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CONCEPT DESIGN REPORT

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Introduction

The Battery Storage and Grid Integration Program (BSGIP) is investigating the use of batteries and distributed generation to improve energy system reliability for communities on the NSW South Coast affected by the Black Summer bushfires, as well as providing positive environmental outcomes related to energy supply in the region. This work is the *Southcoast Microgrid (μ-grid) Reliability Feasibility* (SμRF) project, funded by the Rural and Remote Communities Reliability Fund (RRCRF). Analysis performed by BSGIP has identified eight communities which would benefit from microgrid infrastructure, and for which preliminary feasibility has been researched. Preliminary sizing for three system topologies, outlined below, were supplied to feed into this concept design costing work.

This report provides design justifications for key aspects of the concept design for each site, followed by the costing rationale for the project. The report finishes with design justification and costing for each site.

System Topologies

Three system topologies have been included in this costing exercise: 'large microgrid', 'small microgrid' and 'diesel only'. The large microgrid categorisation describes a microgrid formed by the installation of a large solar farm with a co-located BESS. Co-locating these assets reduces strain on the network as export from the site when the microgrid is islanded is limited to the demand of the consumers on the microgrid, rather than the entire output of the solar farm.

The small microgrid describes the installation of a BESS onto a network segment which includes considerable embedded generation, typically rooftop solar. Note that rooftop solar has no bearing on the predicted system costs presented in this report.

'Diesel only' refers to the simple installation of a diesel generator onto the network segment to create a section which can be black-started after an outage. This system will serve to provide power during an emergency and will do so cheaply, although it doesn't provide the advantages of the other systems as they pertain to emissions reduction and the perceived benefit of increased local consumption of renewable generation.

Primary Equipment Selection

PV Array Mounting Structure

Single Axis Trackers

SAT systems refer to a mounting structure based around a rotating steel pole onto which the solar modules are mounted. SATs have been the chosen technology for solar farms for the past 5 years in unconstrained developments (more on this later) as the financial case favours this solution above all others. Single axis trackers can increase yield by up to 30% (particularly at lower latitude locations with clear skies), while adding only 2% - 5% to system capital costs. They typically change the tilt of the array, rather than its orientation.

Generation from SAT system is higher in the evening; this is beneficial in both energy markets (when prices are higher) and also in systems whereby the alternative would be to store the energy (increasing the cost of supply).

Figure 1: Single-axis tracking array (source: NEXTracker)

PEG

The Belectric PEG mounting system orients the modules such that they are tilted east and west (at an angle of about 10 degrees), rather than towards the equator. The advantage of this approach is that the array can be tightly packed, without the need for spacing to reduce the effect of inter-row shading.

As well as the ability to create compact arrays, the output of the system is greater than that of a conventional equator tilted array in the morning and evening. This can be beneficial in networks where it is advantageous to supply electricity during these times – typically the peak demand period.

The key benefits of the Belectric PEG system are reduced mounting costs and the ability to fit a large number of modules into the available space. On the other hand, the difficulty in accessing individual modules makes troubleshooting and cleaning difficult, and the difficulty in accessing the underside of the array makes vegetation clearance slightly more difficult. Furthermore, given the individual modules will not be operating at their optimum, the specific yield (i.e. kWh produced per kWp of installed capacity) is lower, increasing the cost of generation.

This mounting structure sacrifices some array yield for the array density and ease of installation. For places with expensive or constrained land, PEG can prove a solution for working a positive financial case.

Figure 2: Belectric mounting system (source: ITP Renewables)

Inverters

Central Inverter

The term central inverter refers to a large inverter which is designed to deal with array capacities of several hundred kilowatts and above. Generally, these inverters are in the range of several megawatts capacity and are approximately the size of a 20’ shipping container. The common trade off for central inverter is the low specific cost weighed against the need for technical personnel to work on the inverter. Additionally, central inverters cause a huge loss in system output if they fail as opposed to the minimal losses of a string inverter.

Central inverters present designers with the following advantages:

- Lowest capital cost on a per Watt basis compared to string and microinverters, which is important at a utility scale where cost competitiveness is paramount. Central inverters also have low installation and cabling costs, as high DC voltages (up to 1,500 V) reduce the size of cable required, and only one inverter needs to be installed for a large PV field.
- Easier fleet management, as operators only need to monitor a few inverters rather than many.
- Central inverters are designed for utility-scale applications, and therefore come with utility-grade SCADA and control system interfaces.
- Low AC line losses, as they are usually installed adjacent to a transformer to increase the voltage to several thousand volts. String inverters operate at low voltage (230 V), so need larger cabling for the same current.
- Commissioned, monitored, and maintained by the manufacturer, so inverter works on a project can be separated out. Manufacturers may also provide uptime guarantees, so in case of failure the PV plant owner receives compensation for lost production.

However, the following disadvantages must be considered:

- The servicing is done by the manufacturer, so any breakdowns entail a longer downtime than for string inverters or microinverters (which can be kept on site as spares). If there is no uptime guarantee in place, PV plant owners can face financial losses. This is particularly salient in remote locations, where it may take weeks for spare parts to arrive.
- While the low number of inverters in a PV plant is an asset for fleet management, the downside is that the failure of a single inverter results in a large portion of the plant going offline. To mitigate this, some manufacturers have modularised their central inverters, so if a module is faulty it can be removed while the rest of the inverter remains online.
- Central inverters have the longest lead-time of any inverter class, as they are made to order for a particular project, and must be dispatched from the manufacturer’s factory. For locations far from manufacturing centres (e.g. Australia, New Zealand, the Pacific Islands), shipping can add weeks (and risks) to lead time.

It is typically found that unless the site is particularly remote or difficult, central inverters present a better financial case than string inverters for solar farms.

String Inverter

A string consists of several modules connected in series. String inverters convert the output of one or more strings of modules into single-phase or three-phase AC power. These are the most common type of inverter on the market but are primarily used in residential installations. They are used on systems up to around 3 MW, beyond which they struggle to remain cost-competitive with central inverters. Their size ranges from 3 kW to 175 kW, thereby allowing designers some design flexibility. Manufacturers have in recent years standardised their communications protocols, so that utilities can communicate with the inverters and control their output characteristics to assist with grid support.

String inverters present designers and installers with the following advantages:

- Multiple Maximum Power Point Trackers (MPPTs) allow the output of multiple strings to be optimised. Smaller inverters will only have one MPPT, but larger ones will have up to 12. This allows large systems that are subject to multiple orientations or large amounts of partial shading to have some degree of granularity in their optimisation.
- Flexibility of installation locations. On larger array's, string inverters are typically able to be installed in the array field or in a central location providing design flexibility, allowing for optimal design as per site characteristics.
- Can be installed by one or two workers (depending on the weight of the inverter). They do not require specialist knowledge to install beyond what would be expected of a trained solar installer. As these inverters are usually stocked by wholesalers, they can quickly be deployed in case one needs to be replaced. This is particularly important in remote areas.
- Lower downtime due to inverter failures. Spare inverters can be kept on site and faulty units replaced without the need to specialised technicians. Inverter failures have a lower impact due to the larger number of units deployed across array, this lowers the risk of solar farm outages.

However, the following disadvantages must be considered:

- Communication (and control) between multiple inverters over a large area (e.g. a ground-mount solar farm) can be problematic. A high number of devices on the same network and long distances between each can be a considerable impediment to quick response times or communication reliability.
- In large arrays, string inverters are often installed dispersed throughout the array which can lead to high AC line losses as cable runs to transformers can be long.

BESS

Containerised BESS

Large-scale BESS is typically enclosed in shipping containers - either 20' or 40' - or in a similar form which is compatible with transport infrastructure designed for intermodal containers. These enclosures are shipped with all necessary switchgear and battery mounting structure pre-installed by the manufacturer, reducing the cost of installation. Battery units are transported to site and installed within the enclosure after it has been installed on its footings. They are typically mounted on piers and require site-specific civil design to accommodate the weight of the BESS. BESS of this scale connect to the network at HV and require security fencing to isolate HV equipment from the public.

Community BESS

Community BESS in this instance refers to battery systems connected to the LV distribution system, usually of several hundred kilowatt-hour capacity. These systems have become increasingly popular as battery costs decrease and solar penetration increases in distribution networks. They typically comprise multiple pad mounted LV cabinet containing all necessary switchgear and battery racking. Cabinets must be lockable, but security fencing is not required for community BESS if connecting at LV.

Behind the Meter BESS

Behind the meter (BTM) BESS in the context of this report refers to battery systems connected at single premises, usually in the range of five to two hundred kilowatt-hours of capacity. Government incentives and low battery costs have seen adoption of these single premise batteries rise sharply in the last few years. These BESS are typically modular, all-in-one units; the desired energy storage capacity is achieved by installing as many units as required. Capacity is limited by the management system's capacity to control more units.

BTM BESS typically cost in the region of 1000 $/kWh for systems in the 100-200kWh range, with the cost increasing to 1500 $/kWh in the residential range (6-10 kWh).

Global Costing Assumptions

The following are assumptions made to allow this cost forecasting exercise.

- An exchange rate of 0.65 USD/AUD is used for procurement costing. It is worth noting that both PV and Li-ion batteries have not had stable price trajectories due to raw material availability and that this is likely to continue.
- These forecasts are in current (mid-2023) pricing; there has been no accounting for inflation.
- Transport estimates account for shipping ex Shanghai to Sydney, then trucked to the South Coast.
- All systems make use of 2h batteries except where noted.
- Due to the unusual arrangements for securing land potentially available to the project, land costs are not included in the project costing.
- In the case of 4.99MW limited solar farms, inverters are sized to operate at 0.93 PF while still being capable of exporting 4.99MW.

Capex Costing Breakdown

Costing for each site is broken down into the 5 components listed below. Note that some project costs are fixed, some are proportional to system size and some have fixed and proportional components. To provide context for the solar costings provided in this report, rooftop PV systems typically cost 1,400 – 1,600 $/kW$_p$.

Each of these components is comprised of many sub-elements which are not extensively reproduced in this report, although a brief description of these parts is given below.

Development Works

Component	Description
Prelim/Detailed Connection Enquiries	The stages of the connection application which establishes the project and relationship between the project developer and Essential Energy.
Connection Application Fees	This covers the cost-recovery fees charged by Essential Energy in the assessment of the power system studies and legal costs associated with creating the contracts, agreements and conveyancing related to easement creation.
Connection Application Studies	The costs associated with the power system modelling which is necessary to ensure that the new generator will not negatively affect the operation of the network.
Planning Approval	Costs associated with achieving planning approval with the local council.
Development Works Project Management	The fees associated with assigning a project management resource to the tasks in this category.

EPC Procurement

Component	Description
Tender Documents	Costs associated with the creation of tender documentation to facilitate the appointment of an engineering, procurement and construction (EPC) contractor to the project. This would typically include the contract structure, technical specifications, performance guarantees and annexures.
Tender Evaluation	The costs associated with seeking clarifications required of the tender responses, assessment of the tender responses and provision of assessment outcomes to the project principal.
Contract Negotiations	Costs associated with finalising the EPC contract.

Design and Construction – Principal

Component	Description
Project Management/Contract Administration	Design and Construction Project Management costs are estimated at 20% FTE for 6 months.
Owner's Engineer	Costs associated with the appointment of an Owner's Engineer, which act as a technical oversight on behalf of the principal.
Non-Contestable Connection Works	Costs incurred by Essential Energy in upgrading their assets at the local substation. Not required in all but the largest projects.
Reconductoring/ Augmentation	Costs incurred in upgrading the distribution network to allow the installation of a large generator. This cost is incurred by many of the large microgrid projects in this study.

Design and Construction – EPC

Component	Description
Design and Construction Project Management	Costs associated with both the detailed design and project management throughout the design, construction and commissioning stages of the project.
Site Establishment and Contestable Works	This component of the costing includes the civil works, fencing, creation of access roads, parking, site offices and laydown areas.

PV Installation	• PV Weather Station(s) – necessary for the operation of the single axis tracking (SAT) system where used, also used to validate system performance via the calculation of a performance ratio using meteorological data from the station. • PV Modules (FOB) – Free-on-board (FOB) supply cost of modules. 460W modules are costed on PEG systems, 540W on the SAT system. • PV Mounting System (FOB) – either the PEG (fixed tilt E-W oriented concertina style system) or SAT (single axis tracking) mounting structure cost for the system as specified. • PV MVPS (FOB) – supply cost of inverter/MV transformer/switchgear unit. • PV BOS – PV array balance-of-systems (BOS) cost; all required materials to complete PV installation other than the items specifically outlined above. • PV Install & Commission • PV Shipping to Port – Shipping to Sydney ex. Shanghai for modules. • PV Delivery to Site – Transport via truck from Sydney to site.
BESS Installation	• BESS Project Management • BESS Engineering – non-recurring engineering associated with the project, e.g. programming of the BESS controller to suit system objectives and comms link to dispatcher. • BESS Foundations (fixed) • BESS Foundations (marginal) • BESS Modules, Enclosure, HVAC, Inverters – supply cost of the BESS system. • BESS Transformers • BESS BOS, Install, & Commission
SCADA/Comms and Auxiliaries	Costs associated with establishing a secure internet connection to the site and linking all relevant pieces of equipment to their respective monitoring platforms/SCADA interface. This includes the costs associated with running LV circuits to power these devices as well as tertiary systems e.g. security, lighting, etc.

EPC Margin and Contingency

The EPC margin for these projects is likely to fall in the range of 17.5-22.5%, increasing as the project size decreases and as perceived risk associated with the project works increases. Margin has been assigned to each of these projects on that basis.

Opex Costing Breakdown

Operational expenditure for each site is broken down into the 4 components listed below. Some of these components is comprised of sub-elements which are not extensively reproduced in this report, although a brief description of these parts is given below.

Exclusions from these operational costs are the costs associated with the operation of the entity which will function as the site owner, be that a community group or private commercial entity. As such, costs attached to stakeholder engagement and reporting are not covered. Also excluded are the land costs, which are highly variable and dependant on current use and future rezoning potential.

Component	Description
Management and Administration	Costs associated with the administration and project management throughout the operational phase of the project.
Site Operation and Maintenance Works	O&M contract value can vary greatly depending on up-time guarantees and response times and the associated damages associated with not meeting these metrics; that is, the risk the O&M contractor is asked to take on. Costs used in these estimates are based on 98% uptime guarantee and standard response times, with damages equal to lost generation beyond 2%. These are common terms. This cost is the base contract, no extra callouts for mowing or module washing have been considered.
Insurance	Insurance costs can vary as the insurance industry learns the intricacies of covering renewable energy and energy storage assets, and they have increased markedly recently. Costs are largely proportional to project Capex, with different multipliers applied to the PV and BESS components. These multipliers are backwards-engineered from previous projects, and therefore should be considered ballpark figures only.
Energy Brokerage	This cost is largely fixed; it covers the cost of administering the sale and purchase of energy on various markets which the development will have access to.

Site Level Design Justification

Bodalla

A 4.99 MW solar farm is specified for the large microgrid topology, chosen since it is the maximum capacity that can be installed without requiring formal AEMO registration as a generator. There is limited land availability for a solar farm of this scale. The Belectric PEG mounting system is the most land efficient mounting option, so is most appropriate in most of the sites within this project. At this scale, central inverters are more cost competitive than string inverters.

The location for the development is in the property accessed via Laidley Avenue behind the properties immediately to the east of the Princes Highway. This land is undulating and may present challenges to the developer, but was indicated to be the most appropriate land for the project by SHASA. Land to the north of Potato Point Road may provide an alternative should the identified lot prove unworkable. The land has good network access and is located within the load centre, which is attractive as no existing network asset will need to be able to carry the full demand of the microgrid when it is active.

For the larger microgrid, a 3650 kW/7150 kWh BESS has been specified. Containerised BESS are most appropriate at this scale. As at all sites, the BESS will be located within the solar farm footprint whenever a solar farm is specified.

For the small microgrid, multiple distributed community BESS making up the 1800 kW/1800 kWh total capacity will be more optimal, given their purpose will be to absorb and distribute rooftop PV generation from the community rather than to act as adjunct to the solar farm (as in the large microgrid case).

Bodalla Costing

Forecast project EPC margin: 17.5%.

Table 1: The generator sizing for the Bodalla microgrids

Topology	Generator Sizing
Large microgrid	1533 kW rooftop solar + 4990 kW solar farm + 3600 kW/7150 kWh battery
Small microgrid	1533 kW rooftop solar + 1800 kW/1800 kWh battery
Diesel Only	1800 kVA

Table 2: Modelled capital costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Development Works	*$278,000*	*$278,000*	*$278,000*
EPC Procurement	*$80,000*	*$80,000*	*$80,000*
Design & Construction - Principal	*$681,000*	*$331,000*	*$263,000*
Design & Construction - EPC	*$15,896,000*	*$1,513,000*	*$760,000*
EPC Margin and Contingency	*$1,910,000*	*$233,000*	*$88,000*
Total Projected Cost	***$18,845,000***	***$2,435,000***	***$1,469,000***

Table 3: Modelled operational costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Management and Administration	*$24,280*	*$3,600*	*$2,880*
Site Operation and Maintenance Works	*$100,138*	*$8,600*	*$6,600*
Insurance	*$62,860*	*$12,600*	*$3,420*
Energy Brokerage	*$20,000*	*$10,000*	*N/A*
Total Projected Annual Cost	***$207,278***	***$34,800***	***$12,900***

Broulee

The Broulee topologies call for a small microgrid BESS (4990 kW/5500 kWh). Given these capacities a centralised community BESS will be appropriate for the single site backup and a containerised BESS for the small microgrid.

Space is at a premium within the Broulee township, although some indication was given that land could be available to the project at the Banksia Village retirement community. Consideration was given to this option, although the realities of the installation; visual amenity and noise pollution associated with the operation of the batteries would likely render this option unworkable. The location specified for Broulee, at the corner of Train Street and George Bass Drive, was chosen due to the availability of land and proximity to the 11kV network while still maintaining adequate clearance to residences.

No consideration beyond the purely technical aspects of site selection was made for this site.

Broulee Costing

Forecast project EPC margin: 17.5%.

Table 4: The generator sizing for the Broulee microgrids

Topology	Generator Sizing
Large microgrid	Insufficient space available for large ground-mounted PV array
Small microgrid	6344 kW rooftop solar + 4990 kW/5500 kWh battery
Diesel Only	4990 kVA

Table 5: Modelled capital costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Development Works	*N/A*	*$278,000*	*$278,000*
EPC Procurement	*N/A*	*$80,000*	*$80,000*
Design & Construction - Principal	*N/A*	*$481,000*	*$481,000*
Design & Construction - EPC	*N/A*	*$4,036,000*	*$1,656,000*
EPC Margin and Contingency	*N/A*	*$675,000*	*$243,000*
Total Projected Cost	***N/A***	***$5,550,000***	***$2,738,000***

Table 6: Modelled operational costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Management and Administration	*N/A*	*$11,000*	*$7,984*
Site Operation and Maintenance Works	*N/A*	*$16,000*	*$12,980*
Insurance	*N/A*	*$38,500*	*$9,481*
Energy Brokerage	*N/A*	*$20,000*	*N/A*
Total Projected Annual Cost	***N/A***	***$85,500***	***$30,445***

Mystery Bay

A 4.99 MW solar farm is specified for the large microgrid topology, chosen since it is the maximum capacity that can be installed without requiring formal AEMO registration as a generator. There is limited land availability in Mystery Bay for a solar farm of this scale. The Belectric PEG mounting system is the most land efficient mounting option, so is most appropriate in this context. At this scale, central inverters are more cost competitive than string inverters. The land identified was put forward by SHASA, and will present challenges for solar farm development due to its size and gradients. Alternative lots are available around the Mystery Bay community, which is largely surrounded by cleared land.

For the larger microgrid, a 2000 kW/2000 kWh BESS has been specified. Containerised BESS are most appropriate at this scale.

For the small microgrid, multiple distributed community BESS making up the 550 kW/550 kWh total capacity will be more optimal, given their purpose will be to absorb and distribute rooftop PV generation from the community rather than to act as adjunct to the solar farm (as in the large microgrid case). The location selected for this BESS is adjacent to Lamont Young Drive at the corner of Negus Drive, a location about the centre of the community and with good access to the network which is uncongested (poles are not already in use for substations, links, reclosers, tees, etc.) For a community which is so small and fully reticulated at 11kV, the location is not particularly important from a technical standpoint; greater emphasis should be placed on the desires of the community.

Mystery Bay Costing

Forecast project EPC margin: 17.5% for large microgrid, 20% for small microgrid and diesel only projects.

Table 7: The generator sizing for the Mystery Bay microgrids

Topology	Generator Sizing
Large microgrid	425 kW rooftop solar + 4990 kW solar farm + 2000 kW/2000 kWh battery
Small microgrid	425 kW rooftop solar + 550 kW / 550 kWh battery
Diesel Only	500 kVA

Table 8: Modelled capital costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Development Works	*$278,000*	*$278,000*	*$278,000*
EPC Procurement	*$80,000*	*$80,000*	*$80,000*
Design & Construction - Principal	*$681,000*	*$81,000*	*$81,000*
Design & Construction - EPC	*$12,383,000*	*$1,659,000*	*$407,000*
EPC Margin and Contingency	*$1,910,000*	*$294,000*	*$29,000*
Total Projected Cost	***$15,332,000***	***$2,392,000***	***$875,000***

Table 9: Modelled operational costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Management and Administration	*$13,980*	*$2,200*	*$800*
Site Operation and Maintenance Works	*$89,838*	*$7,200*	*$4,000*
Insurance	*$31,960*	*$7,700*	*$950*
Energy Brokerage	*$20,000*	*$10,000*	*N/A*
Total Projected Annual Cost	***$155,778***	***$27,100***	***$5,750***

Central Tilba & Tilba Tilba

Again, a 4.99 MW solar farm is specified for the large microgrid topology, chosen since it is the maximum capacity that can be installed without requiring formal AEMO registration as a generator. There is limited land availability for a solar farm of this scale, principally due to competing uses for the land surrounding the Tilbas; mostly for use by the dairy. The Belectric PEG mounting system is the most land efficient mounting option, so is most appropriate in this context. At this scale, central inverters are more cost competitive than string inverters.

For the larger microgrid, a 3750 kW/5200 kWh BESS has been specified. Containerised BESS are most appropriate at this scale.

For the small microgrid, multiple distributed community BESS making up the 1300 kW/1300 kWh total capacity will be more optimal, given their purpose will be to absorb and distribute rooftop PV generation from the community rather than to act as adjunct to the solar farm (as in the large microgrid case).

Central Tilba & Tilba Tilba Costing

Forecast project EPC margin: 17.5% for large microgrid, 20% for small microgrid and diesel only projects.

Table 10: The generator sizing for the Tilba microgrids

Topology	Generator Sizing
Large microgrid	960 kW rooftop solar + 4990 kW solar farm + 2600 kW/5200 kWh battery
Small microgrid	960 kW rooftop solar + 1300 kW/1300 kWh battery
Diesel Only	1300 kVA

Table 11: Modelled capital costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Development Works	*$278,000*	*$278,000*	*$278,000*
EPC Procurement	*$80,000*	*$80,000*	*$80,000*
Design & Construction - Principal	*$681,000*	*$331,000*	*$269,000*
Design & Construction - EPC	*$14,422,000*	*$1,907,000*	*$639,000*
EPC Margin and Contingency	*$1,910,000*	*$344,000*	*$75,000*
Total Projected Cost	***$17,371,000***	***$2,940,000***	***$1,341,000***

Table 12: Modelled operational costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Management and Administration	*$19,960*	*$2,600*	*$2,080*
Site Operation and Maintenance Works	*$95,818*	*$7,600*	*$5,600*
Insurance	*$49,900*	*$9,100*	*$2,470*
Energy Brokerage	*$20,000*	*$10,000*	*N/A*
Total Projected Annual Cost	***$185,678***	***$29,300***	***$10,150***

Congo

A 0.99 MW solar farm is specified for the large microgrid topology. The capacity is smaller in this case due to land constraint and lower community load. Limited land availability necessitates the use of the Belectric PEG mounting system, given it is the most land efficient mounting option. At this scale, string inverters are more cost competitive than central inverters. The design includes 22 110 kVA string inverters. Space is at a premium within the community, which is largely surrounded by protected bushland. The solar farm has therefore been located in the field immediately behind the houses at the corner of Congo Road. This site has adequate access to the HV network and is reasonably flat, although the dam currently located at the site could potentially create difficulties during the design and construction phases, particularly in trenching cables. It is understood that this land is currently privately owned and hosts some livestock.

For the large microgrid, a 750 kW/1500 kWh BESS has been specified. Containerised BESS are most appropriate at this scale.

For the small microgrid, multiple distributed community BESS making up the 350 kW/350 kWh total capacity will be more optimal, given their purpose will be to absorb and distribute rooftop PV generation from the community rather than to act as adjunct to the solar farm (as in the large microgrid case). This community BESS has been located adjacent to the road reserve at the corner of Congo Road and Gum Leaf Drive, owing to the proximity of uncongested network access and the Congo load-centre.

Congo Costing

Forecast project EPC margin: 20% for large microgrid, 22.5% for small microgrid and diesel only projects.

Table 13: The generator sizing for the Congo microgrids

Topology	Generator Sizing
Large microgrid	550 kW rooftop solar + 1000 kW solar farm (PEG) + 750 kW/1500 kWh battery
Small microgrid	550 kW rooftop solar + 350 kW/350 kWh battery
Diesel Only	350 kVA

Table 14: Modelled capital costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Development Works	*$278,000*	*$75,000*	*$278,000*
EPC Procurement	*$80,000*	*$80,000*	*$80,000*
Design & Construction - Principal	*$681,000*	*$81,000*	*$81,000*
Design & Construction - EPC	*$4,247,000*	*$1,264,000*	*$376,000*
EPC Margin and Contingency	*$617,000*	*$241,000*	*$23,000*
Total Projected Cost	***$5,903,000***	***$1,741,000***	***$838,000***

Table 15: Modelled operational costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Management and Administration	*$5,000*	*$1,500*	*$560*
Site Operation and Maintenance Works	*$24,200*	*$6,500*	*$3,700*
Insurance	*$13,000*	*$5,250*	*$665*
Energy Brokerage	*$10,000*	*$10,000*	*N/A*
Total Projected Annual Cost	***$52,200***	***$23,250***	***$4,925***

Nelligen

A 0.99 MW solar farm is specified in Nelligen for the large microgrid topology. The capacity is smaller in this case due to land constraint and lower community load. Limited land availability necessitates the use of the Belectric PEG mounting system, given it is the most land efficient mounting option. At this scale, string inverters are more cost competitive than central inverters. The design includes nine 110 kVA string inverters to give a total AC capacity of 0.99MVA, therefore being able to access connection application pathways with less cost and scrutiny.

Flat, available land is at a premium within the Nelligen area, which is largely surrounded by protected bushland and steep hills. The solar farm has therefore been located in a field to the north of Nelligen creek and to the west of the town centre. This site has reasonable access to the HV network and is reasonably flat, although it is possible that this land is subject to flooding. It is understood that this land is currently privately owned, its use is unknown.

For the large microgrid, a 990 kW/3950 kWh BESS has been specified. Containerised BESS are most appropriate at this scale.

For the small microgrid, multiple distributed community BESS making up the 990 kW/990 kWh total capacity will be more optimal, given their purpose will be to absorb and distribute rooftop PV generation from the community rather than to act as adjunct to the solar farm (as in the large microgrid case).

Nelligen Costing

Forecast project EPC margin: 20% for large microgrid, 22.5% for small microgrid and diesel only projects.

Table 16: The generator sizing for the Nelligen microgrids

Topology	Generator Sizing
Large microgrid	715 kW rooftop solar + 1000 kW solar farm + 990 kW/3960 kWh battery (4h)
Small microgrid	715 kW rooftop solar + 990 kW/990 kWh battery
Diesel Only	990 kVA

Table 17: Modelled capital costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Development Works	*$278,000*	*$278,000*	*$278,000*
EPC Procurement	*$80,000*	*$80,000*	*$80,000*
Design & Construction - Principal	*$681,000*	*$331,000*	*$275,000*
Design & Construction - EPC	*$5,970,000*	*$1,022,000*	*$567,000*
EPC Margin and Contingency	*$617,000*	*$186,000*	*$66,000*
Total Projected Cost	***$7,626,000***	***$1,897,000***	***$1,266,000***

Table 18: Modelled operational costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Management and Administration	*$9,900*	*$1,980*	*$1,584*
Site Operation and Maintenance Works	*$29,100*	*$6,980*	*$4,980*
Insurance	*$27,700*	*$6,930*	*$1,881*
Energy Brokerage	*$10,000*	*$10,000*	*N/A*
Total Projected Annual Cost	***$76,700***	***$25,890***	***$8,445***

South Durras

The Broulee topologies call for a single site backup BESS (50 kW/400 kWh) and a small microgrid BESS 1200 kW/1200 kWh). This BESS is of a smaller scale than most others in the project, and could allow alternative form factors, although a containerised solution is still likely to be the most financially appropriate.

The South Durras BESS has been placed near the entrance to the Big4 Holiday Park along Durras Lake Road. This location is appropriate in a technical context due to the location between the two halves of the South Durras community which minimises electrical loading of any individual network asset. During community workshops the ecological importance of this area was highlighted, indicating that the BESS should be moved to another location between these load centres that is not is as environmentally significant. Any location along Durras Lake Road will be appropriate.

South Durras Costing

Forecast project EPC margin: 20% for small microgrid, 22.5% for diesel only project.

Table 19: The generator sizing for the South Durras microgrids

Topology	Generator Sizing
Large microgrid	Insufficient space available for large ground-mounted PV array
Small microgrid	780 kW rooftop solar + 1200 kW/1200 kWh battery
Diesel Only	1200 kVA

Table 20: Modelled capital costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Development Works	*N/A*	*$278,000*	*$278,000*
EPC Procurement	*N/A*	*$80,000*	*$80,000*
Design & Construction - Principal	*N/A*	*$331,000*	*$275,000*
Design & Construction - EPC	*N/A*	*$1,783,000*	*$630,000*
EPC Margin and Contingency	*N/A*	*$319,000*	*$80,000*
Total Projected Cost	***N/A***	***$2,791,000***	***$1,343,000***

Table 21: Modelled operational costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Management and Administration	*N/A*	*$2,400*	*$1,920*
Site Operation and Maintenance Works	*N/A*	*$7,400*	*$5,400*
Insurance	*N/A*	*$8,400*	*$2,280*
Energy Brokerage	*N/A*	*$10,000*	*N/A*
Total Projected Annual Cost	***N/A***	***$28,200***	***$9,600***

Tuross Head

A 4.99 MW solar farm is specified for the large microgrid topology, chosen since it is the maximum capacity that can be installed without requiring formal AEMO registration as a generator. Since land is not constrained at this site, single axis tracking system has been used. At this scale, central inverters are more cost competitive than string inverters.

As land on the peninsula is relatively plentiful compared to other communities in the project, a single axis tracking (SAT) system has been specified. As described earlier, the SAT structure will increase output at the expense of increased footprint and complexity.

For the larger microgrid, a 4990 kW/19960 kWh BESS has been specified. Containerised BESS are most appropriate at this scale. For the small microgrid, the capacity (4990 kW/4990 kWh) is too high for distributed community BESS to be feasible. Instead, a containerised BESS has been proposed to be located at the end of Coila Avenue, a central location within the community with excellent network access.

Tuross Head Costing

Forecast project EPC margin: 17.5% for all projects.

Table 22: The generator sizing for the Tuross Head microgrids

Topology	Generator Sizing
Large microgrid	8830 kW rooftop solar + 4990 kW solar farm + 4990 kW/19960 kWh battery
Small microgrid	8830 kW rooftop solar + 4990 kW/4990 kWh battery
Diesel Only	4990 kVA

Table 23: Modelled capital costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Development Works	*$278,000*	*$278,000*	*$278,000*
EPC Procurement	*$80,000*	*$80,000*	*$80,000*
Design & Construction - Principal	*$681,000*	*$681,000*	*$681,000*
Design & Construction - EPC	*$15,988,000*	*$3,695,000*	*$1,656,000*
EPC Margin and Contingency	*$1,586,000*	*$615,000*	*$243,000*
Total Projected Cost	***$18,613,000***	***$5,349,000***	***$2,938,000***

Table 24: Modelled operational costs for the microgrid sizing listed above

Component	Projected Cost – Large Microgrid	Projected Cost – Small Microgrid	Projected Cost – Diesel Only
Management and Administration	*$29,980*	*$10,000*	*$7,984*
Site Operation and Maintenance Works	*$83,383*	*$15,000*	*$12,980*
Insurance	*$79,960*	*$35,000*	*$9,481*
Energy Brokerage	*$20,000*	*$20,000*	*N/A*
Total Projected Annual Cost	***$213,323***	***$80,000***	***$30,445***

Next Steps

With the forecast capital and operational costings available for these projects, assessment of the project revenue streams can be completed and the financial case for each system established. This will allow selection of the most appropriate system for each location, noting that the most appropriate system may not be the one with the strongest financial justification.

Once this is complete, the system sizes can be presented to Essential Energy to begin the connection process and the broader discussion about embedded microgrids.

Please direct any clarifications about the contents of this report to Matthew O'Regan at moregan@itpau.com.au.