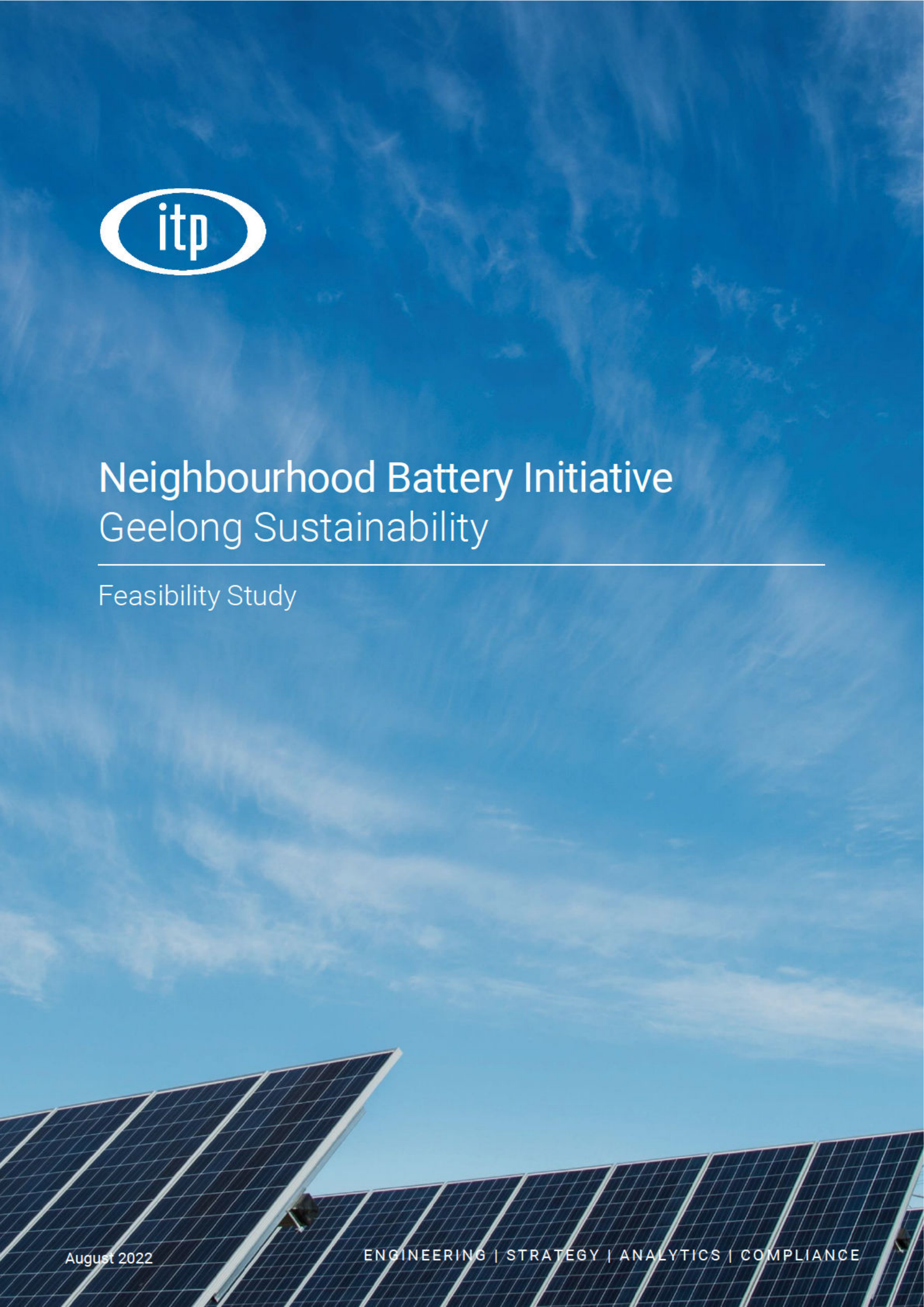

Neighbourhood Battery Initiative

Geelong Sustainability

Feasibility Study

August 2022

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ABOUT ITP RENEWABLES

ITP Renewables (ITP) is a global leader in renewable energy engineering, strategy, compliance, and energy sector analytics. Our technical and policy expertise spans the breadth of renewable energy, energy storage, energy efficiency and smart integration technologies. Our range of services cover the entire spectrum of the energy sector value chain, from technology assessment and market forecasting right through to project operations, maintenance and quality assurance.

We were established in 2003 and operate out of offices in Canberra (Head Office), Sydney, North Coast NSW, Adelaide and Auckland, New Zealand. We are part of the international ITPEnergised Group, one of the world's largest, most experienced and respected specialist engineering consultancies focussing on renewable energy, energy efficiency, and carbon markets. The Group has undertaken over 2,000 contracts in energy projects encompassing over 150 countries since it was formed in 1981.

Our regular clients include governments, energy utilities, financial institutions, international development donor agencies, project developers and investors, the R&D community, and private firms.

ABOUT THIS REPORT

This report analyses the technical, commercial, and regulatory feasibility of BESS under several scenarios for Geelong Sustainability, who have been awarded a grant from the Victorian government to determine the technical and financial feasibility of establishing a series of "neighbourhood" batteries located across Geelong.

This report was commissioned by Geelong Sustainability

ABBREVIATIONS

AEMO	Australian Energy Market Operator
BESS	Battery energy storage system
BTM	Behind-the-meter
DNSP	Distribution Network Service Provider
FCAS	Frequency Control Ancillary Services
IFTM	In-front-of-the-meter
ITP	IT Power (Australia) Pty Ltd
kW	Kilowatt, unit of power
kWh	Kilowatt-hour, unit of energy (1 kW generated/used for 1 hour)
kWp	Kilowatt-peak, unit of power for PV panels tested at STC
NEM	National Electricity Market
NUoS	Network Use of Service
NSP	Network Service Provider
PV	Photovoltaic
VPP	Virtual Power Plant

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EXECUTIVE SUMMARY

This report analyses the current technical, commercial, and regulatory feasibility of lithium-ion battery energy storage systems (BESS) in the following scenarios:

1. Pad-mounted BESS, connected to a Powercor LV feeder, operated by Tango Energy, and participating in NEM Energy and FCAS markets
2. Pad-mounted BESS, connected to a Powercor HV feeder, operated by Tango Energy, and participating in NEM Energy and FCAS markets
3. Pad-mounted BESS, connected to a Powercor LV feeder, operated by Tango Energy with DC Coupled PV generation, and
4. Community BESS providing "storage as a service" to local residential and commercial customers
5. Residential behind-the-meter BESS
6. Behind-the-meter BESS at a community centre

The proposed site for the HV-connected BESS (Scenario 4 above) was found to have insufficient space for a BESS and all required connection equipment, but otherwise all sites are technically feasible of hosting BESS.

In all cases, the financial analysis found that BESS is a marginal or poor investment without subsidy. Poor financial results are found repeatedly in analyses of behind-the-meter BESS (Scenario 5 & 6), but this study also found a poor result when analysing an in-front-of-the-meter BESS that qualifies for the concessional community battery tariff being trialled by Powercor (Scenario 1). This tariff provides only weak incentives for BESS operation that is favourable to network operators (i.e. charging during daytime and discharging during evenings), and is limited to small BESS (<240kW) that are unable to generate the economies-of-scale necessary to compete in energy and FCAS markets.

Larger distribution network-connected BESS (Scenario 2 & 3) do not qualify for this tariff and so are charged standard tariffs. While the financial results for these BESS were the best of the scenarios analysed, this analysis was based on historical market prices and they should not be expected to be competitive with large transmission network-connected BESS that pay lower network charges, have access to more FCAS markets, and benefit from economies-of-scale.

"Storage-as-a-service" (Scenario 4) is generally poorly defined but, in practice, can be expected to have similar economics to distribution network-connected BESS.

1 INTRODUCTION

1.1 Project Background

Geelong Sustainability has been awarded a grant from the Victorian Department of Energy, Land, Water and Planning (DELWP) to determine the technical and financial feasibility of establishing a series of "neighbourhood" batteries located across Geelong. Geelong Sustainability is partnered with retailer Tango Energy and distributor Powercor to analyse BESS in:

- Neighbourhood solar storage applications for residential and commercial customers (in-front-of-the-meter)
- Energy and FCAS market applications
- Behind-the-meter residential applications
- Behind-the-meter commercial applications

To enable the analysis, Geelong Sustainability has identified four potential sites for locating BESS including:

- A community centre in Geelong
- A shopping centre in Geelong
- A Powercor LV feeder
- A Powercor HV feeder

This report will analyse the current technical, commercial, and regulatory feasibility of BESS in the following scenarios:

1. Pad-mounted BESS, connected to a Powercor LV feeder, operated by Tango Energy, and participating in NEM Energy and FCAS markets
2. Pad-mounted BESS, connected to a Powercor LV feeder, operated by Tango Energy with DC-coupled PV generation, and participating in NEM Energy and FCAS markets
3. Pad-mounted BESS, connected to a Powercor HV feeder, operated by Tango Energy, and participating in NEM Energy and FCAS markets
4. Community BESS providing "storage as a service" to local residential and commercial customers
5. Residential behind-the-meter BESS
6. Behind-the-meter BESS at a community centre

1.2 BESS Technology

Lithium-ion batteries are overwhelmingly the dominant energy storage technology deployed in stationary storage applications in both the residential and commercial sectors in Australia. They currently have high energy density, higher efficiency, and longer lifespans than alternative energy storage technologies and hence this report considers only lithium-ion BESS products.

2 IN-FRONT-OF-THE-METER BESS

2.1 Background

When PV and BESS are connected to the distribution network as a standalone connection, the installation is often described as an "In-Front-of-the-Meter" installation. In-front-of-the-meter BESS can generate revenue from trading energy on the National Energy Market (NEM), providing Frequency Control and Ancillary Services (FCAS), and/or providing network support services to the local DNSP[1]. Each of these value streams is discussed below.

2.1.1 Value Streams

NEM

The NEM is a gross pool, energy-only market in which the Australian Energy Market Operator (AEMO) dispatches registered generators in order of lowest bid price until demand is met in each NEM region in each 5-minute interval. The marginal bid price in each interval becomes the "spot price" for that interval.

Generator bids are restricted to a minimum of -$1,000/MWh (-$1/kWh) and a maximum of $15,100/MWh ($15.1/kWh). Because the spot price varies continuously depending on generator bids, electricity demand, and network constraints, there is an opportunity for BESS to generate net revenue by charging during low price periods and discharging during high price periods.

FCAS

While the energy market is designed to match power supply with demand over 5-minute intervals, the FCAS market is designed to correct any imbalances over shorter intervals. To do so, FCAS consists of eight separate markets that provide registered Ancillary Service Providers (typically large generators and large interruptible loads) with financial incentives to increase/decrease real power supply/demand over short periods and thereby maintain power system frequency between 49.85 – 50.15Hz.

The eight FCAS markets cover the following services:

- **Regulation** Raise/Lower
- 6s/60s/5min (Fast/Slow/Delayed) **Contingency** Raise/Lower

Regulation services are continually dispatched (every 4 seconds) by AEMO via Automatic Generation Control (AGC) devices that increase or decrease generator output to modify

[1] Other value streams (e.g. NSCAS, RERT, etc.) are not realistic for BESS of the scale considered in this report.

frequency as desired. Regulation services are continuously utilised by AEMO to remedy minor supply-demand imbalances and correct any accumulated *time error*.

Contingency services dispatch automatically in response to large supply-demand imbalances and resulting frequency deviations that can result from the sudden loss of a large generator or load. Contingency services are maintained until the frequency has been returned to the target frequency.

Because BESS can rapidly detect frequency deviations and ramp up/down accordingly, BESS is technically well-suited to providing FCAS. Due to the high frequency and high security communications requirements associated with regulation FCAS, only large-scale generators participate in this market.

FCAS prices have been high in recent years but are widely expected to fall as BESS enters the market. Metering requirements are currently a significant barrier to FCAS participation for small-scale BESS.

DNSP Support

Distribution network service providers (DNSPs) own and operate the electricity network infrastructure that transmits electricity between the transmission network and consumer points of connection.

The majority of DNSP assets are passive and unmonitored, and therefore must be designed to carry current and deliver voltage to standard (216 V – 253 V) under all anticipated operating conditions.

Distributed energy resources (eg. PV and BESS) impact voltage and current flows on the distribution network, and therefore present both challenges and opportunities for DNSPs. If properly coordinated, BESS is technically well-suited to network support applications as it offers a dispatchable source of real and reactive current that can be easily embedded into a distribution network.

Historically, DNSPs were unable to procure “non-network solutions” to address technical challenges. As a result, DNSP expenditure was directed largely towards capital upgrades to increase network capacity. In April 2018, however, the National Electricity Rules were amended to permit DNSPs to procure alternative solutions under the Demand Management Incentive Scheme. Under the scheme, DNSPs can apply to the Australian Energy Regulator for approval of expenditure on network support services.

DNSPs can only benefit from network support services where they face technical challenges meeting their service requirements with existing infrastructure. Moreover, in some cases, demand-side investments in energy efficiency and embedded generation can incidentally alleviate technical challenges without DNSP intervention, reducing opportunities for network support providers. As a result, the incidence of distribution network service agreements between DNSPs and BESS owners has traditionally been low.

However, increasingly, DNSPs are developing network tariffs that incentivise imports during peak solar generation hours and incentivise exports during peak demand hours. Such a tariff has been assumed in this study.

2.1.2 Regulatory Context

AEMO

The BESS proposed could access energy market prices via Tango Energy's Market Customer registration with AEMO. A Market Ancillary Service Provider (MASP) could be engaged to enable access to FCAS markets, or Tango Energy could become an Integrated Resource Provider from 31st March 2023 and thereby access both energy and FCAS markets.

DNSP

Chapter 5 of the National Energy Rules (NER) regulates the connection process for registered generators (including BESS) with a capacity greater than 5 MW. The process includes defined stages of application and details of the required information exchanges between the Network Service Providers (NSPs) and the applicant, and the timeframes applicable to each stage. This process can be applied to the connection of generators (including BESS) with a capacity of less than 5 MW, though these systems typically follow a less onerous Chapter 5A connection process that is at the discretion of the NSP. Information on the Powercor Chapter 5A connection process can be found online[2].

Installations on Powercor's network must comply with the CitiPower and Powercor Guidelines for Low Voltage/High Voltage Connected Embedded Generation[3], the Victorian Electricity Distribution Code (VEDC)[4], and the Victorian Service Installation and Rules (SIRs)[5].

In general, establishing a new HV connection for an embedded generator adds significant cost owing to the large amount of time that must be spent analysing the impact on the network, and the costly equipment that must be installed for protection and control. As a result, new HV connections tend to be feasible only for larger projects than those considered in this report.

Planning

Effective from the 30th May 2022, amendments to Clause 73.03 of the Victoria Planning Provisions (VPP) exempts neighbourhood batteries from all use and buildings and works

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[2] https://www.powercor.com.au/industry-partners/renewable-generation/connection-process/
[3] https://media.powercor.com.au/wp-content/uploads/2018/11/30122510/customer-gl-for-lv-connected-eg-v8-final-22112018.pdf
[4] https://www.esc.vic.gov.au/electricity-and-gas/codes-guidelines-and-policies/electricity-distribution-code-practice
[5] http://www.victoriansir.org.au/

permit requirements. This was undertaken to support the efficient delivery of neighbourhood batteries into Victoria's electricity distribution network to improve network reliability and assist Victoria's transition to a decarbonised economy.

2.2 Analysis

2.2.1 Sites/Scenarios

Under all three scenarios it is proposed that Geelong Sustainability be the owner of the community BESS infrastructure in partnership with Tango Energy who would be responsible for operating the BESS.

LV BESS

Geelong Sustainability have nominated a Powercor distribution substation named [redacted] as a potential site for an LV connected in-front-of-the-meter BESS. The substation is a 315 kVA, pole mounted distribution transformer located [redacted] in Newtown. The proposed site for the installation of a community BESS is on the nature strip at the base of the pole upon which this substation is mounted.

The BESS is proposed to be pad mounted and connected to a small outdoor rated LV switchboard (mounted on the BESS container or free-standing adjacent to the BESS) containing the LV switchgear and metering equipment for the installation. The switchboard will be connected to the LV terminals of the pole mounted transformer via an underground to overhead transition. Given there is already an Undeground-Overhead (UGOH) link on the pole, there may not be space for such an arrangement, and an aerial connection may be required.

This BESS is intended to be eligible for Powercor's non-distributor owned community battery trial tariff. To be eligible for this community battery trial this installation is to be a battery only site, installed in-front-of-the-meter on the LV network, with a power rating of less than 240 kVA.

A single line diagram of the expected connection configuration is provided in Appendix C.

LV PV+BESS

Geelong Sustainability have nominated a Powercor distribution substation [redacted] as a potential site for an LV-connected in-front-of-the-meter BESS with DC-coupled PV. The substation is a 1,500 kVA, pad mounted distribution transformer located in the carpark of the Bell Post Hill Shopping Centre in Bell Post Hill. The substation has an estimated 180 customers connected to its LV side, and a total of 89kW of PV generation capacity installed across 24 of these customers.

200 kWp of PV was assumed to be mounted on the shopping centre roof. A DC-coupled architecture allows for the PV system and the BESS to share a common inverter. This

generally reduces equipment costs slightly, while reducing the total inverter capacity connected to the grid and potentially simplifying the connection process with the DNSP.

The BESS is proposed to be pad mounted in the shopping centre carpark and connected to a small outdoor rated LV switchboard (mounted on the BESS container or free-standing adjacent to the BESS). The switchboard will contain the LV switchgear and metering equipment for the installation. The switchboard will be connected to the LV terminals of the pad mounted transformer via underground cabling.

A single line diagram of the expected connection configuration is provided in Appendix D.

HV BESS

Geelong Sustainability have nominated a Powercor distribution substation named [redacted] in East Geelong as a potential site for a HV-connected in-front-of-the-meter BESS. The substation is a 315 kVA, pole mounted distribution transformer located [redacted] in East Geelong. The proposed location for the installation of the in-front-of-the-meter community BESS is on the nature strip at the base of the pole upon which this substation is mounted.

The BESS is proposed to be pad mounted and integrated into the Powercor HV (22 kV) network via a dedicated delta/star transformer (with delta on the network side). The interface with the Powercor HV network would consist of 22 kV incomer and generator circuit breakers, protection systems, metering systems, and remote control and monitoring facilities.

Geelong Sustainability have indicated that projects over 2MW are beyond the scale that should be considered in this report. ITP expects the feeder rating exceeds 2MVA.

Given these connection hardware requirements, and the need for fencing and clearances, ITP does not consider the proposed site to be feasible for installation of an HV-connected BESS.

A single line diagram of the expected connection configuration is provided in Appendix E.

2.2.2 BESS Supplier

Geelong Sustainability have selected EVO Power as the supplier of the BESS products to be assessed under this case study. EVO Power are an Australian company located in Croydon South, Victoria, where they manufacture BESS products and provide full technical services and support including design assistance, site commissioning, and preventative maintenance services.

Their NEO commercial and industrial series BESS is the product assumed for this analysis, with flexible sizing from 100 kW to 5 MW and 250 kWh to 20 MWh. The NEO product is a three-phase, on-grid BESS that utilises CATL lithium iron phosphate (LFP) batteries. It is a “turnkey” product, fully integrated with battery cooling, energy management systems, fire suppression, and a Delta Electronics Power Conversion System (PCS). The NEO is IP66 outdoor-rated and ground mounted.

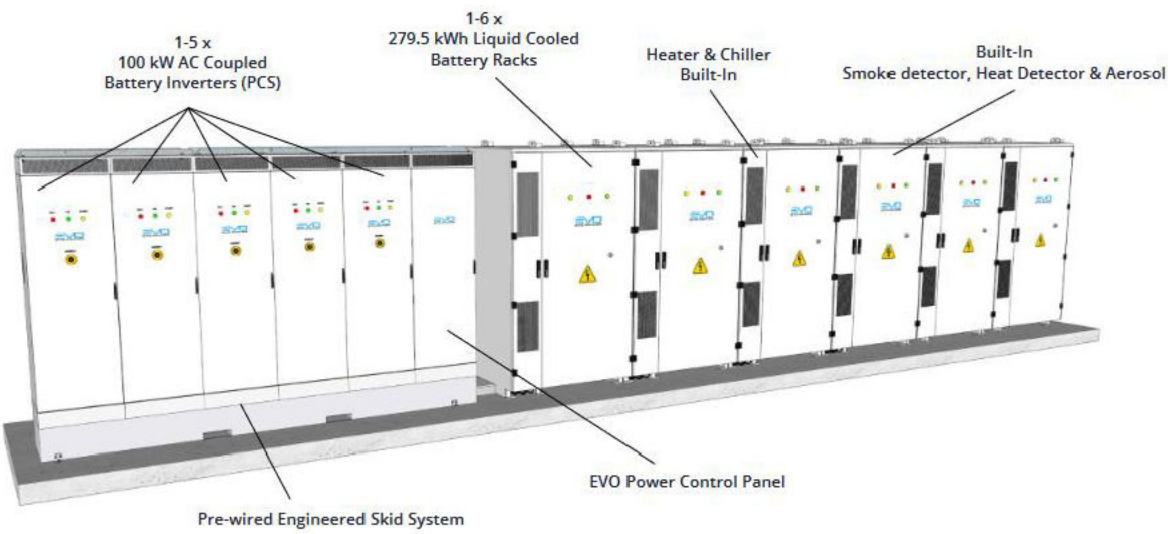

Figure 1 EVO Power NEO 500 kW / 1,500 kWh Example

The NEO series 100 kW inverter skid (for the first 100 kW unit) is 1.2 m long, 0.78 m wide, 2.28 m tall, and weighs 500 kg. Each additional 100 kW unit adds an additional 0.6 m of width and 250 kg, with up to 5 units installed per skid (in parallel). Each NEO series 279.5 kWh battery rack (250 kWh useable energy capacity) is 1.3 m long, 1.3 m wide, 2.28 m tall, and weighs 2,840 kg.

EVO Power are releasing a DC-DC converter module that will enable PV generation to be DC coupled with their BESS product. EVO Power documentation indicates that the NEO system should be sheltered from direct rain via a lean-to-roof.

2.2.3 Capital & Operating Costs

ITP has developed capital cost estimates in accordance with a class 4[6] AACE[7] international guidelines. Cost estimates include allowances for the following components:

- Powercor:
  - Connection fees
  - Connection studies (HV BESS only)
  - Connection works
- EPC Contractor:

---

[6] Expected accuracy of +30% to -20%
[7] Association for the Advancement of Cost Engineering

- Security fence (HV BESS only)
    - Foundations
    - Lean-to-roof
    - EVO Power equipment (ie. BESS, PCS, switchboard, UPS, fire suppression, monitoring & control platform)
    - Transformer (HV BESS only)
    - HV Kiosk (HV BESS only)
    - High-speed metering
    - Power Quality Metering (HV BESS only)
    - Auto-recloser (HV BESS only)
    - Balance of system
    - Installation & commissioning
    - Design and project management
    - Profit and contingency margin
    - Shipping & logistics
- Operation and maintenance:
    - Aggregator service fees
    - BESS inspections and routine maintenance

2.2.4 Network Use of System (NUoS) Charges

LV BESS

Powercor's Community Battery Trial Tariff was assumed. To qualify for the tariff the BESS capacity must not exceed 240 kW. Details of the tariff are outlined below.

Table 1 Powercor Community Battery Trial tariff details[8]

Tariff Component	Rate	Units
Fixed Network Charges	0.45	$/day
Energy Import (10 am - 3pm)	-1.5	cents / kWh
Energy Export (10 am - 3pm)	0.0	cents / kWh
Energy Import (4 pm - 9pm)	25.0	cents / kWh
Energy Export (4 pm - 9pm)	-1.0	cents / kWh
Energy Import/Export (All other times)	-	cents / kWh

[8] Source Powercor

LV PV+BESS

Powercor's tariff schedule includes residential tariffs, commercial tariffs, and tariffs for low voltage, high voltage and sub-transmission connections. Powercor's Large Low Voltage (LLV) tariff was assumed, owing to the size of the BESS considered and the low voltage connection point. Details of the tariff are outlined below.

Table 2 Powercor LLV tariff details[9]

Tariff Component	Rate	Units
Fixed Network Charges	-	$/day
Energy Import (Workdays, 7am-7pm)	14.45	cents / kWh
Energy Import (All other times)	4.28	cents / kWh
Annual Demand (Workdays 7am-7pm)[10]	9.69	$/kVa/month
Summer Demand (Weekdays, 4-7pm, Dec-Mar)[11]	13.81	$/kVA/month

HV BESS

Powercor's tariff schedule includes residential tariffs, commercial tariffs, and tariffs for low voltage, high voltage and sub-transmission connections. Powercor's High Voltage (HV) tariff was assumed, owing to the high voltage connection point. Details of the tariff are outlined below.

Table 3 Powercor HV tariff details[12]

Tariff Component	Rate	Units
Fixed Network Charges	-	$/day
Energy Import (Workdays, 7am-7pm)	2.32	cents / kWh
Energy Import (All other times)	1.50	cents / kWh
Annual Demand (Workdays 7am-7pm)[13]	5.80	$/kVa/month
Summer Demand (Weekdays, 4-7pm, Dec-Mar)[14]	9.93	$/kVA/month

[9] Source: Powercor | 2021/22 Pricing Proposal
[10] Applied to the highest demand in a single 15-minute interval over the previous 12 months
[11] Applied to the highest demand in a single 15-minute interval in that month
[12] Source: Powercor | 2021/22 Pricing Proposal
[13] Applied to the highest demand in a single 15-minute interval over the previous 12 months
[14] Applied to the highest demand in a single 15-minute interval in that month

2.2.5 Operating Revenue

ITP's proprietary modelling optimisation is implemented as a large-scale linear program whose output is a series of BESS charge/discharge and FCAS enablement decisions that satisfy both the performance limits of the BESS, a PV system (if connected), and thermal limits on the connection point, and generate the maximum possible revenue for a given period. Each simulation comprises one year of 30-minute intervals, and five years of historical price data has been used (2016-2020).

Model decision variables include battery charge, battery discharge, PV dispatch, net grid imports, net grid exports and FCAS bids at each 30-minute interval. Model parameters include 30-minute data including PV generation, energy prices/tariffs, FCAS prices/volumes, NUoS charges, and connection point thermal limits, as well as fixed parameters such as battery power capacity, battery energy capacity, battery efficiency, battery state-of-charge limits, etc.

The model co-optimises all its decision variables simultaneously to achieve the highest combined revenue for the parameterised data. This includes whether to charge the BESS from grid imports or the PV system and when to dispatch from the PV and/or BESS system. In addition, decision variables evaluate the trade-off between participating in energy and FCAS markets depending on the combined ability of the PV and BESS system to be enabled across markets.

This battery model simulates the operation of the battery to maximise revenue from spot and FCAS markets. ITP's model assumes that BESS are price-takers with perfect price foresight, and as such, provide the very best-case outcome from the various revenue streams on offer.

For this analysis:

- No FCAS Regulation participation has been assumed, owing to the high cost of entry (see Section 2.1.1).
- Energy and FCAS Contingency revenues are based on five years of historical market price and volume data for Victoria from 2016-2020, obtained from AEMO.
- AEMO's minimum allowable frequency-watt droop setting for BESS is 1.7%. The consequence of this is only 41.2% (or less) of nameplate BESS capacity can be registered for FCAS Contingency services, unless otherwise agreed to by AEMO. Some larger BESS have had different droop settings agreed to by AEMO, but the default specification has been assumed for the BESS considered in this analysis.
- Load data for each transformer as per data provided by C4NET. Where the BESS is connected to the LV side of the transformer (per the LV BESS, the net load for that transformer (consisting of loads, PV Generation distributed on the network, and BESS charge/discharge) is set as a constraint for operation of the BESS.

- The modelling does not account for potential revenues from DNSP network support services. This would be negotiated between the DNSP and the BESS owner on a site-by-site basis. However, Powercor's Community Battery Trial tariff was assumed for the LV BESS scenario, which incentivises charging during peak solar generation time and incentivises discharging during evening peak times.
- NUoS charges as per Section 2.2.4

2.2.6 Results

The analysis showed that BESS with a high power-to-energy ratio generally perform better. This is because FCAS revenues are much more closely linked to power capacity than energy capacity. It is important to note that it is widely expected that the value of FCAS participation will fall in future as large-scale BESS is deployed across the NEM. On the other hand, the value of energy market arbitrage is expected to increase as variable renewable energy penetration increases, and the cost of battery modules is expected to continue falling. These effects are expected to shift the optimum BESS configuration towards lower power-to-energy ratios[15].

Modelling results for the best-performing configurations in each of the three scenarios are shown in Table 4 below (additional results are shown in Appendix A). The configurations are as follows:

- LV BESS: 200kW/250kWh, which is the EVO Power BESS configuration with the highest power-to-energy ratio at that scale[16].
- LV PV+BESS: 200kWdc PV, 1.5MW/1.5MWh BESS, which is the EVO Power BESS configuration with the highest power-to-energy ratio at that scale, and has a power capacity equal to the transformer it is connected downstream of
- HV BESS: 2MW/2MWh, which is the largest capacity considered by Geelong Sustainability, and the EVO Power BESS configuration with the highest power-to-energy ratio

Table 4. In-front-of-the-meter modelling results

Scenario	Capex	Opex p.a.	2016-2020 Net Energy Revenue[17] p.a.	2016-2020 FCAS Contingency Revenue p.a.	NUoS Charges [18] p.a.	Simple Payback (years)

[15] This is reflected in the increasing duration of storage through time in AEMO's Integrated System Plan
[16] If an EVO Power product of 240kW/240kWh was available, this could be expected to deliver the best financial return for this scenario
[17] This is net revenue, accounting for NUoS energy charges payable, as well as the net revenue derived from trading on the NEM
[18] This is inclusive of network energy costs, which are also captured in the energy revenue column

LV BESS	$417k	$15,200	$6,470	$39,500	$199	13.6
LV PV+BESS	$2.16m	$32,600	$47,100	$299,000	$10,000	6.9
HV BESS	$3.23m	$43,300	$41,000	$396,000	$2,000	8.2

The LV PV+BESS scenario outperforms the HV BESS scenario mainly because capex (per unit of BESS capacity) is expected to be lower owing to the high connection process/equipment costs associated with the HV BESS scenario.

Overall, the financial results are marginal to poor. This is to be expected given the high costs associated with establishing new connections to the network and the small scale of the proposed projects. Large-scale BESS projects that compete in the same markets are:

- generally transmission-network connected, where NUoS charges are much lower;
- at much larger scale, resulting in capital costs per unit of capacity that are 30-50% lower than shown above;
- also able to access FCAS Regulation markets.

As a result, significant subsidies are expected to be required to make these projects competitive. Alternatively, Powercor could:

- significantly increase the incentives that the Community Battery Trial tariff provides for favourable BESS operation, and;
- increase the maximum capacity eligible for the Community Battery Trial tariff, or else develop additional tariffs designed for larger BESS.

3 BEHIND-THE-METER BESS

3.1 Background

While market prices vary continuously, retailers insulate their customers from this volatility and typically offer their customers fixed prices over a 1-3 year period.

When distributed energy resources such as PV and BESS are installed on the customer side of a retail electricity meter, the installation is generally described as being *behind-the-meter*.

Behind-the-meter BESS can conduct tariff arbitrage and potentially peak demand charge reduction for large electricity users with peak demand-based tariffs. When coupled with behind-the-meter PV, BESS can also increase PV self-consumption. Each of these value streams is discussed below.

3.1.1 Value Streams

Tariff Arbitrage

Wherever there is a differential between import tariffs across time (eg. time-of-use tariffs), BESS installation has the potential to reduce energy charges by charging during off-peak times when prices are low and discharging during peak times when prices are high.

Tariff arbitrage can be achieved reliably and for minimal additional cost. Current transformers (CTs) are installed at the point of connection and the BESS controller instructs the BESS to charge during off-peak tariff periods and discharge during peak tariff periods.

PV Self-Consumption Maximisation

Where import tariffs exceed export tariffs, BESS has the potential to reduce energy charges as it enables energy imports to be substituted with stored solar energy that would otherwise have been exported.

Storing PV energy that would otherwise be exported has an opportunity cost equal to the export tariff at the time of charging, while the value of discharging is the avoided import tariff at the time of discharge.

Maximising PV self-consumption is equivalent to both import minimisation and export minimisation and, strictly speaking, is a specific form of tariff arbitrage.

PV self-consumption is achieved reliably and for minimal additional cost. CTs are installed at the point of connection and the BESS controller instructs the BESS to charge or discharge to minimise current flowing out through these CTs. System monitoring is advisable, but otherwise there is no administrative burden for BESS owners during normal operation.

Peak Demand Charge Reduction

Peak demand charges are typically incurred by large electricity users in proportion to the maximum average apparent power demand (kVA) over a 30-minute period each month or year. Behind-the-meter BESS can inject real/reactive power during periods of high demand to reduce peak demand and demand charges.

To achieve peak demand charge reduction is more complex, less reliable, and slightly more costly than PV Self-Consumption and Tariff Arbitrage, as the BESS controller must have the additional ability to forecast demand from the grid (in addition to any PV that is expected to be generated) in order to make intelligent charge/discharge decisions.

To do so, advanced BESS controllers typically use weather forecasts and learning algorithms that identify deterministic trends between demand and any explanatory variables (eg. time-of-day, weekend/weekday, season, solar conditions, ambient temperature, etc.). Alternatively, historical and forecast demand can be assessed by an analyst.

In either case, a target peak demand limit is determined and used as a trigger for BESS discharge. Effectiveness is limited by unexplained variation around demand trends, and is highly dependent on the demand profile (e.g. a flat load profile has no potential for peak demand reduction). Further, peak demand charges that are incurred over a longer period (e.g. one year) will penalise imprecision more severely than charges incurred over a shorter period (e.g. one month). The potential for demand charge reduction is therefore highly site dependent and can only be determined following detailed demand analysis.

Virtual Power Plant Participation

Behind-the-meter BESS can be aggregated and orchestrated by an electricity retailer or a third-party virtual power plant (VPP) operator to derive value (or hedges) from wholesale markets. Under this scenario, the BESS owner is compensated by the market participant (i.e. the retailer or VPP operator) for the use of their asset.

While AEMO's VPP Demonstrations program trialled residential BESS providing contingency FCAS under relaxed participation requirements, the Market Ancillary Service Specification currently requires dedicated, high-speed metering that harms the economics at residential scale. Regulation FCAS is also unfeasible for small BESS owing to the high costs of establishing the hard-wired communications link between each site and AEMO.

VPP participation is increasingly offered by retailers to select customers. Many of these offerings have been heavily subsidised and compensation varies significantly. In general, modest compensation can be expected, but this is not sufficient to materially impact the business case for behind-the-meter BESS. VPP revenue has not been considered in the analysis that follows.

3.1.2 Regulatory Context

DNSP Connection Process

Installations on Powercor's network must comply with the CitiPower and Powercor Guidelines for Low Voltage Connected Embedded Generation[19], the Victorian Electricity Distribution Code (VEDC)[20], and the Victorian Service Installation and Rules (SIRs)[21].

Behind-the-meter residential and commercial BESS installations qualify for a basic connection agreement provided that they:

- comply with AS4777;
- have a capacity of no more than 5 kVA on a single-phase LV connection, or 30 kVA on a three-phase LV connection;
- do not require any additional network works or upgrades to accommodate; and
- the customer has sought pre-approval from the DNSP via the eConnect portal[22].

This process of undertaking a basic connection service with the DNSP is typically completed by the Registered Electrical Contractor (REC) engaged to install the BESS as part of the installation service. A basic connection will incur various fixed fee charges, and other (non-connection) charges depending on the connection configuration as outlined in Powercor's General Service Charge Pricing Schedule charges[23]:

Installations that do not qualify for the basic connection outlined above will require a negotiated connection. Negotiated connections will incur a capital cost to the applicant where the cost of establishing the connection exceeds the revenue the DNSP expects to derive from it.

Planning

Building approvals and development approvals are generally not required for behind-the-meter BESS installations on private property. Building approvals may be required where behind-the-meter BESS are mounted to structures that are engineered and/or not covered under the National Construction Code (e.g. non-standard designs).

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[19] https://media.powercor.com.au/wp-content/uploads/2018/11/30122510/customer-gl-for-lv-connected-eg-v8-final-22112018.pdf
[20] https://www.esc.vic.gov.au/electricity-and-gas/codes-guidelines-and-policies/electricity-distribution-code-practice
[21] http://www.victoriansir.org.au/
[22] https://media.powercor.com.au/wp-content/uploads/2022/01/18151112/Powercor-Connection-policy-1-July-2021.pdf
[23] https://media.powercor.com.au/wp-content/uploads/2020/11/26113750/HY2021-Powercor-GSC-Pricing-Schedule.pdf

3.2 Analysis

3.2.1 Scenarios

Residential

Residential BESS predominately generate value to customers via tariff arbitrage and PV self-consumption maximisation. These opportunities exist for most solar PV owners, whose import tariffs exceed their export (i.e. feed-in) tariffs, and for those on time-of-use tariffs.

BESS have become common in Australian households recently, and there is a mature market for consumer products available to residential customers. These products are typically designed for wall or floor mounting on the exterior of a residential property and intended to integrate with existing, or new solar installations. These products are either AC coupled (BESS with integrated inverter/charger), or as a standalone BESS which can then be coupled with a hybrid PV inverter (DC coupled) or dedicated third party BESS inverter/charger. AC coupled BESS require a dedicated circuit connection to the main switchboard of the residential premises, while DC coupled BESS shares the same electrical connection as the PV inverter.

Figure 2. Example residential BESS product - LG Chem RESU 10

Residential BESS power capacity varies but is typically 5 kW or less. Energy capacity also varies but is typically around 10 kWh[24]. These products range from 50 L (~0.5 m x 0.5 m x 0.2 m) to 360 L (~ 1 m x 1.8 m x 0.2 m) in size, and from ~75 kg up to ~150 kg in weight.

[24] https://www.cleanenergycouncil.org.au/resources/technologies/energy-storage

These products are typically designed for installation outdoors on the exterior wall of a residential building.

Commercial / Industrial (Community Centre)

Similar to the residential scenario, BESS installed behind the meter at a large electricity user's facility can generate value via tariff arbitrage and PV self-consumption.

Geelong Sustainability have proposed the Geelong YMCA be considered as a potential site for behind-the-meter BESS. Geelong YMCA is located at 25-33 Riversdale Rd, Newtown VIC. The centre has an existing 60 kWp Solar array on its roof installed and owned by Geelong Sustainability. The proposal is to install a BESS adjacent to the solar inverter located adjacent to the main switchboard and building loading dock at the eastern end of the building.

Commercial BESS are typically larger three phase batteries which are modular and sized to meet the energy needs of a specific site. A single line diagram of the expected connection configuration is provided in Appendix B.

3.2.2 Methodology

ITP's analysis utilised a proprietary in-house modelling tool called BESSIE. BESSIE is a program that simulates the interaction of load, PV and BESS to determine energy flows and estimate electricity bill. BESSIE requires user-provided inputs and controls the BESS to maximise PV self-consumption (*simple control*) or to maximise value across all value streams (*smart control*). Key inputs to BESSIE are:

- Time series load data
- Time series solar generation data
- Tariffs and any other price signals

3.2.3 Assumptions

Residential

- Load:
  - ITP-provided load profile, scaled to 13.4kWh/day
  - No load growth considered
- PV:
  - Solar generation exported from PVWatts assuming 5 kW_{ac} / 5 kW_{DC} existing PV installed at 0º azimuth, 25º tilt, in Geelong VIC
- BESS:
  - 10 kWh/5 kW BESS, typical/representative of a residential BESS)
  - 85% round trip efficiency, appropriate for the Geelong climate

- 2.6% yearly energy capacity degradation, in line with some manufacturer's warranties
- Installed BESS cost (ex. rebate or solar installation) of AU$12,500 (inc. GST)
- Negligible annual operating cost

- Tariffs:
  - Per Tango's residential default time-of-use offer (Offer ID: TAN357107SR):
    - Supply charge: 133.01 c/day (inc. GST)
    - Peak Consumption (3pm – 9pm): 31.46c/kWh (inc. GST)
    - Off-peak consumption (12am - 3pm & 9pm – 12am): 17.46c/kWh (inc. GST)
    - Solar PV feed in tariff: 6.70c/kWh (inc. GST)
  - No tariff escalation considered
- Connection process:
  - Basic

Community Centre

- Load:
  - Load profile provided by Geelong Sustainability
- PV:
  - Solar generation exported from PVWatts assuming a split array with $40kW_{AC}$ / 40 kW_{DC} at 340º azimuth and 10º tilt, and $20kW_{AC}$ / 20 kWp_{DC} at 160º azimuth and 10º tilt, ($60kW_{AC}$ / 60 kWp_{DC} total capacity), in Geelong, VIC.
- BESS:
  - 50 kW / 125 kWh, per Geelong Sustainability estimates
  - 85% round trip efficiency, appropriate for the Geelong climate
  - 2.6% yearly energy capacity degradation, in line with some manufacturer's warranties
  - Installed BESS cost (ex. rebate or solar installation) of $1,060/kWh, per Geelong Sustainability estimates
  - Negligible annual operating cost
- Tariffs:
  - As provided by Geelong Sustainability (per Sunulator tool):
    - Supply charge: $1.7885/day
    - Peak (7am–11pm weekdays): 45.67 c/kWh
    - Off-peak (All other times): 23.24 c/kWh
    - PV feed-in tariff: none
- Connection process:
  - Negotiated

3.2.4 Results

Residential

Table 5 Residential BTM BESS modelling results

Scenario	Peak Imports (kWh/yr)	Off-Peak Imports (kWh/yr)	Total Imports (kWh/yr)	Exports (kWh/yr)	Electricity Bill ($/yr)
No PV, no BESS	1,206	3,685	4,891	0	$1,592
5kWp PV, no BESS	822	2,117	2,939	4,805	$1,170
5kWp PV, 10kWh BESS (simple control)	96	765	860	2,359	$661
5kWp PV, 10kWh BESS (smart control)	3	873	876	2,360	$640

Table 6 Residential BTM BESS financial results

Scenario	Capex ($)	Bill Saving ($/yr)	Simple Payback (years)
Base Case: no PV, no BESS			
+5kWp PV	$5,000	$422	11.8
+5kWp PV, 10kWh BESS (simple control)	$17,500	$931	18.8
+5kWp PV, 10kWh BESS (smart control)	$17,500	$952	18.4
Base Case: 5kWp PV, no BESS			
+10kWh BESS (simple control)	$12,500	$509	24.6
+ 10kWh BESS (smart control)	$12,500	$530	23.6

The results show a poor payback period for PV, mainly because the PV capacity assumed is large relative to the load (resulting in large exports). In general, payback periods for residential PV are good (4-7 years), but a BESS is more likely to be installed where there is significant excess PV and hence the over-sizing is appropriate for this analysis.

Despite the abundance of excess PV generation, the results show that the payback period for residential BESS is also poor. This is consistent with other studies and is to be expected based on current prices. While BESS prices are widely expected to fall in the medium to long term, significant short term price reductions are not anticipated.

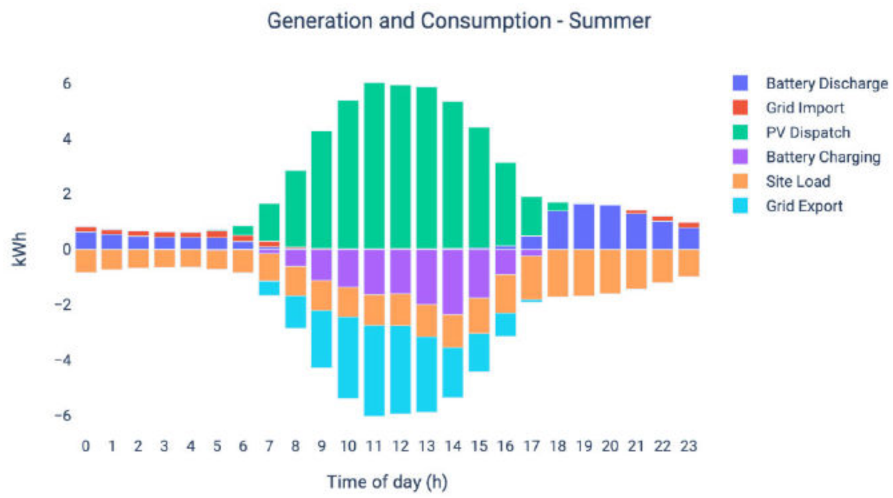


Figure 3 Summer generation and consumption profiles for average Victorian residential customers with PV and behind the meter BESS (with smart control)

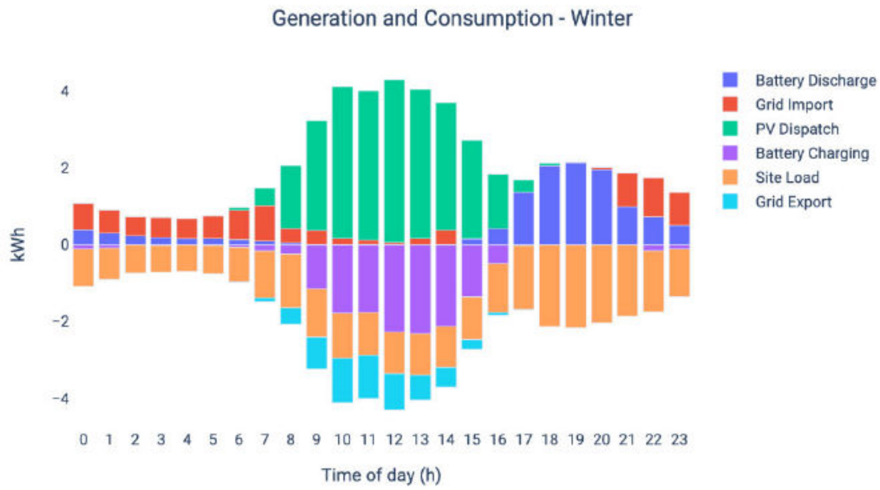


Figure 4. Winter generation and consumption profiles for average Victorian residential customers with PV and behind the meter BESS (with smart control)

Community Centre

Table 7. Community Centre BTM BESS modelling results

Scenario	Peak Imports (kWh/yr)	Off-Peak Imports (kWh/yr)	Total Imports (kWh/yr)	Electricity Bill ($/yr)
60kWp PV, no BESS	20,175	14,314	34,489	$13,193

60kWp PV, 50kW/125kWh BESS (smart control)	2,872	15,369	18,241	$5,536

Table 8. Community Centre BTM BESS financial results

Scenario	Capex ($)	Bill Saving ($/yr)	Simple Payback (years)
Base Case: 60kWp PV, no BESS			
+ 50/125kWh BESS (smart control)	$132,000	$7,657	17.3

The payback period for BESS at the YMCA is shorter than the residential case analysed above owing to the slightly lower cost (per unit) assumed for the (larger) BESS and the higher differential between tariffs. Nevertheless, the payback period is still longer than necessary to make it an attractive investment without subsidy.

Additional analysis by ITP found that a smaller BESS at the YMCA would be more highly utilised than the BESS considered above, but the additional capital cost (per unit of capacity) means the payback period is similar.

4 NEIGHBOURHOOD "STORAGE AS A SERVICE"

4.1 Background

4.1.1 Technical Description

"Storage as a service" is a relatively new concept in which an in-front-of-the-meter BESS is used by residential customers with solar to capture their excess solar generation for use during peak evening demand periods. In theory, this avoids the need for retail customers to commit to the large capital expenditure of a behind the meter BESS on their premises. It also provides an option for energy storage for customers who are unable to install a behind the meter BESS at their premises for whatever reason (e.g. there is no physical space, the property is rented, etc.).

The proposal here is that Geelong Sustainability install an in-front-of-the-meter BESS on Powercor's local distribution network in Geelong and lease it to Tango for the purpose of providing their local Tango customers with "storage as a service".

The BESS would operate as outlined in the in-front-of-the-meter section above, trading on the NEM energy, and FCAS markets to generate revenue. However, Tango would have an additional revenue stream from retail customers who pay for access to the storage service. These customers would pay fees for access to favourable tariffs for the energy they export during the day and then import back again during peak periods. The aim of the program would be to generate additional revenue from customers paying for the service, thus helping with the business case for a front-of-the-meter BESS.

An example of how this model could work is outlined below:

- Storage "slots" made available to customers (with solar) on the distribution network for an annual/monthly fee
- Each slot gives customer access to $0 feed-in tariff for the energy exported each day (up to the capacity of the slot), and then $0/kWh for the import of the same amount of energy in that same day.
- Technical requirement for participation requires user to be signed up to the retailer and have smart metering at their premises.
- Tango dispatch the BESS as needed, trading energy, FCAS, and providing network services to maximise profitability of the BESS (as per the "In-Front-of-the-Meter" scenario above).

4.1.2 Regulations

Key regulatory barriers exist for a project such as this, and it is likely they will only be resolved in consultation either with Powercor or with the AER. The main barriers relate to:

- The application of full NUoS charges to any electricity that is imported through a retail electricity meter, even if that electricity was generated locally and uses only a small fraction of the network.
- Calculating and allocating compensation for the network services such a program would incidentally provide.

Powercor has developed a trial tariff for small community BESS, and the financial impact of this is investigated in Section 2.

Some examples of programs that have deployed community batteries are below.

4.1.3 Example Projects

Below are relevant examples of community BESS currently operating around Australia.

Meadow Springs, Falcon and Ellenbrook Community PowerBanks

Western Power, together with Synergy, is operating the Meadow Springs, Falcon and Ellenbrook Community PowerBanks. They are using Tesla Powerpacks of 106kW/420kWh (Meadow Springs, launched Oct 2018) and 116kW/464kWh (Falcon, launched Nov 2019). The main reason for installing the batteries is to defer network augmentation, driven by population increases in Mandurah. Most new houses in this area have solar, so the relevant zone substation is experiencing voltage rise and reverse power flow. The intention is to encourage third party ownership over time, with Western Power able to recover the costs of contracting for network support services.

Participating consumers can store 8kWh/day (Meadow Springs) and 6-8kWh/day (Falcon). This electricity can then be used by each consumer during peak hours at normal flat rates (3pm-9pm) instead of paying the TOU tariff peak rates. Any electricity that a consumer has stored in the battery but does not use that day is bought by Synergy at midnight and credited to the consumer's bill. Having Synergy as the monopoly retailer simplifies this case.

Consumers pay a $1/day (Meadowbank) or $1.60 to $1.90/day (Falcon) subscription fee (which is passed on to Western Power) and have to be on a TOU tariff. According to Western Power, in the first year of Meadowbank's operation, 95% of consumers saved money, at an average of $228/year/consumer. It is apparent that this is less than the cost of participating ($365/year).

Alkimos Beach Energy Storage Trial

Synergy has operated the 0.25MW, 1.1 MWh Alkimos Beach Community Energy Storage Device since April 2016. It has a total cost of $6.71m, with $3.31m from ARENA[25]. It operates in much the same way as the Meadow Springs and Falcon Community PowerBanks discussed above. All 113 participating consumers are on the Peak Demand

[25] https://arena.gov.au/assets/2021/07/alkimos-beach-energy-storage-trial-report.pdf

Saver TOU tariff (peak charge of 51.2c/kWh between 4-8pm and 26.8c/kWh otherwise) and pay a charge of $11/month. Any electricity they export will be credited against their use during peak periods, and any remaining credit will offset off-peak use between 8pm and midnight. If there is any electricity 'stored' in the battery that has not been used by a consumer by the end of their billing period, Synergy will buy that at the standard Distributed Energy Buyback Scheme rate[26].

Unlike the Community PowerBanks there is no daily limit of the electricity that can be 'stored' by each consumer. According to Synergy, households of four have been saving $47.49/month on average, two-member homes have saved an average of $32.61/month, and single-occupancy homes have saved $28.95/month on average. While this exceeds the participation charge of $11/month, this charge is heavily subsidised.

4.2 Analysis

Given that the BESS will operate to maximise revenues and therefore benefits to Tango and its customers, the analysis is equivalent to the in-front-of-the-meter scenarios investigated above. Any attempts to dispatch the BESS based on instantaneous import/export at each of Tango's customers will only increase cost and reduce revenues.

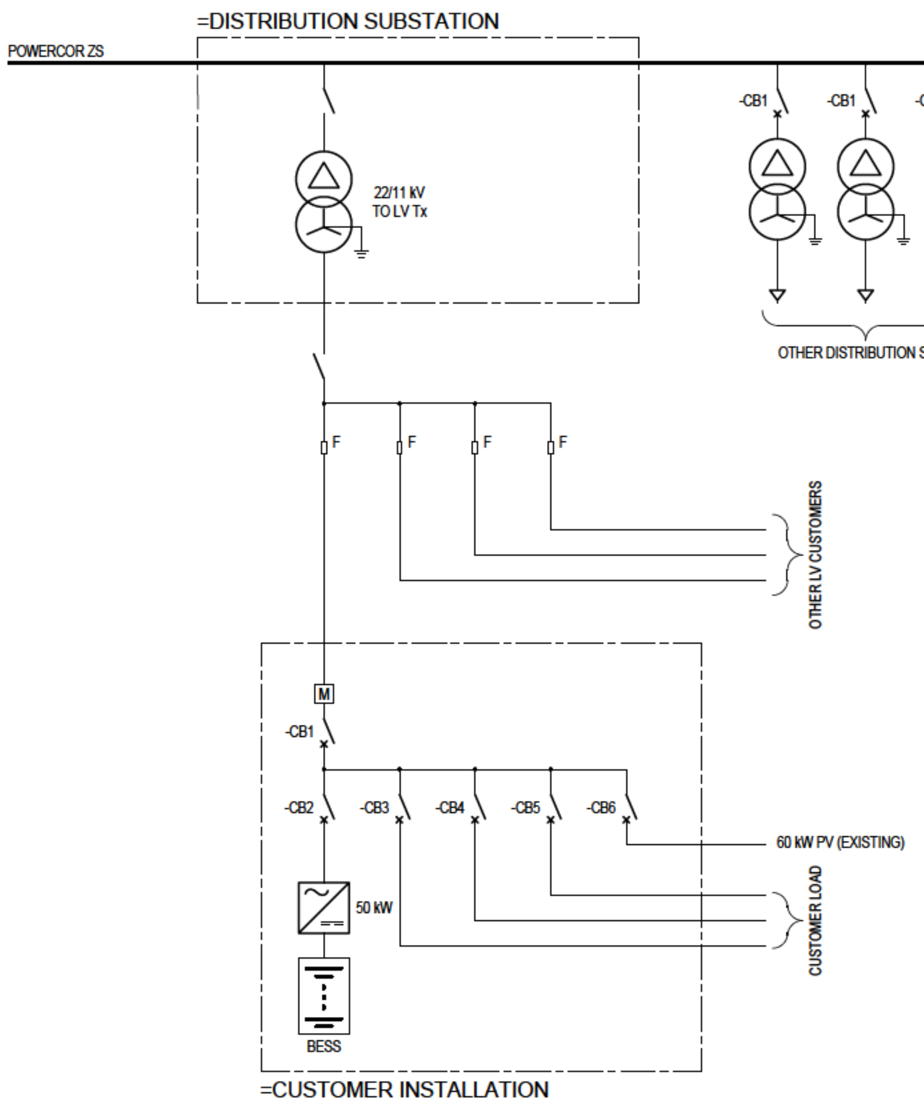
[26] https://www.wa.gov.au/organisation/energy-policy-wa/energy-buyback-schemes

APPENDIX A. IN-FRONT-OF-METER ANALYSIS RESULTS

Scenario	PV Capacity (kWdc)	BESS Power (kW)	BESS Energy (kWh)	Capex	Opex p.a.	2016-2020 Net Energy Revenue[26] p.a.	2016-2020 FCAS Contingency Revenue p.a.	NUoS Charges [27] p.a.	Simple Payback (years)
LV BESS	0	240	500	$626k	$17,300	$14,200	$46,600	-$355	14.4
LV BESS	0	240	750	$803k	$19,000	$19,200	$45,300	-$868	17.7
LV BESS	0	200	250	$417k	$15,200	$6,470	$39,500	$199	13.6
LV PV+BESS	200	1,500	1,500	$2.16m	$32,600	$47,100	$299,000	$10,100	6.9
LV PV+BESS	200	1,000	1,000	$1.57m	$26,700	$37,800	$199,000	$1,270	7.5
LV PV+BESS	200	500	500	$981k	$20,800	$28,200	$99,900	$593	9.1
HV BESS	0	2,000	2,000	$3.23m	$43,300	$41,000	$396,000	$2,220	8.2
HV BESS	0	1,500	1,500	$2.66m	$37,600	$30,800	$297,000	$1,670	9.2
HV BESS	0	1,000	1,000	$2.08m	$31,800	$20,500	$198,000	$1,110	11.1

[26] This is net revenue, accounting for NUoS energy charges payable, as well as the net revenue derived from trading on the NEM
[27] This is inclusive of network energy costs, which are also captured in the energy revenue column

APPENDIX B. GEELONG YMCA BESS SLD



1 CONCEPT BEHIND THE METER LV BESS SLD

SCALE: NTS

FOR INFORMATION

NO.	STAGE	DATE
1	FOR INFORMATION	20/07/2022
2	----	----
3	----	----
4	----	----
5	----	----
6	----	----

NOTES

Vm: RATED MAX MUM VOLTAGE
Vd: RATED SHORT-DURATION POWER-FREQUENCY WITHSTAND VOLTAGE
Vp: RATED LIGHTENING WITHSTAND VOLTAGE
Ir: RATED CONTINUOUS CURRENT
Isk: RATED SHORT-DURATION WITHSTAND CURRENT

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DRAWN MJB
CHECKED MOR
APPROVED JJ

DO NOT SCALE.
ALL MEASUREMENTS IN MM UNLESS OTHERWISE STATED.

DRAWING: LV AC SLD

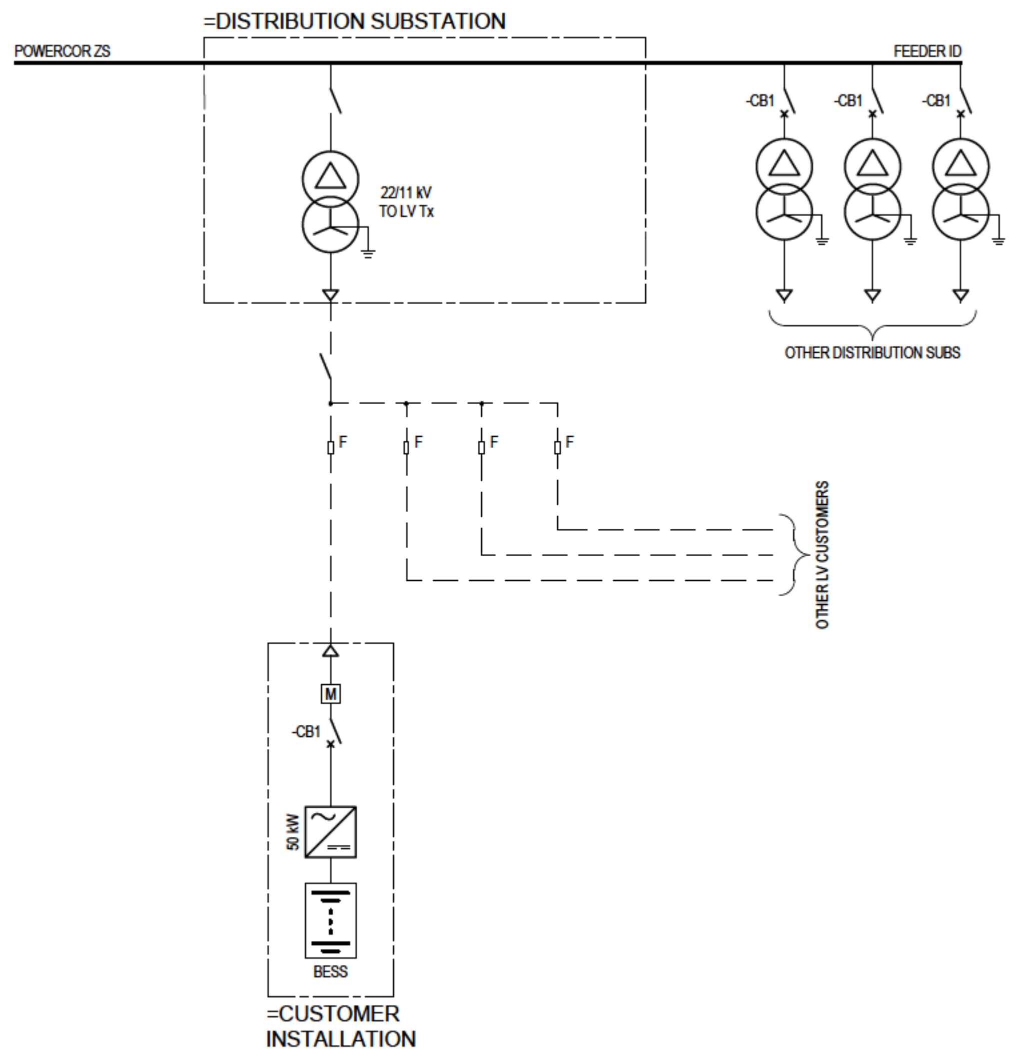
PROJECT: GEELONG NBI - GEELONG YMCA
CLIENT: GEELONG SUSTAINABILITY
ADDRESS: 25-33 RIVERSIDE RD
NEWTOWN, VIC 3220

DRAWING NO. 22018-E-2300

SCALE: AS NOTED
SHEET SIZE: A3
ORIG. DATE: 18/6/20
REV. DATE: 20/7/22
REV NO. 1

G:\Work\22018 - Geelong Sustainability NBI\Project\4 Work\4.03 Drawings\Geelong YMCA\DWG\E-2300 LV AC SLD dwg, PLOTTED BY MATTHEW BARRETT AT 20/7/2022 3 22 PM

APPENDIX C. [redacted] BESS SLD (LV BESS)



1 CONCEPT LV BESS SLD

SCALE: NTS

FOR INFORMATION

NO.	STAGE	DATE
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NOTES

Vm: RATED MAX MUM VOLTAGE
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DRAWN MJB
CHECKED MOR
APPROVED JJ

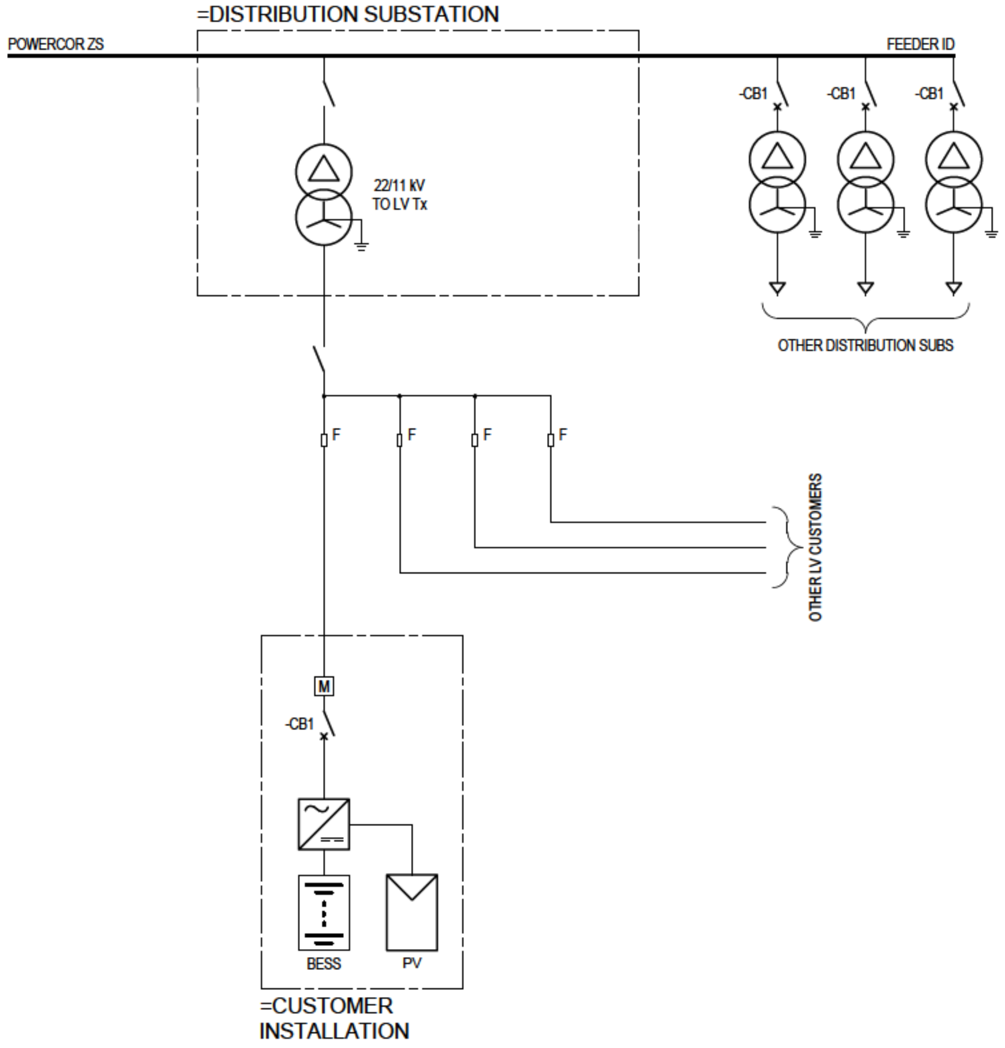
DO NOT SCALE.
ALL MEASUREMENTS IN MM UNLESS OTHERWISE STATED.

DRAWING LV AC SLD

PROJECT GEELONG NBI - [redacted]
CLIENT GEELONG SUSTAINABILITY
ADDRESS [redacted]
NEWTOWN, VIC 3220
DRAWING NO. 22018-E-2300

SCALE AS NOTED
SHEET SIZE A3
ORIG. DATE 18/6/20
REV. DATE 20/7/22
REV NO. 1

APPENDIX D. BELL POST HILL BESS SLD (LV PV+BESS)



CONCEPT LV PV+BESS SLD

1 / -

SCALE: NTS

FOR INFORMATION

NO.	STAGE	DATE
1	FOR INFORMATION	20/05/2022
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3	----	----
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6	----	----

NOTES

Vm: RATED MAX MUM VOLTAGE
Vd: RATED SHORT-DURATION POWER-FREQUENCY WITHSTAND VOLTAGE
Vp: RATED LIGHTENING WITHSTAND VOLTAGE
Ir: RATED CONTINUOUS CURRENT
Isk: RATED SHORT-DURATION WITHSTAND CURRENT

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DRAWN	MJB
CHECKED	MOR
APPROVED	JJ

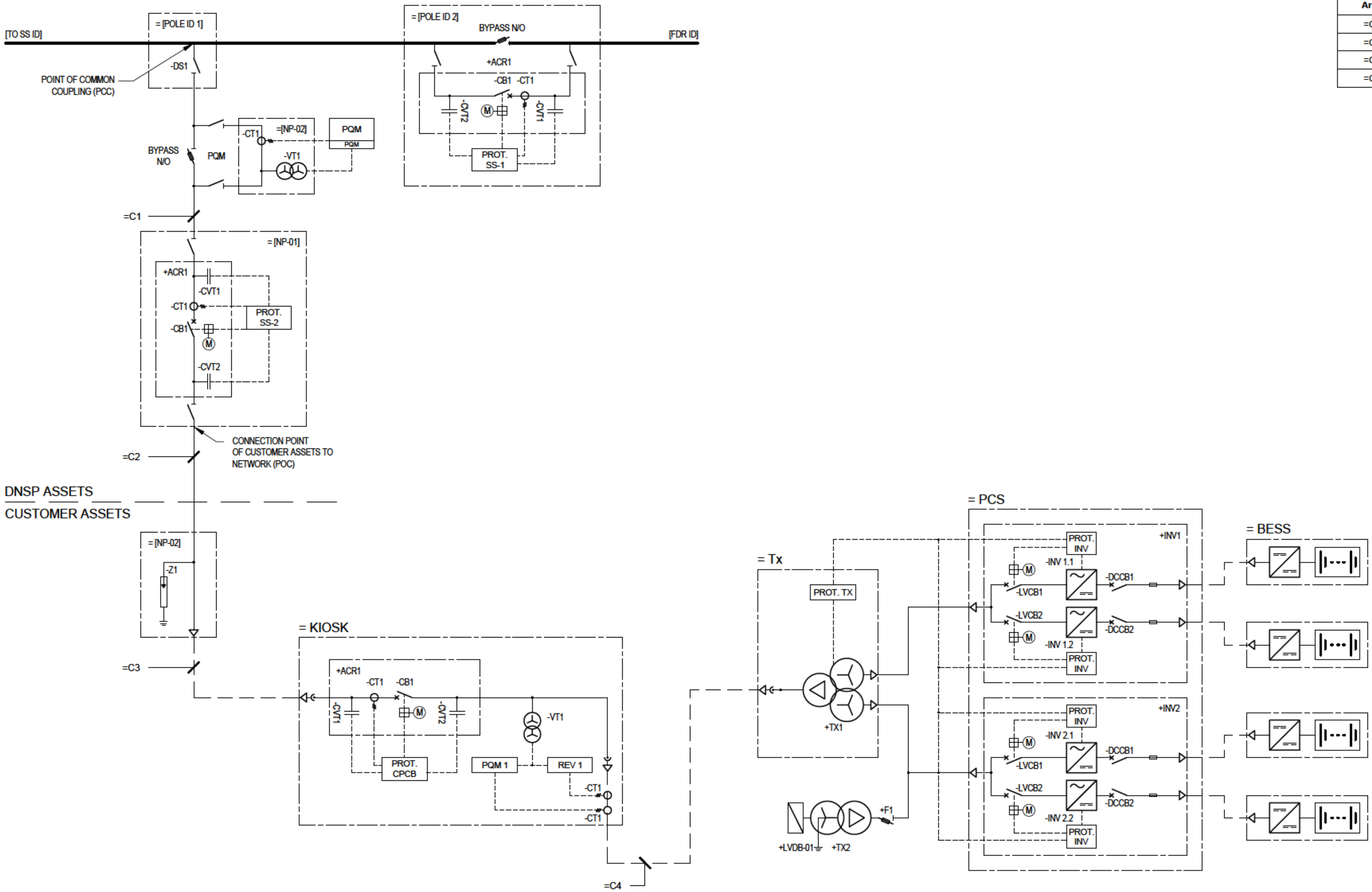
DO NOT SCALE.
ALL MEASUREMENTS IN MM UNLESS OTHERWISE STATED.

DRAWING	LV AC SLD ----
PROJECT	GEELONG NBI - BELL POST PLAZA
CLIENT ADDRESS	GEELONG SUSTAINABILITY CORNER OF ANAK E RD & RENA ST NORLANE, VIC 3214
DRAWING NO.	22018-E-2300

SCALE	AS NOTED
SHEET SIZE	A3
ORIG. DATE	18/6/20
REV. DATE	21/7/22
REV NO.	1

APPENDIX E. [redacted] BESS SLD (HV BESS)

TABLE 1 - CABLE & CONDUCTOR SCHEDULE			
Area	Length (m)	Type	Specification
=C1	TBC	OVERHEAD	TBC
=C2	TBC	OVERHEAD	TBC
=C3	TBC	UNDERGROUND	TBC
=C4	TBC	UNDERGROUND	TBC



1 CONCEPT ELECTRICAL AC SLD

SCALE: NTS

FOR INFORMATION

NO.	STAGE	DATE
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5	----	----
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NOTES

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Ir: RATED CONTINUOUS CURRENT
Isk: RATED SHORT-DURATION WITHSTAND CURRENT

PARTNERS

itp RENEWABLES

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DRAWN MJB
CHECKED MOR
APPROVED JJ

DO NOT SCALE.
ALL MEASUREMENTS IN MM UNLESS OTHERWISE STATED.

DRAWING AC SLD

PROJECT GEELONG NBI - [redacted]
CLIENT GEELONG SUSTAINABILITY
ADDRESS [redacted]
NEWCOMB, VIC 3219
DRAWING NO. 22018-E-2100

SCALE AS NOTED
SHEET SIZE A3
ORIG. DATE 10/5/22
REV. DATE 20/7/22
REV NO. 1