YARRA ENERGY FOUNDATION

SolarQuip
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Trentham Sustainability Group (TSG) | Trentham Microgrid Technical Feasibility Study

Final Report

— July 2025

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Disclaimer

Acknowledgment of Aboriginal land and peoples

We acknowledge Aboriginal and Torres Strait Islander people as the Traditional Owners and custodians of the land and water on which we all rely. We acknowledge the Wurrundjeri Woi Wurrung peoples as the custodians of the land on which the Yarra Energy Foundation is based.

Acknowledgment of funding

TSG would like to acknowledge that this report was funded by Cool Country Community Enterprises and Hepburn Shire Council.

TSG Acknowledgement of Project Partners

Trentham Sustainability Group Inc warmly thanks the following organisations for their partnership and support for the Energy Resilient Trentham project: “A low voltage islandable microgrid technical feasibility study”, conducted in 2025.

Community Bank Trentham & Districts Bendigo Bank

Hepburn Shire Council

Yarra Energy Foundation

FRRR Foundation for Rural Regional Renewal

ANZ

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SolarQuip Renewable Energy Partners

Contents

1. EXECUTIVE SUMMARY 2
2. INTRODUCTION 6
3. NETWORK DATA ANALYSIS 15
4. MICROGRID TECHNICAL DESIGN 25
5. COMMERCIAL PLAN 44
6. COSTING AND FINANCIAL ANALYSIS 48
7. PROGRAM RISK ASSESMENT 55
8. MICROGRID DESIGN ALTERNATIVE 57
9. CONCLUSION 60

APPENDIX A – SUPPLEMENTARY INFORMATION 63

APPENDIX B – RISK ASSESSMENT 70

1. Executive Summary

1. Executive Summary

In this technical feasibility study, YEF and SolarQuip designed a grid connected microgrid (GCMG) for the township of Trentham, based on the requirements of Trentham Sustainability Group (TSG), and assessed the feasibility of deploying this system.

Network data analysis was performed on load and power quality data for the proposed microgrid area, which identified a peak load of 278 kW and potential issues with overvoltage events and phase balancing. This network data study was hindered by its reliance on 30-minute interval consumption data (the highest resolution data that Powercor could provide) and as such the collection of 1-second resolution data, and additional network analysis is recommended if the project is progressed to the next phase of design.

The proposed microgrid design was informed by the network data study and consists of a 300 kW/1.2 MWh battery energy storage system DC-coupled to an 88 kW solar PV system, and a 400 kVA diesel generator. The microgrid also included all necessary switchgear to automatically transfer to island mode in the case of an outage, and a load management system.

The microgrid equipment would connect directly into the Market St low voltage network distribution transformer, powering all 66 residential and 36 commercial properties in this network area. The proposed operating philosophy is for a blended *Resilience and Market Trading* model, in which a portion of the battery is reserved for backup, and the remainder is traded into energy markets to generate operational revenue.

The equipment would ideally be located by the Market St Transformer pole and nearby property owned by the pharmacy, with a kerb-side cubicle for connecting a portable generator. An option of adding solar and battery to the railway shed was considered but deemed too costly.

This design was costed at $2,456,000 based on quotes provided by Engineering, Procurement and Construction (EPC) suppliers and by YEF and SolarQuip industry expertise. Operational expenses were calculated to be $45,340 per annum.

Market revenues were modelled using Gridcog software, with total revenues projected to be $362,185 over a 15-year operation life. After operational expenses are accounted for, this equates to a –$317,915 net position, meaning that the proposed microgrid runs at an operating loss, and is not financially viable.

This finding highlights the significant commercial challenges faced by third party-owned and operated microgrids, which cannot effectively monetise the value of providing the community with energy resilience.

Additionally, this study found that there is a current lack of regulatory clarity regarding third party ownership of grid connected microgrids, and that signification support from the local distribution network service provider (DNSP) is essential to project success.

Based on the findings of this study YEF and Solar Quip recommend that TSG consider behind the meter resilience alternatives to the proposed low voltage microgrid as these may achieve the desired resilience outcomes faster, cheaper and more efficiently.

2. Introduction

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2.1. Project Overview

This project assesses the feasibility of a low voltage (LV) microgrid located in the town of Trentham, Hepburn Shire, in Central West Victoria. This microgrid would connect directly to the existing Market Street network, with ground-mounted equipment installed on potentially available land such as 45 High Street, Trentham, VIC 3458.

Figure 1 Market St low voltage network map

The proposed microgrid aims to enhance community resilience by securing energy supply during emergencies and outages for essential facilities such as the local supermarket, community hubs, and residential areas. It will serve 66 individual households and 36 businesses.

Stakeholder Involvement

The Trentham Sustainability Group (TSG) has engaged the Yarra Energy Foundation (YEF), in partnership with SolarQuip, to produce this technical study analysing the feasibility of an advanced LV microgrid.

TSG is an actively engaged local group working to mitigate and adapt to the impacts of climate change on the community while increasing Trentham's resilience.

YEF is a not-for-profit organisation with expertise in community batteries, electrification, community engagement, and energy initiatives.

SolarQuip, led by Glen Morris, specialises in off-grid energy solutions and operates the Smart Energy Lab, a microgrid and energy technology testing facility in the Yarra Valley.

2. Introduction

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Background and Context

Trentham, located on Dja Dja Wurrung Country, is highly vulnerable to climate change impacts and increasingly frequent extreme weather events such as storms and bushfires. Over the past five years, Trentham has been severely affected by multiple storm events, resulting in disruptions to energy supply, water, communications, and road access.

The local community led by TSG, is working to find solutions to improve the reliability and resilience of Trentham's renewable energy supply through its Energy & Climate Resilient Trentham project. Since 2021, and supported with funding in 2022 from Cool Country Community Enterprises and Hepburn Shire Council, TSG worked with consultants to address the town's unstable energy supply and boost its resilience. Based on the data and modelling developed by TSG a collaboration with Hepburn Shire Council and Central Victorian Greenhouse Alliance was successful in securing a grant for an energy backup system at The Mechanics Trentham.

Prior to this report, the ‘Energy Resilience Design Studies’ commissioned in 2022 by the Victorian Government, explored opportunities to strengthen energy infrastructure resilience and help communities like Trentham avoid prolonged outages. The study proposed a multifaceted approach to energy resilience, comprising site-specific resilience projects, advanced low voltage microgrids, and future high voltage connected microgrids.

In 2022, TSG engaged Middleton Group to explore the feasibility of two of these resilience solutions in Trentham[1] - site backup systems, and an advanced low voltage microgrid. These investigations into site backup systems led to the Trentham Mechanics Institute project, while the exploration of advanced low voltage microgrids directly resulted in this report.

<u>Powercor’s response to Trentham’s energy resilience issues</u>

Powercor is the local Distribution Network Service Provider (DNSP) for Trentham and surrounds and were involved as a partner in the 2022 Energy Resilience Design Study. Following this initial scoping work, Powercor showed interest in delivering a microgrid energy resilience system for Trentham and included this as a project for assessment in their 2026-2031 regulatory reset review alongside proposed microgrids in Apollo Bay, Ballan, Donald and Lancefield.

Of all the Battery Energy Storage System (BESS) and diesel generator microgrids considered, the Trentham project was the only one to return a positive net present value (NPV). Despite this Powercor has chosen not to proceed with a microgrid in Trentham and have instead opted to install a second high voltage feeder from the Ballarat line (BAN003) to connect into Trentham and surrounds. Refer to Figure 2.

[1] Middleton Group, Energy and Climate Resilient Trentham, October 2022.

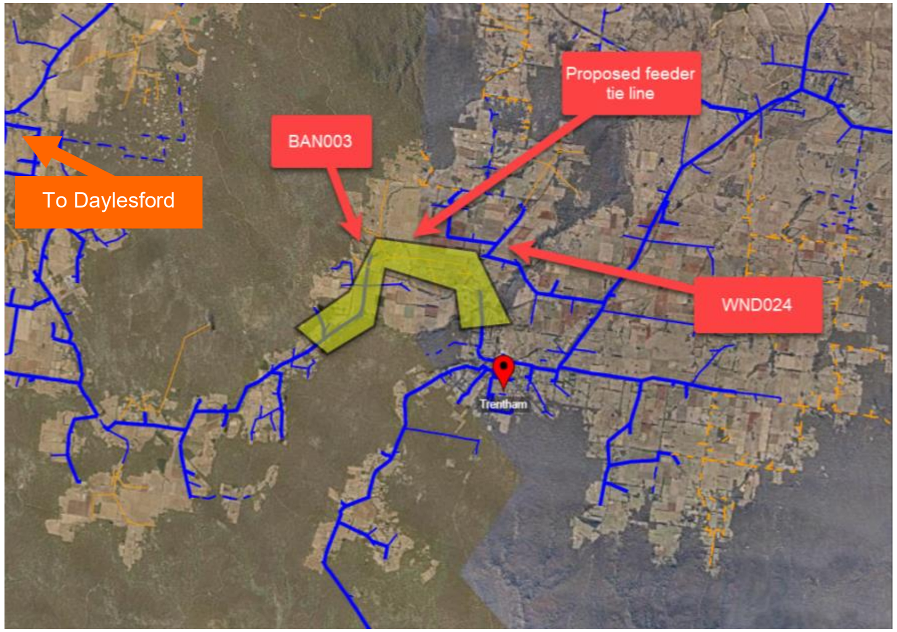

Figure 2: Powercor's proposed feeder tie in line

While this feeder will offer a secondary source of supply to Trentham and surrounding towns, it should be noted that the existing high voltage feeder (WNDO24) and the proposed tie line to the Ballarat existing high voltage feeder (BAN003) were both severely impacted by the June 2021 storm event resulting in extended grid outage.

This new feeder is likely to suffer from similar vulnerabilities as the existing high voltage feeder, and in widespread extreme weather conditions it is possible that both lines could again be impacted simultaneously.

Given the inherent vulnerabilities in this solution, TSG and the community are seeking to deploy an additional layer of energy resilience by pursuing the proposed microgrid as a third party owned and operated system.

Purpose and Objectives

The purpose of this report is to assess the technical feasibility of the proposed advanced microgrid project for Trentham and its community. It also aims to support the development of a business plan to form part of a grant funding application to ARENA’s Regional Australia Microgrid Pilots Program (RAMPP), which is a potential source of funding for project implementation.

The objectives of the project are to enhance energy resilience in Trentham, support the adoption of sustainable and reliable energy generation and storage solutions, and improve overall community preparedness for future energy disruptions.

2.2. Technical Feasibility Study Scope of Works

The proposed grid connected microgrid (GCMG) is to connect directly into the existing 500 kVA Market Street low voltage network transformer (ID: 86620900-WND024) – located at 45 High St, Trentham VIC 3458.

This system will include a dedicated Battery Energy Storage System (BESS), diesel generator and all ancillary equipment to enable the Market St LV network to island from the main grid in times of network outage.

Below is a summary of the scope of works as presented in the TSG's Request for Tender document, dated 7/12/24, as per the understanding of YEF and SolarQuip.

- **Assess the technical feasibility** – this is to be achieved by; assessing network usage data; performing preliminary electrical design; specifying equipment and software specifications to meet the requirements of TSG; investigating solar hosting capacity; and identifying and costing other requirements such as installation, licencing and compliance.
- **Developing an approach to microgrid operations** -– this includes working with TSG, Powercor and possible operators/retailers. Sophisticated energy management systems also need to be included in the microgrid design to ensure it can be safely and reliably operated.
- **Assessing financial & commercial aspects of the microgrid** – this includes a detailed assessment of CAPEX and OPEX; costing the project for delivery in 2027 and commencement of operations in 2028; projecting the financial performance of the proposed microgrid; and identifying a suitable commercial approach.
- **Futureproofing the project** – the design of this Stage 1 microgrid must be compatible with a future Stage 2 microgrid, and should support future technologies such as V2G, VPP integration, load increase from electrification and uptake of EV charging; and possible peer-to-peer (P2P) energy sharing arrangements.
- **Lead engagement of Powercor** – this is a critical relationship as implementing the proposed microgrid would require a high level of integration with Powercor's network and control systems. The success of the technical feasibility study is also contingent on Powercor providing detailed network data.

2. Introduction

Key Outputs

YEF and SolarQuip have determined that the following deliverables will provide the necessary information to complete the feasibility study and the essential elements of TSG's business plan:

- **Microgrid Network Analysis** which includes network and usage interval data and analysis for Market St Transformer, either based on Powercor or YEF and SolarQuip assumptions.
- **Technical Design and Specification** developing high level electrical design with a single-line diagram; specifying hardware sizing (BESS, genset, solar, switchgear, network integration); defining software needs (energy management system (EMS), safety systems, DNSP/retailer integration, and load management); determining a specific location for microgrid equipment and installation requirements; and defining the microgrid operation strategies balancing cost and resilience.
- **Commercial Plan** developing a microgrid business model with proposed retail and commercial agreements.
- **Costing and Financial Analysis** conducting a financial modelling to optimise hardware and project viability; and assesses CAPEX, OPEX, potential revenue streams (e.g., energy arbitrage, FCAS), ROI, and payback period.
- **Risk Assessment** which identifies risks in design, implementation and operation; and defines mitigation strategies.

2.3. Microgrids in the Australian Context

The term *microgrid* encompasses a broad spectrum of system configurations and operational contexts. In Australia, various projects have used the term with nuanced definitions, resulting in diverse interpretations. A few definitions of the term are shown below:

"*A microgrid can be thought of as a small 'subset' of the electricity grid that provides energy generation and storage to properties at a local level...microgrids can operate independently of the grid during power outages (also referred to as islanding), which can be particularly helpful for communities in regional and rural settings*." — DEECA[2]

"*A Microgrid is a system that efficiently controls and integrates the electricity supply and demand on behalf of locally interconnected users, either connected to the grid or as a stand-alone system*." — Monash University[3]

"*A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can operate in either grid-connected or in island mode, including entirely off-grid applications*." — US Department of Energy[4]

A review of recent microgrid projects in Australia reveals two broad categories of projects: grid-connected and stand-alone microgrids.

Grid-Connected Microgrids

These are microgrids connected to main electricity grid but retain the capability to disconnect from the main grid and operate independently (island) when required. They can be classified into four subtypes:

(1) **Single Site Microgrid -** backup power and islanding capability for a single user at a single location. Also known as energy backup systems, an example is the Birchip Cropping Group Microgrid Demonstration in Victoria[5].

(2) **VPP of Single Site Microgrids -** resilience through independent generation and storage across multiple properties, each capable of islanding individually. When grid-connected, they operate collectively as a Virtual Power Plant (VPP), offering grid services. Examples include Origin Energy's Victorian Microgrid VPP[6] and the Yackandandah Microgrid Development Trial[7].

[2] DEECA, *Microgrids* [webpage], link
[3] Monash University, *About Microgrids* [webpage], link.
[4] U.S Department of Energy, 'Microgrid Overview' [report], link.
[5] DEECA, 'Microgrid Demonstration Initiative', *SwitchDin – Birchip Cropping Group Microgrid Demonstration* [factsheet], link.
[6] Origin, *Victorian Microgrid Virtual Power Plant* [report], link.
[7] Totally Renewable Yackandandah, *Yackandandah Microgrid Development Trial* [report], link.

(3) **Embedded Network Multi-User Microgrid -** In this configuration, multiple users within an embedded network—such as apartment blocks or college campuses—operate as a single market-facing entity. These embedded networks manage their own internal electrical infrastructure and maintain the capability to island during outages. An example is Microgrid Electricity Market Operator[8] model implemented by Monash University.

(4) **Third-Party Multi-User Microgrid** - In this configuration, a third-party owned microgrid maintains the capability to supply power to multiple users during a power outage but does not operate as a single market facing entity for all users. These type of microgrids can be owned by Distribution Network Service Providers (DNSPs) or third parties. Mondo, a subsidiary of AusNet services, operates third-party owned multi-user microgrids in Victorian regional towns of Corryong and Mallacoota.

Stand-Alone Microgrids

These are microgrids that are not connected to main electricity grid but are rather small grids that can function independently of the main electricity grid. They can be classified into three subtypes:

(1) **Single Site Off-Grid Systems -** Designed for individual remote properties, these systems operate independently from the grid, often in rural or hard-to-reach areas.

(2) **Multi-Site Off-Grid Systems -** These support multiple properties (typically up to 50), using shared generation and storage infrastructure. Common examples include island resorts and off-grid communities such as Moora Moora Community Cooperative in Victoria.

(3) **Stand-Alone Power Systems (SAPS)** - Owned and operated by DNSPs, SAPS are typically deployed in remote communities where main grid connection is economically unfeasible. Many examples can be seen in Western Australia which has a well-established network of SAPS.

[8] Monash University, *Microgrid Electricity Market Operator* [brochure], link.

2. Introduction

The proposed microgrid project in Trentham falls into the grid-connected third-party multi-user microgrid category. For simplicity, the proposed microgrid will be referred to as Grid-Connected Microgrid (GCMG) in this report. The GCMG implementations are relatively new and regulatory frameworks for such systems are still evolving.

A few examples of GCMGs currently operational and planned in Victoria's distribution networks are highlighted below.

Microgrid projects in the AusNet network

AusNet and Mondo (an unregulated subsidiary of AusNet) are deploying three islandable microgrids in eastern Victoria with the support of grant funding.

<u>Corryong Islandable Microgrid</u>

This grid-connected microgrid is currently being deployed in the township of Corryong and will provide resilience to over 900 residents in times of need. The microgrid includes a 4.99 MW battery that is operated commercially by Mondo during normal times; a 3 MW diesel generator, ancillary islanding equipment; and rooftop solar and batteries assets installed in the microgrid. During times of network outage AusNet will assume control over all network assets and operate the microgrid as a stand-alone system.

<u>Mallacoota Microgrid</u>

The Mallacoota Microgrid is of a similar scale to Corryong (~800 customers) and is installed at the end of the feeder line suppling Mallacoota in the far east of Victoria. This system is operated by Mondo and AusNet for resilience and network support, and it does not have any market trading functionality.

<u>Omeo Microgrid</u>

The Omeo microgrid is a smaller scale microgrid that delivers resilience through behind the meter resilience systems at multiple sites. These systems are aggregated by Mondo into a Virtual Power Plant (VPP) so that their operation can be coordinated. When the grid falls these systems provide resilience to each individual site, without energising the local LV network.

Planned microgrids in Powercor network

Powercor have proposed 3 microgrid projects in their 2026-31 regulatory reset plan. These systems are expected to be DNSP owned and run and are expected to be the first low voltage network microgrids in the Powercor network area. It is assumed that in delivering these three projects, Powercor will clarify the rules and regulations for a project of this type in their network, thus setting a clearer precedent for projects such as the third party owned microgrid proposed by this study.

3. Network Data Analysis

3.2. Network Data Analysis Methodology

The Grid-Connected Microgrid (GCMG) design was informed by detailed analysis of energy consumption, demand profiles, power quality, and solar hosting capacity across the Market Street low voltage (LV) network.

YEF, in partnership with SolarQuip, assessed the 30-minute interval consumption and 5-minute interval power quality data provided by Powercor. Consumption data was provided as the aggregate of all National Metering Identifiers (NMIs) within the network, and voltage was measured using data from the NMI nearest to the transformer.

Load Analysis – Consumption

The analysis of energy consumption data from April 2023 to 2025 indicates a modest year-on-year growth in total daily consumption, particularly during winter (illustrated in Figure 5).

Seasonal variations in energy consumptions were pronounced, with summer showing the lowest median daily consumption at 2.17 MWh per day and winter the highest at 3.69 MWh per day. The median daily consumption in autumn and spring are in a similar range at approx. 2.7 MWh per day. There is however a significant variance in consumption patterns in all seasons demonstrated by the whiskers and outliers of boxplot in Figure 3. A notable difference is also observed in consumption patterns for a weekday vs weekend, with the latter having slightly elevated consumption as shown in Figure 4. The average daily consumption across the two years was 2.8 MWh per day.

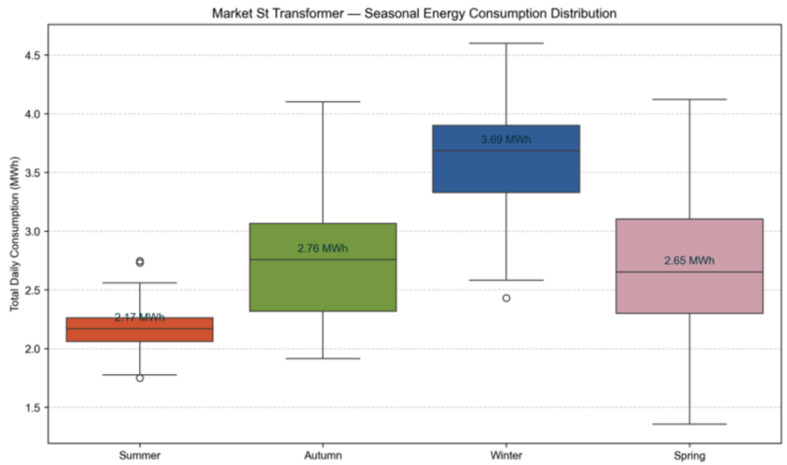

Figure 3: Seasonal variation in energy consumption

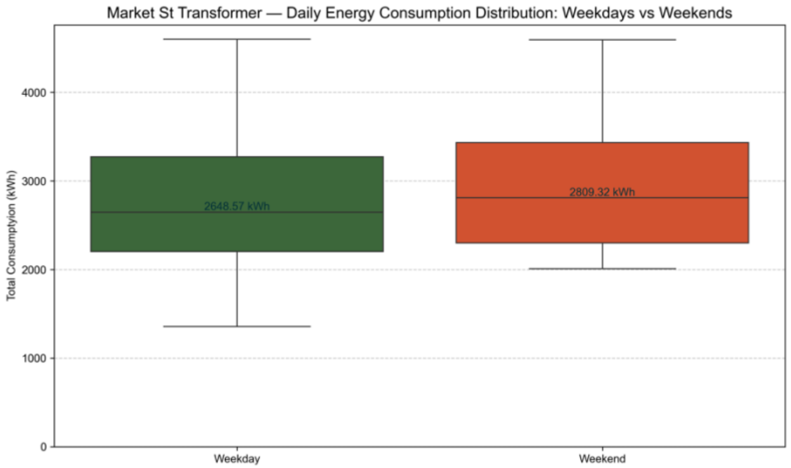

Figure 4: Weekday vs weekend variation

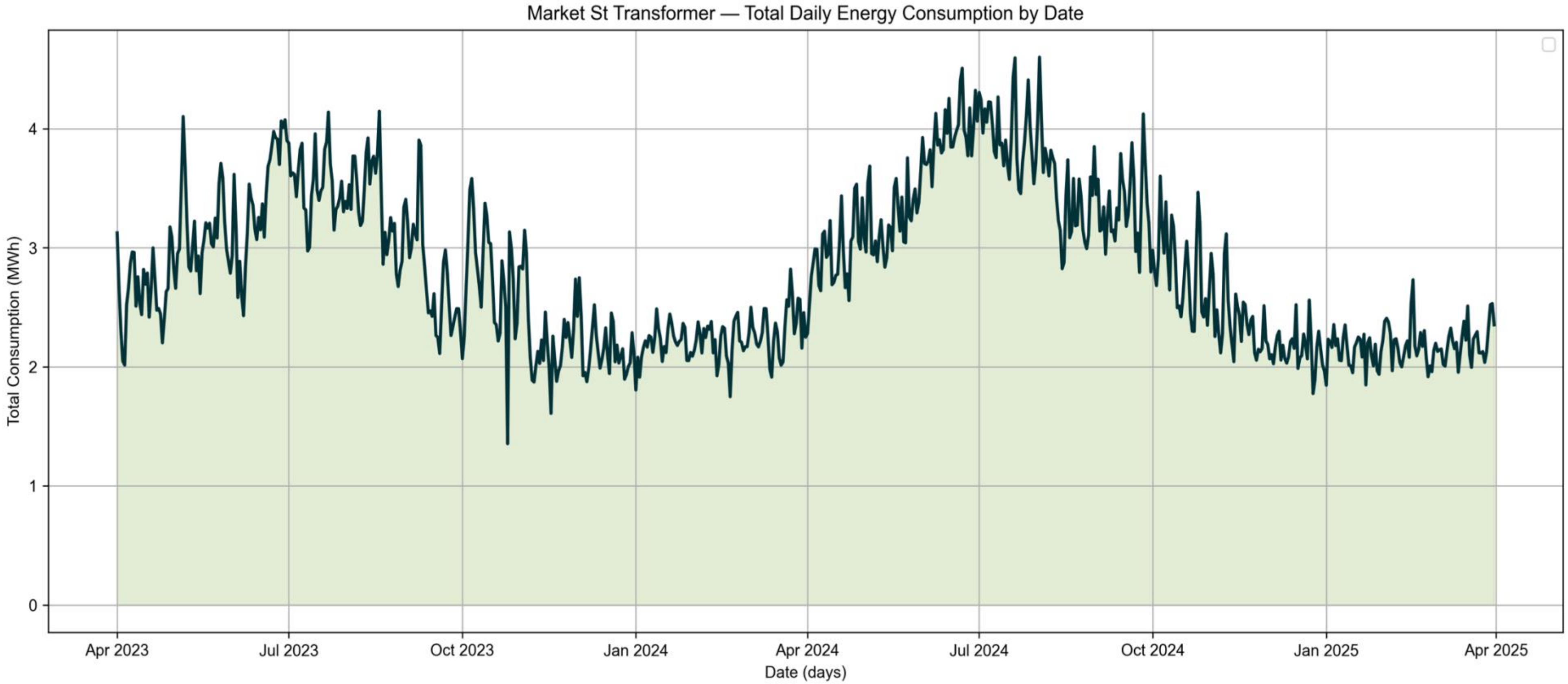

Figure 5: Market St Transformer total daily energy consumption - April 2023 to April 2025

Load Analysis – Demand and Generation:

The demand and generation data of the Market St transformer was evaluated to inform the inverter sizing and load handling capabilities of the microgrid. Due to low resolution energy data (30-minute intervals), demand and generation were assessed by assuming uniform power input/output within each interval. This introduced a level of approximation to the analysis, and it is important to note that the actual peak demand and generation figures may be significantly different.

Figure 6 and Figure 7 show the daily import and export from the Market St transformer represented in kW. Each individual grey line depicts a single day, while the blue and orange lines are the averages.

Figure 6 shows the average daily demand is generally below 150 kW, with peak demand occasionally exceeding 250 kW, and a calculated maximum demand of 278 kW. On certain days, the demand dropped to 0kW indicating power outages.

Figure 7 shows that average daily generation peaks slightly above 40 kW with exports occurring between 6:00 am and 8:30 pm. Peak export occasionally exceeds 100 kW, indicating notable solar generation.

A further analysis of net energy flows (imports minus exports) revealed a small number of net export days occurring in summer. This suggests there is excess local generation feeding back into the grid which may coincide with periods of low demand. However, these instances were infrequent and marginal in scale, indicating that net export is not a persistent characteristic of the current Market St network.

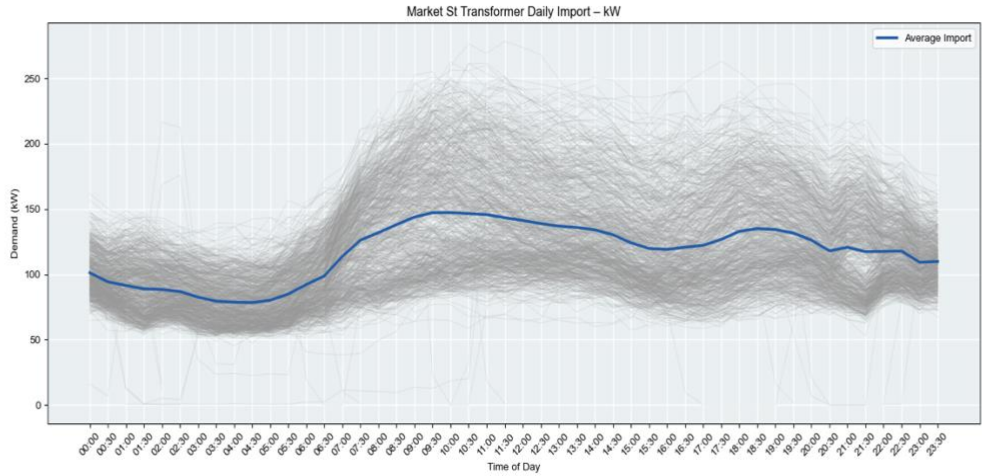

Figure 6: Daily demand & average — imports

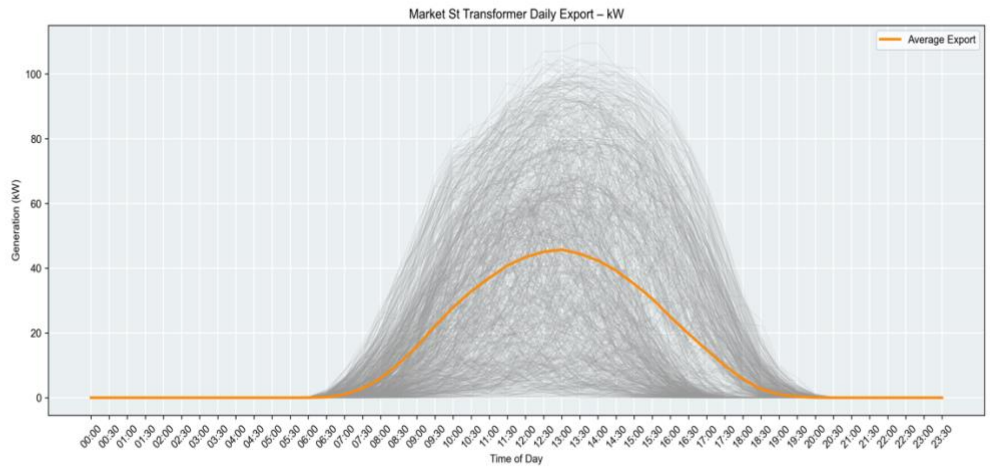

Figure 7: Daily generation & average — exports

Power Quality Analysis

Voltage Variation

To assess power quality, voltage data was analysed to understand variations and phase balancing across the three phases. Australian Standards for voltage were used as a guiding metric for the assessment.

In Victoria, nominal voltage supplied by the electricity distributors in 230 volts (V). For power supply under 1000 V, they are required to maintain the voltage within an allowable range of +10% to –6% from nominal value, to comply with their service obligations[9].

Figure 8 shows how the voltage on the transformer varied during a sample week in March 2025. It can be observed that average voltages for all three phases (Red, White, and Blue) consistently exceed the nominal voltage by a few volts but stayed within the regulatory limits. The variations in voltage shown using the min/max range in lighter shaded areas indicate a persistent breach of the upper and lower regulatory limits. This trend was not isolated to this sample week but was rather a typical pattern throughout the year.

Further scrutiny of phase-specific voltage data indicated a distinct behaviour across each phase. Heatmap analysis in Figure 9 shows median standard deviation of voltage by hour. The map reveals that the red phase sees heightened voltage variability during midday indicating a higher standard deviation at that time, this could be potentially due to high solar exports causing a rise in voltages. The white phase also showed high variability, but it was throughout the day, suggesting higher loads with fluctuating consumption patterns. The blue phase in contrast showed lesser variability amongst the three phases, indicating a steady and balanced consumption profile.

Current Variation

The current in Amperes was also analysed to assess the load on the transformer within a given interval. As illustrated in Figure 10, the average current flowing on the white phase was significantly higher than red and blue phases. This aligns with the voltage data, where white phase showed higher daily standard deviation, likely driven by heavier and variable loads. Additionally, the average current on red and blue phases drops noticeably in the afternoon, indicating the presence of rooftop solar generation which reduces the demand from the transformer. During these periods, households are likely to self-consume solar energy generated on their rooftop panels which reduces the current drawn from the grid and lowering the current measured at their meters.

[9] Essential Services Commission, *Electricity Distribution Code of Practice* [guideline], link.

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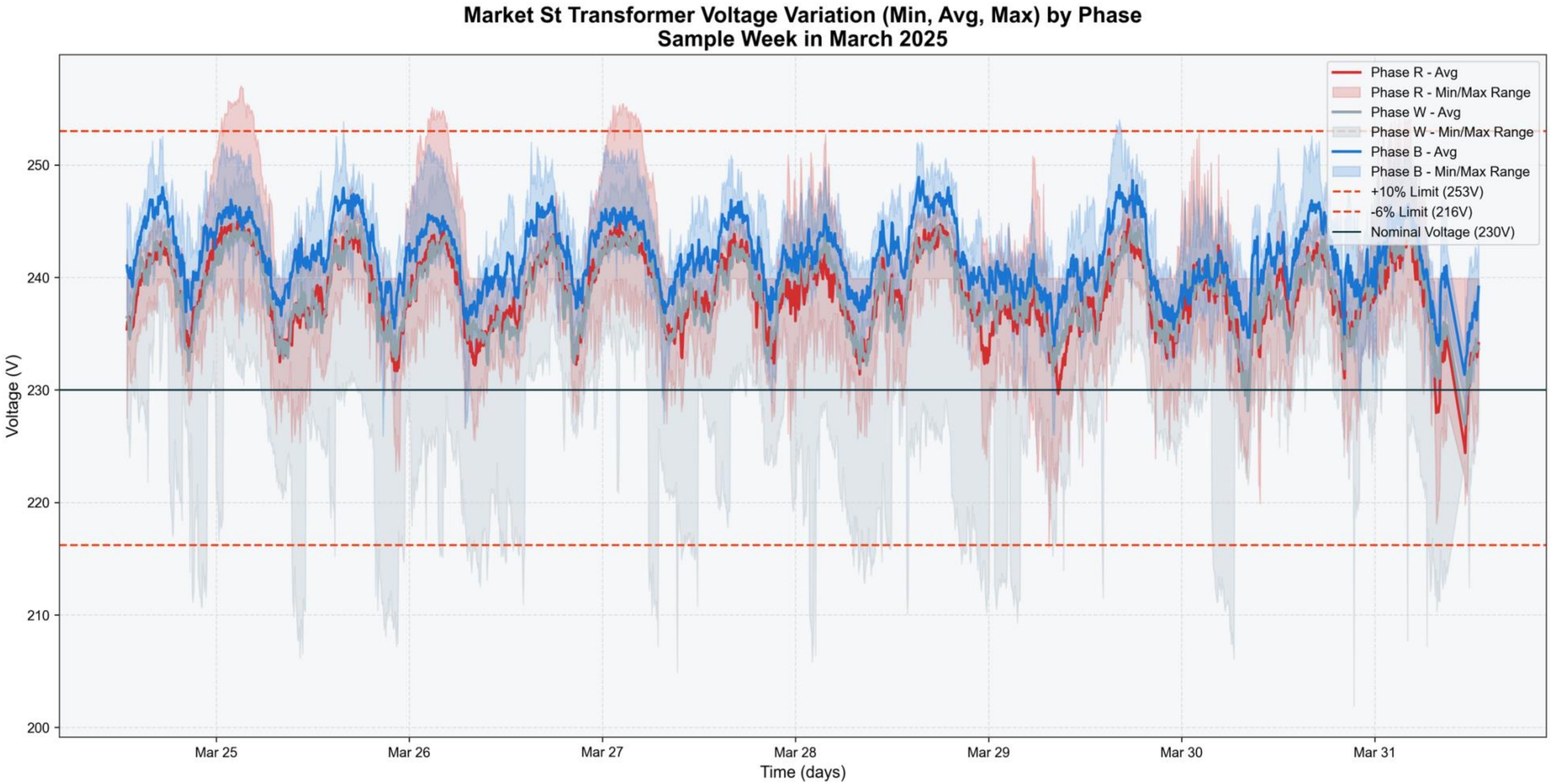

Figure 8: Market St voltage variation by phase for a sample week in March 2025

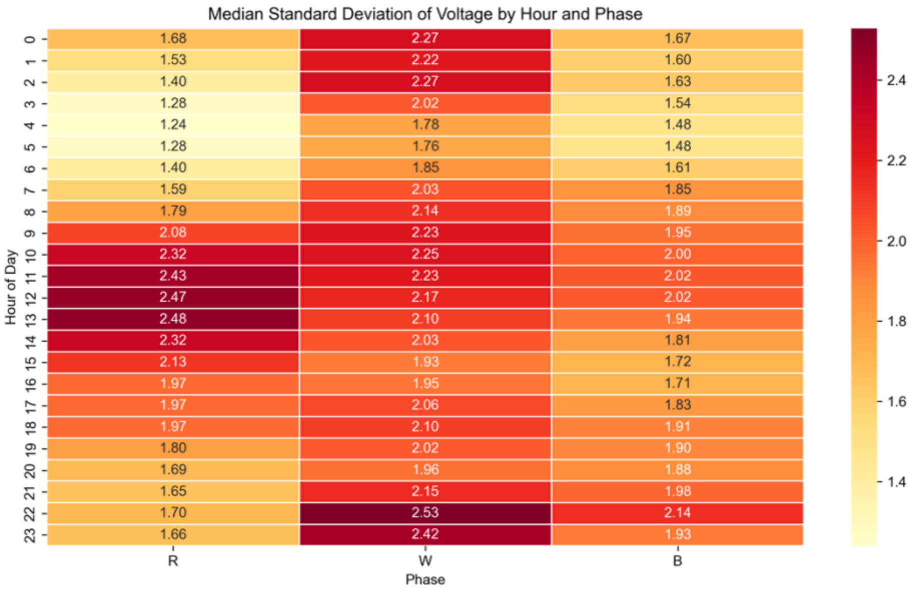

Figure 9: Median standard deviation of voltage

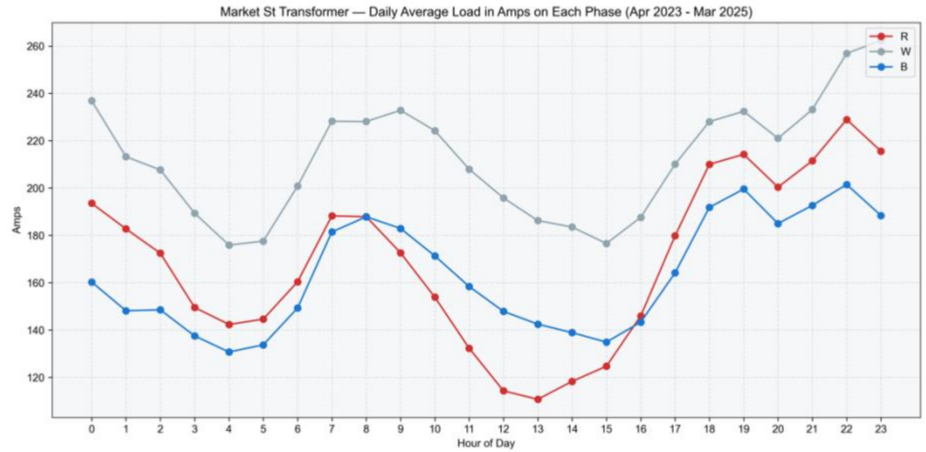

Figure 10: Daily average current on each phase

Current Solar Capacity

The current solar capacity on the Market Street network, as of April 2025 is 153 kWp, with an export limit of 127 kW (Figure 11). To support longer islanding capability and reduce reliance on backup generation such as diesel gensets, YEF conducted a solar hosting capacity assessment to determine the feasibility of further PV deployment in the network area. This analysis is crucial, as expanding solar will increase the availability of renewable energy within the microgrid, especially during peak sun hours, enabling longer islanded operation and enhancing the microgrid's overall sustainability and resilience.

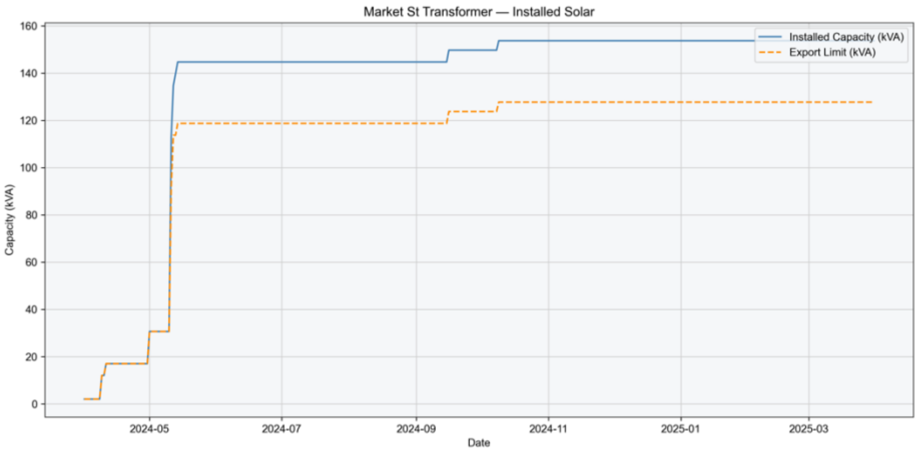

Figure 11: Installed solar capacity

Solar Hosting Assessment

YEF and SolarQuip assessed the solar hosting capacity using the following process:

(1) **Network coverage analysis** – YEF developed GIS map of the Market St LV network and used this to identify rooftops with hosting capacity.

(2) **Assessment of hosting capacity sites** – the solar hosting capacity of large, vacant roof spaces (e.g., commercial rooftops) was assessed using SolarPlus software. Smaller rooftops (e.g., residential properties) were assumed to have a 6.6 kW hosting capacity. This assessment considered all properties connected to the Market St network.

(3) **Calculation of overall hosting capacity** – the hosting capacities of all sites were summed to give the overall capacity.

This assessment identified a potential to host an additional 349 kWp of rooftop solar in the microgrid, assuming a 67% uptake vs the theoretical maximum, this would equate to an additional 234 kWp, taking the assumed future solar capacity of the microgrid to 387 kWp. Note that this figure is contingent on Powercor approval and does not consider export limitations that may be imposed on future solar systems. For the purposes of the design, YEF has assumed a hosting of 400kWp in the Market St Network.

Refer to Appendix A – Supplementary Information for detailed solar analysis and results

3.3. Network Data Analysis Results

Limitation of the Analysis and Recommendations

It is important to acknowledge a key limitation of this analysis: the 30-minute interval data that we analysed does not capture instantaneous peak loads occurring on a sub-minute or second scale. These short-duration spikes which are common and often occur, can materially influence the sizing and specification of microgrid equipment. Accordingly, YEF recommends undertaking a more granular load analysis using high-resolution data monitoring equipment at 1-second or sub-second intervals to better understand the magnitude and frequency of these instantaneous peaks. We recommend this investigation be conducted prior to procurement to inform the final system design of the microgrid.

Equipment Sizing Recommendations

This analysis of daily, seasonal, and annual usage trends, as well as demand and generation patterns has formed the basis for determining appropriate storage capacity and inverter specifications of the microgrid equipment.

To inform battery sizing, the highest observed daily demand and average daily consumption on the Market Street transformer network were used as key reference metrics. The peak demand observed is 278 kW, while the average daily consumption is approximately 2.8 MWh. Considering commercially available battery products in the market, cost of equipment, and the project’s core objectives of renewable generation and local energy resilience, a battery with 300 kW inverter and 1.2 MWh of storage is determined as the optimal configuration.

The inverter component of the battery is sized to be capable of responding to the observed short-term peaks and troughs in demand and to maintain stable supply under microgrid operation. While the storage component was sized to enable microgrid operation at maximum demand for approximately four hours. In practice however, the battery can sustain backup for longer as it is likely that load will decrease after entering microgrid mode, due to behaviour changes, load shedding protocols, and coordinated demand response with residents and businesses.

To ensure resilience for longer duration outages, a genset was specified at 400 kVA rating with 0.8 power factor. The operational duration of the genset is theoretically unlimited, contingent on fuel supply. It is estimated that approximately 3,300 litres of diesel would be required to supply power for 4 days using the generator only, however in reality the fuel required may be less if the BESS and local solar can meet a portion of the backup supply requirements.

Power Quality Management

Due to the significant voltage variations observed in the network data, we anticipate that these fluctuations will persist when the microgrid enters island mode. In such a scenario, responsibility of managing voltage across the three phases will fall on the microgrid operator. The system will be required to respond dynamically to voltage spikes and drops, drawing upon its inverter functionality and battery capacity to stabilise supply. This ongoing regulation imposes an operational burden on the microgrid, potentially diverting energy from load-serving functions to power quality management.

Therefore, we recommended that voltage and power quality issues on the Market Street low voltage network are addressed prior to microgrid procurement. Proactive measures such as phase-load balancing, voltage regulation upgrades, or demand-side controls will enhance network stability and reduce the strain on microgrid infrastructure.

4. Microgrid Technical Design

4.1. Design Options

Two Microgrid Design Options

The project aims to implement a resilience solution for the low voltage (LV) network supplied by the Market St transformer.

A desire was expressed to consider extending the network to include the Station St Shed (located north of the railway station, 200 kW solar hosting capacity), and two properties at the periphery of the network:

- The IGA Supermarket, which has its own generator for backup, would add load but could also reduce it with rooftop solar.
- The Cosmopolitan Hotel is a popular venue for which a power outage may affect many patrons of the town.

This has led to the following two options:

- **Option 1**: focus on the existing Market St LV Network only, with minimal work required of Powercor, mainly allowing the street feeders to be fed from the microgrid upon grid outage.
- **Option 2**: add solar and battery to the Station St Shed – sized to the maximum solar capacity, with a 200 m overhead line connecting the shed installation including tenants to the Market St LV network. Also change the connections of the IGA and Cosmopolitan Hotel. Note that this option requires substantial work by Powercor which is not included in the costings of option 1.

The design proposed in this document only covers Option 1, with Option 2 only as a possible follow-on project.

A Microgrid Design Exclusion

Diverting the connection of the Mechanics Institute to the microgrid network was considered in this study. It was excluded for lack of load data and because the export limit was set to 0 kW for reasons unknown, potentially signifying a need to store or use all excess solar in times of power outage.

Refer to Appendix A – Supplementary Information for more details on possible Option 2 extensions to the microgrid, including the Mechanics institute.

A Microgrid Design Alternative

An alternative to a centralised microgrid solution is a network of decentralised site microgrids, i.e., individual backup systems for both residential and business customers. In normal times, the battery systems at customer premises would be enrolled in a Virtual Power Plant. In island times, they would provide backup. Although, 3-5 days of supply autonomy may not be achieved, it offers a cost-effective alternative and may be more empowering for all participants.

This alternative is presented in Section 8.

4.2. Hardware Design Specification

Performance Requirements

For the 66 dwellings and 36 businesses of the Trentham Market St LV Network, the scope of works requires the following performance.

Performance Metric	Requirement
BESS + solar only backup	4 hours
Generator extended backup	3-5 days

BESS Power Design

The data provided by Powercor suggests a peak demand of 278 kW. However, due to the lack of power quality data for the transformer and only 30-minute interval sampling, it is not possible to know the exact peak demand. Moreover, a significant phase imbalance of up to 50 V between red and white phases is shown in Section 3.

Unlike the grid, an inverter-based system such as a BESS, when in island mode, can only be overloaded and for a period of seconds. This means that the power rating of the BESS must always exceed the expected demand. Before procuring a solution, detailed power quality measurements must be carried out.

Two design choices were made accordingly:

(1) Increase the stated peak demand from 278 kW to 300 kW, and size BESS to have a 300 kW power rating.

(2) Include a load shedding system to ensure the demand remains below that stated peak of 300 kW.

BESS Storage Specification

To meet the BESS + Solar resilience target of 4 hours, a 4-hour BESS was chosen, with the benefit of potentially extending that period were the demand to be less. However, 4 hours of backup supply requires the average demand to be less than 300 kW.

It is assumed that the BESS is charged up to 90% (considering a typical operating range of 10-90% of storage) prior to a grid outage. The average demand over the following 4 hours would need to be 240 kW and it would draw 960 kWh from the BESS. It is assumed that the proposed load management systems will limit average demand to 240 kW or less during islanded operations.

Moreover, all BESS' have inherent efficiency losses during AC-DC and DC-AC conversions, and from ancillary loads such as controls and cooling. A typical 85% BESS roundtrip efficiency is assumed, requiring greater charging than discharging.

While in island mode and to restore full BESS supply, solar generation must produce 1,130 kWh for 960 kWh of BESS supply to be available again. With a prospective 300 kW of solar capacity within the microgrid, the BESS would be replenished in 4 hours.

Portable Generator Specification

In concert with the 300 kW BESS, a portable generator rated at 400 kVA with a typical 0.8 Power Factor (PF) would extend the island time. It connects into the microgrid through a generator connection cubicle, with power and control cabling.

Being portable, it can either be locally stored or transported to site while the BESS is supplying. This brings two opportunities to TSG:

(1) The generator can be shared, possibly co-funded with Shire, and
(2) The generator can be replaced in the future by an electric truck with bidirectional charging capability, for greener sustainability.

Fuel supply would come from external sources (e.g., local service station or private farm supplies).

For generator control, refer Section 4.3: Software Design Specifications.

Load Shedding Design

To limit demand, the design calls for a system to turn off non-essential services when in island through a load shedding system. The proposed load shedding system targets residential hot water systems or similar non-essential loads, of which there would be 66 in theory. It is assumed that these loads have an average 2 kW demand per system, meaning the total demand on the islanded microgrid could be reduced by up to 132 kW through loadshedding, albeit in a gradual fashion.

For greater equity, the load shedding system can use a random selection algorithm to reduce demand until it reaches a trigger setpoint.

The design involves a central controller and remote agent devices, small enough to easily be installed at customer premises. Each device would be equipped with a transmitter/receiver communicating by an Internet of Things (IoT) protocol.

Upon the return of grid power, the central controller would re-enable the hot water systems that were shed during the island event. The return to service may be staggered over a longer period – depending on the number of hot water services that were shed – to prevent overloading the network with a demand peak.

The load shedding system is subject to the installation and commissioning of all necessary hardware and will require close collaboration with the community. Project proponents will need to engage extensively with the community to avoid confusion and secure the necessary social licence to implement the load shedding system.

Solar Generation During Island Mode

Solar analysis suggests that up to 400 kW may be installed on rooftops in Option 1. This number exceeds the rating of the BESS and may force the generator to its minimum load of 30% (about 100 kW), when in island mode. However, the microgrid controller will ensure that solar generation is curtailed to an acceptable level when required.

Moreover, Powercor would need to cooperate in removing backstop controls and any export limits during times of network outage so that the microgrid can benefit from maximum solar production.

Hardware Design Specification Summary

The following table summarises the specification of the equipment to be procured. This covers an operating period of 15 years starting in 2028 and was provided to Engineering Procurement and Construction (EPC) tenderers as the basis for their design proposals.

Table 1 Hardware design specification

Option 1: Market St low voltage network only	
Market St BESS, main BESS for supporting islanding mode	300 kW / 1.2 MWh
Market St Portable Generator, diesel generator offloading Market St BESS	400 kVA, 0.8 PF
Load shed equipment, central controller and local connect/disconnect devices	1 central controller and 66 control devices in all Market St households
Residential & commercial solar, from 2028 to 2043	200 kWp to 400 kWp
GCMG-only solar DC-coupled with Market St BESS 76 kWp solar roof on the adjacent land, 12 kWp on toilet block	88 kWp to 88 kWp
Residential & commercial peak demand, from 2028 to 2043 (1.5 multiplier, load managed in island mode)	278 kW to 417 kW (300 kW in island mode)

4.3. Software Design Specifications

The following specification was provided to the EPC tenderers as the input to the microgrid software to be supplied.

Grid-connected Mode

When connected to the grid, the microgrid is to be operated by a market trading Financially Responsible Market Participant (FRMP, or retailer).

All equipment (except the diesel generator and load shedding system) in the microgrid is used for commercial purposes to maximise income generation. The BESS will be traded on the electricity market by wholesale energy arbitrage and Frequency Control Ancillary Services (FCAS). The microgrid operation is driven by the optimised dispatch system of an electricity retailer.

Island Mode

Upon grid outage, the microgrid automatically switches to island mode and engages a microgrid controller to perform the following functions:

- Grid power failure detection and islanding in milliseconds, preventing customer equipment from switching off;
- Simultaneous switching of Market St BESS inverter to voltage forming supply;
- Supply of power throughout the islanded microgrid matching instantaneous demand;
- Demand management by remote load limiting devices at specified locations, as required;
- Staged load shedding at configured demand thresholds to protect supply capacity;
- Automatic frequency-based management of LV network solar generation and Station St Shed BESS (if Option 2 is deployed);
- Automatic genset startup and transition to voltage forming with Market St BESS entering grid-following mode;
- Detection of grid power restoration and grid voltage synchronisation, whether the BESS or genset is voltage forming;
- Instantaneous switchover to grid supply and voltage-following mode of Market St BESS inverter;
- Resumption of grid-connected mode and commercial dispatch optimisation;
- Black start function with load shedding enabled, and;
- Deactivation of microgrid by Powercor for grid maintenance work.

Controls Handover

The transition between modes corresponds to a handover between a retailer's EMS/dispatch software that optimises commercial returns in grid-connected mode, and a microgrid controller that matches supply and demand in island mode. The technical solution needs to implement a seamless transition back and forth, always allowing for continuous supply to the GCMG customers.

4.4. Physical Layout

YEF proposes that microgrid equipment be installed across two sites:

(1) At the base of the Market St transformer power pole (north of the toilet block): this site will host the switchgear, ancillary islanding equipment and the generator connection cubicle (next to the curb).

(2) A secondary area, approximately 25 x 25 m will host the BESS and dedicated solar system.

The identified options for the secondary equipment area are as follows:

Location A – Central Trentham (preferred option)

This option would utilise the vacant block of land adjacent to the Market St transformer and toilet block. It is currently held on the same title as the pharmacy and would require a lease agreement with the owner or a subdivision and sale to the microgrid owner.

Location B – Council lot across the road from the toilet block.

This lot is council owned and currently hosts a small playground facility which would need to be removed. The lot would be leased for use of the microgrid. It is further away from the transformer and switchgear and would involve more civil works and higher cost.

Location C – Vacant block on Victoria St near Railway Station

At the top end of Market St, this would have inefficient solar exposure due to trees and distance to the switchgear.

We recommend pursuing Option A, with Option B as a fallback.

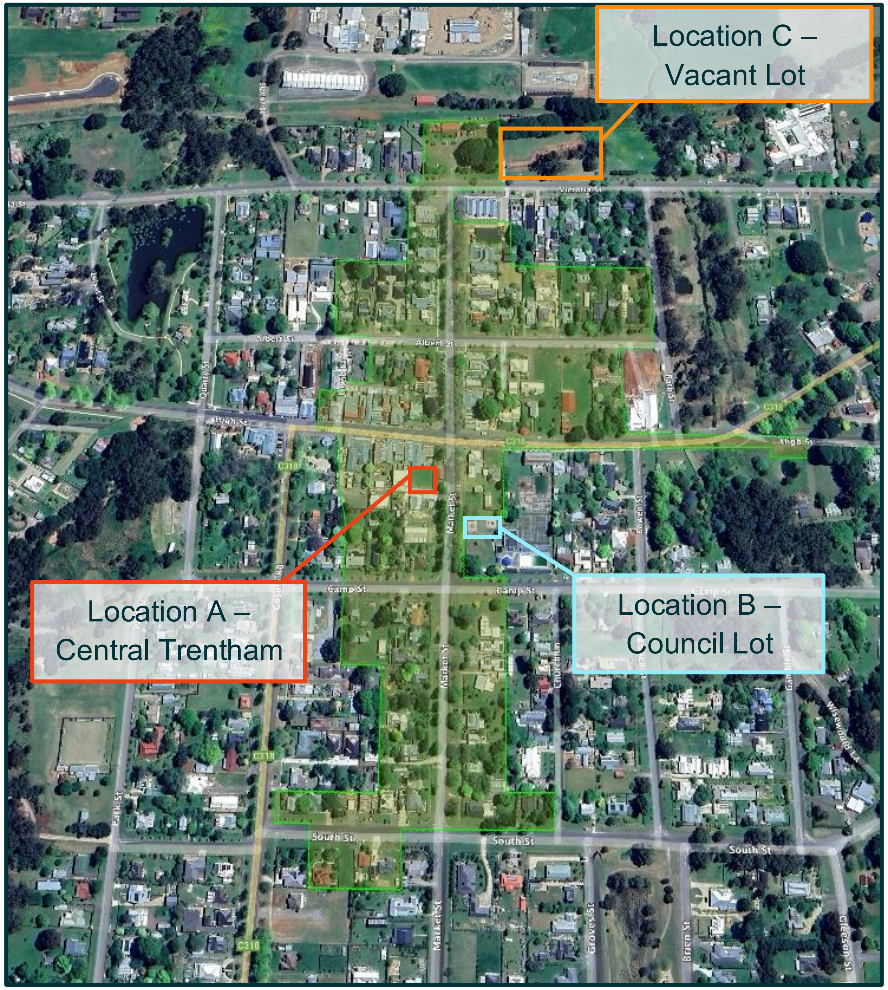

Figure 12: Market St Microgrid site options

4.5. Microgrid Concept Design Summary

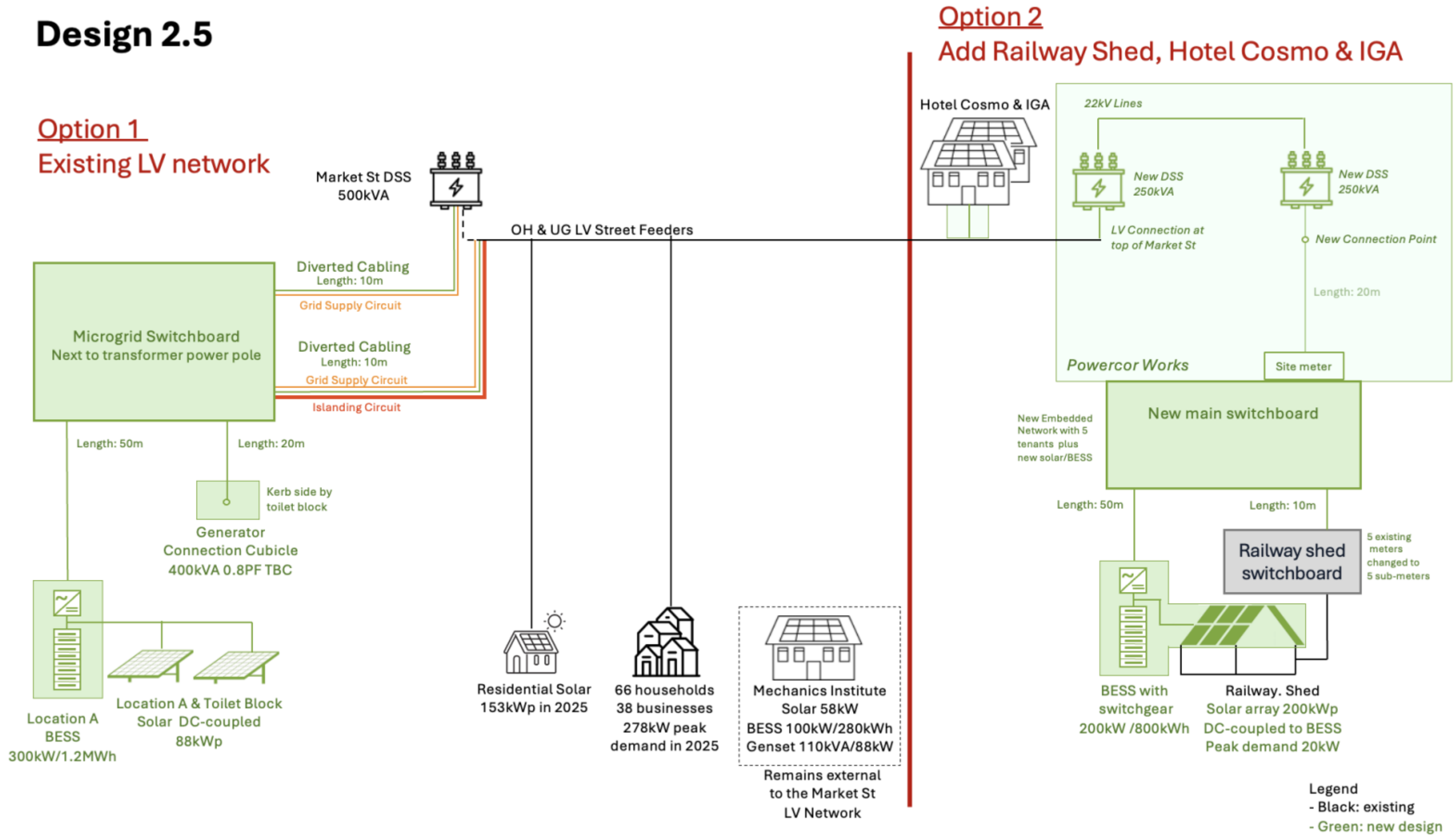

Figure 13: High level diagram of proposed low voltage microgrid options

Figure 14: Plan view of Location A - the centre of Trentham with indications related to the microgrid

4.6. Microgrid Operational Modes and Philosophies

YEF and SolarQuip propose the microgrid be operated according to the two operational modes detailed below.

Grid-Connected Mode

This mode refers to operations when the main grid is live, and equipment is used to generate revenue in the energy markets. The grid connected operating philosophy of microgrid is highly dependent on the chosen retail operating model. For the purposes of this study YEF is assuming a *profit optimised* model, however we note that TSG may wish to explore other options (e.g. Virtual Energy Network or Retail Benefit Sharing models) subject to the outcomes of community engagement.

Grid Connected Operating Philosophy

In grid connected mode the Retail partner is granted full control of the Market St BESS and co-located solar. All other microgrid equipment (e.g. diesel generator, islanding switch gear, load management systems) remains in a standby state. Retail control is to be implemented through the installation of Retailer's edge device (local controller that interfaces between BESS and Retailer's asset dispatch system) or an API (direct cloud interface between Retailer's Dispatch System and Battery).

The retailer will dispatch according to an intelligent optimiser that seeks to maximise returns from the wholesale energy market, FCAS markets, and the network tariff. The optimiser will be limited by the BESS' allowable state of Charge (SoC) range of 30-90%, which reserves the bottom 20% of battery capacity for backup functionality[10]. This optimisation may result in curtailment of the co-located solar system when wholesale energy prices are negative.

In addition to this retail operation, the BESS is likely to provide incidental support to the Market St LV network, including:

- Voltage stabilisation, which may in turn reduce local solar curtailment and increase the local production of energy.
- Reduced likelihood of reverse flow at the Market St transformer
- Reduced evening demand on the Market St transformer

This benefit is not a priority for the project but would be realised when market price signals coincidentally align with local network support needs.

Powercor will also need to have an interface with the retail partner's dispatch system to allow for override of the microgrid for maintenance and safety purposes (similar to the residential backstop mechanism).

[10] The standard SoC range for a BESS of this type is 10%-90%, by reserving 20% of capacity for resiliency the lower SoC limit for market trading is raised to 30%.

Island Mode

This mode refers to operations when the main grid is offline and the microgrid equipment is islanded.

Island Mode Operating Philosophy- Technical

In this operating state the Microgrid Controller operates all microgrid equipment, including load management, to balance the supply and demand of energy in the microgrid network. The BESS is operated in *grid-forming mode* by setting the voltage of the microgrid. It must meet instantaneous demand with supply and will control solar generation by the AS4777.2 control function (e.g. raising microgrid grid frequency to curtail solar production).

The BESS will supply until its SoC reaches a low setpoint which will trigger the generator to come online. It then transitions to generator support, i.e *grid following mode*. During this time, the BESS will operate alongside the diesel generator to minimise the fuel consumption.

Depending on equipment selection, the transitions from grid to BESS, to generator, and back to grid supply, can be synchronised without loss of load. This is preferable to avoid the challenges of a *black start* which is very demanding for the BESS.

During Islanding mode, the microgrid will prioritise commercial loads, as providing power to shared services is a key outcome of the project. This prioritisation will be achieved by implementing load management on residential properties. The load management consists of an automated load management system and a behavioural load management strategy, both of which require the community support.

Island Mode Operating Philosophy – Behavioural

Behavioural interventions offer a powerful means to manage the load on the microgrid if implemented well. These interventions are somewhat akin to water restrictions – a set of self-implemented usage restrictions that help manage a finite resource during times of limited supply.

YEF recommends that TSG work closely with the community to design and implement a behavioural operating strategy that minimises the use of energy during times of network outage.

Given the need for this strategy to be developed in conjunction with the community YEF are unable to comment on the impact that this may have on the longevity of the BESS only backup of the Market St microgrid. However, if the community can achieve a 50% reduction in consumption across the whole LV network, then this could in theory double the backup supply time of the BESS.

4.7. Ownership and Operation Roles

The following section details the key ownership and operational roles that will need to be filled to support the delivery and operation of the microgrid.

Trentham Sustainabiltiy Group (TSG)

TSG are acting as a key proponent for this project and have been instrumental in initiating the works leading to and including this technical feasibility study. YEF anticipates that TSG will play the leading role in progressing this project to a funding application, however as a small community organisation their capacity to own and operate a microgrid is limited and others will need to provide these functions. YEF recommends that TSG play a leading role in representing the voice of the community, managing the administration of the grant funds, supporting the implementation of a behavioural operation strategy, and potentially contributing in-kind services (e.g. cleaning any graffiti from equipment as required) to support the microgrid operation.

Microgrid Retailer

The primary role of the retailer is to manage the market trading operations of the microgrid and to handover control to the local microgrid controller when the system transitions into island mode. YEF recommends that the retail contract include ongoing microgrid equipment monitoring to reduce the day-to-day burden on the microgrid operator, and notes that the retailer will need to be involved in integrating the microgrid with Powercor’s control interface.

Microgrid Operator

The Microgrid Operator function is responsible for the operation and maintenance of the GCMG system and the microgrid operation during islanding mode. The Microgrid Operator may outsource maintenance to a third party but maintains responsibility for coordinating these activities. It is possible that this role will also involve some level of daily online equipment monitoring, the extent of which will be determined by the level of monitoring provided by the Retailer.

Microgrid Owner

The Microgrid Owner is the entity that will own the microgrid equipment, this may include some responsibility for administering the benefit sharing program. The Owner will receive the revenues generated by the system and be responsible for using these funds to cover the cost of operational expenses. The owner will be liable for the system and as such it is recommended that the Owner take on the Retailer and/or Operator role to strengthen the value proposition of their involvement in this project.

Powercor

Powercor is Distribution Network Service Provider (DNSP) for Trentham and will need to be heavily engaged in both delivery and operation for this project to be feasible. Key operational responsibilities will include integrating with the microgrid control system to enable network override and isolation of microgrid equipment when required for safety and maintenance purposes. Powercor will play an important role in connection design and approval of the microgrid for installation in their network. They would also need to be involved on a collaborative level to enable a detailed study of power quality, the proposed phase balancing works, and possible future extension of the microgrid network.

The local community

The broader local community have an important role to play in the microgrid operations as they can greatly support the microgrid though the future uptake of DER and reducing their energy consumption in times of standalone microgrid operation. The community will need to work closely with TSG to develop and implement a behavioural microgrid operating strategy that focus on reducing consumer consumption and demand when the system is in island mode. TSG should also encourage community uptake of solar and batteries as this will improve the microgrid performance an provide an additional layer of energy resilience.

Table 2 Operational Responsibilities Matrix

Responsibility for key operational activities	Retailer	Operator	Owner	TSG	Powercor	Community
Grant Administration (Reporting)			✓	✓		
Microgrid Administration (day-day monitoring)	✓	✓				
Microgrid Maintenance (can be contracted out)		✓				
Administration of benefit sharing program	?[11]		✓			
On market operations	✓					
Islanding Operations		✓				
Powercor network control integration	✓				✓	
Management of behavioural operation strategy				✓		✓
Responsibility for OPEX	**Retailer**	**Operator**	**Owner**	**TSG**	**Powercor**	**Community**
Grant/Project Administration			✓	?		
Land lease costs			✓			
BESS insurance – product damage			✓			
BESS insurance – public liability			✓			
BESS Administration (day-to-day monitoring)			✓	?		
Funding of community benefit program			✓			
Metering fees			✓			
Market fees			✓			
BESS maintenance costs			✓			
Site maintenance costs (graffiti cleaning, etc)			✓	?		

[11] The Retailer may be responsible for benefit sharing if the community benefit takes the form of a retail product offer or virtual energy network.

Third Party Ownership Options

An Energy Retailer (subject to procurement)

Energy retailers are well placed to own microgrid equipment given many already own BESS and other generating assets, have extensive energy market experience, and can access to significant capital. Selecting a retailer as the primary owner would likely require them to be granted exclusive rights to dispatch the BESS.

Subject to a profit from operations being realised, benefit sharing could take the form of a retail product (e.g. virtual storage credit) or a cash benefit (e.g, a lease payment or similar the landholder or community).

A limitation of retailer ownership is their financial interest in market operations, not resilience. Unless Powercor provides substantial resilience payments for unserved energy, which is unlikely, commercial terms would need to include resilience as a service to the community.

Hepburn Energy

Hepburn Energy are a community owned energy co-operative based in the Daylesford region with existing projects spanning wind generation, solar and batteries. They would be a suitable owner and operator based on their experience operating similar generating assets in the local area and may be interested in providing operational services or owning the asset if there is a suitable business case for their shareholders.

DJAARA, Hepburn Shire Council, or other local investment

TSG has identified several local organisations that have expressed an interest in investing in a microgrid project. While it is unlikely that these organisations would be willing to take on majority ownership of the microgrid they may be willing to participate as minority shareholders in the project. YEF has not engaged with these parties during this study and notes that each may have varying motivations for investment and requirements for financial returns. TSG would need to engage with these parties while progressing a funding EOI to understand the amount they may invest, and the likely terms of such investment.

A DNSP (Powercor) or the unregulated arm of a DNSP (e.g Mondo)

Current GCMG projects in Victoria have been delivered by DNSPs in partnership with third parties such as Mondo (an unregulated arm of AusNet). While these organisations maintain distinct separations due to ring-fencing requirements, they are heavily integrated and are incentivised to work together on projects such as this.

The benefit of this ownership model is the heavy involvement of the DNSP which could help navigate the key technical and regulatory issues, and that a clear precedent exists from projects such as the Corryong microgrid. While this model represents the easiest path to Microgrid delivery, YEF does not believe that it is a feasible approach for TSG given Powercor's decision to pursue a second high voltage tie instead of a microgrid in Trentham.

4.8. Orchestration Opportunities – VPPs, VENs and P2P

In addition to the business plan presented above, YEF notes that there are additional operational models and benefit sharing mechanisms that are becoming available in the market. TSG has clearly stated interest in these alternative models throughout the project, however, without a confirmed owner for the project, YEF does not feel that an alternative benefit sharing model can be selected. It is also important to note that that the community are a key stakeholder in benefit sharing and should be involved in the development of the project's benefit sharing arrangement.

Virtual Power Plants (VPPs)

A Virtual Power Plant (VPP) aggregates DER to operate as a unified power plant, providing grid services.

This aggregation usually involves a retailer, or similar, implementing remote connections to DER such as BESS, rooftop solar and smart devices with demand response capability. These remote connections allow the controlling party to establish a level of dispatch and load control over the individual devices incorporated into the VPP.

These controls could include activating home batteries for trading into the FCAS market, performing loadshedding based on network constraints or market signals, and coordinating generation by solar and BESS. The exact level of control is governed by any agreement between the VPP operator and the owners of the assets that are being aggregated.

In the context of the Market St network a VPP service could deliver a retail benefit to local residents. This would be achieved by working with the selected retail partner to implement a retail VPP product to generate benefits for owners of DER such as home batteries.

Historically these products have aggregated home energy storage systems for participation in FCAS markets, generating a return for owners. More recently, emerging VPP products are now also targeting wholesale energy markets by pairing VPP control with a market exposed residential retail offers. In all cases these retail VPP products require participants to opt-in and may not be of interest to all residents due to their complexity compared to a standard retail offer.

Peer-to-Peer (P2P) / Virtual Energy Networks (VEN)

Peer-to-Peer (P2P) energy networks, also known as Virtual Energy Networks (VEN) are a mechanism for sharing generation and load across multiple sites. Typically, VENs have been deployed by entities such as councils that have multiple sites and are seeking to reduce cost by using excess generation at one site to offset the consumption at another site. This offsetting of energy is achieved by bringing all sites onto a single retailer's VEN product, under which the retailer implements a billing logic that aggregates all participating sites' meters into a single market entity. The energy imported and energy exported by the sites in the VEN will be netted off at an aggregate level. In practical terms this means:

- There is no electricity usage charges if imports and exports are balanced at an aggregate level.
- Any excess imports/exports are settled at spot market prices at an aggregate level.
- At a 5-minute interval level, charges for an individual household will be apportioned based on individual usage and generation.
- Individual participants receive a bill consisting of Network Charges (not expected to be reduced by VEN arrangement), wholesale charges for any energy used or exported, and the retailers VEN fee (e.g. $/MW of energy supplied to VEN, apportioned to the site based on consumption[12]).

In the context of the Trentham Microgrid a VEN product could be used to share energy between participating sites, and the microgrid equipment. This would require the microgrid retailer to offer a VEN product to residents, and to dispatch the battery based on the supply and demand in the VEN, and external market signals (e.g. wholesale energy prices). If delivered well, a VEN could potentially reduce resident's electricity costs and enable the virtual maximisation of self-consumption across the local network. One additional benefit of a VEN approach is that it could be offered to properties outside of the market St LV network and to properties without DER, making the benefit sharing arrangement accessible to more residents of Trentham.

Potential downsides of a VEN approach include the exposure of residents to wholesale prices, uncertainty in anticipated returns for participant's solar exports, and the requirement for participants to sign up to a single variable retail offer to access the benefits of the VEN.

It should also be noted that there has not been a significant uptake of P2P/VEN arrangements, most probably due to limited benefits and complexity.

[12] Note that other arrangements exist, this is just an example based on Diamond Energy's VEN product.

4.9. Emerging DER Opportunities

Home Batteries and distributed energy storage

Home batteries and other forms of distributed energy storage could play an important role in supporting the microgrid, both currently, and into the future.

Key benefits of widespread uptake of storage could include contributing to addressing power quality issues identified in the network data study. They also have the potential to buffer the microgrid from spikes in production and consumption and will help address future load growth. Distributed, BTM storage also offers an additional level of resilience for the community.

With a federal government battery subsidy program effective on 1st July 2025, the business case for BTM storage will only improve.

YEF and SolarQuip highly recommend that TSG make a coordinated effort to encourage the uptake of solar and battery installations in Trentham, regardless of the outcome of the proposed microgrid project.

EV charging and Vehicle-to-Grid (V2G) technology

Electric Vehicles (EVs) are an emerging force in the Australian transport industry, with sales growing from less than 1% of new car sales in 2020, to approximately 10% of sales in 2024[13]. As EVs continue to make up an ever-increasing proportion of vehicles in Australia there will be a corresponding growth in network demand caused by vehicle charging. While emerging approaches to smart charging may help limit the impact of EV's on the grid, it is critical to factor in EV charging as a key load that will grow and will require careful management in the microgrid.

Strategies for charging management that TSG should consider include behavioural interventions (e.g. a community code of practice for charging), potential integration of EV chargers with the microgrids (e.g. giving the microgrid a means to coordinate charging when in island mode) or direct load management. YEF recommends that these strategies be developed with the community as EV uptake grows.

However, there is also a significant opportunity in the form of bidirectional charging, specifically, Vehicle to Home (V2H), Vehicle to Load (V2X), and Vehicle to Grid (V2G). All three of these bidirectional charging modes allow for electric vehicles to become a form of energy

[13] Electric Vehicle Council, *State of Electric Vehicles 2024* [Report] link

storage which can supply power to a BTM site (V2H), or to a handful of consumer devices (V2X), or even back into the microgrid (V2G).

The first two of these modes (V2H and V2X) could reduce consumer demand and reliance on the microgrid in island mode, while V2G could see EVs connected to the microgrid to provide additional storage capacity and potentially extend the backup capability of the microgrid. To have this benefit, V2G bidirectional chargers and compatible vehicles would need to be aggregated so that the microgrid controller could control these energy storage assets in island mode.

YEF notes that significant community support will be needed to unlock the potential of V2G, and it will be critical for vehicle owners to give informed consent for their EV’s to be used to support the microgrid.

Current options for bidirectional charging equipment are limited in the Australian market, and significant hurdles, such as DNSP and EV manufacturer approval must be overcome before V2G is an option.

YEF and SolarQuip recommend that TSG focus short term efforts on promoting smart charging strategies in the microgrid network area and the resilience benefits of V2X and V2H, whilst continuing to monitor the progress of V2G technology in Australia.

5. Commercial Plan

5.1. Business Model

To meet the key project priorities of energy resilience and financial sustainability YEF proposes that the microgrid operate a blended business model of *Resilience with limited FOM Market Trading.* The *Resilience* component of this business model will see a portion of the BESS remain on standby to provide backup power if required, while the remainder of the BESS capacity will be made available for market trading when in grid-connected mode.

The details of the two elements of this model are as follows:

<u>FOM Market Function</u>

Goal: Maximise financial return through trading the BESS in the wholesale energy market, FCAS markets and battery network tariffs.

Operation: The owner of the BESS would either contract operations to a retailer or act as the BESS retailer (if they are a registered FRMP) to participate in the target markets. Retailer price forecasting and optimisation services are used to dispatch the battery for maximal returns. Revenue generated by the project is then shared with the community through a community benefit fund or similar mechanism.

<u>Resilience Function</u>

Goal: Reliably provide backup power from the BESS and diesel generator at any time of day, in accordance with the design targets (4-hour BESS backup and 3-5 day diesel generator backup).

Operation: The resilience capacity of the microgrid is enabled by reserving a portion of the BESS to always remain on standby, and by keeping the generator in an operable condition and on standby. In addition to this passive standby capacity, the selected BESS retailer will also need to provide a market trading override function through which the microgrid owner, operator or TSG can trigger an event preparation mode in which the BESS will charge to 100% and halt market trading to ensure full capacity is available for backup.

5.2. Proposed Retail Arrangement

For the purposes of the financial assessment, it is assumed that the project is operated under a fixed fee retail arrangement, whereby the owner of the microgrid pays the retailer a fixed amount monthly for their dispatch services and then receives all market revenues generated by the BESS. This model is used for modelling as it clearly demonstrates the market value of a BESS and typically enables the BESS owner to maintain full control over the dispatch strategy. This is particularly important for a microgrid as the Owner must balance Resilience priorities with market trading potential.

It is important to note that other retail arrangements exist, and that the preferred model may vary based on the preference of the Microgrid owner, and the community. Other options that TSG and project proponents could consider are listed below.

Revenue sharing arrangement

In a revenue sharing arrangement, the BESS owner and retailer agree to split system revenues between both parties, most often on a percentage split basis. In some cases, retailers may request a minimum payment guarantee, or a blended model with a fixed payment element and a revenue split element.

Pros and cons

A revenue sharing arrangement incentivises the retailer to improve battery performance and lowers the operational and financial risks on the BESS owner. A key downside of revenue sharing is that the Owner has less control over the approach to battery dispatch, which makes resilience outcomes harder to achieve.

Capacity lease arrangement

Under a capacity lease arrangement, the retailer pays the BESS owner a set amount monthly. In exchange, the Retailer can dispatch the battery however they see fit and keep all market revenues. A variation of this model is the retail benefit sharing mechanism presented in Section 4.8, which provides the fixed capacity lease benefit in the form of a community retail product.

Pros and cons

This arrangement provides the owner with a fixed revenue stream but gives them little control of daily dispatch. For this approach to work the Owner would need to limit the capacity lease terms to a portion of the battery (e.g. only 50% of the BESS capacity), to include terms that enable the BESS to be reserved a set number of days a year for resilience functions (e.g. retailer is obliged to provided resilience services for up to 5 days a year). These limitations are likely to reduce the potential capacity lease payments that could be achieved.

5.3. Proposed Commercial Arrangement

To simplify project delivery YEF recommends that TSG look to secure a single third party to perform both the Owner and Operator project roles. Ideally this this third party would also perform the retail role, however this has not been included as a necessity as it would greatly limit the pool of ownership candidates.

Figure 15 illustrates the proposed commercial approach to this project. The Owner-Operator of the microgrid will work with the retail partner to deliver the market trading function and any necessary integration with Powercor (e.g. network tariff billing and any Powercor controls integration that may be required for safety reasons).

All system revenues will be collated by the Owner-Operator who will then use these to funds to pay for microgrid operations, maintenance and the community benefit.

TSG will interface with the Owner-Operator and may be involved in the delivery of community benefits. If TSG decides to purse a retail benefit sharing model, or a Retail VPP product then contracts may exist between the Retail partner and the community.

It is also important to note that this proposed approach assumes that the Owner-Operator owns the microgrid host site. If the host site is instead leased from a third party then a land lease or licence agreement will need to be implemented.

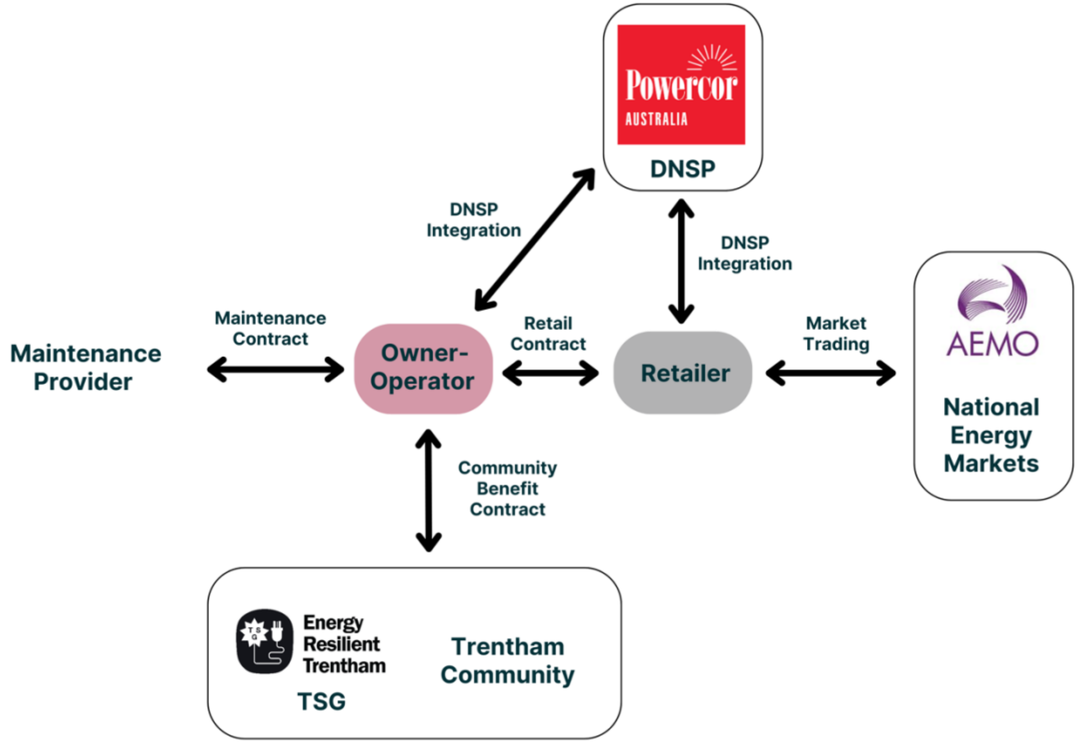

Figure 15: Overview of proposed commercial arrangements

6. Costing and Financial Analysis

6.1. Microgrid Costing

Capital Expenses (CAPEX)

The capital expenditure (CAPEX) for the Market Street microgrid project is shown in Table 3. A Request-for-Information process was conducted after the technical design stage to inform the pricing, and the submissions from Engineering, Procurement, and Construction (EPC) contractors were used a basis for the estimates.

Where required, Yarra Energy Foundation (YEF) and SolarQuip have made informed estimates based on engagement with equipment manufacturers and industry benchmarks.

Due to direct costings not being available from Powercor, assumptions were made for engineering and connection works. We recommended to refine these provisional estimates through formal engagement with Powercor during the detailed design phase. Additionally, the budget does not include provision for the recommended granular load and power quality study. Powercor should be consulted to obtain a cost estimate for this component.

A contingency of $250,000 was included to address the cost uncertainty and mitigate against possible pricing fluctuations. The total estimated CAPEX is **$2.45 million**.

Table 3 CAPEX estimates

GCMG Equipment	Cost
Solar (88 kWp)	$220,000
BESS (300 kW/ 1.2MWh)	$650,000
Switchboard, incl. metering, microgrid controller & switchgear	$250,000
Generator connector cubicle	$30,000
Portable generator or portable BESS equipment (400kVA)	$130,000
Load management hardware	$36,000
GCMG Construction	
EPC Design & Planning	$100,000
Project Management and Community Engagement	$105,000
Land Procurement	$500,000
Installation costs	Incl. in Equip.
Environmental mitigation (Fire, Noise, Soil, Electrolysis)	$30,000
Regulatory/Permit/Approval Fees	$20,000
Site fencing, security, traffic management	$25,000
Retailer Setup Fees	$10,000
Powercor costs	
Estimated Powercor connection and feeder routing works	$100,000
Contingency	$250,000
Total CAPEX	**$2,456,000**

Operational Expenses (OPEX)

Table 4 presents the annual operating expenses for the microgrid on the Market St Network. These figures are based on EPC estimates and YEF and SolarQuip's industry experience. The total estimated annual OPEX is $45,340.

Note that these estimates assume a generic third-party ownership model for the microgrid. Actual operating costs may vary depending on the chosen owner and operator arrangements.

Table 4 OPEX Estimates

GMCG OPEX	Cost
Administration	$2,000
EMS Software fees	$2,000
Insurance	$5,000
Equipment maintenance	$15,000
Site maintenance	$5,000
Load management hardware	$5,540
Retail OPEX	
Metering	$800
Retail fees	$5,000
Other OPEX	
Fuel Costs (est. 100 hours of backup per year)	$5,000
Total OPEX	**$45,340**

6.2. Financial Analysis

This financial analysis presents preliminary estimates of revenue potential of the GCMG operating in 'grid-connected' mode. In this mode, the microgrid equipment operates as a as a front-of-meter asset, with the BESS providing market services including energy arbitrage, frequency control ancillary services (FCAS), and network support services. In our discussions, Powercor have indicated that microgrid equipment may not be eligible for network support services payments as it does not address a specific technical constraint on the network, such as congestion on the transformer or supply cables. They instead advised that a large LV generator flexible trial tariff would apply to microgrid equipment, which was used in financial modelling.

In 'island' mode, the microgrid delivers resilience by supplying electricity to residents during grid outages. While this service offers a significant community value, it remains unmonetised—i.e., neither the DNSP nor the residents currently provide financial contribution to support or sustain the availability of this service. This results in a misalignment between the benefits delivered and the existing revenue streams/incentive structures.

DNSPs quantify resilience value using Australian Energy Regulator (AER) benchmarks for Value of Customer Reliability (VCR) and Value of Network Resilience (VNR).

For instance, the 2024 residential VCR for unserved energy is calculated as $35.69 per kWh in regional areas such as Trentham[14]. These figures are used calculate the value of resilience and justify DNSP's investments into network infrastructure, which is then recovered through tariffs. However, a third-party microgrid owner cannot recover in the same way directly from consumers or the DNSP under current regulatory frameworks, meaning this resilience benefit remains economically unrecognised. This is despite the microgrid providing value from a societal and energy resilience perspective.

In our modelling, the value from network resilience is not considered as value stream as it is currently unmonetizable for a third-party owner.

[14] AER, *'Final Report 2024 VCR review'*, link (accessed 27 May 2025).

Modelling methodology and assumptions

Revenue projections for the microgrid were modelled using Gridcog, a software tool for intelligent asset optimisation. The simulation covers the period from 2028 to 2042, assuming a 15-year project life, and assumes a 4% annual CAPEX escalation till 2027 to reflect inflation.

Revenue Modelling Results

A summary of results of economic modelling for microgrid system is presented in Figure 16. It can be observed the revenue from wholesale arbitrage varies from year to year with highest revenue achieved in 2029 at roughly $42,000, this indicates a volatile energy market in that particular year, possibly caused by closure of ageing coal power stations. The average annual revenue from wholesale arbitrage over the project’s life is $32,800. FCAS generates modest returns, averaging $1,433 annually, with projections showing a steady decline in this streams’ revenue over time. The network tariff component from Powercor is expected to cost an average of $10,000 per year. Other potential revenue sources, such as from DNSP network support services payments are excluded from the analysis due to low likelihood of them materialising based on our conversations with Powercor.

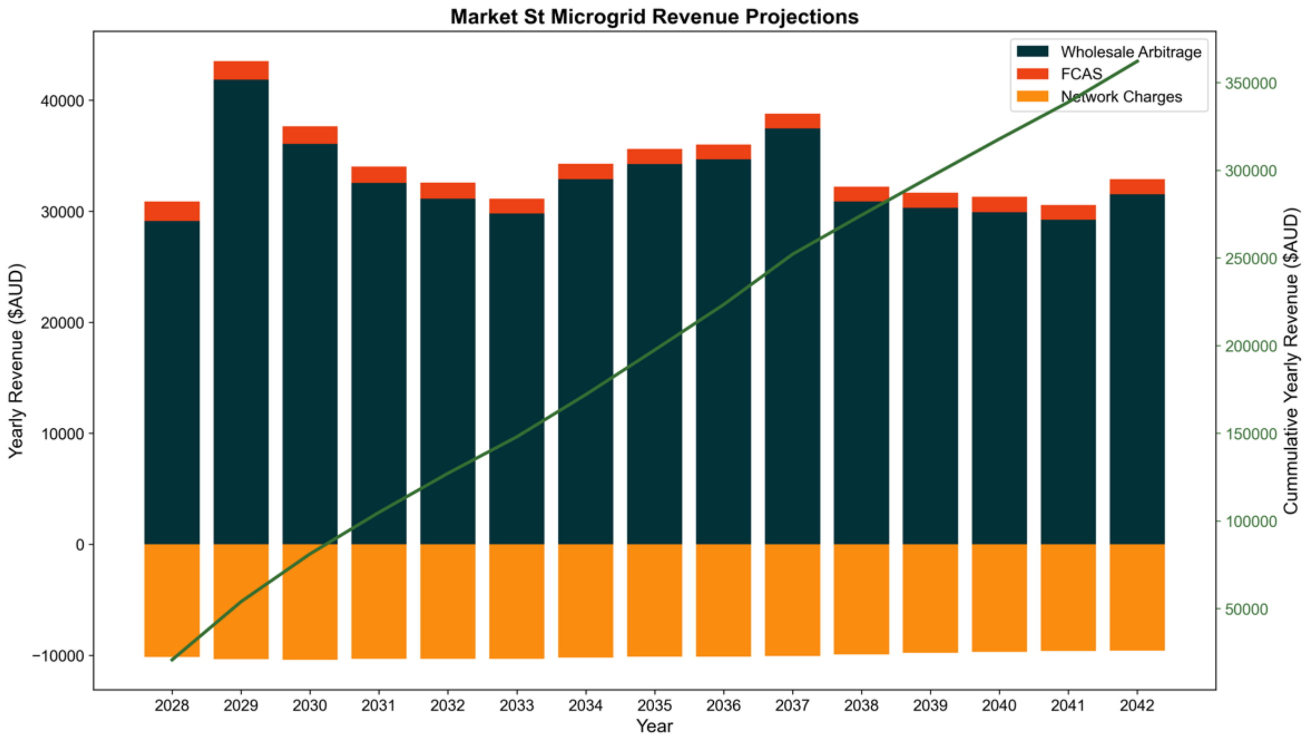

Figure 16: Microgrid revenue

Over 15 years, the total cumulative revenue is **$362,185**. This figure highlights the limited revenue-generating potential of the microgrid when compared with the required CAPEX investment, creating a gap between outlay and income.

6.3 Commercial Analysis

Earnings, Net Present Value, and Return on Investment

The commercial feasibility of the microgrid is evaluated based on Earnings, Net Present Value (NPV), and Return on Investment (ROI) metrics. Earnings are calculated by subtracting annual OPEX from projected revenues, which results in Earnings Before Interest, Taxes, Depreciation, and Amortisation (EBITDA). Commercial viability was assessed against the goal of recovering the upfront capital investment costs, and a discount rate of 4% was used for NPV and ROI calculations. The results are summarised in Table 5.

Table 5: Commercial Analysis Results

Modelling Results	
Revenue (15 years)	$362,185
Earnings (15 years)	–$317,915
Net Present Value	–$2,889,978
Internal Rate of Return	—
Return on Investment	-91%
Payback Period	—

As it can be seen, over the 15-year modelling period, total earnings are projected to be negative, at –$317,915. The projects' NPV is significantly negative at –$2,889,978, and ROI is –91%, indicating a commercially unviable business case. Even under a hypothetical assumption that capital investment is fully grant-funded and does not require recovery, annual operating revenues remain insufficient to cover yearly operating expenses.

The poor financial case is driven by two factors: (1) high capital and operational expenditure requirements, and (2) lack of monetisation for the resilience services provided by the microgrid.

These findings indicate that under present market conditions, the microgrid does not represent a commercially viable investment.

NPV — Sensitivity Analysis

A sensitivity analysis was conducted to evaluate the impact of variations in CAPEX (±10%) and revenue (±15%) on NPV outcomes. All scenarios resulted in a negative NPV, strengthening the conclusion that the project remains commercially unfeasible due to the structural cost-revenue imbalance.

The commercial analysis confirms that, given present investment costs and revenue projections, the microgrid does not offer a financially sustainable investment case.

6.3 Alternative Modelling Scenario

As part of the financial modelling, alternative system configurations were examined to identify the optimal equipment sizing, taking capital costs into account. The optimal sizing scenario recommended reducing battery size to approximately 220 kWh with 4-hour duration, paired with a 400 kVA diesel generator.

In this configuration, the BESS primarily functions to smooth power supply to the load, while the generator serves as the primary power source during extended outages. The microgrid will follow a ‘break-before-make’ protocol i.e., there will be a momentary loss of power in the network before restoration of supply. This approach significantly lowers capital expenditure associated with battery storage, thereby reducing overall project costs.

However, this cost reduction comes with notable trade-offs:

- **Limited Revenue from Market Participation**: The reduced battery capacity substantially restricts revenue generation opportunities in the energy market.
- **Deviation from Project Objectives**: The system’s dependence on diesel generation for backup supply undermines the objective of powering the microgrid with renewable energy for up to four hours.
- **Emissions Impact**: Increased reliance on fossil fuel generation negatively affects the microgrid’s emissions profile.

While this alternative scenario presents a lower-cost option, it compromises both the revenue performance and environmental goals of the project.

7. Program Risk Assesment

7.1. Program Risk Asessment

In this project, YEF and SolarQuip have drawn on out experience with microgrids and neighbourhood battery projects to develop a detailed risk assessment schedule that can be readily applied to the project if it is carried forward. This detailed risk assessment can be found in Appendix B – Risk Assessment. Below is a summary of key risks, and the general mitigation measures that can be applied to overcome these risks.

Table 18: Summary of key risks and mitigation strategies

General Risk Classification	General Mitigation Strategies
Financial viability risks Such as the lack of a financially sustainable business case and the risk of BESS financial underperformance if the project were to be pursued.	**Informed decision making on viability of the project** Based on the findings of this study, the proposed design is not a viable resilience solution. A GCMG should only be considered, if an alternative financially viable project approach is identified. Otherwise, TSG should explore other approaches to meeting resilience needs.
Project delivery risks Such as unexpected costs, schedule overruns, and connection issues.	**Realistic and informed project planning** The high level of technical and regulatory uncertainty in this project means it is probable that the project would encounter unexpected costs if delivered. Further work needs to be done to determine the design requirements facing a project of this kind, and to cost all engineering works that would be required to prepare a construction ready design.
Engagement issues – key project stakeholders and community Risks associated with the community facing nature of GCMGs.	**Comprehensive engagement with stakeholders throughout project** The proposed design relies on community support, proactive engagement of community as project “owners” is essential.
General BESS Safety Issues – fire, electrical, system malfunction Risks associated with the failure of BESS due to malfunction or external factors.	**Adhere to Australian standards for equipment and safety** Procure only from reputable suppliers who can demonstrate their compliance to Australian standards and safety practices.

8. Microgrid Design Alternative

8.1. Microgrid Design Alternative: A network of site microgrids

Concept

Each participating household and business install a 13 kWh and 30 kWh battery, respectively, and 5 kW of solar. The installation includes a gateway for backup, allowing the property to be islanding from the grid on power outage. The battery supplies with supplemental solar generation until power is restored. Customer-funded Electric Vehicle bidirectional charging is optional to extend islanding time.

Eligibility

Each property on the Market St LV Network is eligible to apply, with a maximum of 66 residential properties and 36 businesses, for the purpose of the ARENA funding application. Any deviation from the original scope of the study is at the discretion of TSG.

Costings

With the benefit of the federal battery rebate, for 66 households and 36 businesses, the total cost of and funding required for solar and battery fully installed, at an average $6,284 per solar array and $1,000/kWh of battery is $2,605,368 or $1,878,540 with the federal rebate.

Trade-offs

Participating in the VPP is likely to reduce cost and even generate an income for participants. Yet, only with customer-funded EV Vehicle-to-Building would more than 4 hours autonomy be achieved.

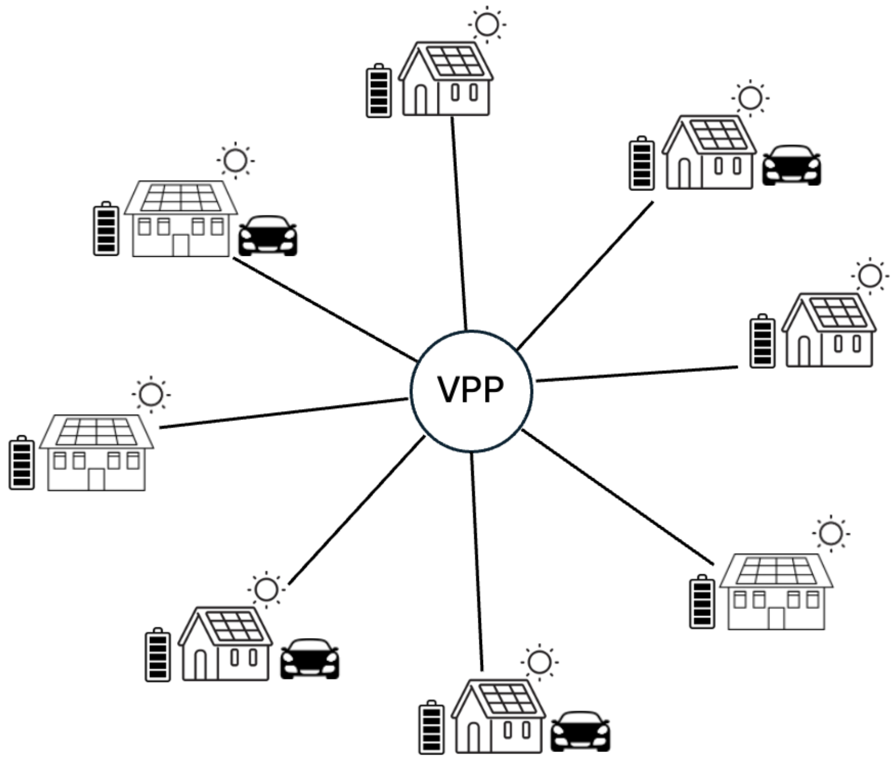

Figure 17: Conceptual representation of a network of site microgrids

Resilience Augmentation to a Network of Site Microgrids

The resilience trade-off can be resolved by combining elements of the Market St microgrid with single site microgrids. A simple solution is to implement a manual changeover switch from grid to generator supply.

The 400 kVA generator mentioned earlier can either be portable with a generator connection cubicle, or stationary. It would be started when household and business resilience is waning. This is most likely after 4 hours or more depending on weather conditions.

The costings would be a small subset of that provided for the Market St microgrid. The main elements of the capital expense (CAPEX) are:

Equipment	Cost
Switchboard, incl. switchgear and controls	$40,0000
Generator connector cubicle	$30,000
Portable generator (400kVA)	$130,000
Powercor connection and feeder routing works	$100,000
Total CAPEX	**$300,000**

Generator running costs are estimated at $15,000 for maintenance and fuel for 4 days outage per annum, based on EPC estimates and YEF and SolarQuip's industry experience, and may need to be subsidised.

The manual mode solution can be improved with greater sophistication of a synchronous and automated transfer switch, and furthermore with automatic activation based on signals from site battery systems.

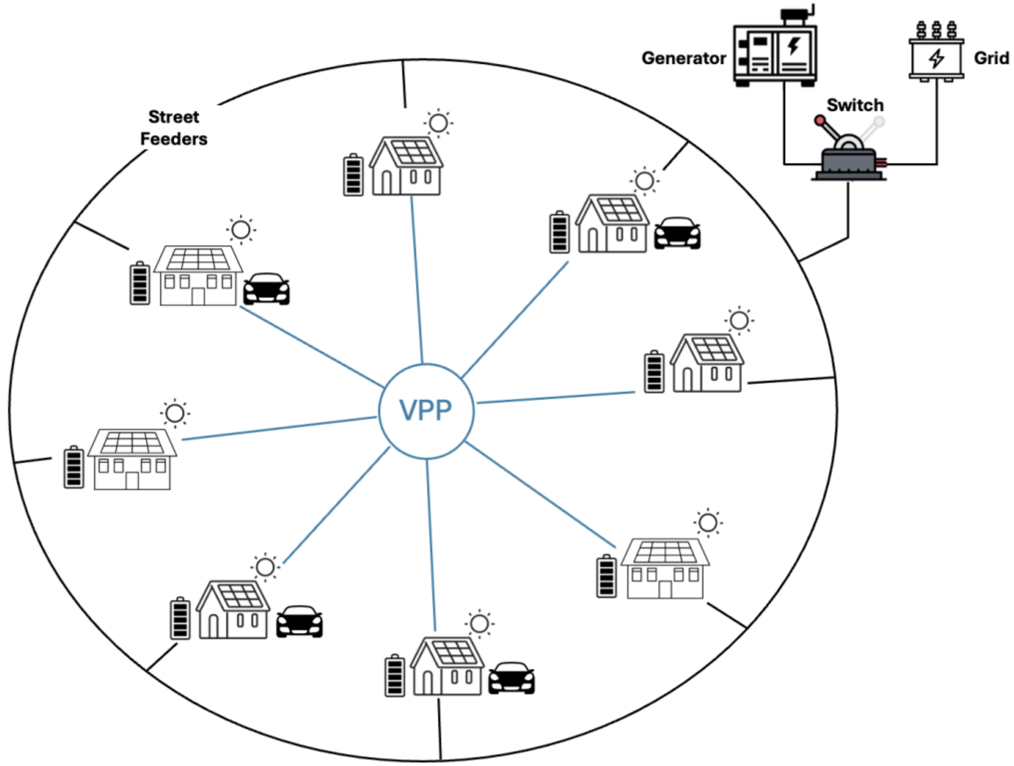

Figure 18: Network of site microgrids augmented by generator supply

9. Conclusion

9.1. Conclusion

Based on this study YEF and SolarQuip advise that the proposed microgrid design is not financially viable due to the GCMG's inability to generate enough revenue to cover operating costs. This highlights a core issue facing third party owned microgrids which, unlike network-owned systems, cannot recover the cost of investment through mechanisms such as a regulated asset base or avoiding costs due to unserved energy.

Despite this finding we believe that this project may be an opportunity for TSG to advocate for a subsidised approach to third party-led microgrids. While current market conditions are not favourable; projects such as this may become viable as technology costs fall, and more DNSP led projects are deployed in Victoria.

The key challenges identified in this study include:

- **Challenges securing quality network data to inform design:** YEF and SolarQuip were only able to secure transformer level data at 30-minute intervals for the Market St Network. As a result, this study was unable to make an informed assessment of instantaneous peak power on the microgrid, and a load management system had to be specified to safeguard the BESS from being overloaded. Future design works would benefit from more granular network data (5-minute intervals at a minimum, and ideally 1 second interval) however this may require expensive data collection activities.
- **The lack of a clear precedent for an independent third party microgrid:** as a result, the regulatory requirements, and network provider's design requirements remain uncertain. This makes it challenging to fully cost the project and to understanding all obligations for the third party owner.
- **The design requirements and technology available are likely to evolve significantly:** this makes it advantageous to build flexibility into microgrid design. The rapid development of low cost solar, storage, and electrification is driving a rapidly changing energy landscape in Australia. The proposed design includes a flexible load management system to help adapt the microgrid to changing network load, and TSG should be open to incorporating emerging technologies into the microgrid design.
- **Locating microgrid equipment in a central location is essential, but costly:** the project budget has allocated $500,000 for the purchase of a site to host the microgrid equipment. Alternative locations on the fringe of the network work considered, however voltage drop issues and network constraints make it essential to locate the BESS and diesel generator close to the distribution transform. This is likely to be a common challenge for LV microgrids of this kind. The central location poses possible operational challenges (e.g. the operation of a generator close to residential properties) and aesthetic challenges (e.g., installation of electrical equipment in a prominent location).

9.2. Recommendations

Consider behind the meter microgrid alternatives

Given the feasibility issues of the proposed design, it is recommended that alternative approaches be considered and delivered. This could be done as a standalone initiative, or alongside further efforts to pursue a low voltage network level microgrid.

One promising alternative is the deployment behind the meter batteries on key facilities to provide site backup services. Benefits of this approach include potentially lower costs, uncertainty and lower project complexity.

Refer to Section 8: Microgrid Design Alternative for more details on this approach.

Continue to advocate for subsidised third party led microgrids

While the leading nature of this project presents a challenge, it is also an opportunity for TSG to advocate by doing and help to overcome the barriers to a microgrid of this kind becoming a reality. It is recommended that TSG continue to explore this solution, alongside other pathways to energy resilience, and share learnings with other proponents.

Appendix A – Supplementary Information

YARRA ENERGY FOUNDATION

Glossary of abbreviations

Acronym	Meaning
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ARENA	Australian Renewable Energy Agency
BESS	Battery Energy Storage System
BTM	Behind the Meter: a system configuration where the battery is connected to the network behind an existing connection point with an existing meter. In this case the battery can be market exposed (when it has a dedicated child meter) or non-market exposed (connected without a dedicated child meter).
CAPEX	Capital expense
DEECA	Department of Energy, Environment, and Climate Change, Victoria.
DNSP	Distribution Network Service Provider
EOI	Expression of Interest
EPC	Engineering, Procurement, and Construction
EMS	Energy Management System
EV	Electric vehicle
FCAS	Frequency Control Ancillary Services
FOM	Front of Meter: a system configuration where the battery is connected directly to the network with a dedicated connection point and dedicated meter.
FRMP	Financially Responsible Market Participant
GCMG	Grid Connected Microgrid
GW	Gigawatt
kW	Kilowatt
kWh	Kilowatt-hour
kWp	Kilowatt-peak output (of a Solar PV system)
LV	Low voltage
LVN	Low voltage network
MV	Medium Voltage
MVA	Megavolt-Ampere
NEM	National Electricity Market
NB	Neighbourhood Battery
NBs	Neighbourhood Batteries
OPEX	Operating expenses
PV	Photovoltaics (Solar)
SOC	State of charge
RFI	Request-for-Information
VEN	Virtual Energy Network
VPP	Virtual Power Plant
VRE	Variable renewable energy
YEF	Yarra Energy Foundation

Possible extensions of the Market St Microgrid

During this technical feasibility study YEF were asked to assess three possible extensions to the microgrid – the Station St Sheds, the IGA Supermarket (Country Grocers Trentham), the Cosmopolitan Hotel and the Mechanics Institute.

The Station St Sheds

The Station St Sheds are located ~200m to the north-west of the Market St LV network and are connected into an adjacent low voltage network. This site was identified by TSG due to its large rooftop which has an estimated solar hosting capacity of 200+ kW. The site also has potential room to host a BESS and generator, and is located on the edge of town, thus limiting the impact of equipment operation on residents.

YEF and SolarQuip assessed this site as a potential location for a secondary BESS and solar system with a view to reducing the sizing of the equipment needing to be installed in central Trentham.

Possible connection method

Given the long connection distance, we propose connecting this site to a new voltage step up transformer that connects to another new step down transformer on the north end of the Market St LV network through 22 kV cables, ideally strung on the existing HV poles used for the site's current connection. This approach would limit the voltage drop and maximise the power that the BESS and solar system could provide to the microgrid.

Recommendation on inclusion into microgrid

YEF and SolarQuip do not recommended including the Station St Sheds in the microgrid currently due to the following reasons.

- The connection works required would be costly and would require significant additional support from Powercor.
- The load characteristics of the sheds have not been assessed and thus it is uncertain how much of the proposed solar would be consumed locally. It is possible that the benefit to the microgrid could be limited if the sheds are a significant load.
- The feeder cables running from the proposed connection point (the top end of Market St) to the Market St Transformer are low capacity and would introduce significant voltage drop. This would make it inefficient to power the microgrid from a BESS located at the Station St Sheds.

The IGA Supermarket (Country Grocers Trentham)

The Supermarket is an essential service for the community and was highlighted by TSG as a key resilience priority. Currently the supermarket has a diesel generator for use during outages and has a large rooftop with a possible solar hosting potential of 50 kW. This site is currently connected to an adjacent network but is less than 100 m from the end of the Market St Network.

Possible connection method

Connecting the supermarket would require Powercor to extend the boundary of the market street network to the corner of High St and Cosmo Rd or connecting the supermarket to the closest pole of current Market St network. Both would require Powercor connection works and corresponding costs.

Recommendation on inclusion into Microgrid

YEF and SolarQuip do not recommend including the supermarket into the microgrid at this time as the costs remain unclear, and the business case for this extension is yet to be considered. Meter data for this site would be required to assess the load profile and understand if adding this site to the microgrid would necessitate an increase in BESS power and storage. Given the technical and financial implications of this possible extension are unclear, we recommend TSG conduct additional investigations to determine the impact of including this site in the microgrid and consider a possible behind the meter solar and BESS site resilience system for this facility.

The Cosmopolitan Hotel

This venue does not have any power resilience solution. It would connect into the Market St LV Network in a similar fashion to the Supermarket. For similar reasons, we do not recommend including it in the main design.

The Mechanics Institute

The Mechanic's institute is a local community hub, which currently hosts 28 kW of solar, a diesel generator and an EV charger; and is a designated emergency response centre for the local area. The Mechanics Institute is soon to be upgraded with funding from the *100 Neighbourhood Batteries program* to include a ~100 kW/280 kWh BESS and an additional 30 kW of solar.

Possible connection method

The Mechanics Institute is located at the junction of the Market St LV network and an adjacent LV network. The connection point for this site is on a pole shared by these two networks, and transferring this site onto the Market St network is expected to require simple connection works (subject to Powercor approval).

Recommendation on inclusion into Microgrid

After assessing the data provided by TSG and Hepburn Shire Council, YEF does not recommend connecting the Mechanics Institute into the microgrid network at this time. Our reasoning is as follows:

- Currently It appears the site is export limited to 0kW meaning that it is not providing any energy to the local network. This issue may be overcome, however based on the provided meter data we are unable to assess the potential exports from the current solar system, and it remains unclear how the proposed resilience upgrades will impact export potential.
- Currently the meter data provided for this site covers less than 365 days which limits YEF's ability to accurately model the site with the planned 100NB upgrades.
- The institute will be equipped to act as a standalone resilience site in case of emergencies. In YEF's view, the benefit of a standalone site that can operate independently during emergencies outweighs the benefits of adding the site to the microgrid network. This is considering that the microgrid would itself be vulnerable to potential disruptions from extreme weather events.
- Whether the site will be a net load, or net exporter would depend on a variety of factors such as time of day, BESS/diesel generator configuration, optimisation logic etc. The site backup equipment will seek to reduce energy imports at the gate meter while trying to maximise generating revenue in the market. It is likely that BESS would be a net load at most times, while exporting mostly during evenings, which may limit the benefits to the microgrid.

Solar hosting capacity results

Network coverage analysis

This assessment was undertaken by first assessing Powercor GIS network map. This assessment produced an initial list of properties in the network which was then validated through an on-street network walk through completed by members TSG. YEF then produced a network coverage map (See Figure 1) which was then used to manually identify rooftops in the network that would likely be suitable for new solar installations.

The network coverage analysis identified a total of 113 properties connected to the Market St LV network. These properties include a mix of residential, commercial and industrial (C&I) and other sites. A detailed breakdown of these sites is provided in Table 7.

The network coverage map is presented in Figure 1 on page 7.

Table 7: Market St LV Network Connections

Site type	# connections
Residential	66
Commercial, Industrial & Other	36
Total connections:	**102**

Current solar hosting

Current figures provided by Trentham Sustainability Group indicate that there is 153 kWp of rooftop solar PV installed in the Market St LV network. This is considered the 2025 baseline solar hosting and is used to inform assumed 2028 hosting for modelling.

Potential future hosting capacity

The potential future hosting capacity was assessed individually for large capacity sites (e.g. large C&I rooftops) and residential properties. The results for the large site assessment are presented in Table 8 and the results for the residential assessment are presented in Table 9.

Table 8 Hosting capacity of sites with large rooftops

Site	Hosting capacity
Country Grocers Trentham[15]	50 kWp
Trentham Pharmacy and Medical Clinic	33 kWp
39 High St,Trentham	15 kWp
Hotel Trentham	20 kWp
Total hosting capacity	**118 KWp**

[15] Note that the supermarket is not currently on the Market St low voltage network and would need to be connected to be serviced by the microgrid.

Table 9 Residential solar hosting capacity

Residential solar hosting capacity	
Residential customers with solar potential	35
Assumed average solar system size	6.6 kWp
Theoretical residential hosting capacity	**231 kWp**

The total solar new hosting capacity of the Market St low voltage network was determined to be 349 kWp, comprising of 118 kWp of solar on large site installations, and 231 kWp on residential rooftops.

Factoring in the existing solar (153 kWp) in the network, the theoretical maximum solar hosting capacity of the network is assumed to be 502 kWp.

It is important to note that this would represent a 100% uptake of identified potential solar across the network and it is not likely that all this solar will be deployed. To maximise the amount of rooftop solar in the microgrid network area we recommend that TSG deploy suitable initiatives to encourage as much solar uptake as possible.

For the purposes of microgrid modelling YEF has assumed that 67% of the maximum solar hosting potential can be achieved by the start of 2028. This equates to an additional 234 kWp solar in addition current installations, this would bring the total rooftop solar in the microgrid to 387 kWp.

Appendix B – Risk Assessment

Appendix B – Risk Assessment

This content has been intentionally removed from the public version of this document.

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