. Our recommendation is to install a solar-only system. The resulting system is a 6.6 kW system that has a payback period of 7.3 years with an initial capital investment of \$8,321.

At current rates and market conditions, battery storage systems are not economically viable and have a significantly longer payback period compared to a solar-only system. Battery systems coupled with solar begin to become economically viable when export tariffs reduce to 2c/kWh and battery prices fall to \$840/kWh.

The site is typically unmanned with low power consumption during daylight hours. The low usage means minimal self-consumption of solar during the day, one of the key benefits and paybacks for solar when it can offset more costly power from the grid. This significantly reduces the financial benefit of the solar system, with the primary return only from the feed-in tariff.

Reliability measures have been taken in response to past issues with long-term power outages. The CFA station has been fitted with a generator able to supply the power needs of the site.

The existing generator can support the site power needs and is likely quite oversized for the duty. A solar and battery system could provide a more seamless transfer in event of grid failure (without manual change over) without the noise and carbon emissions. However, it is a more expensive option and at current power prices, does not provide a reasonable return.

A.1.1 Country Fire Authority – Recommended System Summary

Table 30: Solar and Generator Table Summary

Solar and Generator Summary (Recommended)	
Solar System Size	6.6 kW
Generator Size	17.6 kW
Economics Summary	
Average annual energy bill savings:	\$826
CAPEX	\$8,321
Payback time (simple/discounted):	7.3 / 8.0 years
Internal Rate of Return (IRR)	10.7%
Project lifetime savings over 15 years:	\$12,393

Table 31: Solar and Generator - Predicted Electricity Monthly Bill Summary

	January	February	March	April	May	June	July	August	September	October	November	December
Predicted Energy Bill	-\$15	-\$1	\$25	\$49	\$129	\$137	\$63	\$60	\$60	\$32	\$22	-\$11
Consumption (kWh)	169	204	355	405	829	229	854	496	489	372	313	171
Export (kWh)	797	655	634	424	224	148	195	368	451	576	566	740
Peak Demand (kW)	2	2	3	4	5	4	4	2	4	4	3	2
Fixed charges (\$)	\$23	\$21	\$23	\$22	\$23	\$22	\$23	\$23	\$22	\$23	\$22	\$23
Monthly Total (\$)	\$8	\$20	\$48	\$71	152	\$150	\$160	\$87	\$83	\$55	\$45	\$12
Annual Total (\$)	\$891											

A.2 Country Grocers – IGA Supermarket

Trentham Sustainability Group (TSG) have engaged Middleton Group to undertake an energy assessment of the power system at Country Grocer's IGA. The supermarket was nominated by TSG as an essential service that could benefit from a backup supply system in emergency situations.

The energy assessment of the existing power system was based on historical power data. Our recommendation is to do nothing as all proposed systems have a longer payback period than the supermarket is to remain at the site. A solar or battery system also could not be practically sized for the required load given the space available.

The system with the least payback period is a 30 kW solar system with no batteries, which has a capital cost of \$28,527 and a payback period of 5.9 years.

At current rates and market conditions, battery storage systems are not economically viable and have a significantly longer payback period compared to a solar-only system. Storage systems coupled with solar (with no limit applied) would only begin to be viable if the solar export tariff reduces to 1c/kWh and battery prices fall to \$960/kWh.

Existing power reliability measures for the supermarket have been taken as the facility has installed a standby generator that is sufficiently sized for an extended outage.

A.2.1 Country Grocers IGA Supermarket – Recommended System Summary

Table 32: Solar and Generator Summary Table

Solar, Batteries and Generator Summary	
Solar System Size	30 kW
Generator Size	100 kVA / 86 kW
Economics Summary	
Average annual energy bill savings	\$4,866
CAPEX	\$28,527
Payback time (simple/discounted)	5.8/6.3 years
Internal Rate of Return (IRR)	15.77%
Project lifetime savings over 15 years	\$62,796

Table 33: Predicted Electricity Bill - Solar and Generator

	January	February	March	April	May	June	July	August	September	October	November	December
Energy Charges (\$)	\$2,531	\$2,224	\$2,357	\$2,185	\$2,192	\$2,224	\$2,165	\$2,117	\$2,100	\$1,982	\$2,131	\$2,350
Consumption (kWh)	22,775	19,917	20,951	19,401	19,662	19,738	19,272	18,859	18,617	17,929	18,986	20,854
Export (kWh)	0	11	0	0	0	0	0	0	0	39	0	49
Demand Charges (\$)	407	382	355	358	345	379	350	343	346	324	333	375
Peak Demand	53	52	49	47	46	47	45	44	48	43	48	52
Fixed charges (\$)	306	276	396	296	306	296	306	306	296	306	296	306
Monthly Total (\$)	\$3,244	\$2,882	\$3,018	\$2,834	\$2,841	\$2,899	\$2,820	\$2,766	\$2,742	\$2,611	\$2,760	\$3,031
Annual Total	\$34,451											

A.3 Sportsground Pavilion

Trentham Sustainability Group (TSG) has engaged Middleton Group to undertake an assessment of the Sportsground Pavilion and its energy resilience. The Sportsground was nominated by TSG as a facility that could be used in emergency situations that benefit from a renewable-powered supplementary power system.

Power data from the past 12 months were used as inputs into the energy economic assessment, along with some details from the redevelopment. Based on further assumptions, our estimations show a likely increase in the maximum demand by 32 kW.

Our recommendations include installing a solar-only system between 10 - 15 kW. A 15 kW solar-only system would result in a payback period of 8.9 years with an initial capital cost of \$15,349.

This payback period would provide a greater return if the actual load profile of the refurbished sportsground pavilion consumes more load during the day, as the solar generation would directly offset the energy consumption. As an example, the sportsground pavilion would benefit from using heat pumps for hot water. This would replace gas usage and provide additional load during the day that could be supplied by solar at a low cost.

Based on the current market and existing load profile, battery systems would not be economically viable for the sports ground. Battery coupled with a solar system would begin to become viable when export tariffs reduce to 2c/kWh and battery prices fall to \$960/kWh.

There is currently no backup power system at the sports ground. A generator or solar and battery system would improve the power supply reliability of the facility; however, this would be at a cost to the Sportsground.

A.3.1 Sportsground Pavilion – Recommended System Summary

Table 34: Solar and Generator Table Summary

Solar and Generator Summary (Recommended)	
Solar System Size (Total)	18 kW
	Economics Summary
Average annual energy bill savings:	\$1,724
CAPEX	\$15,349
Payback time (simple/discounted):	8.9 / 9.9 years
Internal Rate of Return (IRR)	7.36%
Project lifetime savings over 15 years:	\$25,859

Table 35: 18 kW Solar - Predicted Electricity Monthly Bill Summary

	January	February	March	April	May	June	July	August	September	October	November	December
Energy Charges	\$463	\$429	\$961	\$1,195	\$1,412	\$1,398	\$1,259	\$1,145	\$561	\$499	\$452	\$483
Consumption (kWh)	2,491	2,277	4,537	5,482	6,328	6,219	5,660	5,251	2,765	2,578	2,390	2,571
Export (kWh)	2,046	1,767	1,644	1,165	690	485	691	1,088	1,385	1,726	1,818	2,016
Peak Demand (kW)	31	31	66	93	95	98	95	89	81	32	31	32
Fixed charges (\$)	\$44	\$40	\$44	\$43	\$44	\$43	\$44	\$44	\$43	\$44	\$43	\$44
Monthly Total (\$)	\$507	\$469	\$1,005	\$1,237	\$1,456	\$1,440	\$1,303	\$1,189	\$604	\$543	\$495	\$528
Annual Total (\$)	\$10,775											

A.4 Community Hub

Trentham Sustainability Group has engaged Middleton Group to undertake a renewable energy assessment of the Community Hub. The community has selected the Hub as a disaster relief centre in emergency circumstances and thus, a backup power supply to the centre is essential.

The Community Hub is being refurbished with a new solar system and standby generator supplying backup power in the event of an extended outage.

An economic assessment of the power system for the Community Hub was conducted based on historical power data. At current market rates, results show that the best system is a solar-only system. Our recommendation endorses the rooftop solar design as designed (32 kW).

Our assessment recommends maximising the rooftop solar space as far as practicable; however, it is understood that the existing design may have used the appropriate roof space. Available roof space, shading and setbacks from roof edges limit the capacity that can be installed.

The community hub redevelopment includes for a standby generator to supply essential load.

At current rates and market conditions, battery storage systems coupled with solar are not economically viable and have significantly longer payback periods compared to a solar-only system. Potential battery system sizes for the IGA are limited to the practical solar limit at the Community Hub.

Modelling shows that battery systems coupled with solar begin to be economically viable when solar feed-in tariffs decline to 4c/kWh and battery prices reduce to at least \$840/kWh. Solar and batteries are a more viable solution in summer and spring periods but are challenged in autumn and winter periods as there is less solar generation. There is not sufficient space for a solar/battery solution to replace the generator.

A.4.1 Community Hub – Recommended System Summary

Table 36: Solar and Generator Summary

Solar and Generator Summary	
Solar System Size	32 kW
Generator Size	110 kVA / 100 kW
Economics Summary	
Average annual energy bill savings:	\$9,891
CAPEX	\$31,106
Payback time (simple/discounted):	3.1/3.2 years
Internal Rate of Return (IRR)	31.6%
Project lifetime savings over 15 years:	\$127,642

Table 37: Solar and Generator Predicted Bill Summary

	January	February	March	April	May	June	July	August	September	October	November	December
Energy Charges	\$1,675	\$1,575	\$1,817	\$1,978	\$2,186	\$2,264	\$2,157	\$2,130	\$2,024	\$1,749	\$1,642	\$1,725
Consumption (kWh)	7,547	6,876	7,938	8,332	9,103	9,418	9,167	8,724	8,388	7,794	7,251	7,607
Export (kWh)	846	936	765	449	266	190	301	441	713	719	829	909
Peak Demand (kW)	50	53	57	50	50	50	50	50	50	50	50	53
Fixed charges (\$)	\$37	\$33	\$37	\$36	\$37	\$36	\$37	\$37	\$36	\$37	\$36	\$37
Monthly Total	\$1,712	\$1,608	\$1,854	\$2,014	\$2,224	\$2,300	\$2,194	\$2,167	\$2,060	\$1,786	\$1,678	\$1,762
Annual Total	\$23,359											

Appendix B Retailer Engagement and Selection Process

B.1 Retailer Engagement

The following retailers were engaged as part of the long-term partnership expression of interest:

- Shinehub
- Indigo Power
- Diamond Energy
- Acacia Energy
- Flow Power
- Komo Energy
- Powerclub
- Amber Electric
- Energy Locals
- AGL

Based on the retailer engagement, the following retailers responded to the expression of interest to the following scope¹³:

Table 38: Retailer Engagement Interest Summary

Retailer	Solar and Battery Bulk Buy	General Low Tariff Offering	Community Battery Experience	Operation within Powercor Area
Shinehub	✓	✓	✓	No, by Q1-Q2 2023
Indigo Power	✓	✓	✓	No, expanding soon
Diamond Energy	✓	✓	✓	Yes
Acacia Energy	x	x	✓	Yes
Flow Power	✓	✓	✓	Yes

¹³ No response was provided from Komo Energy, Energy Locals, Amber Electric and AGL. The Expression of Interest request was declined by Powerclub.

B.2 Selection of Retailer Partnership

Middleton Group developed a weighting criterion with TSG / CCCE for selection of the appropriate retailer. Based on the expression of interest, retailers were asked to provide the following responses. Weightings were assigned to each response (refer to Table 39).

Table 39: Retailer Partnership Criteria

No.	Description of Query	Weighting
1	The retailer is to highlight any previous experience with community retailer partnerships	25%
2	Confirmation that the retailer can provide an offer within the Powercor area.	25%
3	The retailer is to provide a brief on previous experience with community initiatives and renewable energy initiatives.	25%
4	The retailer is to highlight current VPP offerings and solar and battery bulk-buy programs.	10%
5	The retailer is to provide detailed information on low tariff offers for commercial and residential customers.	10%
6	The retailer is to provide a brief on their previous experience with community batteries.	5%

A scoring of 0 – 3 was assessed for each of the queries with a weighting applied to each score.

Appendix C Community Battery Model Assumptions

To accurately determine the cash flows, the following assumptions model assumptions were made for all cases:

Project lifetime	20 years
Expected inflation rate	3%
Nominal discount rate	5%
Real interest rate	1.9%

C.1 Existing Solar

The existing solar for each case was calculated by analysing the total solar export from each generator. The solar self-consumption was assumed to be 30% (i.e., 70% of total solar generated is exported into the grid).

C.2 Tariff Rates

HOMER can accurately estimate the electricity bill for annual total load using the consumption, feed-in, demand, fixed and tax rates. For all cases, a two-rate time of use (TOU) tariff for the Powercor network was assumed. The tariff was based on current Victorian Default Offer price for FY22/23¹⁴.

Electricity charge (all year)	Tariff (incl. GST)
Daily supply charge	131.02 c/day
Peak consumption (every day, 3 – 9pm)	32.68 c/kWh
Peak consumption (every day, 3 – 9pm)	18.55 c/kWh
FY22/23 solar feed-in tariff rate	5.20 c/kWh

Note, HOMER currently does not support community battery trial tariffs for connection charges.

C.3 System Architecture

Figure 26 shows the typical model for each case which consists of the following system architecture:

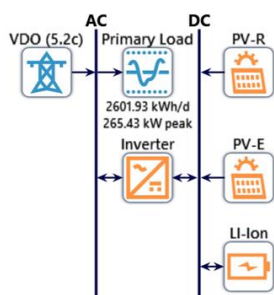


Figure 26: HOMER Model schematic

4. Utility grid connection
5. Transformer load
6. System converter (Inverter)
7. Existing solar PV (PV-E)
8. New solar PV (PV-R)
9. Battery storage (LI -Ion)

¹⁴ [Victorian Default Offer price review 2022–23 | Essential Services Commission](#)

Please note, HOMER is designed to optimise sizing for converters, solar PV, and batteries – however, upper limits have been set for the converter and PV to ensure compatibility with existing grid infrastructure.

Converter limit: The upper limit for the converter in each case is based on the transformer size (i.e., maximum inverter size of 500 kW when connected to a 500 kVA transformer.).

Solar PV size limit: The upper limit for the total solar PV size (PV-E + PV-R) is based the ratio of PV to inverter power, measured as the DC/AC ratio.

The recommended DC solar panels have been sized close to, or slightly higher than, 1.33x the inverter rating, as per the CEC recommendation for solar systems to have an DC/AC ratio less than 1.33 which maximise the benefits of STCs.

Export limit: The Powercor export limit is 5 kW for single phase connections and 15 kW for three phase connections. However, for the model, the grid export was set equal to the converter limit.

C.4 System Costs

Battery: The battery cost was assumed to be \$1,000 per kWh for the nominal case¹⁵.

Solar and Inverter: Please see Appendix D for the solar and inverter costs.

- For simplicity, prices for single-phase inverters were assumed.

C.5 Operations and Maintenance (O&M) Costs

The models do not include any replacements or annual O&M costs over the project lifetime.

C.6 Model Limitations

The HOMER model only allows for a single converter for the system. This means that all decentralised solar and inverter systems (commercial and residential) supplied under the transformer are aggregated into a single component (E.g., all inverters are summed into a single inverter component, refer to Figure 26).

This equipment size in each model considers one inverter is used for both the PV and battery system. It provides a useful indication of total allowable solar & inverter size and battery capacity required to support the community load, though a detailed study would be required to investigate explicit inverters.

The model aims to minimise the net present cost of the total aggregated system under a single transformer.

C.7 Sensitivity Parameters

The optimal configuration from the HOMER simulation outputs is sensitive to the capital costs for the battery, solar and inverter; and the solar feed-in tariff rates.

As such, the market street transformer model was used to sensitivity test the following:

- **Solar feed-in tariff** was varied between:
 - Minimum feed-in tariff (effective 1st July 2022) of 5.2 c/kWh¹⁶.

¹⁵ [Solar Battery Price Index - May 2022 | Solar Choice](#)

¹⁶ [Minimum feed-in tariff review 2022-23 | Essential Services Commission](#)

- Conservative estimate of future rates at 4 c/kWh.
- **Li-ion battery base costs** were set to a typical \$1,000 per kWh. However, the cost was varied between 80% - 120% in 10% increments.
- Reduction of payback period based on **FCAS participation** from the community battery.

The detailed findings of the sensitivity analysis are discussed in Section 3.2.4.

C.8 High Export Solar Case – Rahills Road

The following transformer on Rahills Road was assessed in the case that the Market Street microgrid was not feasible. A community battery or microgrid on Rahills Road would be less feasible due to the lesser number of customers supplied under this transformer.

C.8.1 Case 2: Highest Export

This model is based on the Transformer 20614201-WND024 on Rahills Road, rated at 200 kVA.

It represents the transformer with the most commercial customers and the highest solar export with the highest solar export-to-consumption ratio (71.25% in December 2021).

Existing customer profile

There are approximately 49 residential customers and 13 solar customers, representing around 6.82% of the total residential community.

Customer type	Total customers	Solar customers	PV penetration
Residential	49	13	26.53%

Based on the solar export data and a conservative assumption that solar self-consumption is 30%, the estimated existing solar PV size is 78 kW (DC).

Transformer load profile

Figure 27 shows the consumption and solar trend from this transformer in the last two years.

Total consumption (MWh) and Total solar export (MWh) by Date

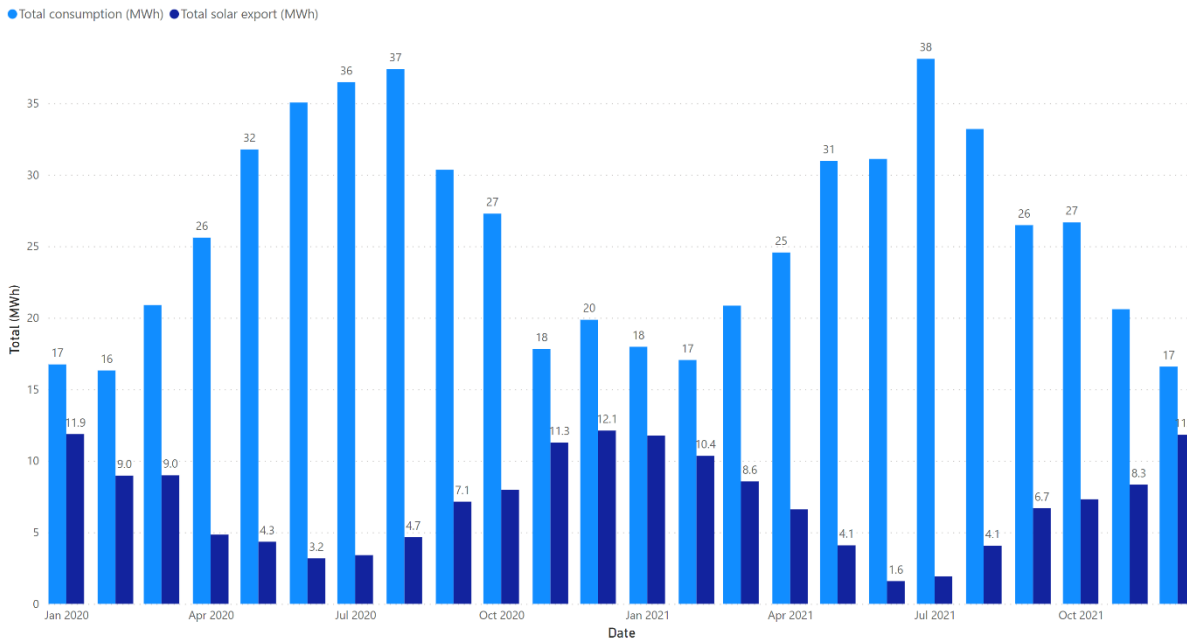


Figure 27: Consumption and Export Profile of 20614201-WND024, Rahills Road

Figure 28 shows the transformer load profile in 2021, which was applied for this model.

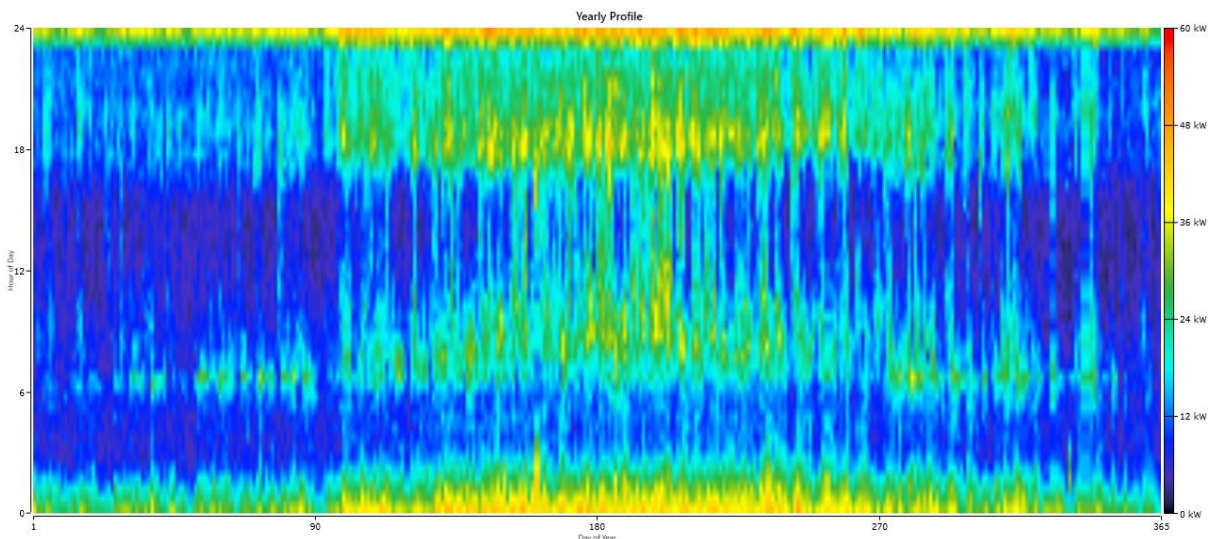


Figure 28: 20614201-WND024 Rahills Road, Highest Export 2021 Load Profile

The average load of this transformer is 856.48 kWh per day. The peak load has been recorded at 105 kW.

Simulation outcome

CURRENT SYSTEM



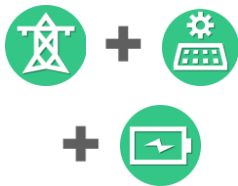
The electric needs of the area serviced by transformer 20614201-WND024, Rahills Road Trentham VIC 3458, Australia are met with a grid connection and 78 kW of PV. The customers currently spend \$55,035p.a. in total on their utility bills.

Total Net Present Cost: \$928,411

Levelized Cost of Energy (\$/kWh): \$0.1578

Estimated Carbon Emissions (tonnes/year): 157.072

PROPOSED SYSTEM



We propose adding 222 kW of PV and 93 kWh of battery capacity. This would reduce the combined annual utility bill to \$26,156. Your investment has a payback of 12.77 years and an IRR of 4.71%.

Total Net Present Cost: \$823,112

Levelized Cost of Energy (\$/kWh): \$0.0812

Estimated Carbon Emissions (tonnes/year): 157.072

Winning system architecture

Table 40: Winning system architecture for Case 2 – 20614201-WND024 Rahills Road

Component	Name	Size	Unit
PV #1	Additional PV	222	kW
PV #2	Existing solar PV	78	kW
Battery system	Li-ion BESS	93	kWh
System converter	Inverter	200	kW
Transformer load	86620900-WND024	856.48	kWh/day
Utility	2 Period TOU - VDO (5.2c)		

Economic feasibility

Table 41: Economic feasibility for Case 2 – 20614201-WND024 Rahills Road

Simple payback	12.6 yrs.
Return on Investment	2.92 %
Internal Rate of Return	4.85 %
Net Present Value	\$104,924
Capital Investment	\$346,587
Annualized Savings	\$27,458

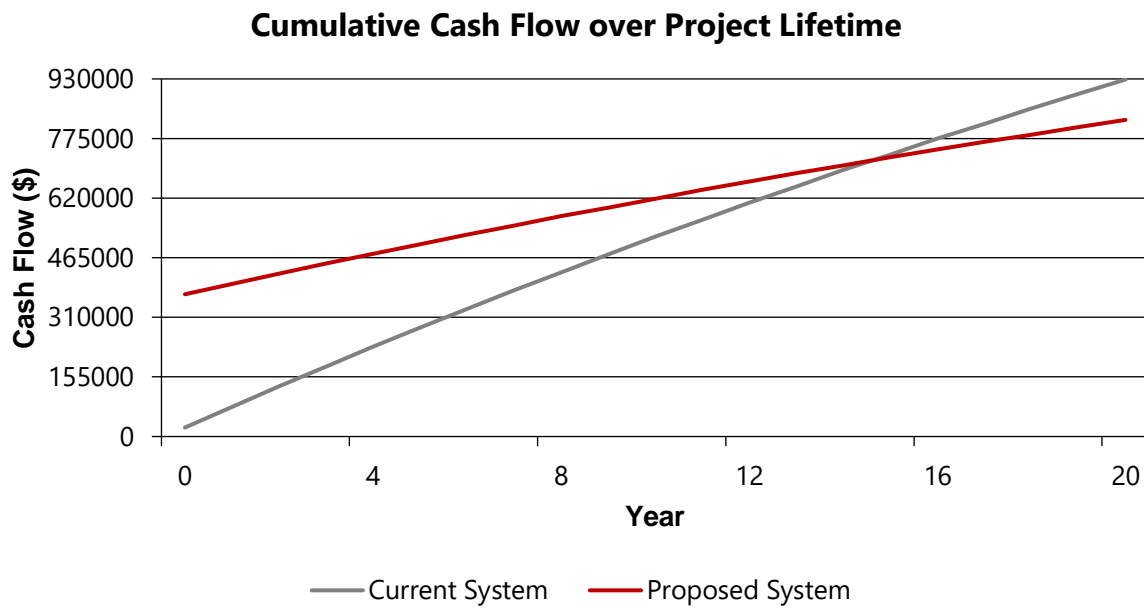


Figure 29: Case 2 – Cumulative cashflow over 20 years

Analysis

For the high export model, the optimal solution for community is to install more solar PV and battery storage.

The model indicates the best NPC over 20 years would be achieved by installing 222 kW of DC solar in additional to the estimated 78 kW of existing solar, totalling to 300 kW of DC solar. The recommended total DC solar is based on a 1.5 DC/AC ratio and the upper limit of total inverter capacity, at 200 kW. The most effective way for the community to achieve this is by increasing the amount of rooftop solar PV in the area.

Potential implementation scenarios

To achieve the proposed total 300 kW solar inverter capacity from this model, the optimal solution for this transformer could be implemented by assuming customers adopt the following solar and battery configurations:

Residential customers – to install 6.6 kW DC panels / 5 kW AC inverter, with a minimum 10 kWh battery.

Table 42: Estimated available solar capacity for high export case

Customer Type	Customers		Potential additional solar system		
	Total	Existing solar	New solar	DC panels (kW)	Inverter (kW)
Residential	49	13	36	237.6	180

This transformer has an estimated 180kW of potential new solar inverter capacity which means the community could very reasonably meet the 200kW solar capacity limit.

The 93 kWh batteries would be best realised by implementing at least ten 10kWh residential batteries.

Appendix D Battery Revenue Streams

D.1 Summary of Revenue Streams

The summary of all available and potential battery revenue streams based on battery services is shown in Table 43:

Table 43: Summary of all battery revenue streams

Service	Existing revenue stream	No revenue stream
Wholesale energy market	✓	
Regulation FCAS	★	
Contingency FCAS	★	
SIPS		✓
FFR		✓
Synthetic Inertia		✓
System Strength		✓
System Restart	✓SRAS	
Voltage Support	✓VCAS	
Curtailment Management	✓	
Causer Pays Factor	✓	

★ "premium" I.SBS service

✓ existing I.SBS service

In Q1 2021, the total net battery market revenue was \$9.9 million, with frequency control ancillary services (FCAS) continuing to be the largest source of income at 83% of the total, as shown in Figure 30.

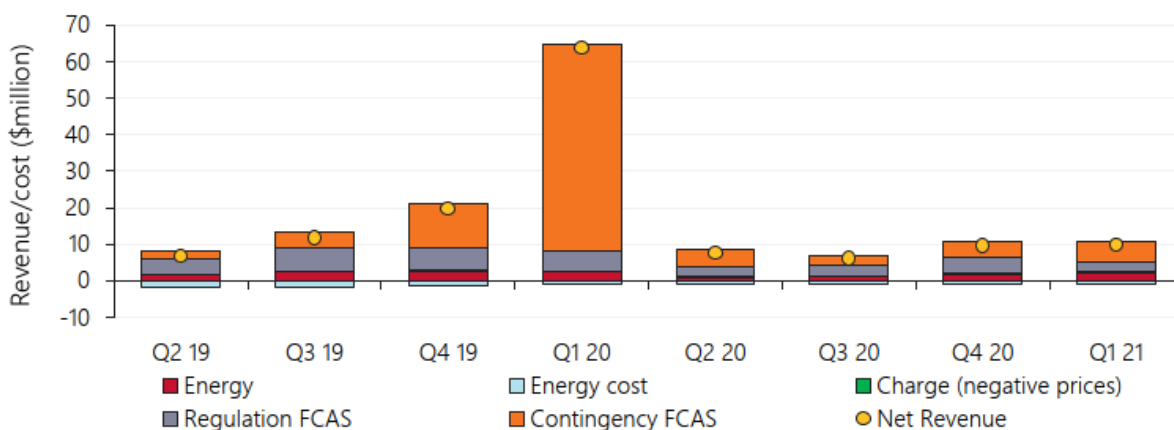


Figure 30: Battery net market revenue from Q2 19 to Q1 21

It should be noted that this data comes from a small number of currently operating batteries. There is significant variability in elements of the market – particularly contingency FCAS. This is due to unplanned issues in the grid such as transmission and generator failures. This variability makes clear forecasting difficult, and this revenue can have limited bankability for projects currently.

D.2 Energy Arbitrage

One of the primary revenue streams for BESS are energy arbitrage as proponents can participate in the wholesale energy market. Energy arbitrage involves charging the battery when energy prices are low and discharging during more expensive peak hours, based on energy market price signals.

By charging the battery with low-cost energy during periods of excess renewable generation and discharging during periods of high demand, BESS can both also reduce renewable energy curtailment and maximize the value of the energy developers can sell to the market.

Negative prices

An increase in negative prices has improved the value of an energy arbitrage strategy and has seen the charging behaviour of the BESS shift from prioritising charging overnight in some instances, as shown in the case study for Lake Bonney in SA.

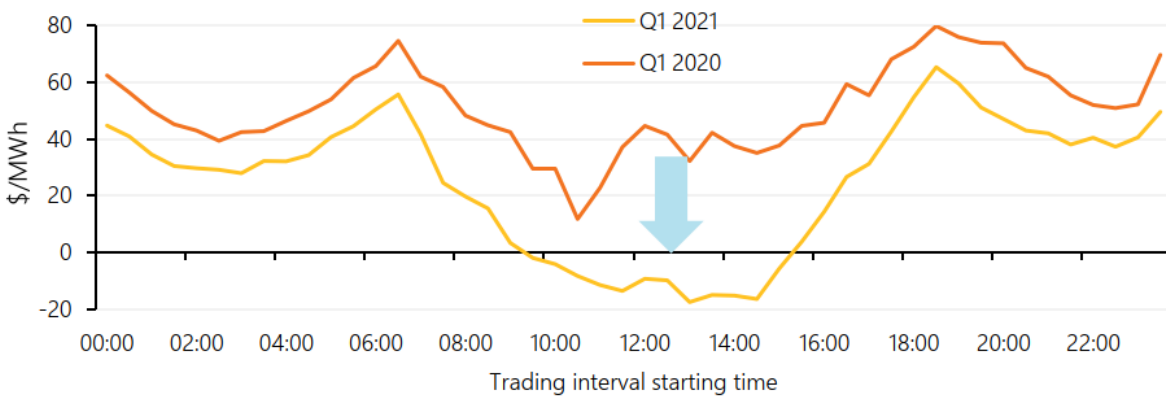


Figure 31: Trend in negative daytime average prices in SA

The penetration of renewable energy, particularly solar, increases the trend in negative energy prices. This can be seen in the difference between SA and Vic. This trend to negative prices in the middle of the day can be expected to continue, improving the economics of arbitrage for batteries due to their fast response.

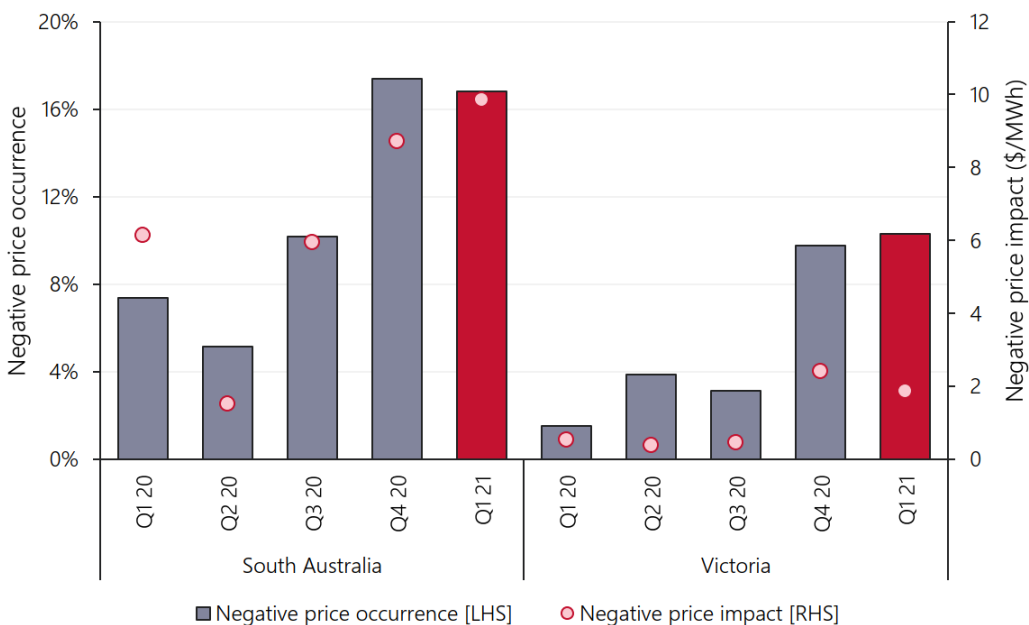


Figure 32: Negative spot price occurrences in SA and VIC

D.3 Frequency Control Ancillary Services (FCAS)

Frequency Control Ancillary Services (FCAS) are used by AEMO (Australian Energy Market Operator) to maintain or rebalance the frequency on the power system, at any point in time, close to fifty cycles per second (50 Hz) as required by the NEM (National Electricity Market) frequency operating standards set by the AEMC (Australian Energy Market Commission) Reliability Panel.¹⁷

There are eight markets in the NEM for procuring sufficient FCAS at any given time, as shown in Figure 33. These are listed below under the two types of frequency control:

Contingency FCAS – corrects the supply/demand balance in response to major frequency disturbances causing frequency to move outside the normal operating frequency band, which can occur after contingency events such as the loss of a generating unit or a major load.

Regulatory FCAS – provides frequency correction in response to minor deviations in the demand/supply balance.

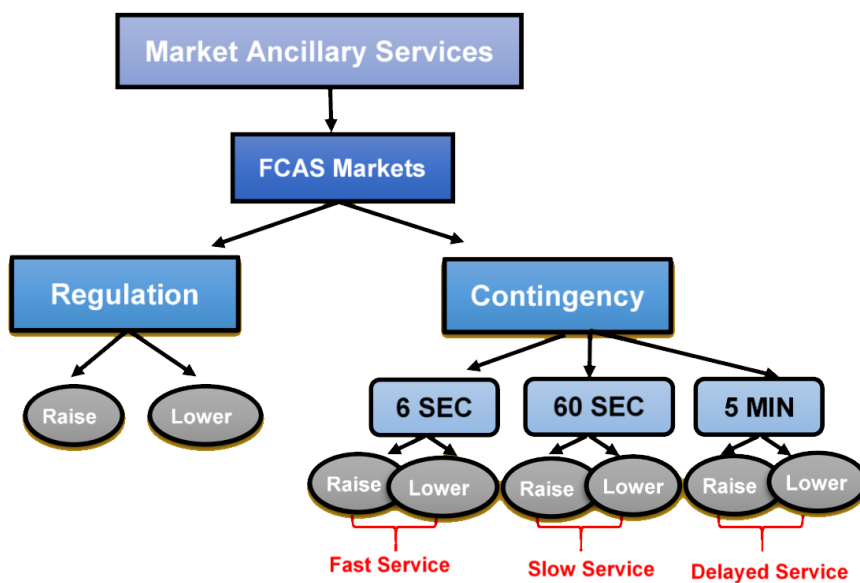
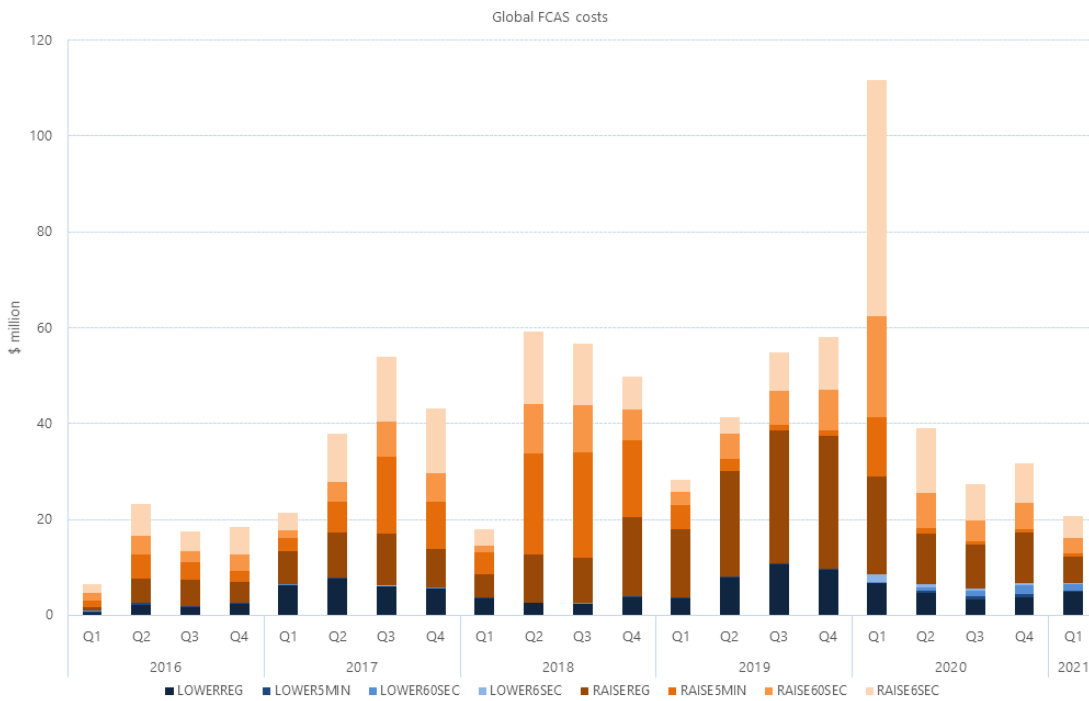


Figure 33: Market ancillary services summary

FCAS is one of the primary services offered by grid-scale batteries and continues to drive most revenues for battery storage in the NEM. The average FCAS revenues from batteries increased by 25% in 2020 compared to 2019.

The nature and duration of contingency events are expected to drive significant variations in battery storage returns over the next decade. The historic variability of FCAS services across the NEM for the past five years are shown in Figure 34.

¹⁷ AEMO Settlements Guide to Ancillary Services Payment and Recovery, [URL](#)



Source: AER; AEMO, Last updated: 8 Apr 2021 - 4:17 pm

Figure 34: Quarterly global FCAS costs by services

In the 2018 Integrated System Plan ¹⁸, Figure 35: Projected FCAS requirements for increasing penetration of solar and wind generation AEMO projects the FCAS requirement will increase with renewable energy penetration, as shown in Figure 35.

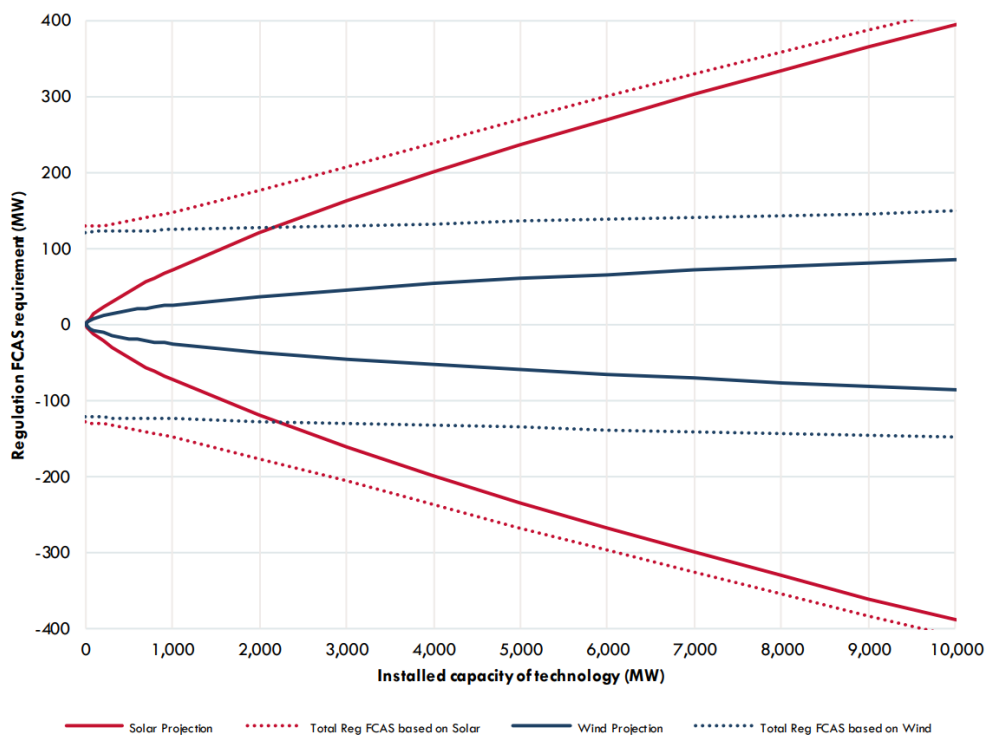


Figure 35: Projected FCAS requirements for increasing penetration of solar and wind generation

¹⁸ AEMO – Integrated System Plan 2018, [URL](#)

D.4 Other Services

D.4.1 Non-market Ancillary Services

Utility-scale batteries are also able to offer some non-market ancillary services, including:

1. System Restart Ancillary Services (SRAS) – to enable the power system to be restarted following a complete or partial black-out.
2. Voltage Control Ancillary Services (VCAS) – using generators to absorb or generate reactive power from or onto the electricity grid and control the local voltage accordingly.

The availability of these services will depend on the network needs. Retirement of larger established generators will create opportunities.

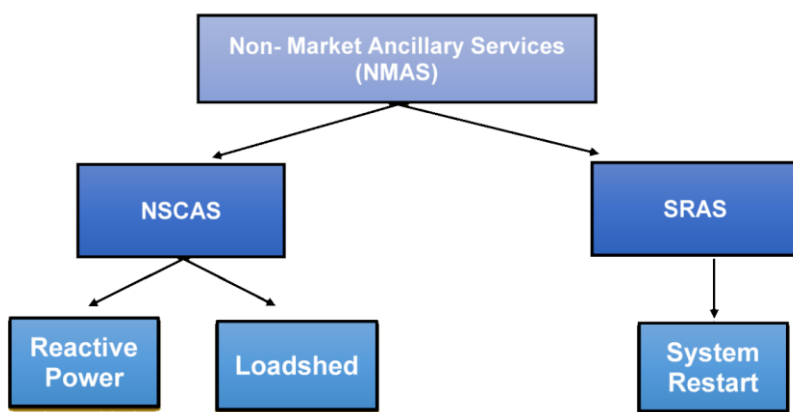


Figure 36: non-market ancillary services

D.4.2 Future Revenue Streams

Proponents continue to develop innovative solutions to extract value from the potential for utility-scale batteries to operate within the existing market structure, including for curtailment management and minimising Causer Pays costs.

Additional potential revenue sources for batteries include short term forward market, operating reserve/ramping reserve market, augmented or new FCAS frameworks in addition to the existing revenue source including energy market, NSCAS, TNSPs and SRAS.¹⁹

The technology used in utility-scale batteries also means the following services may be available for additional revenue:

1. System Integrity Protection Scheme (SIPS) – SIPS is specific only to South Australia at the present time, however similar schemes to protect other interconnectors could be implemented in future. Battery projects currently participating in the SIPS are HPR and ESCRI-SA, which are South Australian Government and ElectraNet sponsored projects respectively, with specific system security objectives.
2. Fast Frequency Response (FFR) – The capability to provide FFR is standard for battery systems, however its implementation to date has been dependent on project specific requirements, and this “premium” frequency control service is not currently valued beyond the revenue available through the existing contingency FCAS markets.

¹⁹ ARENA Large-Scale Battery Storage Knowledge Sharing Report

3. Synthetic inertia – The provision of “synthetic” inertia by non-synchronous generators is a topic currently being explored by the AEMC, including options to facilitate co-optimisation of energy, FCAS, and inertia. As more synchronous generators retire, the need for synthetic inertia will increase hence there will be growing pressure for a mechanism to incentivise this as a service.
4. System strength – Increasing numbers of VRE developers are reporting cost impacts due to an emerging requirement to install synchronous condensers as part of the grid connection application process. Some battery systems can be designed with inverters that can provide this service.

The following market changes are likely to commercially benefit future utility-scale battery proponents:

- 5-minute settlement period rule change
- NEM registration - to facilitate bi-directional resource participation
 - AEMO Emerging Generation and Energy Storage – Grid Scale work program
- Market reform / augmentation
 - E.g., to incentivise Fast Frequency Response / SIPS

Appendix E Technology prices

E.1 Rooftop solar PV systems

The solar cost estimates (including installation) were based on the solar price index published by Solar Choice every month.

Solar Choice has been tracking the PV price index since 2012 and represents reasonable estimate of the total retail price of the system to the customer including the STC discount and GST.

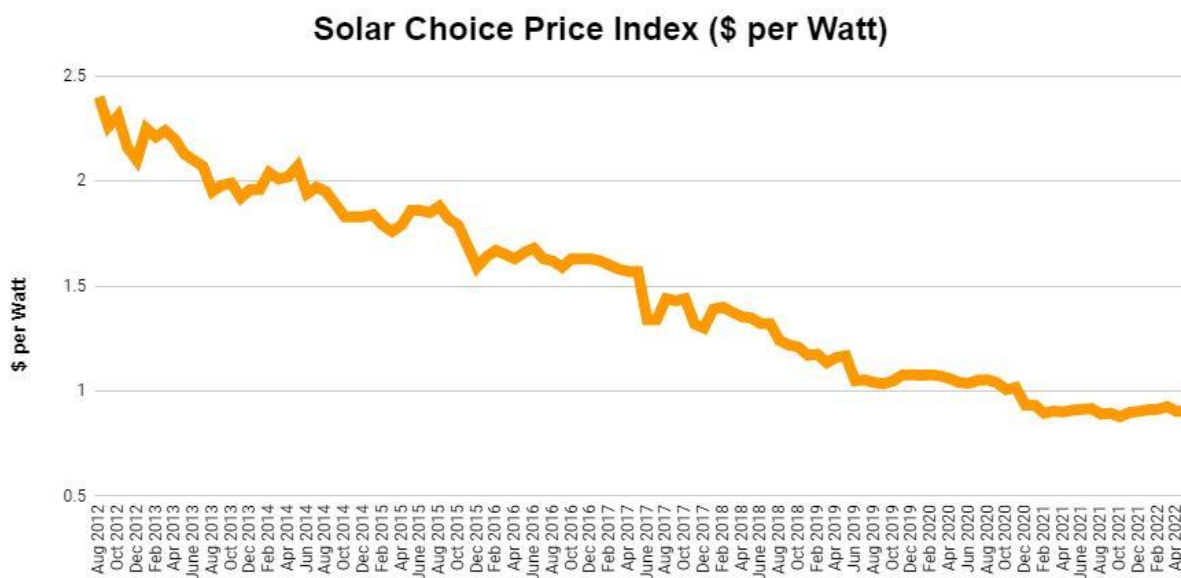


Figure 37: Solar Choice price index

For model cases, the Melbourne prices were assumed for the residential solar PV costs:

Table 44: Total retail price of solar systems for residential and commercial customers (June 2022)²⁰

Average cost	3kW	4kW	5kW	6kW	7kW	10kW	30 kW (commercial)
Melbourne, VIC	\$4,000	\$4,240	\$4,680	\$5,210	\$6,060	\$8,720	\$24,540

²⁰ [Solar Panel Costs: Solar Choice Price Index | Solar Choice](#)

E.2 Battery storage

The Solar Choice battery price index was used to estimate the solar battery storage costs.

Solar Choice has been tracking the solar battery price index since 2017 and presents a reasonable estimate of cost per kWh of battery capacity (including installation but excluding inverter costs).

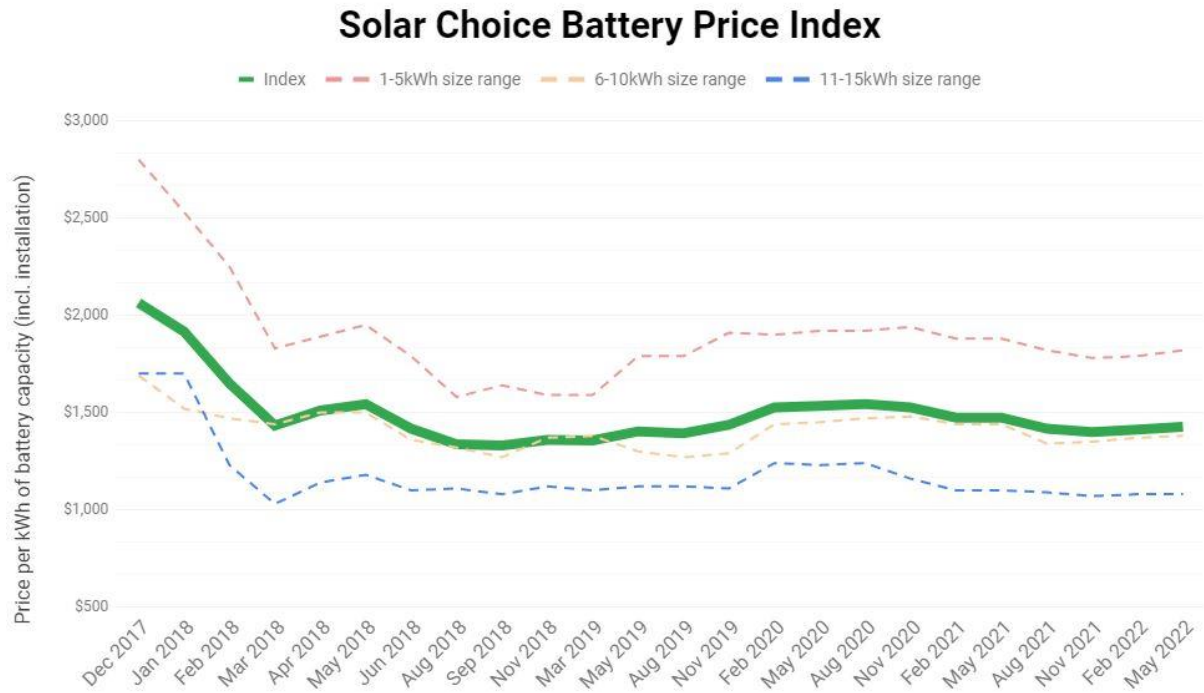


Figure 38: Solar Choice Battery Price Index – December 2017 – May 2022

For all model cases, the average installed cost of \$1,200 per kWh was assumed.

Table 45: Average battery installation costs (May 2022)²¹

Average battery installation prices – May 2022			
Battery capacity range	Installed cost per kWh capacity	Cost per kWh throughput (total cycle life)	Cost per kWh throughput (1 cycle per day)
1-5 kWh	\$1,560	\$0.32	\$0.40
6-10 kWh	\$1,290	\$0.27	\$0.29
11-15kWh	\$1,030	\$0.24	\$0.29
16-20kWh	\$1,010	\$0.22	\$0.30
All	\$1,220	\$0.26	\$0.32

E.3 Inverters

Solar 4 Ever, an accredited CEC installer, publishes costs for popular inverters each month. Using the May 2022 list of 41 inverters which include a combination of single phase & three phase and battery-ready & solar-only options, the following estimates were developed:

	5 kW (All)	10 kW (All)	5 kW (Solar only)	10 kW (Solar only)	5 kW (Battery-ready)	10 kW (Battery-ready)
Average	\$2,243	\$3,900	\$1,648	\$2,988	\$2,838	\$4,813
Median	\$2,008	\$3,685	\$1,540	\$3,033	\$2,960	\$4,675

For model cases 1 and 3, the median cost of \$2,008 for a 5 kW system was assumed.

For model cases 2, the median cost of \$3,685 for a 10 kW system was assumed.

²¹ [Solar Battery Price Index - May 2022 | Solar Choice](#)

Appendix F Additional Data and Graphs

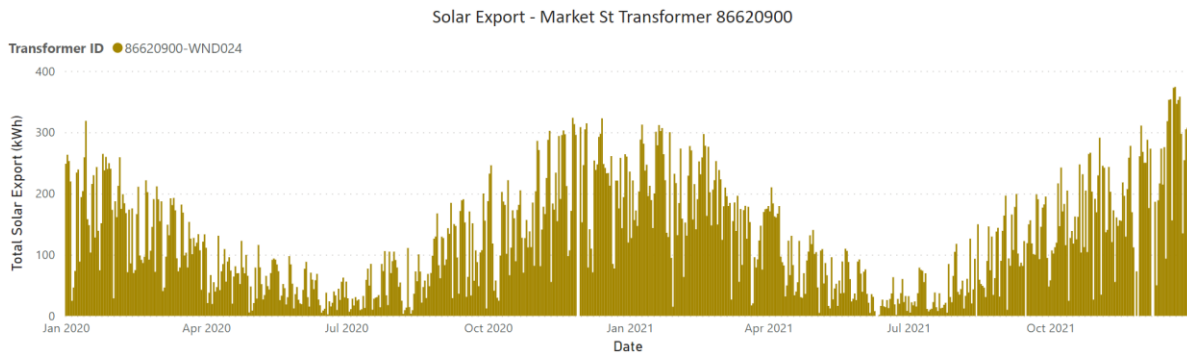


Figure 39: Market St Transformer 86620900 Solar Export

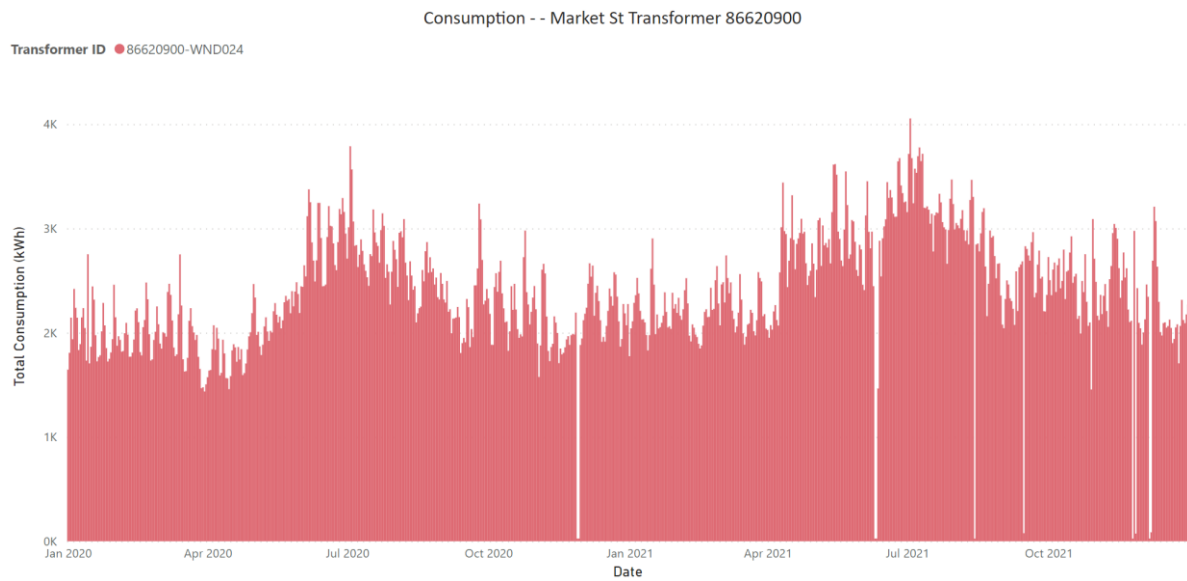


Figure 40: Market St Transformer 86620900 Consumption Profile (includes outages and meter failures)

Table 46: 2020 Monthly Data Table

Customer type	Residential		Commercial		Domestic Farms		Agricultural		Industrial		Total	
	Consumption (kWh)	Solar export (kWh)	Consumption (kWh)	Solar export (kWh)	Consumption (kWh)	Solar export (kWh)	Consumption (kWh)	Solar export (kWh)	Consumption (kWh)	Solar export (kWh)	Total Consumption (kWh)	Total Solar Export (kWh)
Jan 2020	239,022	77,431	54,605	348	14,151	2,289	5,260	0	19,622	5,827	332,660	85,895
Feb 2020	219,697	58,924	49,200	245	13,892	1,595	1,238	266	18,315	3,901	302,341	64,930
March 2020	289,768	59,188	47,811	275	17,333	1,456	7,578	421	18,350	4,050	380,841	65,390
April 2020	384,842	30,811	30,479	141	21,646	782	3,242	232	14,035	2,609	454,245	34,574
May 2020	501,979	25,733	38,197	116	27,560	611	1,381	212	16,838	2,169	585,955	28,841
June 2020	560,623	18,191	49,706	78	28,388	417	1,568	164	20,900	1,253	661,185	20,102
July 2020	575,052	21,060	52,808	92	30,926	484	1,889	127	23,804	1,212	684,479	22,974
August 2020	574,507	29,473	46,020	135	31,039	705	1,251	184	18,960	2,236	671,777	32,733
September 2020	450,252	49,110	44,603	222	22,462	1,181	2,036	89	17,923	3,341	537,276	53,943
October 2020	398,750	57,051	51,600	235	20,232	1,402	2,710	98	18,755	3,568	492,069	62,353
November 2020	272,820	84,700	50,433	332	14,257	2,079	2,408	142	16,828	4,998	356,746	92,250
December 2020	295,360	90,371	55,876	330	17,654	2,244	2,460	331	18,307	5,386	389,657	98,662
Total	4,762,673	602,041	571,340	2,549	259,539	15,244	33,023	2,265	222,658	40,549	5,849,232	662,647

Table 47: 2021 Monthly Data Table

Customer type	Residential		Commercial		Domestic Farms		Agricultural		Industrial		Total	
	Date	Consumption (kWh)	Solar export (kWh)	Consumption (kWh)	Solar export (kWh)	Consumption (kWh)	Solar export (kWh)	Consumption (kWh)	Solar export (kWh)	Consumption (kWh)	Solar export (kWh)	Total Consumption (kWh)
Jan 2021	262,490	90,931	58,534	418	16,661	2,006	2,602	528	17,639	5,650	357,926	99,534
Feb 2021	238,326	78,708	51,230	354	15,931	1,748	1,728	462	15,639	4,410	322,854	85,681
March 2021	313,891	63,858	55,050	165	18,256	1,367	1,782	410	19,312	3,526	408,292	69,327
April 2021	389,786	49,597	55,234	111	21,503	1,062	2,433	351	21,330	2,834	490,287	53,955
May 2021	515,096	30,817	60,378	48	28,433	666	2,205	273	23,591	1,894	629,702	33,699
June 2021	536,304	11,771	54,314	24	30,765	228	2,081	102	22,507	569	645,972	12,694
July 2021	680,446	14,512	64,425	30	38,939	262	3,035	79	25,030	767	811,875	15,650
August 2021	575,771	33,074	57,678	91	36,118	600	3,311	146	21,903	1,778	694,781	35,689
September 2021	464,610	60,190	52,004	207	30,033	1,054	2,524	193	16,596	3,181	565,757	64,825
October 2021	435,426	69,312	54,653	284	26,411	1,233	3,268	163	21,145	3,356	540,812	74,348
November 2021	361,467	77,817	56,583	384	21,636	1,382	3,230	189	18,455	3,749	461,430	83,522
December 2021	278,183	110,112	52,456	504	17,601	1,869	2,246	430	17,554	5,388	368,041	118,303
Total	5,501,796	690,700	672,448	2,620	302,288	13,476	30,514	3,329	240,682	37,101	6,297,728	747,226

Creating a sustainable energy future for our communities

Strategic consulting for



Industrial



Power utilities



Renewables



Water



Transport

middleton
Group

Melbourne

Suite 3 L10, 350 Collins Street
Melbourne VIC 3000

Sydney

Tower 2 Darling Park L20
201 Sussex Street, Sydney NSW 2000

www.middletongroup.com.au