Mullewa Renewable Microgrid

Feasibility Study Report

Document Revision: 1.0

Date: 31 August 2023

sunrise
energy group

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ABBREVIATIONS

AEMO	Australian Energy Market Operator
AES	Alternative Energy Services
AOS	Alternative Options Strategy
ARENA	Australian Renewable Energy Agency
BESS	Battery Energy Storage System
CBH	Cooperative Bulk Handling
CGG	City of Greater Geraldton
CMD	Contracted Maximum Demand
CMS	Customer Main Switch
CPI	Consumer Price Index
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CT	Current Transformer
DC	Direct Current
DER	Distributed Energy Resources
DPLH	Department of Planning, Lands and Heritage
DSOC	Declared Sent Out Capacity
EFTPOS	Electronic Funds Transfer at Point of Sale
EMN	Embedded Network (Microgrid)
EMNOP	Embedded Network (Microgrid) Operator
EOPA	Energy Operators (Powers) Act 1979 (WA)
EPWA	Energy Policy WA
ERA	Economic Regulation Authority (WA)
ERG	Emergency Response Generator
ESOO	Electricity Statement of Opportunities
ESS	Essential System Services
ETAC	Electricity Transfer Access Contract
EV	Electric Vehicle
FCAS	Frequency Control Ancillary Services
FEED	Front End Engineering Design
FFR	Fast Frequency Response
FID	Final Investment Decision
GHI	Global Horizontal Irradiance
HV	High Voltage
IRR	Internal Rate of Return
JDAP	Joint Development Assessment Panel
LGC	Large-scale Generation Certificate
LiDAR	Light Detection and Ranging
MEEDAC	Midwest Aboriginal Employment and Economic Development
MO	Microgrid Operator
MWDC	Mid-West Development Commission
NAQ	Network Access Quantity
NCESS	Non Co-optimised Essential System Services
NCS	Network Control Service
NDA	Non-Disclosure Agreement
NER	Neutral Earthing Resistor
NMI	National Metering Identifier
NOJA	Brand of Recloser
NOM	Network Opportunity Map
NZE	Net Zero Emissions
PPA	Power Purchase Agreement
PPC	Power Park Controller
PV	Photovoltaic
REIWA	Real Estate Institute of WA
RGS	Renewable Generation and Storage
RMC	Remote Monitoring and Control
ROI	Return on Investment
SAFD	Step-away From Decarbonisation
SCGZ	Galvanised Steel Conductors
SLD	Single Line Diagram
SPS	Stand-Alone Power System
STC	Small-scale Technology Certificate
SWIS	South-West Interconnected System (WA's main electricity grid)
TDL	Temperature Dependant Load
UPS	Uninterruptable Power Supply
VPP	Virtual Power Plant
VT	Voltage Transformer
WA	Western Australia
WEM	Wholesale Electricity Market (WA)
WP	Western Power
WPN	Western Power Network
YSRC	Yamatji Southern Regional Corporation

1 PREFACE

With the current upheaval being seen in the energy sector, driven by the need to decarbonise, it is an exciting time to be exploring the possibilities around the deployment of renewable microgrids at the fringe-of-grid, and the role they can play in this overall transition to a new energy landscape.

Recent forecasts for increased energy demand in the SWIS from the 2023 WEM ESOO [13] (ref. Figure 1-1) suggest there are serious challenges ahead in meeting this demand, as reflected in the capacity shortfalls being predicted.

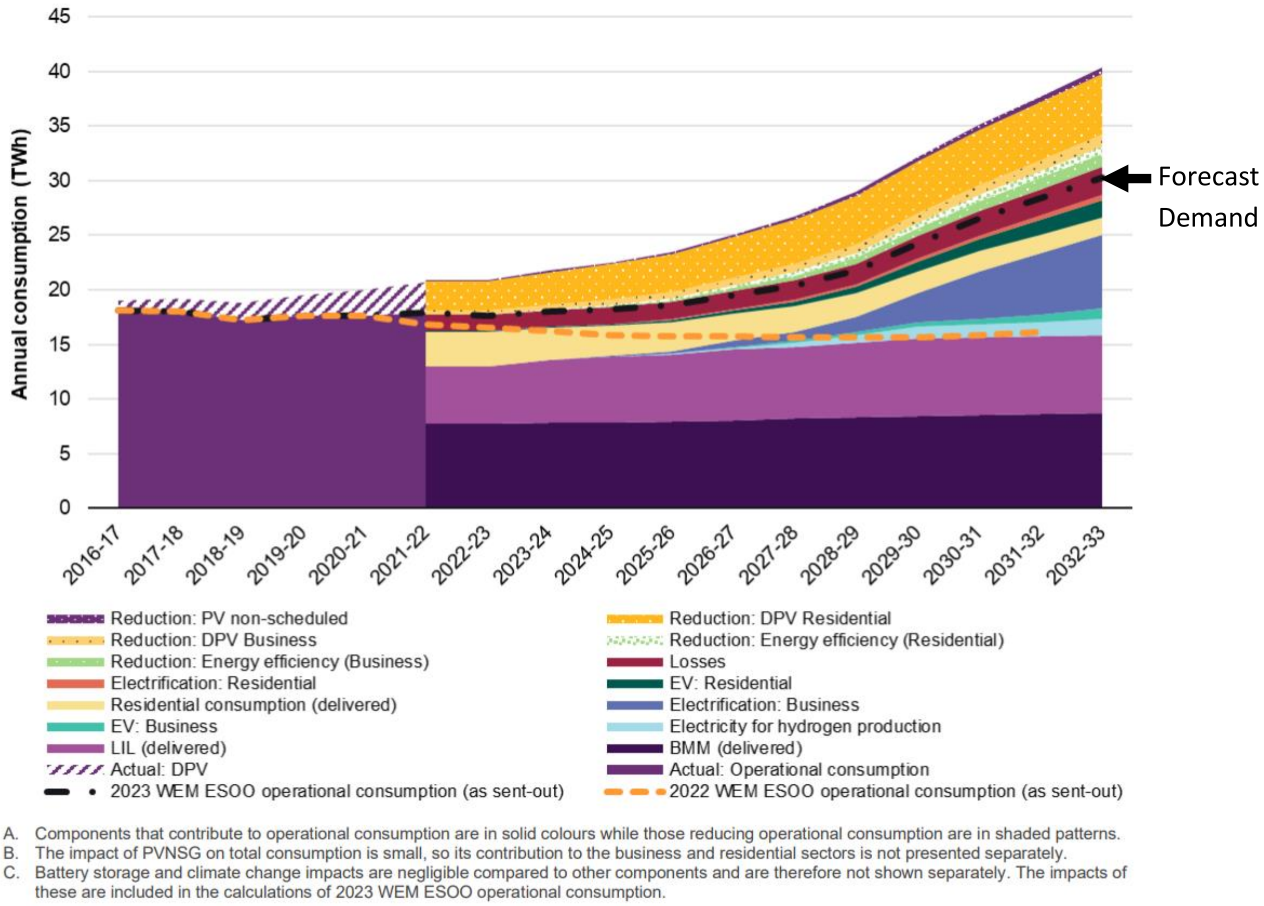


Figure 1-1: Forecast consumption in the WEM (source: 2023 WEM ESOO [13], Figure 15)

These challenges are focussing attention on the transmission work that will be necessary to connect new generation capacity, however what also needs to be understood is that this generation will be consumed via the distribution network, and so although there are challenges, Sunrise Energy Group (Sunrise) believe this also opens up possibilities in the distribution network, e.g. to harness as much as possible of the existing distribution network, through innovative solutions, to make a significant contribution in the grid transformation process that supports a decarbonised energy system.

Integral to this will be utilising the distribution network to deliver renewable generation close to where it is consumed in the least capacity restricted areas of the network, which includes most of the fringe-of-grid. This inherently improves reliability of supply to these areas and supports them in their transition to the "electrify everything" goal and also contributes to the overall SWIS decarbonisation objective plus delivers savings to the entire SWIS through the reduction in lines losses (which can be significant).

Unlike what is being seen in the east of Australia, where grid transformation driven by new transmission can see opposition from the affected local communities, this multiple small scale approach where the benefit to the local area is clearly evident, is typically supported and welcomed by these communities.

It is in this context that the impetus to conduct this study, to test and prove these concepts, was derived, and which Sunrise believe the outcomes from the study, has achieved.

For Sunrise, the job doesn't finish with the completion of the study as we aim to pursue this development through to execution and operation of a pilot demonstration in Mullewa that will provide a proof-of-concept that enables this model to be rolled out to other fringe-off-grid communities looking for improved power reliability and the associated benefits this brings.

2 Introduction

The Mullewa Renewable Microgrid Feasibility Study (the Study) involved a 21 month examination into the viability of deploying a renewable energy microgrid in the fringe-of-grid town of Mullewa, a town in the City of Greater Geraldton located in the mid-western Region of WA, approximately 450km north of Perth, ref. Figure 2-1 .

Figure 2-1: Mullewa location within Western Australia

Mullewa has an estimated population of approximately 450 and its location (relative to the SWIS) and the network connections of the Mullewa township can be seen in Figure 2-2.

The Project has been completed by Sunrise Energy Group Pty Ltd (Sunrise), in collaboration with Enzen Australia Pty Limited (Enzen), a developer of a digital twin for the Mullewa network.

The Electricity Networks Corporation, trading as Western Power (Western Power) and the Electricity Generation and Retail Corporation, trading as Synergy (Synergy) have also have had involvement in the Study.

Collaborating and providing support to the Study has in no way been a commercial commitment or solution preference on Western Power's part, particularly given its work on other regional reliability and network augmentation projects. Similarly, Synergy is not a party to the Study and has made no commercial commitment. Its role in the Study is only to provide data, engage the community (as requested), and to provide support to Sunrise. All statements, opinions, modelling and outcomes set out in this report are wholly those of Sunrise Energy Group, and do not reflect and may not be attributed in any way to Synergy or Western Power.

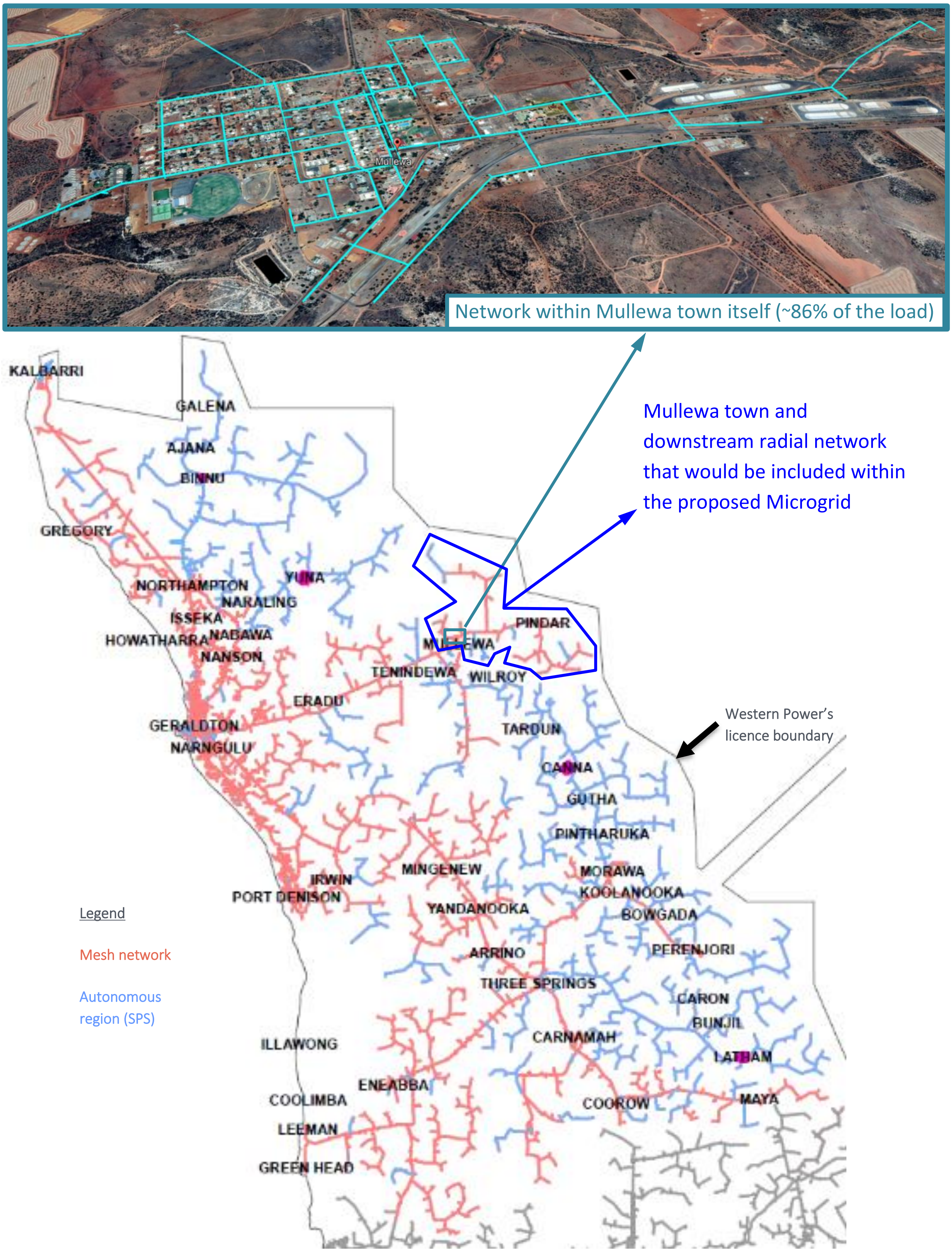


Figure 2-2: Mullewa town and downstream radial network in relation to the SWIS

The Study was initiated as a result of the initial question of: "*How do we solve the 'problems' of fringe-of-grid towns on the SWIS with a replicable model*"? The problems being:

- the low reliability of these towns, typically on long radial feeders
- the subsidisation of these towns by the rest of the SWIS
- the uncertainty surrounding long term sustainability of a grid supply (given Western Power identifying fringe disconnection as part of their "Grid Evolution" discussions).

This led to Sunrise applying for funding to complete a Microgrid Feasibility Study at a specific location, and entering into a Collaboration Agreement with Enzen, Western Power and Synergy in respect to the nature and scope those parties have agreed to collaborate and provide support to the Study.

In 2019 Western Power provided a list of ten worst performing locations, which included Mullewa. From this list Mullewa was selected as the location for the Study. Mullewa is located at the end of a 100km radial feeder, which has suffered from poor reliability, has significant line losses and dated infrastructure.

The Study aims to develop a commercially sound, technically and economically feasible solution to significantly improve energy reliability, improve amenity for Mullewa residents and to retain and attract business to the town. The objective is that the model is replicable at other fringe of grid and potentially off-grid sites around WA and Australia, with key learnings and knowledge disseminated as part of the Study.

The Study scope includes modelling the use of renewable energy generation such as solar panels or wind, supported by battery energy storage systems (BESS), which would be distributed to the town via the microgrid solution. Innovative technology and software will play a key role in automation and control. Key activities focus on engaging with the Mullewa community to develop the best solution for its needs, while equally ensuring that the solution is technically, commercially, and financially feasible and viable.

The study was executed in 6 phases:

- Phase 1 – Establish Digital Twin of the Target Network
  - Capture/collection of data describing various attributes of the network and represent in a digital environment that can be used as a tool in the efficient management of that infrastructure.
- Phase 2 – Model Technical/Commercial Solutions
  - Development of a technical solution that reduces outages and improves reliability and model under different commercial assumptions to establish the most viable solution.
- Phase 3 – Test Future Scenarios on Proposed Solution
  - Run the proposed solution through a series of potential scenarios that could occur over the long term.
- Phase 4 – Community Engagement
  - Engage with the community to understand their appetite for a Microgrid reliability solution, understand their priorities in relation to service from the system and test the reception of the proposed solution.
- Phase 5 – Development Activities
  - Undertake development activities to prepare the proposed solution for investor readiness for upscaling.

- Phase 6 – Document Results and Seek Investors
  - Prepare documentation that records all the results that were obtained from the modelling process. The documentation will be used when engaging with potential investors to portray the benefits of the Project.

3 DEFINITION OF MICROGRID

In order to execute a study around a "Microgrid solution", it is a good idea to have a definition of what a Microgrid is. The answer to this is not as obvious as it may seem, and in exploring this, it was evident that the term Microgrid does not have a unique/fixed definition and has widely been used to describe several different small electrical grid configurations.

After looking into the varying definitions that have been applied and in consultation with the other participants in the study, for the purpose of this study the following, relatively loose definition, has been selected:

In the SWIS, a microgrid is a section of the Western Power network that:

a) is still connected to the meshed network (grid)
b) has the ability to be islanded as an autonomous system, and
c) Includes local renewable generation and storage

4 SUMMARY

The outcomes from the Study are:

- It is feasible to deliver a technically and commercially viable Renewable Microgrid Pilot Project in the town of Mullewa, with this conclusion supported through detailed commercial modelling and significant development activities including thorough FEED work and associated fully costed estimate, culminating in the submission of a development application to the City of Greater Geraldton and regional JDAP, and submission of an Alternative Options proposal to Western Power for a reliability service.
- The selection of an "in-front-of-the-meter" commercial model over an "embedded network style" model was based on avoiding current policy/regulatory hurdles, despite commercial and other benefits recognised in the study for the "embedded network style" model and development of a pathway through these regulatory hurdles.
- This Microgrid would significantly improve the reliability of power supply to the town.
- This Microgrid would contribute to reduction in line losses in the SWIS benefitting all customers in the SWIS by reducing overall operating costs.
- The development of a renewable microgrid in Mullewa has the support from the local community through to the WA Minister for Mines and Petroleum; Energy; Hydrogen Industry; Industrial Relations.
- There are funding grants available that the pilot project is eligible to apply for, on the completion of this feasibility study, and investors interested in renewable energy projects exist, that would enable the execution of the pilot project, which is estimated to offer an IRR close to 9%. Key to executing the pilot project will also be Western Power acceptance of the Alternative Options Proposal.
- The production of a digital twin for the Mullewa network has validated that this is in fact an achievable construct and demonstrated the potential value for this technology in terms of managing an electricity network and improving the operating efficiency.
- Lessons learnt while completing the Study (ref. Section 13) which, in addition to those that will be learnt from executing and operating an actual microgrid pilot project in Mullewa, should assist in reducing the risks and cost of a repeatable model applied to other fringe-of-grid towns in the future.

The integration of the proposed Microgrid is shown in Figure 4-1 and comprises the following main features:

- 1.1MW solar array and 3MWh battery co-located.
- Connection point site located adjacent to the solar array and approximately 1.5km from existing Western Power HV powerline. This is the site where the protection and automation controls are located that initiate the islanding of the Microgrid on loss of the grid supply and then allows the town load to be taken up by the Microgrids renewable generation and storage infrastructure, controlling the operation until the grid power is restored.
- One 750kVA diesel genset located at the connection point site.
- Two 600kW wind turbines located approximately 1.3km from the connection point.
- Automated recloser for islanding of the Mullewa network and associated downstream radial line. Located approximately 3.4km by line of sight from the connection point with radio communication between the recloser and the connection point.
- Western Power Network Control Communications implemented via combination of mobile radio (4G) and satellite communications.

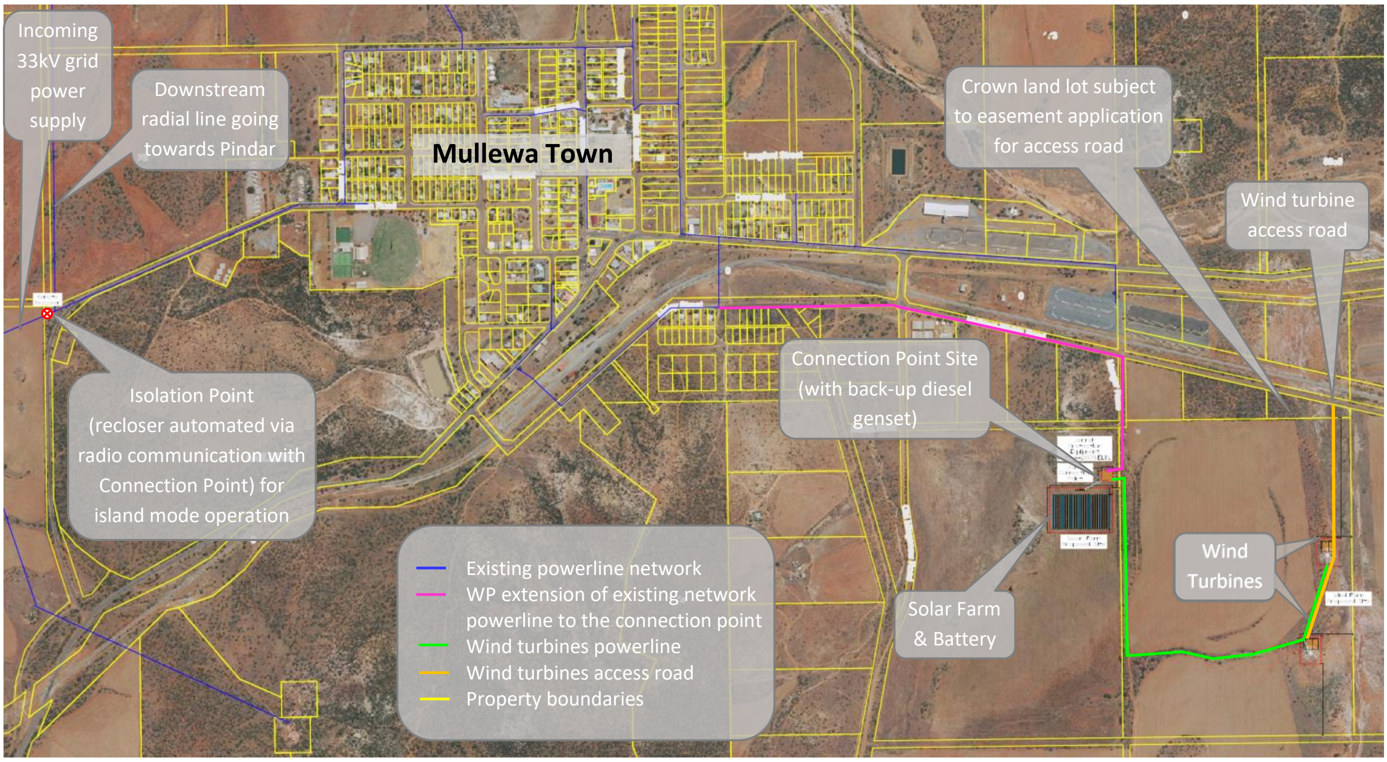


Figure 4-1: Layout showing the integration of the Microgrid infrastructure

The commercial model is based on generating income through:

- Sale of the generated energy via a long-term offtake agreement with a retailer or via a 3rd party service in the WEM at the balancing market price.
- Sale of the LGC certificates earnt from the renewable generation.
- Charging Western Power an annual fee for a reliability service, that would involve automatic islanding off the Mullewa network and uptake of the load by the Microgrid on loss of grid supply. The fee is based on WP power waiving the network tariff for the renewable generation connection point (if WP preferred, the network tariff would still apply but be added to the fee charged for the reliability service).
- Capacity credits earnt from the reserve capacity market for the combined renewable generation capacity, battery capacity and diesel generation capacity.

Execution of the project after achieving FID is expected to take 13 months (ref. project execution schedule under Appendix A) with the critical path driven by the long lead delivery of connection point equipment and the connection point site construction and then system commissioning.

Risks and Opportunities associated with the project have been evaluated and summarised under Section 12, with the top risks being:

- Western Power not accepting the Alternative Options Proposal for the reliability service.
- Inability to secure funding form ARENA necessary to de-risk the project and make-up the difference in capital associated with the first-off nature of a pilot project.

In terms of opportunities the most promising is estimated to be an opportunity to transition the Microgrid at some point in the future, to an "embedded network style" Microgrid that would incentivise the Microgrid Operator to encourage development in the region that would grow the load and by association the town and opportunities in the town.

Sunrise are also keen to look at some of the opportunities for demonstrating agrivoltaics at small scale rural solar farms, and the possible benefits that this can provide for the local communities.

Ref. Table 16 for a list of other identified opportunities.

5 MULLEWA

The following section provides an overview of the Mullewa township with an attempt to put into context the value of a reliable power supply for this community. Mullewa's solar and wind resources are also examined.

5.1 Demographics

Mullewa is a small town in the Mid-West region of Western Australia, it is a vibrant, diverse and resilient community, rich in both natural and cultural heritage. Mullewa is well known for an abundance of wildflowers in spring, and it is one of the few places in the world that the wreath flower grows. The surrounding areas of Mullewa produce wheat and other cereal crops and the town is a receival site for Cooperative Bulk Handling (CBH) at the towns railyard.

Mullewa has an estimated population of approximately 450, with the most recent Census data indicating Aboriginal and/or Torres Strait Islander people comprising 34% of the Mullewa population. The top five industries by employment in Mullewa are:

- Grain growing (11.6%)
- Local government administration (11.6%)
- Arts education (9.9%)
- Primary education (9.1%)
- Hospitals (8.3%).

Census data in 2021 indicates Mullewa has a lower proportion of its population in the labour force (39.4%) compared with average national levels (61.1%). The average unemployment rate of 9.3%, which is considerably higher than the Australian and WA average. The average household income was also much lower than the national average, documented to be $828 weekly compared to $1,746 in Australia. However, the census data shows that 53.4% of the community own their own home or own with a mortgage. This is considerably higher than the national average (31.5%) but could be attributed to the lower average cost of homes in the town (average $102k according to REIWA).

Technicians, trade workers / labourers and community and personal service workers make up 51.5% of the labour force in Mullewa.

Population decline of about 20% since the 2016 census and limited economic activity are likely to impact on local business and services to the community.

5.2 Health

Health care services in Mullewa include a Hospital, Medical Centre and a Pharmacy and they are all co-located on the same site. In 2016, the State Government announced plans to build a new Health Centre to replace the ageing Mullewa Hospital. As of August 2023, the new Health Care Centre has not progressed from the planning stages. In February 2023 the Health Minister Amber-Jade Sanderson advised that the construction on the Mullewa Health Centre would begin sometime after upgrade work commences on the Geraldton Health Campus, which is still in the expression of interest stage.

The unplanned power outages documented in section 7.1 can have a significant impact on healthcare services. In a 2019 ABC News report [7] the Mullewa town doctor, GP Nalini Rao had described the power supply to Mullewa as “fourth world” after she had to dispose of vaccines for the third time in as many years. Dr Rao said the electricity outage in 2019 cut power to the surgery's refrigerator and a backup system also failed. In the same year, the Geraldton mayor Shane Van Styn, also echoed the doctor’s frustrations saying that the yearly power problems were creating "great hardship" for the community during summer, and there were no alternative sources of power.

Since the Emergency Response Generator (ERG) was installed in 2019 there have been 10% less outages recorded in the town. However, the total number of hours power has been out has actually increased by an average of 19 hours annually (ref. Table 3 in Section 7.1).

5.3 Education

There are two schools in Mullewa. Mullewa District Schools serves kindergarten through to year 12 students and Our Lady of Mount Carmel is a Kindergarten to Year 6 Catholic Primary School.

Energy reliability can impact on the quality of education that can be provided at schools, and in particular in regions like Mullewa that are relatively remote and experience high temperatures. Reliable energy enables the provision of a comfortable learning environment as well as consistent access to the internet. Energy interruptions may require school closures or at least impact on attendance rates and limit access to online curriculum and resources.

5.4 Employment Opportunities

With employment levels currently below national levels, there are direct employment opportunities that may come with deployment of a renewable microgrid as well as the indirect opportunities through potential to attract and grow businesses in the town because of an increase in the reliability of power supply.

Table 1: Employment opportunities from microgrid implementation

Scope	Employment Opportunity
Construction, operation, and maintenance	Opportunities for direct employment including indigenous labour to undertake project construction works and maintenance
Energy related skill development	Opportunities for creating career paths through upskilling and training community members in energy related skills including operation and maintenance of project components
Local primary production business stimulation	Opportunities for local businesses to operate without interruption, increasing their output and in turn their number of employees
Hospitality, tourism, and other services	Opportunities to maintain or increase services to holiday rentals, increased visitation resulting in more expenditure in local hospitality business. Ability to maintain EFTPOS, mobile and landline phones, cooking facilities and online business so business able to remain open. Less food spoilage.

5.5 Solar Resources

Figure 5-1 below shows the daily and annual global horizontal irradiance (GHI) that can be used to generate power on a kilowatt hour per square metre basis. It is evident that Australia has high levels of irradiance with much of Australia's daily average levels exceeding 5.4 on the GHI index.

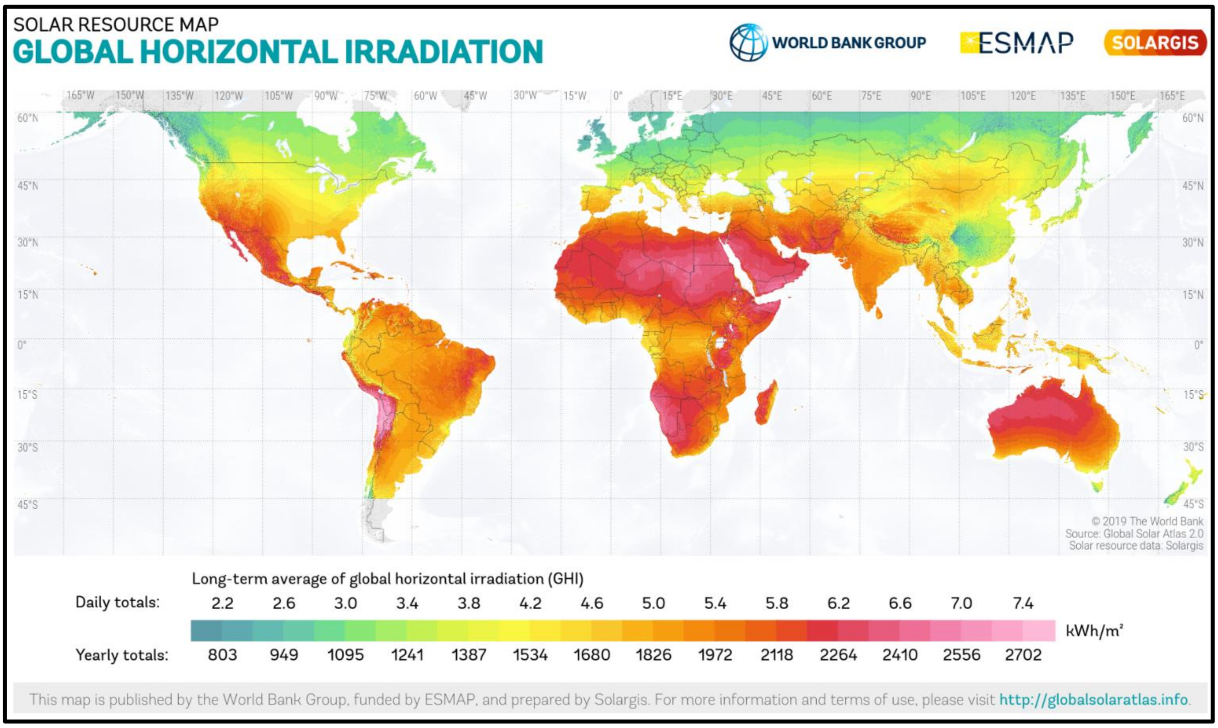


Figure 5-1: Global Horizontal Irradiation (GHI): Long-term yearly average of daily and yearly totals

Analysis of the Mullewa GHI data (ref. Figure 5-2) from PVSyst software shows that it has better than average levels with seasonal variance. The annual total generation capacity based on the GHI in Mullewa is 2,129.5 kWh per square meter.

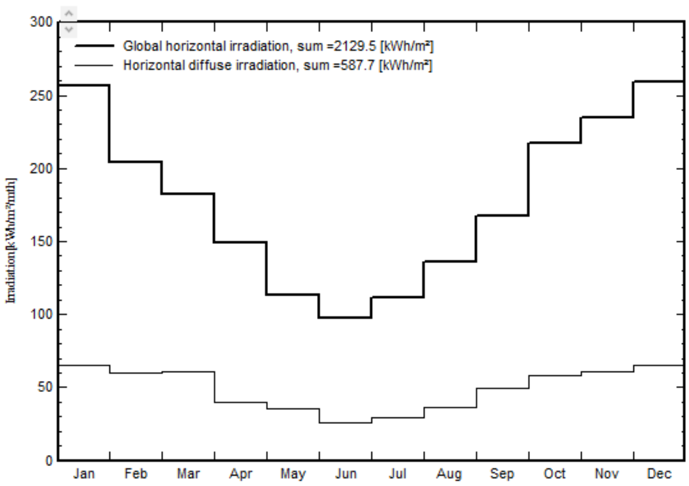


Figure 5-2: Extract from PVSyst showing the average monthly energy production based on GHI for Mullewa

The daily data for Mullewa in PVSyst shows a similar seasonal pattern with the values in Figure 5-3 below shows the daily irradiance of one day, in kWh/m²/day.

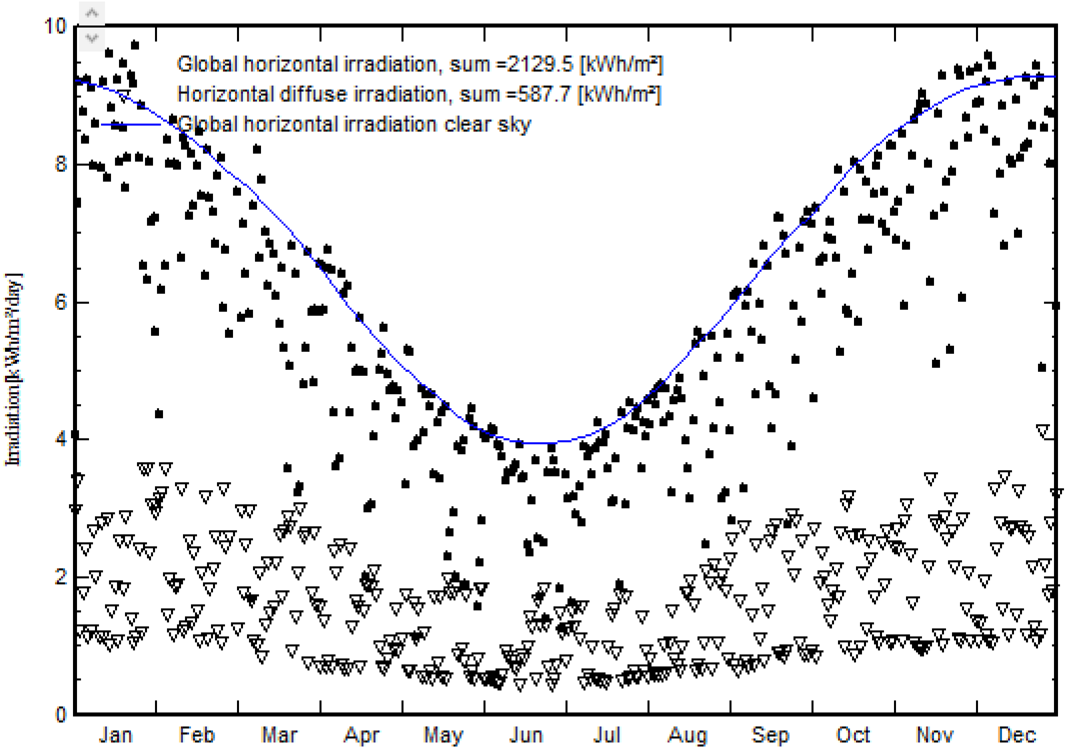


Figure 5-3: Extract from PVSyst showing the average daily energy production based on GHI for Mullewa

5.6 Wind Resources

From a simple assessment of the wind resources in the mid-west region of WA, based on mean wind speeds and comparisons with existing wind farms (ref. Figure 5-4) Mullewa appears to having a potentially viable wind resource.

Wind speed data at the Mullewa specific site is not available so to evaluate the wind resource further, a theoretical dataset was constructed by BlairFox and a high-level desktop analysis used to estimate the combined annual energy yield of the turbines to be 2.982GWh. The estimation is based on various factors, including the predicted wind speed and direction, the height of the turbines, and the turbine specifications. Figure 5-5 shows the predicted wind speed distribution around Mullewa.

This estimated energy yield equates to a capacity factor of 28%. Typical values could be expected to vary between 25 and 45%. Although on the low side, 28% would still be a reasonable supplement to onsite Solar, particularly if it has a complimentary profile. Without specific site measurements however, this is not possible to confirm. Predicted summer and winter daily averages (ref. Figure 5-6) don't show a complimentary profile in terms of seasons, however over the day it looks more complimentary, even with a slight increase in generation in summer during peak demand times between 4 & 9pm.

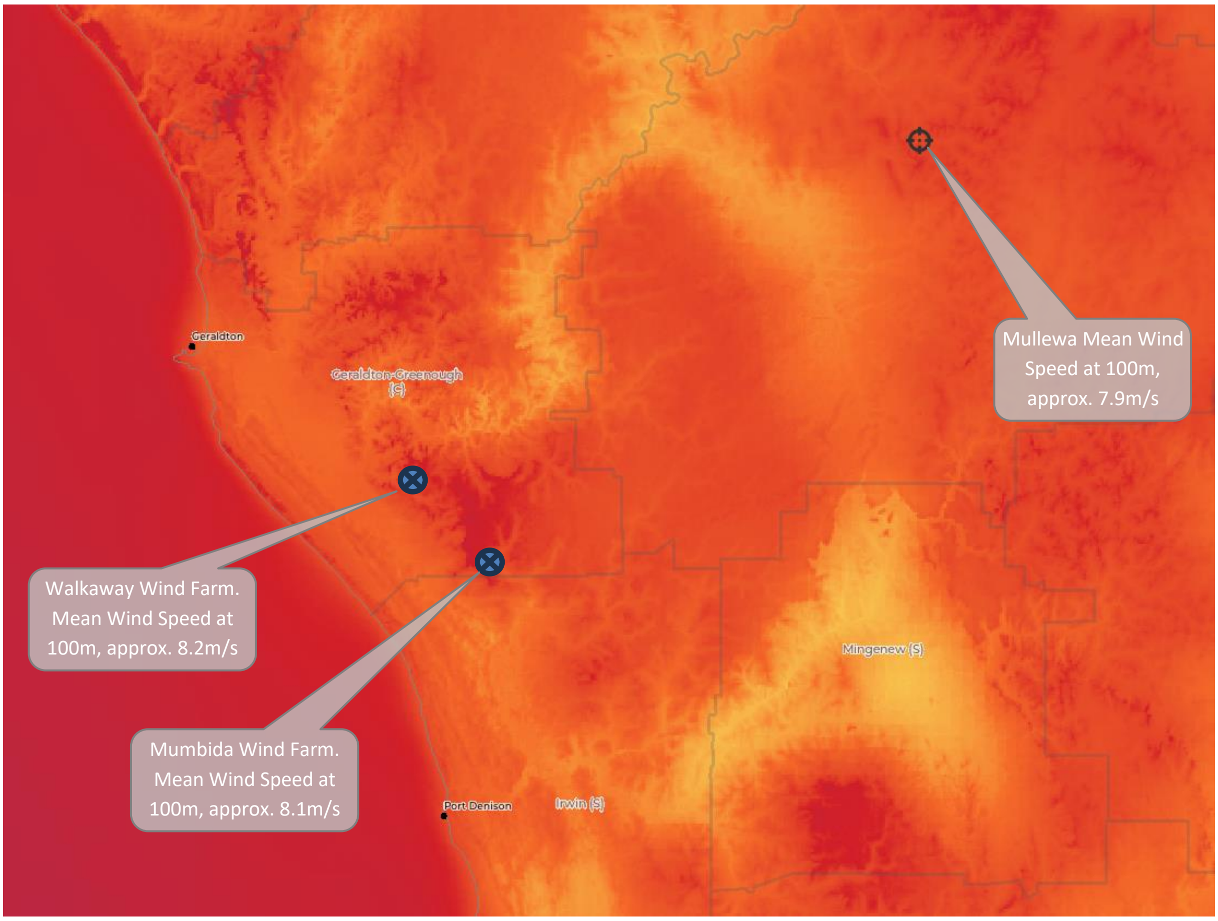


Figure 5-4: Mean Wind Speeds at 100m in WA Mid-West area according to the Global Wind Atlas (globalwindatlas.info/en)

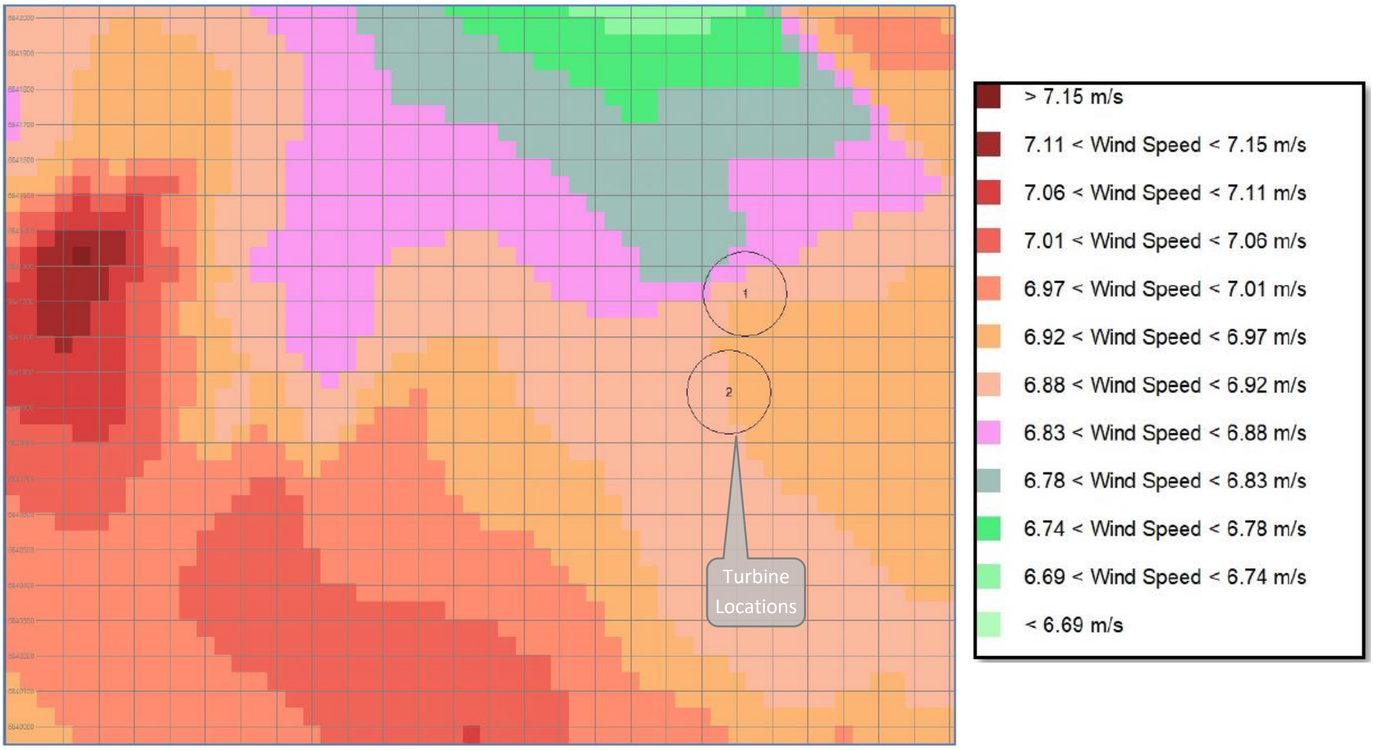


Figure 5-5: BlairFox predicted annual Wind Speed Distribution at Mullewa. Grid spacing is 100m

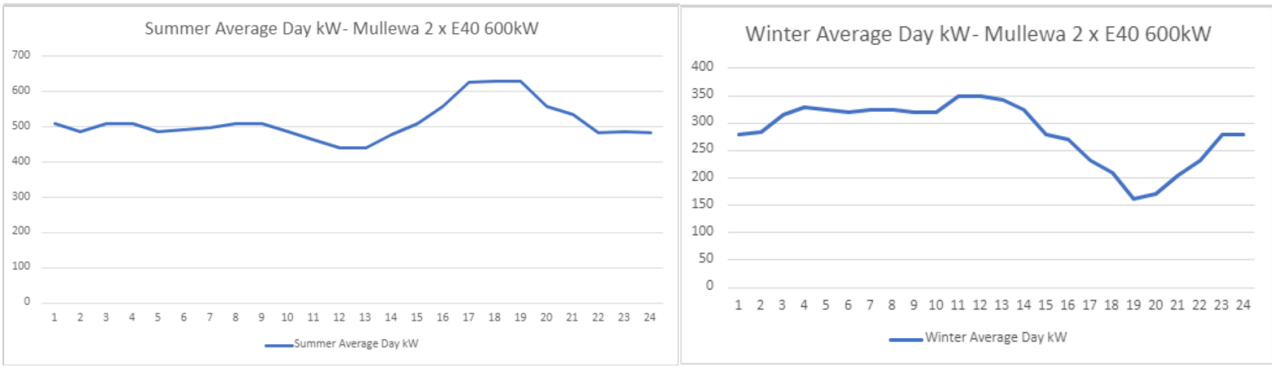


Figure 5-6: BlairFox predicted daily average wind generation profiles

6 Phase 1 – Digital Twin

6.1 Data Access

The value of a digital twin is fundamentally tied to the richness of it's underlying dataset. For the Mullewa digital twin this data was mostly coming from Western Power and Synergy. Both WP and Synergy have responsibility for the security of their data and so it was realised early on that it was necessary to establish a collaborative agreement between WP, Synergy, Sunrise (study owner) and Enzen (digital twin producer) to ensure satisfactory levels of protection in place to facilitate handover of the data.

Establishing this agreement was not a trivial matter and took several months due to negotiations around the various commercial sensitivity issues and NDA's and settling on the final terms before being signed by all parties. Even if a complete digital twin is not an objective, the energy modelling required to size a renewable brownfield microgrid and evaluate the commercial viability requires access to the meter data which would still require a formal agreement with Synergy and Western Power which should be planned for. The alternative would be to have to go to each of the individual customers and obtain their permission in writing to access their data, and this approach was required for the five contestable customers that were not with Synergy and it took considerable time to obtain their permission and then receive the data.

6.2 Input Data

6.2.1 Network Topology and Asset Data

The network topology data and asset data was provided by Western Power and handed over directly to Enzen for incorporation in the digital twin. LiDAR data was also required for producing a digital twin, and was provided by Western Power via their LiDAR services contractor.

In terms of asset data, Western Power provided some technical details and some age data, however did not provide inspection, condition or maintenance data. Although this would have provided for a more richer experience with the digital twin it was still sufficient to support a working model and give a good example of the potential benefits.

The expectation is that once Western Power become more familiar with the operation and potential benefits of a digital twin there would be motivation to build out the capability by adding additional data.

6.2.2 Outage Data

Western Power provided outage data from January 2015 through to June 2023. This period includes the time at which the emergency response (diesel) generator (ERG) was installed, March 2019, and so enables an evaluation of the impact of this action on the reliability in Mullewa as discussed in Section 7.1.

Data was also provided by Westen Power on the operation of the ERG from March 2019 through to March 2022, identifying the periods in which it operated and for how many hours in each instance.

6.2.3 Customer Meter data

Western Power provided the following data in February 2022 for the Mullewa township and the downstream radial connections:

- 322 NMIs
- 284 NMIs that are current Synergy customers

- 224 in the Mullewa township “Mullewa” connections
- 60 outside the Mullewa township “Radial” connections
- 5 with other retailers (contestable customers)
- 1 “extinct” NMI
- 31 vacant properties
- 1 currently moving out (soon to be vacant)

Synergy confirmed the number of Synergy customers and provided a more detailed breakdown of these NMI’s:

- 284 NMIs
- 83 Business with 18 on a home business plan (K1)
- 6 contestable customers
- 201 Residential
- 13 Interval enabled
- 184 Interval capable (not enabled)
- 87 Not interval capable
- 10 different tariff products, with the vast majority (198 customers) on the A1
- 0 customer with a battery

The breakdown in terms between Mullewa and the Radial was:

Mullewa

- 47 Business with 4 on a home business plan (K1)
- 177 Residential
- 40 with a solar system
- 228 kW panel capacity

Radial

- 36 Business with 14 on a home business plan (K1)
- 24 Residential
- 4 with a solar system
- 21kW panel capacity

6.2.4 Meter Consumption data (or network consumption data if no time of use available)

Synergy provided annual meter consumption data totals broken down by commercial and residential loads and also by Mullewa town versus radial loads. The load attributed to contestable customers was provided. They also provided the interval data as a yearly load profiles in half hourly readings.

Obtaining interval data for the 5 non-Synergy contestable customers was a more difficult and long process. Western Power had to first obtain permission from non-contestable customers to provide their contact details to Sunrise. Each customer then had to be contacted individually by Sunrise to explain what their data would be used for and then ask them to sign a Western Power form giving Western Power permission to hand over their interval data. Eventually all of the 5 non-Synergy contestable customers agreed and their interval data was obtained.

6.3 Data Manipulation

6.3.1 Network Topology and Asset Data

Asset data required alignment of the pick ID data before matching to Fugro 3D model data.

Schema "point cloud" (terrain and height) was classified to get it into poles and wires and vegetation, ref. Figure 6-4. Vector overlays were added to the point cloud engine to bring into one visualization with contextual information.

Dashboards and reports (ref. Figure 6-3) were built to profiles like age, type of carrier etc. For example 30% of the SCGZ conductor is 25 years of age. Because condition was not available for the network age profiles had to be used as a proxy to profile assets for reliability. This could be further enhanced if inspection / last inspected data or possibly current working loads of the poles etc. was provided as could be used to simulate a profile for a better reliability outcome.

6.3.2 Meter Data

In terms of the energy modelling it was decided the best compromise in terms of resolution versus efficiency was to model the loads broken down by contestable customers (all within the Mullewa town) and then non-contestables broken into those in Mullewa town and those on the radial network. Residential and non-contestable commercial customers data was merged and Synergy contestable load extracted.

These loads accounted for the installed rooftop solar and so the amount of solar that would have been generated from the installed capacity was estimated and backed-out of the load data so that the data represented the full load before the rooftop solar was accounted for, allowing the rooftop solar to be modelled separately.

A rooftop solar split between contestable and non-contestable customers was not available and so an approximate 50/50 split was assumed based loosely on satellite data showing rooftop installations.

6.4 Loading of Data Sets

6.4.1 Network Topology and Asset Data

The Network Topology and Asset Data was processed by Enzen and prior to establishing the final digital twin it was initially loaded into an intermediate database format accessible from google earth (ref. Figure 6-1 and Figure 6-2) and also via a data dashboard supporting a number of different report formats (ref. Figure 6-3).

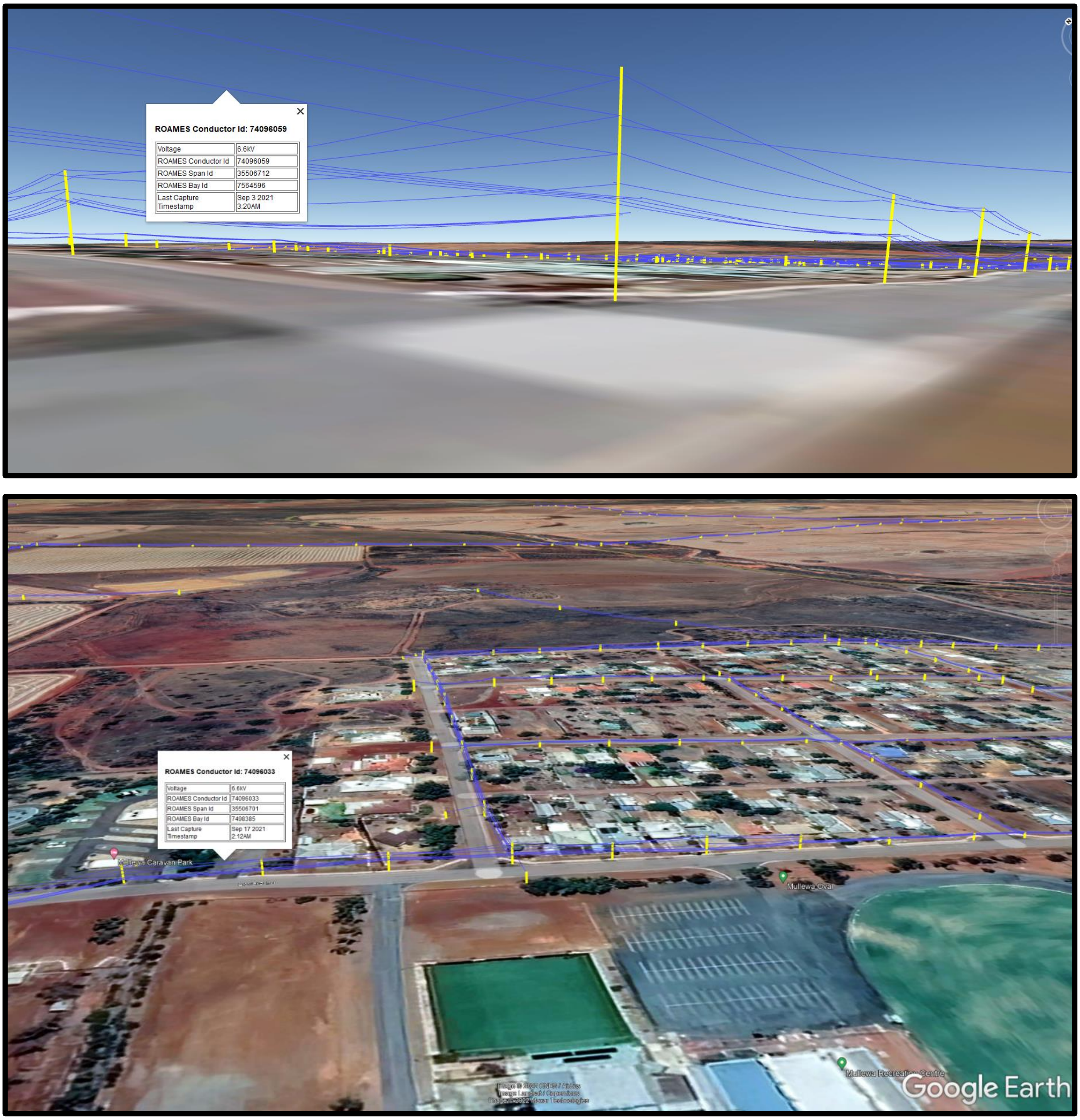


Figure 6-1: View of asset data overlayed onto Google Earth

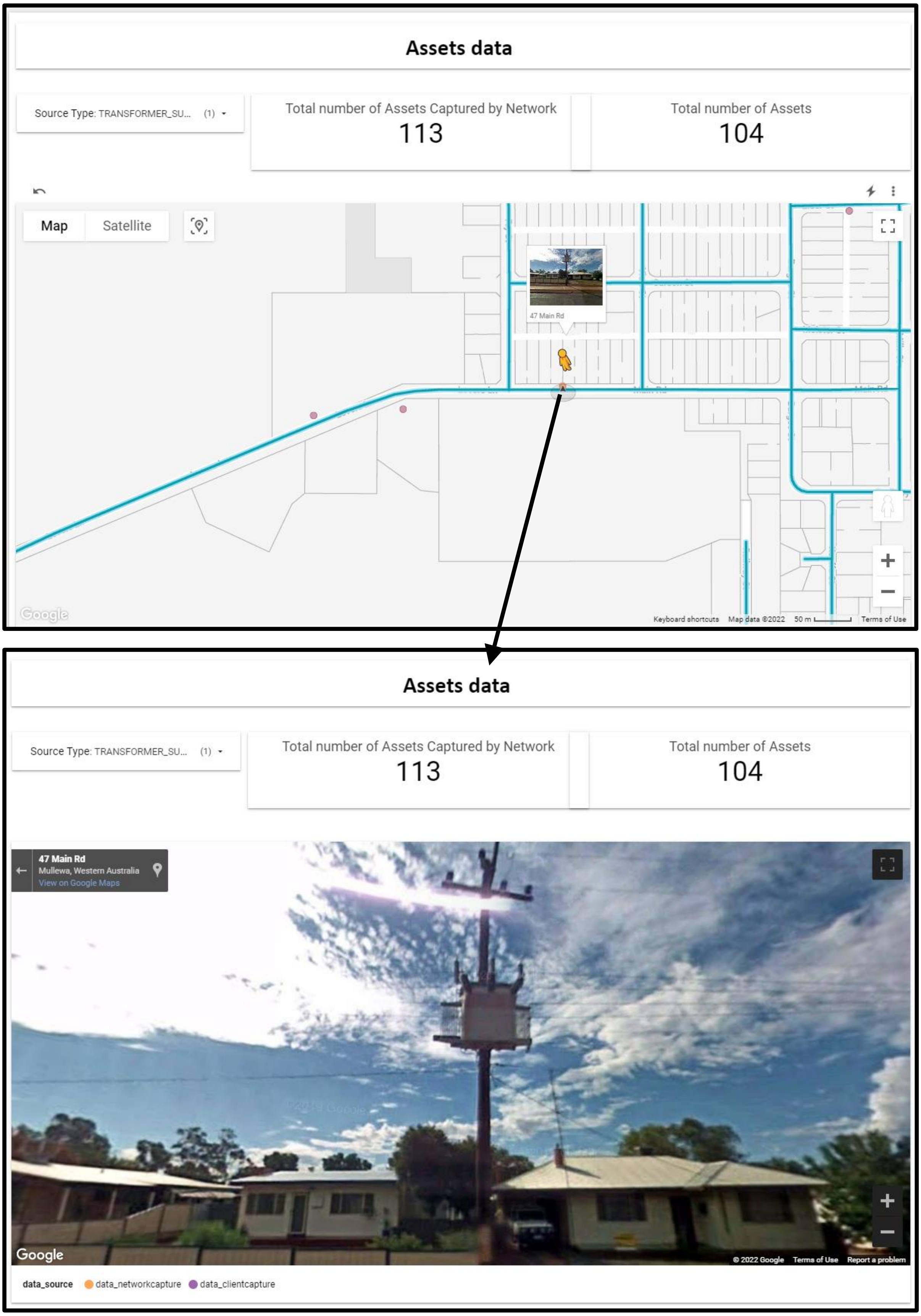
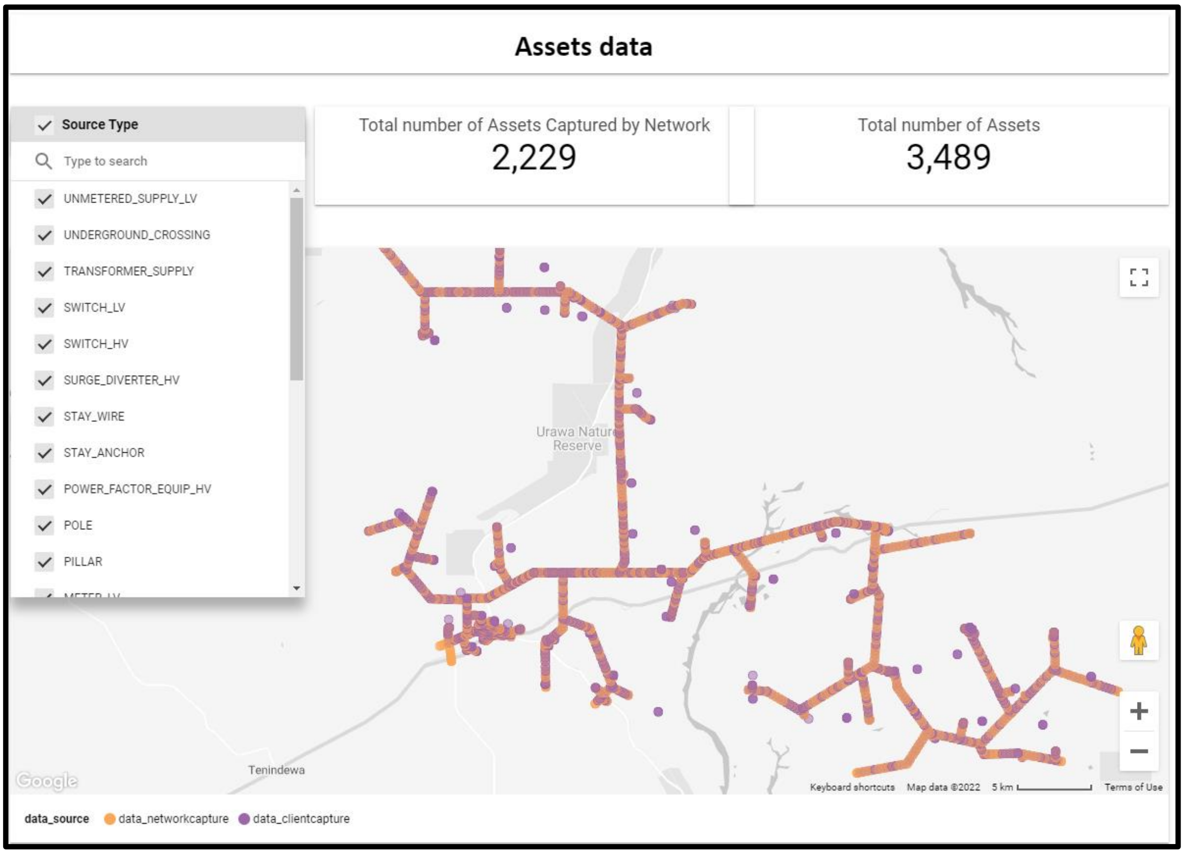


Figure 6-2: Locating a specific asset using Google Streetview



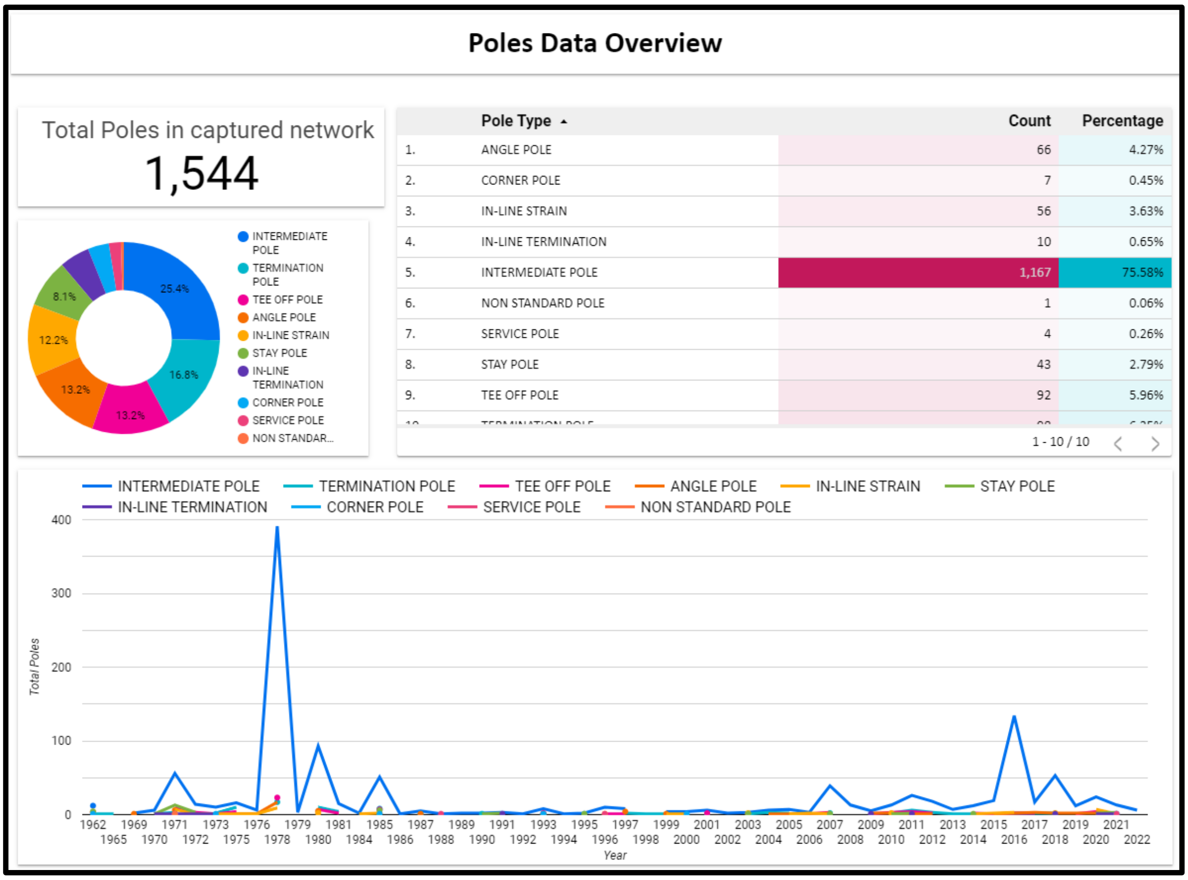


Figure 6-3: Examples of different data dashboard views for presenting of the asset data

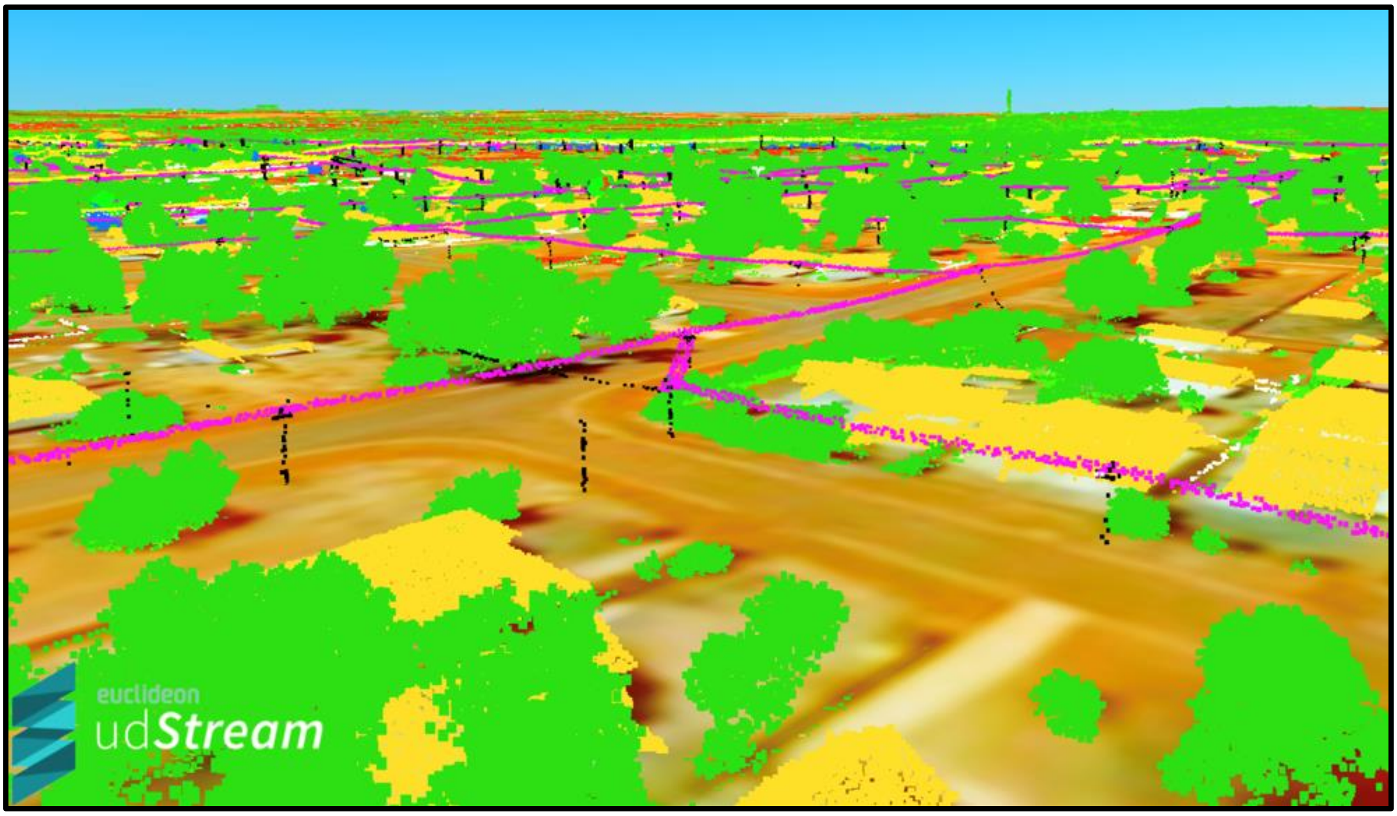


Figure 6-4: Sample of point cloud data. Power poles in black, conductors in pink and vegetation in green

6.4.2 Meter Data

From the manipulated data the following datasets were loaded into the GridCog modelling tool:

- Non-Contestable Customer Load Profile for the Town (866MWh annual consumption)
- Non-Contestable Customer Load Profile for the radial network (355MWh annual consumption)
- Synergy Contestable Customer Load Profile (542MWh annual consumption)
- Non-Synergy Contestable Customer Load Profile (440MWh annual consumption)

Datasets were not created and loaded into GridCog for the rooftop solar generation. This was calculated internally within GridCog based on the rooftop solar capacity.

6.5 Data Validation

6.5.1 Network Topology and Asset Data

During a site visit to Mullewa in April 2022, the digital twin in its intermediate format, accessible via google earth and preliminary data dashboard was available to do a spot check against some of the physical assets in the town. Several checks against asset numbers available on the power line poles was performed and found to match up against the data in the digital twin dashboard.

What was discovered however were some anomalies in the conductors reported in parts of the digital twin. The digital twin was showing changes in line voltages at certain locations where there were no transformers actually present. This discovery was fed back to Enzen for review. The explanation for the anomalies was due to use of “ROAMES® World” (not an authorized source of network voltage data) to fill in some of the gaps in the data. After recognizing this the anomalies were corrected.

The basis of the Enzen proposal for the digital twin was that the Mullewa twin would be built on the back of the much larger model being developed for TasNetworks, covering all of Tasmania. The TasNetworks digital twin was a much larger undertaking than expected and developing the model took Enzen considerably longer than expected with the resulting knock-on effect impacting significantly on the delivery of the Mullewa digital twin. The digital twin has been presented to Sunrise and a presentation is being planned for Western Power and Synergy for some time in September 2023.

6.5.2 Metering Data

As means of checking whether the Synergy load data and that obtained from the 5 non-Synergy contestable customers accurately reflected the total load for the town, Western Power were able to provide data from the nearest recloser on the incoming line to the town. The data from the recloser resulted in a total annual load for the town of 2694MWh whereas the Synergy + 5 non-Synergy contestable load added up to only 2203MWh for a year, leaving 491MWh per year unaccounted for. It is estimated that streetlights would account for somewhere in the order of 40MWh per year with the remainder associated with unmetered consumption.

The representation of the metering data and the actual modelling performed on the basis of this data was reviewed together with Western Power and Synergy during a workshop at Western Power in October 2022, Ref. Appendix A for a copy of the workshop presentation. The feedback from this was positive with no corrective actions recorded.

7 PHASE 2 – MODEL SOLUTIONS

7.1 Analysis of Technical Problems (Outages and Root Cause)

The technical problems with the current energy situation in Mullewa is a lack of reliability which is essentially a result of it being a radial network. Any failure along the almost 100km of above ground distribution line can lead to an outage of power and this is only exacerbated by an ageing network.

With 100km of exposed line susceptible to failure the typical root causes and their likelihood of occurring (based on the past history provided in the Western Power outage date) are given in Table 2.

Table 2: Causes of interruptions to the Mullewa power supply

Cause of Interruption	Pre ERG	Post ERG	Total	Total as a %
Equipment Failure	21	22	43	34%
Unknown	22	16	38	30%
Emergency Outage for Hazard	8	6	14	11%
Wind or Wind Bourne Debris	6	6	12	10%
Lightning	2	5	7	6%
Vehicle	3		3	2%
Bird	2	1	3	2%
Customer Installation or Appliance	2		2	2%
Machine or Tool	1		1	1%
Animal	1		1	1%
Fire		1	1	1%
Human Error		1	1	1%

Equipment failures topping the list at 34% correlates reasonably well with the assessment in the Western Power NOM2022 [6] which states that generally less than a third of outages are directly controllable by Western Power and the remainder due to windborne debris, extreme weather events or caused by a 3rd party.

When talking of solving reliability it is in relation to the reliability of the feed from Geraldton that supplies Mullewa and the downstream radial. Solving this means providing power to the town and radial when a fault somewhere along the 100km of line from Geraldton to Mullewa disrupts the grid supplied power. Faults within the town that may impact a portion of the town or faults downstream of the town which may impact customers on the radial line, is not solvable within the scope of a microgrid proposal.

More detailed outage data was provided by Western Power as part of the actual study, as referred to in Section 6.2.2. This outage data includes the number of customers affected and the cause of the interruptions. With the number of customers affected identified, a judgement can be made as to whether the fault was upstream of downstream of the town. Also when analysing the data in relation to reliability, planned outages could be ignored. Where the number of customers affected was less than the 290 NMI's identified (excluding extinct and vacant properties) then it was assumed the fault lay downstream of the entry point of the town ie. within the town or on the radial network and so these outages were discounted when considering outages that may be addressed through implementation of a microgrid. The data also identified outages associated with transmission or generation failures where the number of customers affected exceeded 18000 and so evidently not associated with the reliability of the 100km radial feed to

Mullewa and so these were also disregarded from a reliability review perspective (although a Microgrid with local renewable generation and storage would also solve outages related to those causes as well).

Table 3: Interpretation of outage data in terms of reliability pre and post installation of the Emergency Response Generator (ERG)

	Pre ERG		Post ERG	
Data period (days)	1525 (Jan 2015 – Mar 2019)		1466 (Mar 2019 – Apr 2023)	
No. of outage events over the data period	68		58	
Ratio of events to the data period	4.5%		4%	
Event Durations *	Until Initial Restoration	Until Final Restoration	Until Initial Restoration	Until Final Restoration
Total outage hours over the data period	180	459	199	633
Average outage hours per event	2.7	7	3.4	11
Max during the period (hrs)	15	24	30	94
Max difference between Initial and Final	23		78.4	
No. of events as % of total below 1 hr duration	49%	25%	70%	49%

* Note, as an outlier event, the outage resulting from cyclone Seroja in April 2021 was not accounted for in the durations data

Evaluating the data in terms of reliability, Table 3 expresses this from the perspective of number of outage events, and also in terms of outage durations. In terms of the number of events there is no significant change pre and post the ERG installation. Similar for most of the outage duration metrics, there is nothing to suggest any improvements since the ERG installation, in fact it could be argued the data suggests a possible decline in reliability. If these two perspectives aren't looked at in isolation, and the number of outage events that have a duration below 1hr considered, it appears that this is where the provision of the ERG may have resulted in some positive results.

The ERG can only react to an outage and so in essence doesn't solve reliability but can mitigate the consequences. This is evident in that essentially there are still the same number of outages of the main 100km radial feed supplying Mullewa pre and post ERG. Even though there is not a reduction in total outage hours observed, the number of instances where outages have been kept below 1 hour has increased since the ERG was installed.

The main thing that can be concluded from this is that the ERG has a limited effect on reliability, merely reducing the consequences of outages, without solving the reliability issue – meaning another solution is required.

What is not evident from this data is what the reliability would have been like if the ERG had not been installed. The ERG operating data provided gives an indication of this. It showed that between March 2019 and March 2022 it operated for a total of 611 hrs across the two generators, 416 hrs of which are assumed to be associated with cyclone Seroja in April 2021. The ERG has therefore clearly had a positive impact on the town of Mullewa, even if it is not a complete reliability solution. It also reinforces the value of local generation in whatever form it takes.

7.2 Identification of the Network Limitations Inherent in a Radial Network

The network limitations inherent in a radial network come down to its susceptibility to a single point of failure. In a meshed network the interconnections within the system allow for alternative energy distribution routes should single failure occur (or potentially more – depending on the complexity of the mesh).

7.3 Risk Exposures that Cannot be Mitigated due to System Architecture

All of the above possible root causes for outages in Mullewa can be mitigated by a change to the system architecture whereby generation and associated storage is installed locally and the local network islanded from the SWIS on loss of gird supply. This mitigates the reliance of such a long section of line that is susceptible to a single failure. On detection of failure along the incoming grid supply line the microgrid can go into island mode, operating on self-generation and battery storage (with diesel generation as a last means of resort for extra long outages). Also mitigated to some extent would be risks in the form of external forces impacting on the cost and service of electricity supply to Mullewa – generating a significant portion of the energy locally will provide more control and certainty of the supply and reduce lines losses for the SWIS.

Risk exposure that cannot be mitigated by the system architecture are:

- physical risks to the microgrid, ie. outages within the microgrid itself or on the downstream radial (due to natural forces or accidents) that cause outages, not for the whole town but to those downstream of the faults.
- risks in the form of societal forces that could lead to depopulation of the town and subsequent reduction of load.
- risks in the form of external forces impacting on the cost and service of electricity supply to Mullewa.

7.4 Range of Potential Technical Solutions Applied in the Model

At a high level the technical solutions applied to a Microgrid model are essentially what is described in the adopted definition of a microgrid (ref. Section 3), which is a technical solution that incorporates local renewable generation and storage to reduce the dependency on the grid and can island the Microgrid on loss of the grid supply and then support the town on the local generation and storage until grid supply is restored. This sounds relatively straightforward but is actually technically challenging and requires significant innovation to achieve, which is described in greater detail in Section 10.2.4

More specifically, within this high level outline of the technical solutions, the potential renewable generation solutions considered were solar PV generation and generation from wind turbines. In terms of storage a lithium ion battery was considered for providing an instantaneous (essentially) short term reliability solution, but as a solution for possible long terms outages, diesel powered generation was considered.

Initially technical solutions for islanding the microgrid and controlling the embedded generation to support the load, were considered on the assumption that the generation and storage would be co-located with the grid connection/isolation point, given the protection and controls at the connection/isolation location would need technically compliant communications via fibre optic connection. Technical solutions using radio compliant communications were also considered in order to remove this constraint of having to co-locate the connection/isolation point with the generation/storage.

7.5 Improvements in Performance and Reduction in Risk Achieved form the Technical Solutions

The technical solutions describe in Section 7.4 would achieve the following performance benefits and risk reductions:

1. Local renewable generation
    - Improves the performance of the entire grid in terms of reduced CO_2 emissions by displacing grid power, of which 65% is still on average (based on the last 12 months) generated from hydrocarbons.

- Reduces overall line losses for the SWIS by generating a significant portion of the energy where it is consumed (ref. Line Loss Calculations by Jarrah Solutions under Appendix G).
- Improves the performance of the 100km radial supplying Mullewa by reducing the load on it, hence freeing up capacity for others.

2. Combination of Solar and Wind Generation.
   - Typically the solar and wind generation profiles are complimentary in that often when the sun isn't shining there's a good chance the wind is blowing and vice versa which improves the performance of the Microgrid.
   - Provides a general reduction in risk by not having to rely on a single source of generation.
3. Battery Storage
   - Can improve the performance of the Microgrid by helping timeshift the generation profile to better match the load profile and hence reduce the amount of grid consumption.
   - Can reduce the risk of upstream grid outages impacting the microgrid by supporting near to instantaneous changeover to island mode operation.
   - Provide frequency stability when running in island mode
   - Reduce reliance on diesel (non-renewable) generation during island mode. Excess generation can be used to charge the battery and defer the possibility of having to operate on diesel.
4. Diesel Generation
   - Diesel generator improves the reliability performance by providing long term energy storage. In the event of a long duration grid supply outage during periods of low renewables generation leading to battery depletion the diesel generator switches on to recharge the battery.
   - Also reduces the risk from renewable generation or battery failures as the diesel generation can support the load directly if necessary.

7.6 Baseline Technical Solution

The proposed baseline technical solution is:

- Solar PV generation and co-located BESS
- Back-up diesel generation co-located at the connection point
- Compliant radio communications between connection and grid isolation point

7.7 Initial Commercial Screening

The approach taken by the study was to perform an initial high-level screening of several commercial models against a baseline technical solution, the objective being to confirm which of these models would be best suited to achieve a viable commercial outcome. That model would then be subjected to a more thorough analysis to refine the model and size the renewable generation and storage that would form the basis for the development activities.

There are at least four different commercial models that could theoretically be applied to introduce renewable energy generation and storage to fringe-of-grid towns such as Mullewa. These are:

- Model 1 – "As-Is" Model

- Model 2 – “As-Is + Network Control Services (NCS)” Model (further defined later on as Non-Co-optimised Essential System Services “NCESS Microgrid” model and then subsequently as Alternative Options Strategy “AOS Microgrid” model)
- Model 3 – “Microgrid” Model (further defined later on as Embedded Network “EMN” Microgrid model)
- Model 4 – “Local Geographical Virtual Power Plant (VPP)” Model (not necessarily falling within the Microgrid definition, however explored based on feedback from Synergy and Western Power)

The baseline technical solution to which the first three models was applied, was a Solar PV array together with a BESS. Because of the difference in how the models operate commercially, the best commercial outcome from each of the models may be achieved with different energy generation/storage arrangements. A mix of different generation and storage scenarios was therefore evaluated for each model. 25 scenarios made of 5 different solar farm sizes and 5 different battery sizes were applied to the first three models. The sizes were:

- Solar Farms: 0.5MW, 1MW, 2MW, 3MW & 4MW
- Battery Storage: No Battery, 1MWh, 2MWh, 3MWh & 4MWh

Even though the VPP commercial model was not strictly a Microgrid solution, there was still deemed to be merit in evaluating this a comparison to the other models. Due to the nature of a VPP the baseline technical solution differs from the other three models in that the Solar PV is based on a collection of small individual residential rooftop systems as opposed to a large single PV array and instead a single large BESS, the VPP is based on a collection of small residential size batteries. The number and size of the individual systems was modelled to achieve the equivalent combined solar generation and storage as used for the other three models (and identified above), except that only a combined 0.5MW and 1MW of Solar was considered as there was not sufficient residences in Mullewa to produce solar generation greater than this in a VPP context.

7.7.1 As-Is Model

An as-is commercial model is the simplest arrangement for provision of local generation & BESS to the Mullewa community and represented in Figure 7-1.

The features of such a model would primarily consist of a connection of the generating assets and BESS to the network and a commercial arrangement (PPA) with an energy retailer to purchase the power generated, whereby the retailer paid agreed rate for the locally generated energy consumed and then on-sold it at a mark-up to its customers.

To evaluate this model an assumption for a plausible PPA rate is based on other agreements that Synergy have in place for purpose of energy from local solar generation. It should be noted however that purchasing solar generation is not a particularly attractive model for Synergy, given they already have access to excess solar generation in the grid at a low price. Therefore this model may come up against some difficulties with the practical implementation in terms of even securing a PPA.

In addition to a PPA other revenue in this model would come from sale of LGC’s and Generation Capacity Credits. At the time it was assumed Generation Capacity Credits could typically generate about $100k per MW of a nominal generation capacity which typically would be based on the greater of 20% of Solar Generation Capacity and Battery Storage/Discharge Capacity (the lower of: battery storage divided by 4, versus inverter capacity).

Expenses include asset operating costs, Insurance & Network Tariff costs (RT1, Entry Service Tariff).

Capital costs will be for Generation and storage assets and the grid connection.

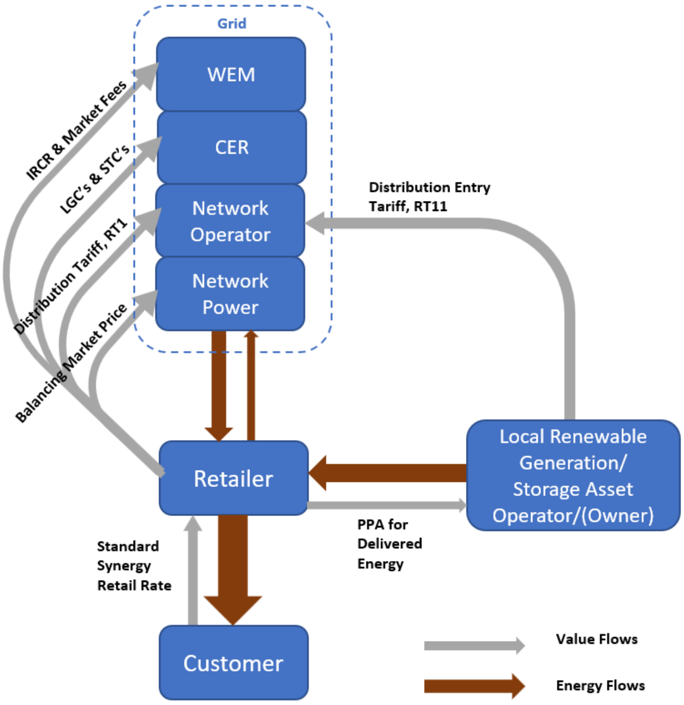


Figure 7-1: Representation of "As-Is" Model

7.7.2 As-Is + NCS (NCESS/AOS Microgrid) Model

A network control service (NCS) scenario would involve the likes of Western Power compensating the supplier of local generation and BESS for providing Network services, such as UPS or voltage control service. In effect this would be subsidising the cost of the electricity, making an arrangement with a retailer more attractive. The As-Is Model with NCS added, is represented in Figure 7-2.

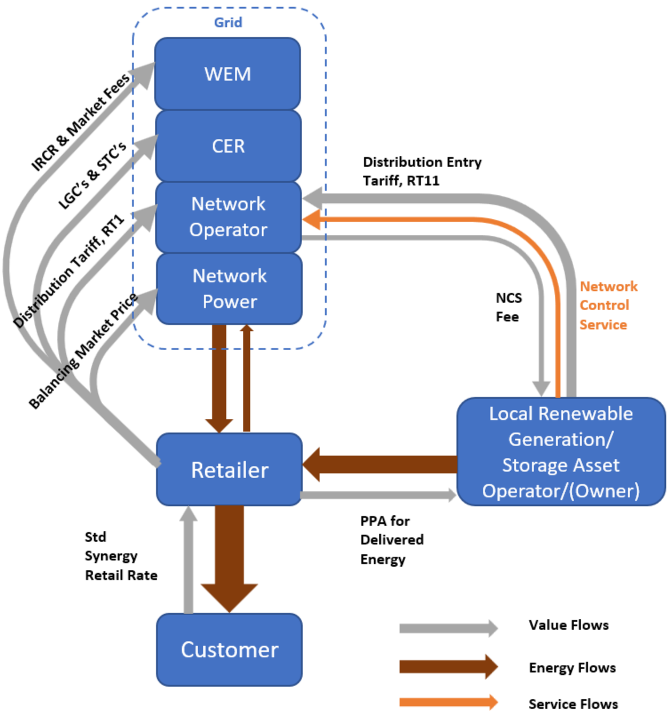


Figure 7-2: Representation of "As-Is" + NCS (NCESS/AOS Microgrid) Model

For this high level analysis it was kept simple with an NCS fee based on retaining 50% of the BESS capacity available for a UPS service.

Less energy will be sold during peak-rate hours because half of the battery capacity is reserved for UPS and so not available for shifting energy generation during off-peak times over to use during peak times. Revenue, expenses and capital costs are the same as for model one except for the reduction in revenue due to less generation being sold at the more profitable peak rate. This however, is more than compensated for by the additional revenue from the NCS fee.

7.7.3 Embedded Network (EMN) Microgrid Model

The difference between the above two models and the EMN Microgrid model is that a master meter would be installed at the entry point to the town (and downstream network) and then the solar generation and storage connected behind this meter, as part of what would now perform as an embedded network, as represented in Figure 7-3.

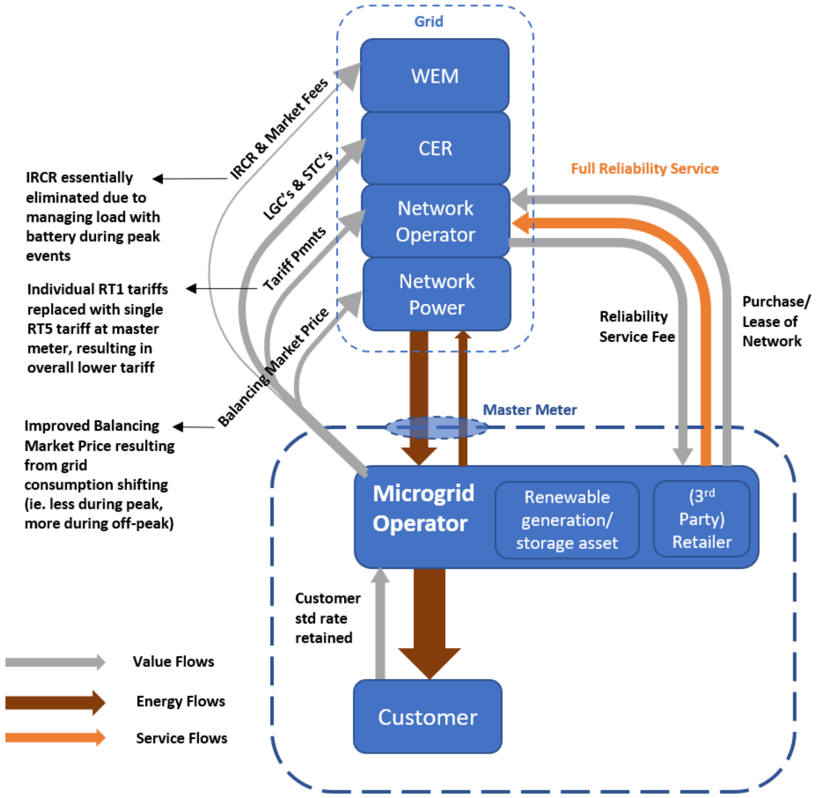


Figure 7-3: Representation of EMN Microgrid Model

From the perspective of Western Power all of the small individual loads are now consolidated as one single load service via the master meter, with only the energy in excess of what can be locally generated behind the meter being subject to network tariffs. As a single larger load a new network tariff would also apply, RT5 likely, but may be other better suited tariffs depending on the size of the local generation and how much was not consumed locally and available for export.

Under this model the Microgrid Operator (MO) would now not only be responsible for the single consolidated network tariff, but also the WEM market fees and any IRCR charges, LGC & STC liabilities and via a nominated retailer the purchase of extra power from the grid not supplied from local generation and sale of energy to all the consumers. For this service the retailer would earn a % of the energy sold. Having control of the energy flow within the microgrid means the operator would have the ability to manage the battery to reduce DSOC and hence RT5 Tariff expenses and avoid IRCR changes.

7.7.4 Local Geographical Virtual Power Plant (VPP) Model

A virtual power plant is the organisation and aggregation of individual distributed energy resources (DER) to generate and store electricity at a local level. Typically, this is connecting rooftop solar and individual batteries via smart communications and control technology so that the individual assets can be managed as what appears to the network as a single large energy entity to leverage the benefits associated with this for an improved outcome for the individual participants.

7.7.5 Results/Conclusion

The results from this initial screening was presented to Western Power and Synergy at Workshop in June 2022. The presentation from workshop can be found in Appendix A. Figure 7-4 is an extract from that presentation and shows the results from the analysis of the 25 different scenarios applied to the first three models and 10 scenarios applied to the geographical VPP model. The different models are compared for commercial performance based on their simple payback (in years), ie. the number of years that would be required to payback the initial capital costs based on the estimated annual net revenue.

Scenarios		Model 1 "As-IS"			Model 2 "As-Is + NCS"			Model 3 "Microgrid"			Model 4 "Geographical VPP"			
Solar Farm Size	Battery Size	Capital Cost	Net Revenue	Simple Payback	Capital Cost	Net Revenue	Simple Payback	Capital Cost	Net Revenue	Simple Payback	No. of 5kW Systems to give equivalent output to stated Solar Farm Size	Capital Cost	Net Revenue	Simple Payback
MW	Mwh	$million	$1000's	Years	$million	$1000's	Years	$million	$1000's	Years		$million	$1000's	Years
0.5	0	$ 1.9	$8	219	$ 1.9	$8	219	$ 3.9	$217	18	140	$ 1.9	$82	24
1	0	$ 2.9	$92	32	$ 2.9	$92	32	$ 4.9	$305	16	280	$ 2.6	$81	33
2	0	$ 5.0	$130	38	$ 5.0	$130	38	$ 7.0	$408	17				
3	0	$ 6.9	$170	41	$ 6.9	$170	41	$ 8.9	$428	21				
4	0	$ 8.8	$211	41	$ 8.8	$211	41	$ 10.8	$449	24				
0.5	1	$ 2.4	$21	116	$ 2.4	$12	202	$ 4.4	$289	15	140	$ 2.9	$125	24
1	1	$ 3.7	$107	34	$ 3.7	$98	37	$ 5.7	$368	15	280	$ 3.6	$129	28
2	1	$ 6.1	$137	45	$ 6.1	$128	48	$ 8.1	$458	18				
3	1	$ 8.5	$172	49	$ 8.5	$163	52	$ 10.5	$474	22				
4	1	$ 10.7	$209	51	$ 10.7	$200	53	$ 12.7	$491	26				
0.5	2	$ 2.7	$35	78	$ 2.7	$42	65	$ 4.7	$299	16	140	$ 3.9	$160	25
1	2	$ 4.0	$146	27	$ 4.0	$153	26	$ 6.0	$378	16	280	$ 4.6	$178	26
2	2	$ 6.4	$161	40	$ 6.4	$168	38	$ 8.4	$460	18				
3	2	$ 8.8	$187	47	$ 8.8	$194	45	$ 10.8	$476	23				
4	2	$ 11.0	$224	49	$ 11.0	$231	48	$ 13.0	$493	26				
0.5	3	$ 3.1	$50	62	$ 3.1	$60	51	$ 5.1	$306	17	140	$ 4.9	$107	46
1	3	$ 4.3	$186	23	$ 4.3	$196	22	$ 6.3	$386	16	280	$ 5.6	$252	22
2	3	$ 6.8	$200	34	$ 6.8	$211	32	$ 8.8	$459	19				
3	3	$ 9.1	$216	42	$ 9.1	$227	40	$ 11.1	$475	23				
4	3	$ 11.4	$238	48	$ 11.4	$249	46	$ 13.4	$492	27				
0.5	4	$ 3.4	$64	53	$ 3.4	$79	43	$ 5.4	$314	17	140	$ 5.9	$126	47
1	4	$ 4.7	$225	21	$ 4.7	$240	19	$ 6.7	$394	17	280	$ 6.6	$271	25
2	4	$ 7.1	$240	30	$ 7.1	$254	28	$ 9.1	$458	20				
3	4	$ 9.5	$256	37	$ 9.5	$270	35	$ 11.5	$474	24				
4	4	$ 11.7	$273	43	$ 11.7	$287	41	$ 13.7	$491	28				

Figure 7-4: Results from Commercial Models High-Level Analysis

Model 3, the EMN Microgrid model, achieves the best performance with several models (highlighted in green) outperforming Model 2, the next best model. As would be expected the additional income from NCS fees result in Model 2 outperforming Model 1 and then the VPP Model 4 is behind Model 1.

The distinction in how models 1&2 function differently from Model 3 is evident from how the better performing commercial scenarios for Models 1&2, are achieved via different solar/battery combinations than for Model 3. Models 1&2 benefit from a large battery size as the main income is from energy sold and with a much higher rate available during peak. The larger battery means more energy can be transferred to peak rate selling times, hence the better outcome. The energy sold in Model 3 is sold at a flat rate so the value of the battery in impacting revenue from energy sales is not as significant, and so the impact of the battery size on the outcome is not as significant. In addition to best Model 3 scenario there are also several scenarios which still out perform the other models (highlighted in green).

It's not unexpected that Model 4, the VPP performs poorly by comparison as it is fundamentally unable to compete due to:

- Installation of numerous roof top solar systems and associated individual batteries is cost prohibitive compared to a single installation.
- The energy generation profile of fixed rooftop installation (compared to single access tracking) is of limited value, given the current excess of rooftop solar generation in the SWIS.
- The smart communication and control technology required for each DER asset is relatively new and expensive.

Looking in general at these four models a list of pros and cons was established, as presented in Table 4.

The conclusion drawn from the initial screening was that Model 3 the EMN Microgrid model was identified as the model with the best opportunity for commercial success and so a more detailed analysis of this model and associated scenarios would be performed to refine the commercial modelling, size the generation and storage and test for robustness.

The feedback from workshops with Western Power and Synergy, was that although the high level modelling identified the commercial promise of Model 3, the study should not necessarily rule out Model 2 at this stage given this model had a more straight forward path towards implementation and it could be useful to understand the commercial mechanisms of the Model 2 in more detail and possibly reveal ways for improving its commercial performance. Based on this both Model 2 and Model 3 were taken forward to the next stage of more detailed modelling using the GridCog energy modelling software.

Table 4: Pros and Cons of the four models from initial commercial screening

	Model 1	Mode 2	Model 3	Model 4
Pros	Easy - no regulatory changes required / status quo maintained Western Power revenue increase from new Solar Farm connection	Same as "As-Is" Model, plus can support the town during outages (ie. increased reliability of power supply) and slight commercial improvement due to increased revenue from NCS's	Increased reliability of power supply in Mullewa Most attractive commercial model for investors (demand & supply combined) Positioned to enable disconnection from the grid in the future, should that occur. Reduces Western Power exposure to maintaining ageing infrastructure, if network sold. If leased WP would be paid for the upkeep.	Increased reliability of power supply in Mullewa
Cons	No significant improvement in reliability Difficult to implement as not attractive to investors because: High risk – no certainty over future of grid connection (required to export excess generation) Longer payback period compared to Microgrid model Unlikely to gain approval above 1MVA DSOC Most commercially viable scenarios require larger batteries – with inherently greater commercial exposure (e.g. Batteries have limited life and replacement costs have not been accounted for in the analysis). Requires a retailer to underwrite, of which they have little incentive to do (uncontracted solar power already available today – likely at lower cost as at larger scale).	Same as "As-Is" model, except that as this scenario can support the town during outages, reliability issues is no longer a concern. Western Power have already installed diesel generators to do this (ie. support town during outages) – so may be better suited to towns with no emergency generation. Western Power costs increase to fund the NCS service. May be constrained to 1MVA DSOC	Some challenges to navigate on some regulatory requirements Synergy uses less wholesale energy to supply Mullewa Reduces Western Power tariff revenue (offset by embedded network services income & asset sale/lease) May be constrained to a 1.5MVA CMD & 1MVA DSOC	Difficult to implement as not attractive to investors because: VPP model relies on selling services to the market – however currently only Synergy can sell services to residential customers. High risk – no certainty over future of grid connection (required for services to support VPP model) High risk - uncertainty over future revenue opportunities, e.g. FFR/FCAS/ESS, Wholesale Demand Response Mechanism Longer payback period compared to Microgrid model Some challenges to navigate on some regulatory requirements Reduces Synergy revenue – with no reduction in commercial risk Reduces Western Power tariff revenue – with no reduction in responsibility Not proven (e.g. for grid forming, meaning centralized battery/inverter may still be required to provide these services) and no obvious provider in the market

7.8 Detailed Modelling

7.8.1 GridCog Modelling Tool

The GridCog modelling software provides techo-economic modelling, tracking and optimisation of distributed energy projects. Projects can span multiple markets, multiple sites and multiple distributed energy resources. It has 3 main parts which are:

- Planning for pre-project techno-economic modelling
- Tracking for post-deployment performance management
- Library for managing reusable modelling inputs

The tracking part allows for tracking of delivered commercial and environmental value against pre-project baseline, project baseline and optimal operations. The Mullewa Feasibility Study is “pre-delivery” and so it is the planning and library parts of GridCog that have been used for the Study. However, with a pre-project baseline model having been developed for Mullewa, implementing the GridCog tracking features would enable a means of assessing the value of the project post-delivery and support the ongoing optimisation of the operation of the Microgrid.

In the planning tool, a project has a baseline scenario representing the business-as-usual electricity supply arrangements. Alternative scenarios with different market pricing assumptions, different load assumptions, different combinations of and sizes of different energy resources, different commercial models and different asset and control strategies, can then be created and examined relative to the baseline scenario.

GridCog supports many kinds of energy resources, including solar, storage, wind, electric vehicles, load flexibility and gensets and enables these resources to be co-optimised to deliver the maximum commercial and environmental value.

The GridCog library provides a repository of modelling inputs that includes load profiles, network tariffs, retail tariffs, markets and market prices (with the WEM included), DER assets, project costing assumptions (capex and opex), demand response contracts and control and utilisation schedules. Some of the library items are generic, produced and maintained by GridCog such as many of the network and retail tariffs (including Western Power and Synergy tariffs) and markets and market prices (including the WEM). User generated library items are also possible for all library categories.

7.8.2 Modelled Scenarios

The baseline Scenario (existing case) for Mullewa is simply the present arrangement which is the Mullewa town and downstream radial electricity supply being provided by a combination of rooftop solar (for those that have it) and directly from the SWIS, via a 100km radial line coming from Geraldton. The energy supplied to customers from the SWIS is via a retailer according to the applicable bundled tariff, with the retailer then covering the energy costs, network tariff costs, market fees, certificate charges and IRCR charges. It also accounts for the emergency response generator (ERG) that has been located at Mullewa and estimated cost of this to Western Power.

The baseline scenario is useful to compare the two Microgrid scenarios that are modelled as possible solutions for Mullewa, and these are:

- Renewable Generation & Storage + Network Control Services (RGS + NCS) Microgrid
  (update in terminology from “Existing Case + NCS” Microgrid used during the initial commercial screening)
- Embedded Network (EMN) Microgrid

The distinct features of these scenarios that separate them from each other is represented graphically in Figure 7-5.

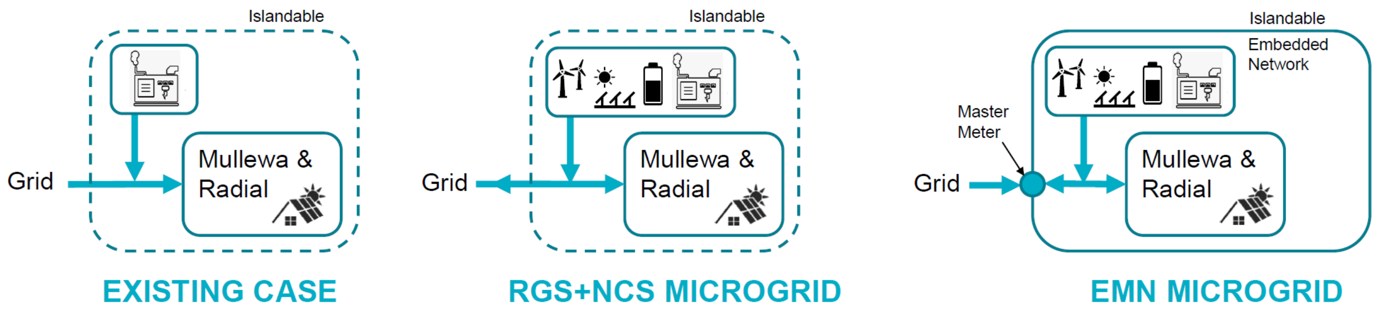


Figure 7-5: Representation of the 3 scenarios modelled in detail using GridCog

7.8.3 Participants

As part of assessing the impact of the different models it is necessary to understand how the different participants are affected. For this modelling exercise the following participants have been accounted for:

- Network Operator, Western Power (Network)
- Non-Contestable Customers (Customer)
- Contestable Customers (Contestable Customer)
- Retailer for Non-Contestable Customers, with the assumption this entity will fulfill the role of the Microgrid Retailer (Microgrid Retailer)
- Retailer for Contestable Customers (Contestable Retailer)
- Representative for costs associated with the unmetered load (Recloser Load)
- Representative for costs associated with estimated streetlight use (Streetlight Retailer)
- Microgrid Operator (Microgrid Operator)
- Representative for costs associated with Line Losses (Line Losses)

7.8.4 Modelling Parameters

Parameters used in the modelling were:

- Model Lifetime: 20 Years
- No CPI increase predictions applied
- Assumed Load Growth: 1.33% per annum (based on projections for Geraldton of 8% over 6 years) after 1st year.
- 278 Non-contestable NMI's, 11 Contestable NMI's
- Existing 249kW rooftop split equally between contestable and non-contestable customers.
- Time constraint (between 4&8pm) on 1.5MW export limit only applicable in first 3 years of operation. Based on the assumption of being be subject to NAQ during this period (despite discovering later on from conversation with AEMO that this might not be the case, ref. Section 10.3.3)
- Generating Capacity Credits available to RGS+NCS scenario after first 3 years of operation (despite discovering later on from conversation with AEMO that may be eligible from project start, ref. Section 10.3.3).
- No change in cost to Mullewa customers. The premise for the Microgrid is not to provide a direct commercial benefit to the residents of Mullewa but a reliability benefit. Where there is potential for a commercial benefit

the intent is to deliver this to the entire SWIS, ie. to contribute to the overall reduction in costs of the SWIS which would impact all customers including those in Mullewa.

- For EMN Microgrid scenario, no reduction in retailers (Microgrid Retailer Participant) revenue for non-contestable customers compared to existing case.
- For EMN Microgrid scenario, no reduction in contestable retailer revenue compared to existing case.
- For EMN Microgrid scenario, no reduction in revenue for Western Power from RT5 tariff and network lease income, compared to existing case of RT1/RT2 tariffs less NCS cost of existing diesel gensets.

7.8.5 Loads

The annual consumed loads used in the modelling are based on the data collected from Synergy, Western Power and direct from non-Synergy contestable customers with total annual loads as defined in Section 6.4.2. The load profiles from which these totals arise, are from actual raw data sources and so these actual profiles are what have been used as the load profiles for the modelling. The total peak load according to the combined load profile is 522kW.

7.8.6 Asset Sizes

For each of the two Microgrid scenarios the following asset sizes were modelled:

- Solar: 500kW, 750kW, 1000kW, 2000kW, 3000kW
- Wind: 0, 600kW, 1200kW
- Battery (2hrs): 0, 2300kWh, 4600kWh
- Diesel Generation: 750 kVA (for back-up only so single size selected sufficient to support peak load)

7.8.7 Asset Data

Details on the Asset data including costs and performance are summarised in Table 5

Table 5: Asset Data used as input to Grid Cog Modelling

Asset	Generation (first year)	Capacity Factor	Performance	Capex	Annual Opex
Existing Rooftop Solar	428 MWh / 249kW DC	19.6%	89% derating factor, 0.4% degradation per year	N/A - existing	N/A
Solar Farm	2289 MWh / MW DC	26.1%	89% derating factor, 0.4% degradation per year	$2.16m/MW	$16k pa + Ins. @ 1% of Capex + $5k/ha for land
Wind Farm (2nd hand refurbished turbines)	1630 MWh / 600kW Turbine (GridCog prediction prior to BlairFox assessment (ref. Section 5.6)	30.9%	17.25% losses, 1.6% degradation per year	$1.86m/MW	$30k for connection + $35k/turbine + Ins. @ 1% of Capex + land @ $5k/turbine
BESS	Lithium battery, 2hr duration		90% depth of discharge, 85% round trip efficiency, 2% degradation per year	2300kWh @ $826/kWh 4600kWh @ $717/kWh	Ins. @ 1% of Capex
Microgrid Diesel Genset	750kVA diesel generators and transformer (for back-up only, so operation not modelled)			$360k	N/A
Existing ERG	2x500kVA diesel generators and transformer			N/A	$210k
Streetlights	Approximately 160 streetlights in Mullewa			N/A	$12k income to EMN MO
Grid Connection	1.5MW export constraint (export between 4pm-8pm only, first 3 years only)			$1m	$55k + Ins. @ 1% of Capex
Embedded Network (EMN only)	Based on ownership retained by Western Power with network lease by the Microgrid Operator (MO)			N/A	$56k for lease + $40k general (paid to Network Operator

7.8.8 Network Tariffs

Network tariffs [1] used in the modelling were as follows:

- Non-Contestable Customer: RT1 (applied to each NMI)
- Contestable Customers / Unmetered Load: RT2 (applied to each NMI)
- RGS+NCS Model: RT11 (based on 1.5MW DSOC and 92km to Geraldton substation)
- EMN Model: RT5 (based on <1kVA half hourly CMD and so distance charges don't apply)

7.8.9 Energy Costs and Retail Tariffs

The following assumptions were used in the modelling for retail tariffs and energy costs:

- Non-Contestable Customer: Synergy A1, applied to each NMI
- Contestable Customers / Unmetered Load: Synergy L1 (for loads <50MWh/yr), applied to each NMI
  - (Note: Contestable customers generally use >50MWh/year, which would mean in terms of standard Synergy tariff L3 would apply. L3 tariffs however are considered to be significantly higher than what is realistically available to contestable customers in the market, and so the L1 tariff is adopted as a better reflection of realistic prices for contestable customers).

- RGS+NCS Model: Sale of energy based on the balancing market price
- EMN Model: Sale and purchase of energy based on the balancing market price

Synergy were approached for indicative rates that could be used for wholesale supply and purchase of energy however at that stage the feedback was that the balancing market price would be a suitable proxy for contract rates.

7.8.10 Certificates, Market FEES and IRCR Charges

Income earnt from sale of certificates and charges associated with certificate obligations were based on the following pricing assumptions:

- LGC Certificates:
  - From 2022: $50 per certificate
  - From 2025: $44 per certificate
  - From 2026: $38 per certificate
  - From 2027: $32 per certificate
  - From 2031: $15 per certificate equivalent (this is based on there being a replacement scheme after 2030, or if not, then to reflect the expected resulting increase in the wholesale energy price if no replacement scheme)
- LGC Obligations: 18.54% of certificate price
- STC Obligations: 28.8% based on STC price of $38

Market Fees were based on a cost of $6/MWh, with $1.4004 towards Admin fees and the remainder towards ancillary services)

IRCR Charges were based on a cost of $114,134.15/MW with TDL ratio of 1.6. This is taken from the published rate for 2020-21 capacity year and is expected to remain at this level for the foreseeable future.

7.8.11 Line Loss Assumptions

The line feeding Mullewa from the Geraldton substation is approximately 92km long. An estimate for the line loss factor was requested from Western Power however they were not able to provide this input. Although not a very detailed approach, in lieu of anything else, an estimate of 25% was assumed based loosely on a simple review of line loss factors reported for some of the other "long distance" radial distribution lines in the Western Power 2020/21 Loss Factor Report [2] as seen in Table 6.

Table 6: Reported loss factors for other "long distance" distribution lines

Information from WP Loss Factor Report		Fed From Substation	Approx Line Length	%loss per km
Distribution Line	**Loss Factor to apply in 2020/21**			
Bremer Bay Wind Farm	1.3643	Albany	181 km	**0.20%**
Evolution Mining (Mungarri) Pty Ltd	1.091	Black Flag	34 km	**0.27%**
Northen Star (Kanowna) Limited	1.0878	Boulder	27 km	**0.33%**
Paddington Gold Mine	1.0476	Black Flag	20 km	**0.24%**

As part of the FEED work conducted under Phase 5 of the study, Jarrah Solutions who were engaged to do the HV design (including automation and protection systems) performed line loss calculations (ref. Appendix G). Due to the early stage of the project development Western Power were unable to provide all the input data necessary for Jarrah to calculate a specific line loss figure. However, based on some broad assumptions, Jarrah were able to demonstrate that the operation of renewable generation in Mullewa at the end of a long feeder can have a significant impact on lines losses. On the assumptions made in the calculation, a reduction in losses of 162kW was calculated during export of renewables at 100% of installed capacity and a reduction in losses of 58kW during export of renewables at 20% of installed capacity.

7.8.12 Network Control Services

The assumptions used in the modelling for costing the Network Control Services were:

- Existing Case - Rental of existing back-up diesel gensets by the Network Operator is deemed an NCS for current existing case (estimated at $210k pa).
- RGS+NCS Microgrid - The Microgrid would operate an NCS in the form of access to reserved 50% of battery capacity (paid at $95k/MWh pa for reserved storage) and permanent back-up diesel to support the town in event of grid failure. Based on this service Western Power could demobilise the current ERG installation.
- EMN Microgrid - The microgrid will manage their resources (including permanent diesel back-up) to support the town+radial in event of grid failure and so no formal NCS service required. Based on this, Western Power could demobilise the current ERG installation.

7.8.13 Capacity Credits

At this location the network is currently congested and so because of the NAQ regime capacity credits are deemed to not be applicable for the first 3 years of operation, based on ERA Triennial review of the effectiveness of the Wholesale Electricity Market 2022, discussion paper [9].

Beyond the first 3 years of operation Generation Capacity Credits are available to for the RGS+NCS scenario and calculated as per Table 7.

It should be noted that it was discovered later on from conversation with AEMO that it was likely a NAQ would not apply and likely that Capacity Credits could be assumed to apply from project start, ref. Section 10.3.3.

Table 7: Basis for application of Capacity Credits

Combinations of Assets seeking Capacity Credits			Resulting Capacity Credits
Wind + Solar < 1MW, Battery < 4MWh or < 1MW			0
Wind + Solar > 1MW	20% of Capacity Sum		Maximum of these x $100,000/MW pa
Battery Storage > 4MWh*	¼ of Size MWh	Minimum of these two	
Battery Inverter > 1MW	Size MW		

* Where an NCS service reserves % of the battery, then only unreserved portion of this storage is considered in terms of being available for earning capacity credits

It was not possible to include an algorithm that defines this logic in a single GridCog model. Therefore 3 separate projects were run in GridCog to allow comparisons between the different cases based on the correct application of Capacity Credits.

7.8.14 Modelling Results

Figure 7-6 shows the results from GridCog for performance of the various scenarios (from the Microgrid Operator perspective), correlating to the different asset sizes (as indicated in the two highlighted scenarios), in terms of cashflow (vertical axis) and emissions reduction (horizontal axis).

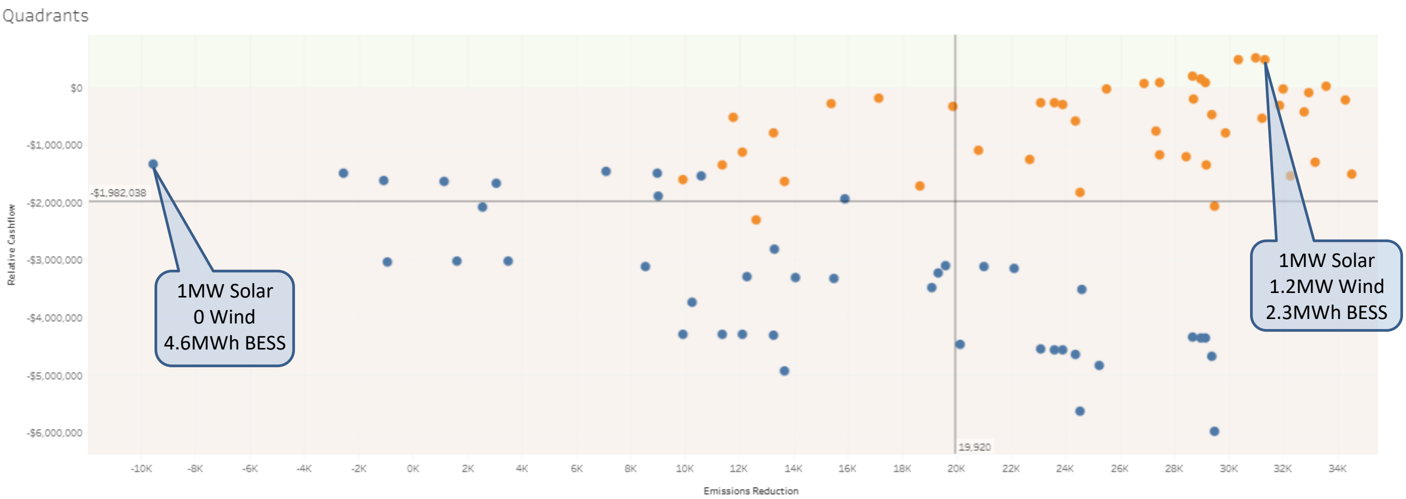


Figure 7-6: GridCog comparison of the performance of the different scenarios for the two different models

The orange dots represent scenarios from the EMN model and the blue dots scenarios from the RGS+NCS model, and so gives a good indication of the general performance of the two different models, with only EMN model scenarios achieving a positive cashflow.

In addition to the graphical representation of the results shown in Figure 7-6, GridCog can provide a summary table of performance which can be ranked in terms of relative cashflow, ROI and emissions reduction. The rankings according to these categories are shown in Figure 7-7.

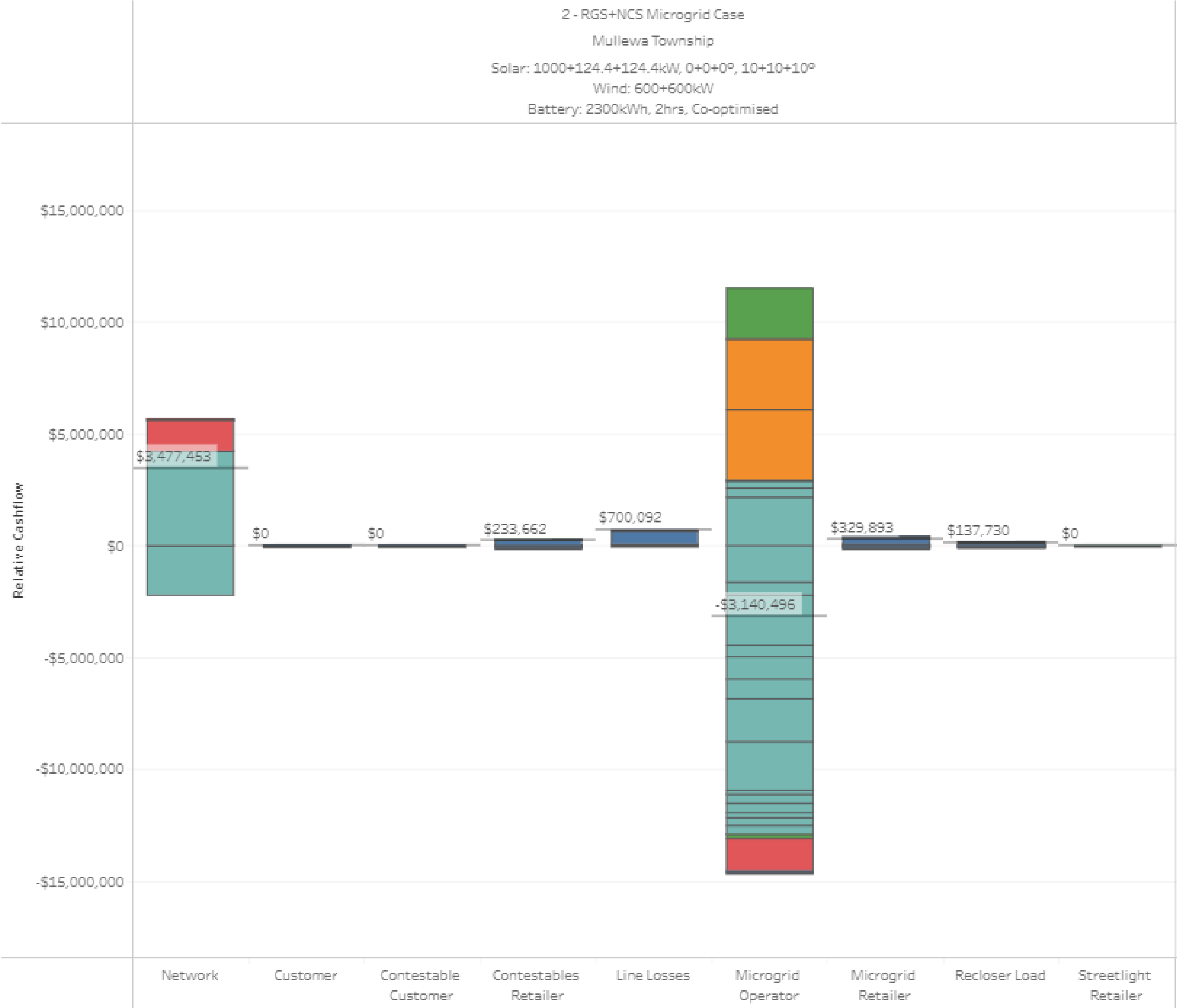
Figure 7-7: GridCog rankings for positive cashflow scenarios

The results above are from the Microgrid Operator perspective. As per the modelling parameters there were several conditions set pertaining to the performance of other participants. Figure 7-8 shows the relative cashflow results (relative to current operation today) for all of the participants in the model. For both the RGS+NCS and EMN models it can be seen that these conditions, ie.

- No change in cost to customers
- Retailers are no worse off
- Network operator is no worse off

are met across both the RGS+NCS and EMN models. What is observed is that the Network Operator would be significantly better off in RGS+NCS model which is in most part because not only does it retain all of the tariffs from all of the individual customers, but is also paid a tariff from the Microgrid Operator on the export of the renewable generation.

Figure 7-8 also provides an indication of the potential savings for the SWIS if current line losses were in the order of 25% as assumed for this exercise. In both models this is in the order of high hundreds of thousands, which is significant – particularly if this is considered to be indicative of similar fringe of grid towns and similar savings could be replicated across all of these via a repeatable Microgrid model.


2 - RGS+NCS Microgrid Case
Mullewa Township
Solar: 1000+124.4+124.4kW, 0+0+0º, 10+10+10º
Wind: 600+600kW
Battery: 2300kWh, 2hrs, Co-optimised
$15,000,000
$10,000,000
$5,000,000
$0
-$5,000,000
-$10,000,000
-$15,000,000
Relative Cashflow
$3,477,453
$0
$0
$233,662
$700,092
-$3,140,496
$329,893
$137,730
$0
Network
Customer
Contestable Customer
Contestables Retailer
Line Losses
Microgrid Operator
Microgrid Retailer
Recloser Load
Streetlight Retailer

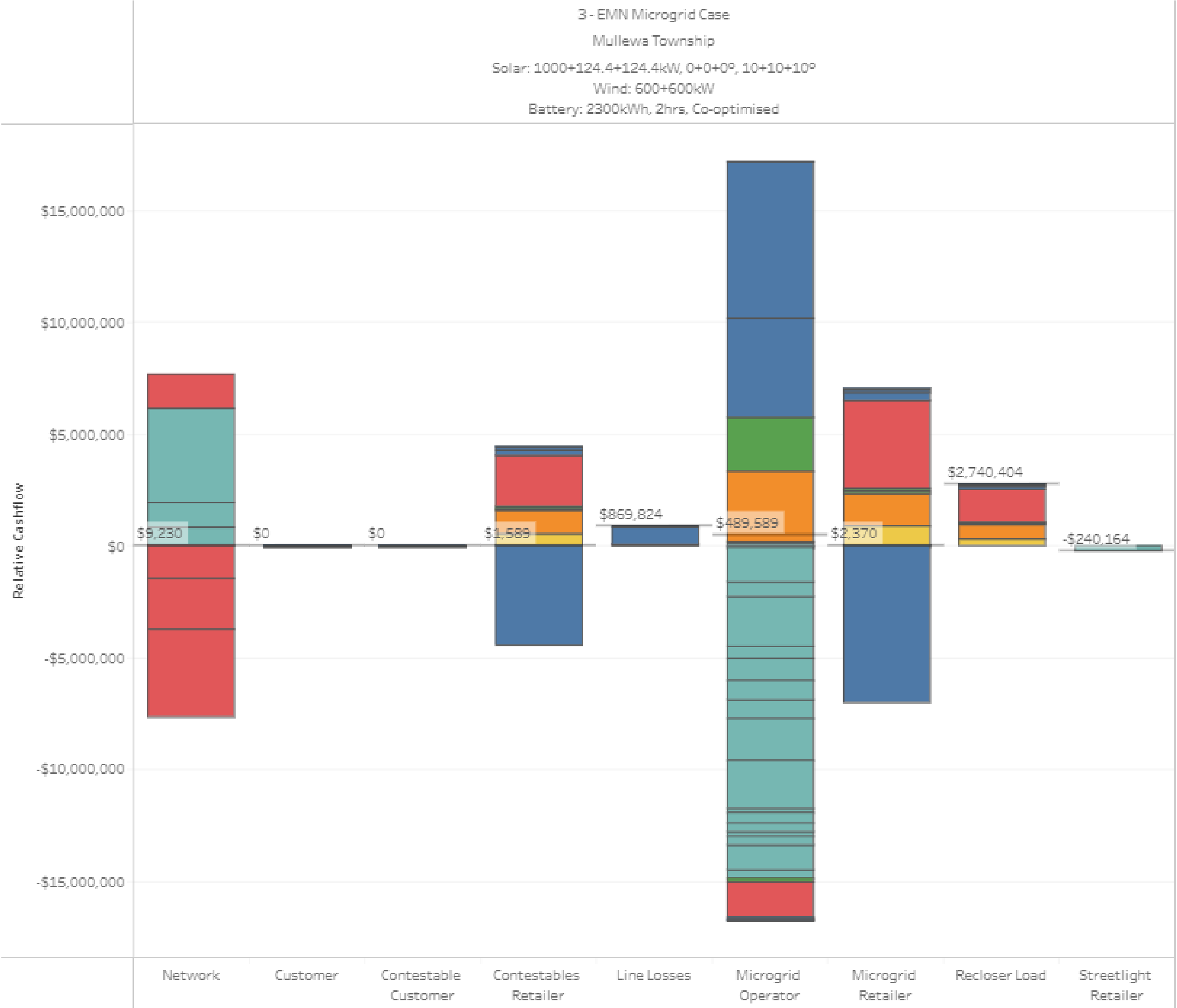


Figure 7-8: Relative cashflow results (relative to current operation today) for RGS+NCS (upper) and EMN (lower) Microgrid Models based on asset sizing of 1000kW Solar, 1200kW Wind & 2300kWh battery

7.9 Baseline Best Commercial Model

Based on the modelling results the best commercial model is the Embedded Network (EMN) Microgrid model. Within the EMN model there were a few combinations of asset sizes that showed similar overall performance. From these, the selected combination of asset sizes chosen as the basis for moving forward with, was that with 1000kW of Solar, 1200kW of Wind and 2300kWh battery. Even though the modelling indicated that in some rankings there may have been a potential for small gains with less solar capacity than the 1000kW, the EMN model incentivises growing the load, and a 1000kW would provide the ability to support such growth. It is significantly cheaper to put in a little extra generation during the initial build, while already mobilised on site, than installing at a later date.

8 PHASE 3 – TEST FUTURE SCENARIOS

8.1 EMN Microgrid Model

Future scenario testing was performed prior to obtaining the feedback that government policy would not support an EMN Microgrid model. At that time, based on the modelling that had been performed, the EMN model was the selected model to develop and so it was the EMN Microgrid configuration of 1000kW of solar, 1200kW of Wind and 2300kWh battery that was tested against future scenarios. This modelling was performed in GridCog again. The scenarios tested were:

- Loss of the radial load, ie. the load on the radial powerline downstream of the Mullewa town.
- Increase in the amount of Rooftop Solar
- General reduction in load
- General increase in load
- Introduction of a constant load
- Introduction of EV charging
- Step-away from decarbonisation (SAFD)
- Variation in wind generation

Details of the assumptions used and how these were implemented in the GridCog model for each scenario, are described in the following sections with a summary of outcomes provided in Section 8.1.9.

8.1.1 Loss of Radial Load

This scenario is based on the possibility of the radial load reducing due to the disconnection of properties from the radial network because of the Western Power policy of continued roll-out of SPS's for single remote loads at the end of long radials, for which properties downstream Mullewa are a prime candidate for.

Two scenarios were considered:

- Scenario 1: Radial loads drops 20% per year until zero after 5 years

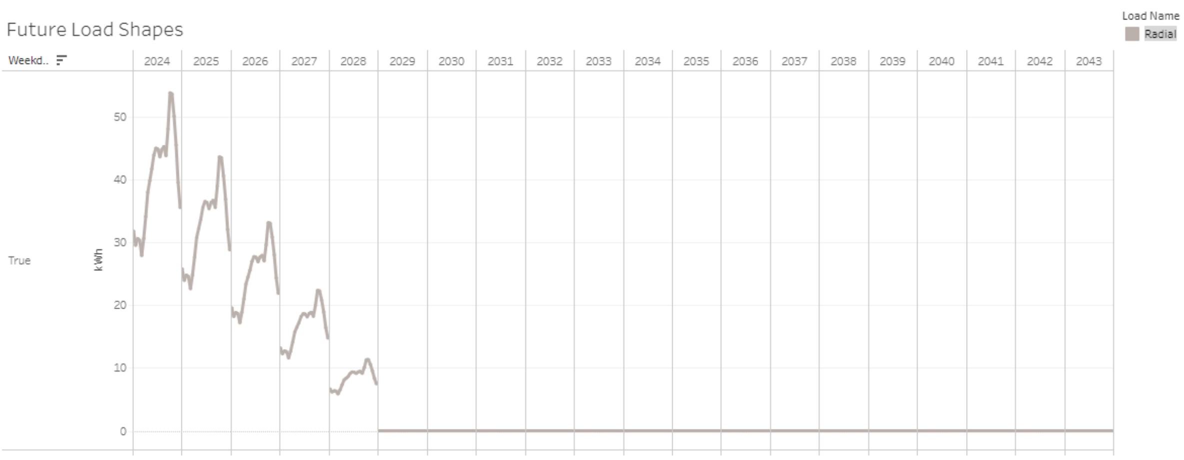


Figure 8-1: Grid Cog input representing the radial load dropping by 20% per year over 5 years

- Scenario 2: Radial loads drops 5% per year until zero after 20 years

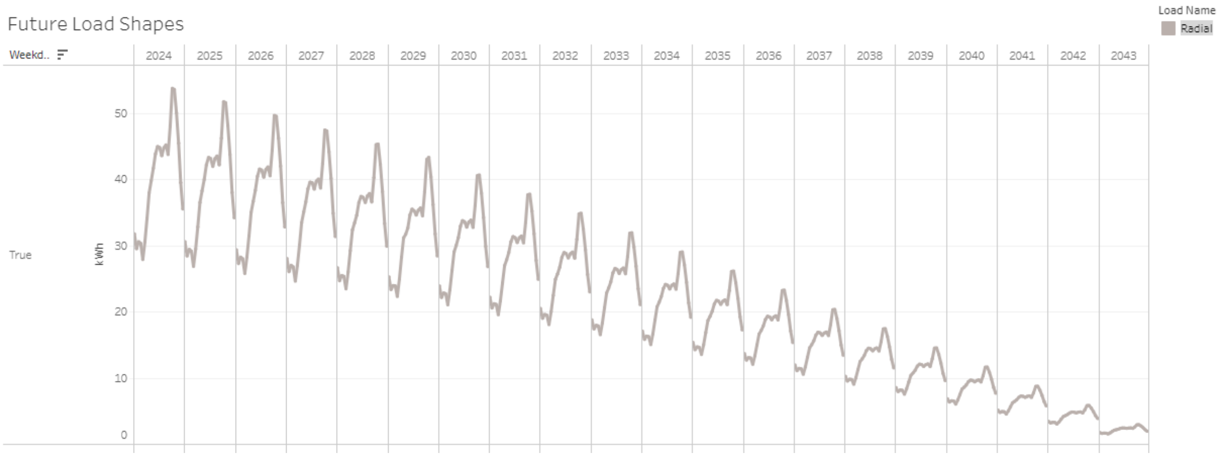


Figure 8-2: GridCog input representing the radial load dropping by 5% per year over 20 years

8.1.2 Increased Rooftop Solar

The assumption for rooftop solar in Mullewa today and estimate future uptake modelled is given in Table 8.

Table 8: Estimate of rooftop uptake for future scenario

	Total Combined	Non-Contestable Customers (NC's)	Contestable Customers (C's)
No. of Customers	289	278	11
No. with Rooftop Solar (base case)	44	39 (estimate)	5 (estimate)
%	15%	14%	45%
Solar Rooftop generation (base case)	249kW	124.5kW (estimate)	124.5kW (estimate)
Estimated uptake in Solar over 20 year life		3% (8 customers) per year over 5 years up to max of 29% (79 in total)	9% (1 customer) per year up to max of 73% (8 customers) in 3 years
Max rooftop solar after years		252 kW	200 kW

The generation profile of this estimated increase in rooftop solar is represented for both the Non-Contestable and Contestable customers in Figure 8-3.

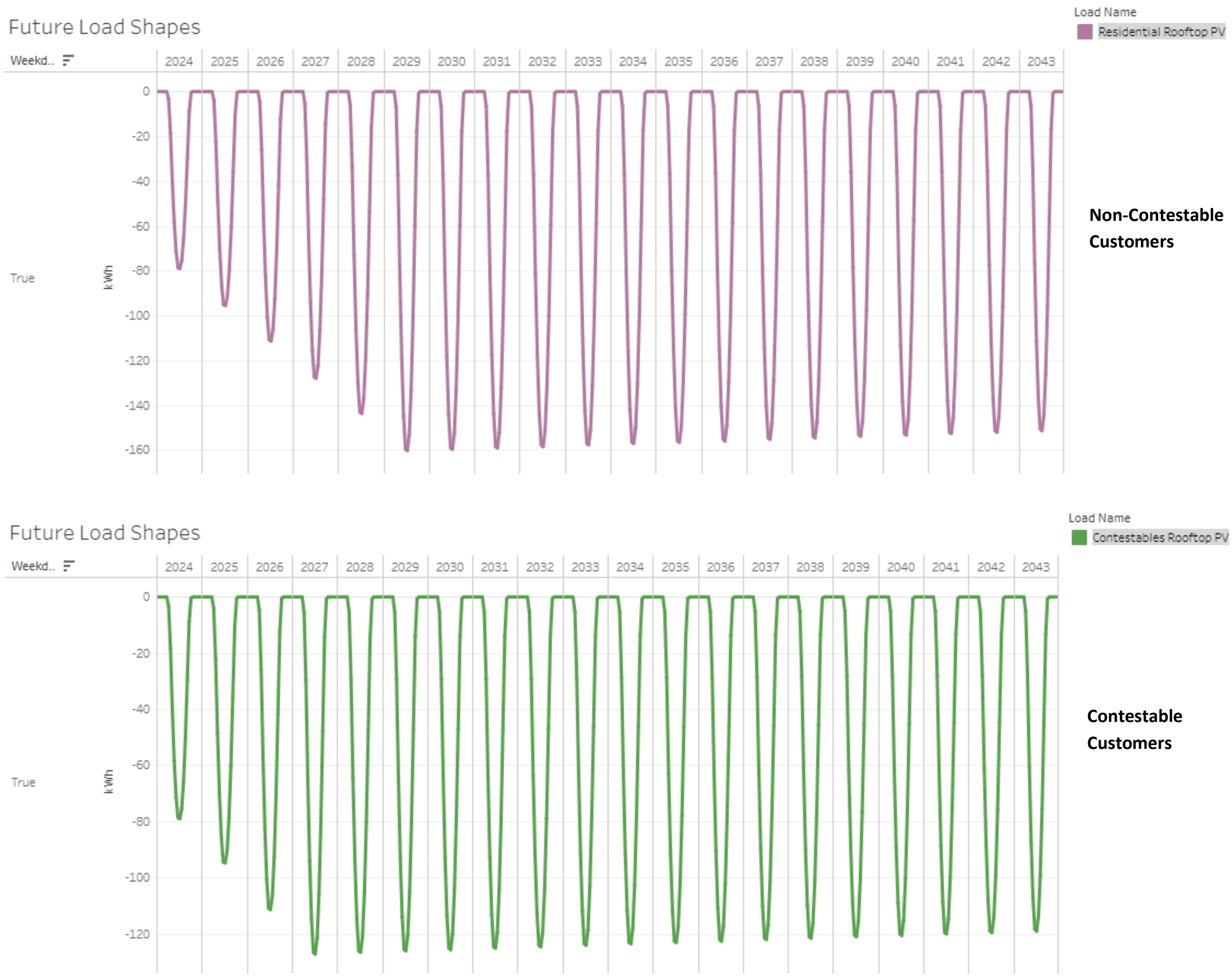


Figure 8-3: GridCog input representing future rooftop generation scenarios for Non-Contestable and Contestable Customers

8.1.3 General Reduction in Load

The basis for considering a general reduction in load is population decline and the resulting adjustment to the load profile is according to the following assumptions:

- Same profile shape
- Same variation applied to both Contestables and Non-Contestables
- General 1.33% annual growth no longer applied

Two scenarios were considered:

- Scenario 1: Load declines by 10% per year for 5 years

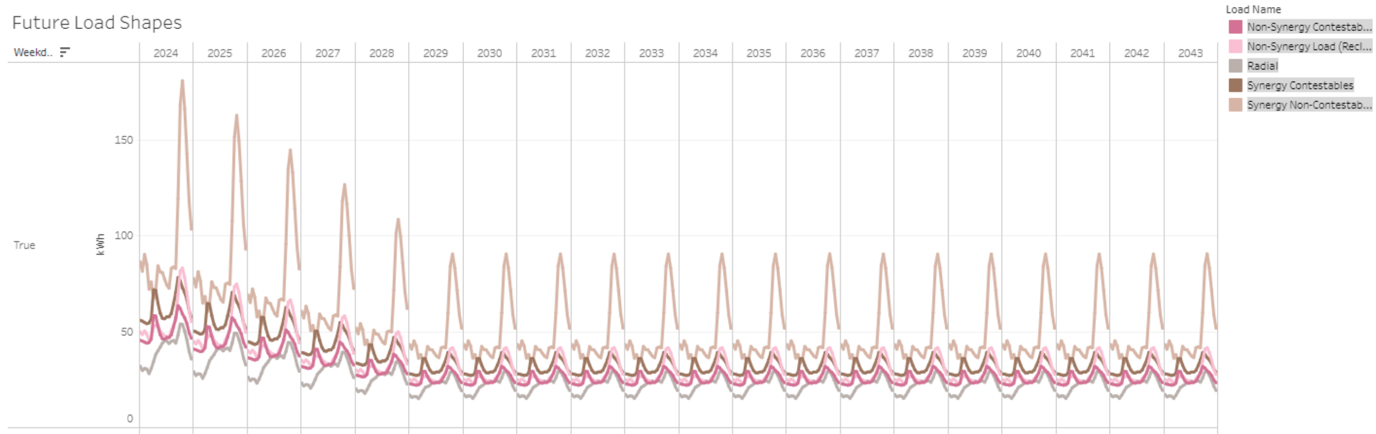


Figure 8-4: GridCog input representing reduction in load by 10% per year over 5 years

- Scenario 2: Load declines by 2% per year for 20 years

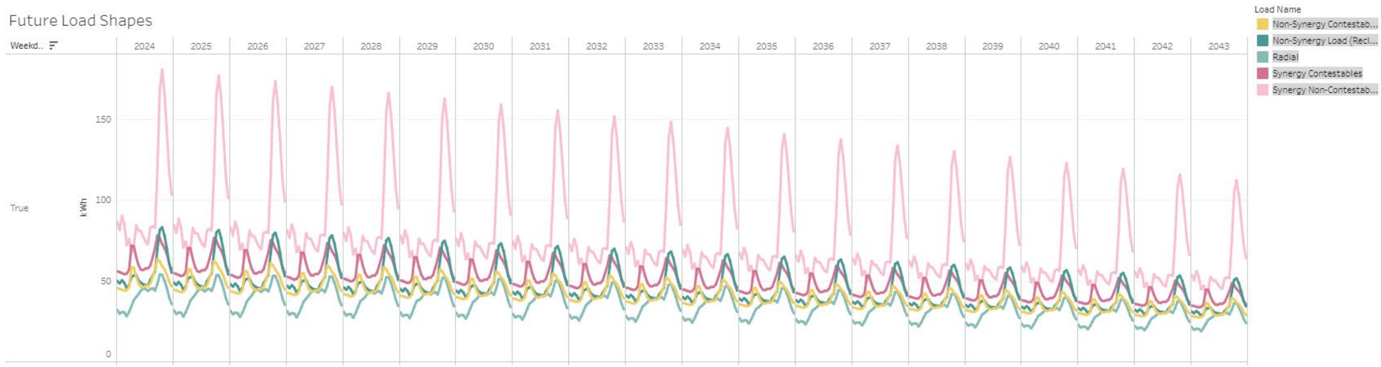


Figure 8-5: GridCog input representing reduction in load by 2% per year over 20 years

8.1.4 General Increase in Load

The basis for considering a general increase in load is population increase and through the “electrification of everything” principle (although not including vehicles). The resulting adjustment to the load profile is according to the following assumptions:

- Same profile shape
- Same variation applied to both Contestables and Non-Contestables
- Load from “electrification of everything” assumes that appliances currently operating on gas will be changed over to appliances operating on electricity. Mullewa Farm Supplies (Distributor of the Kleenheat 45kg gas bottles) estimates that they would go through approximately 200 of the 45kg bottles per year. There is approximately 2205MJ (613kWh) of energy in a 45kg bottle which equate to 123MWh for 200 bottles consumed over a year. Assuming this amount of energy was displaced directly by electricity it would mean a 4.5% increase on the current load estimate of 2694MWh per year.

Two scenarios were considered:

- Scenario 1: Annual growth goes from 1.33%pa to 10%pa over 5 years then back to 2% for remaining years

Figure 8-6: GridCog input representing increase in load by 10% per year over 5 years, then reducing to 2% per year for remaining years

- Scenario 2: Annual growth goes from 1.33%pa to 3%pa over 20 years

Figure 8-7: GridCog input representing increase in load by 3% per year over 20 years

8.1.5 Introduction of a Constant Load

The basis for considering the introduction of a constant load is the possibility of some type of small mining operation setting up in the area. With Mullewa being on the doorstep of significant mining operations further east and north and having access to the port of Geraldton via railway and road it could be (with access to reliable energy added to that) an attractive area for locating final processing operations looking to export a product to market through Geraldton.

Two scenarios were considered on this basis:

- Scenario 1: Small mine with 1MW load begins operations after 2 years and continues over the project life

Figure 8-8: GridCog input representing an additional 1MW constant load from year 3 for the life of the project

- Scenario 2: Small mine with 1MW load begins operations after 2 years and shutdowns after 5 years of operation

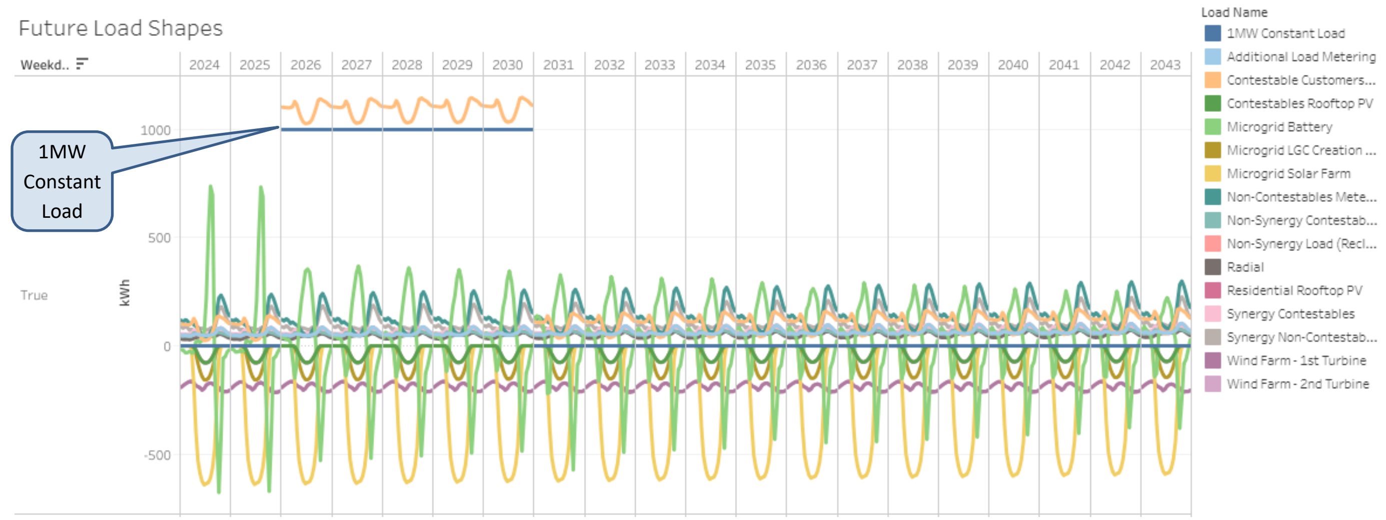


Figure 8-9: GridCog input representing an additional 1MW constant load from year 3 for a period of 5 years

8.1.6 Introduction of EV Charging

The modelling for introduction of EV Charging is based on the following assumptions:

- Load will comprise of mostly residential slow charging occurring at night with some visitor quick charging occurring at midday. This seems to correlate with current trends showing main charging peaks for electric vehicles to be at night (ie. during off-peak power) or around middle of day (ie. when excess solar available) [3].

- From Mullewa 2021 Census: 186 people in Mullewa in driving age (17-79). Assume 75% of these drive and have access to one vehicle means a possible 140 vehicles could become electric. According to Census there is 171 registered vehicles. Assuming some of these not actually in regular use, 140 vehicles appears to be a reasonable assumption for vehicles currently in use in Mullewa.

- Assume yearly growth in electric vehicles results in corresponding growth in yearly load,
- Assume the % of vehicles changing to electric is per Table 9.

Table 9: Estimated uptake of EV's in Mullewa for future scenario (also reflected in Figure 8-10)

By Year	2029	2030	2037	2041
% of EV's	7%	21%	43%	65%
No. of EV's (accounting for growth in total no. of vehicles)	10	33	71	114

- Assume 60kWh battery with 5.5kWh consumed per day per vehicle, so 11 day recharge cycle and 10kW chargers.

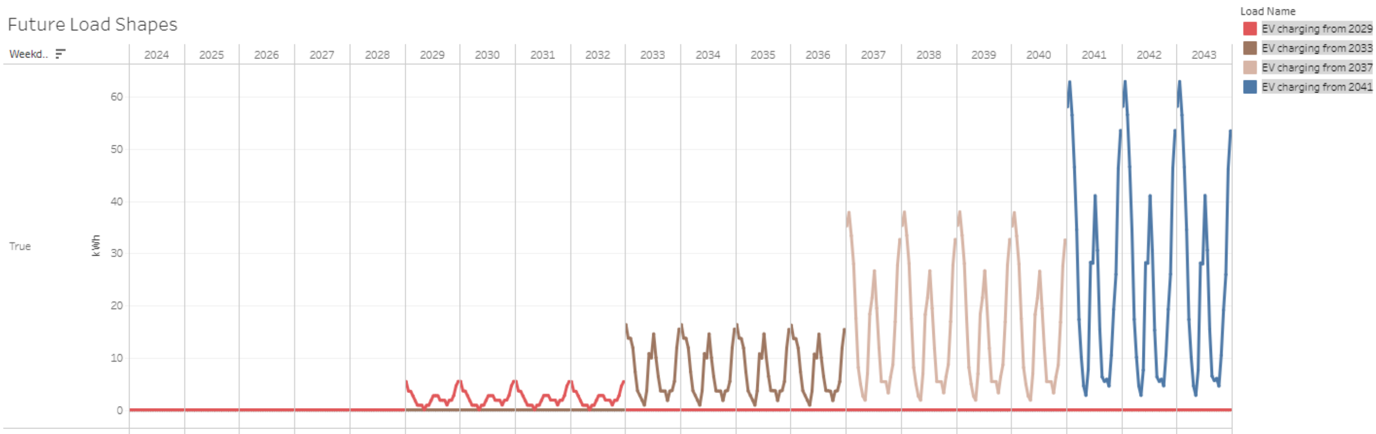


Figure 8-10: GridCog input representing the additional load for future EV charging scenario

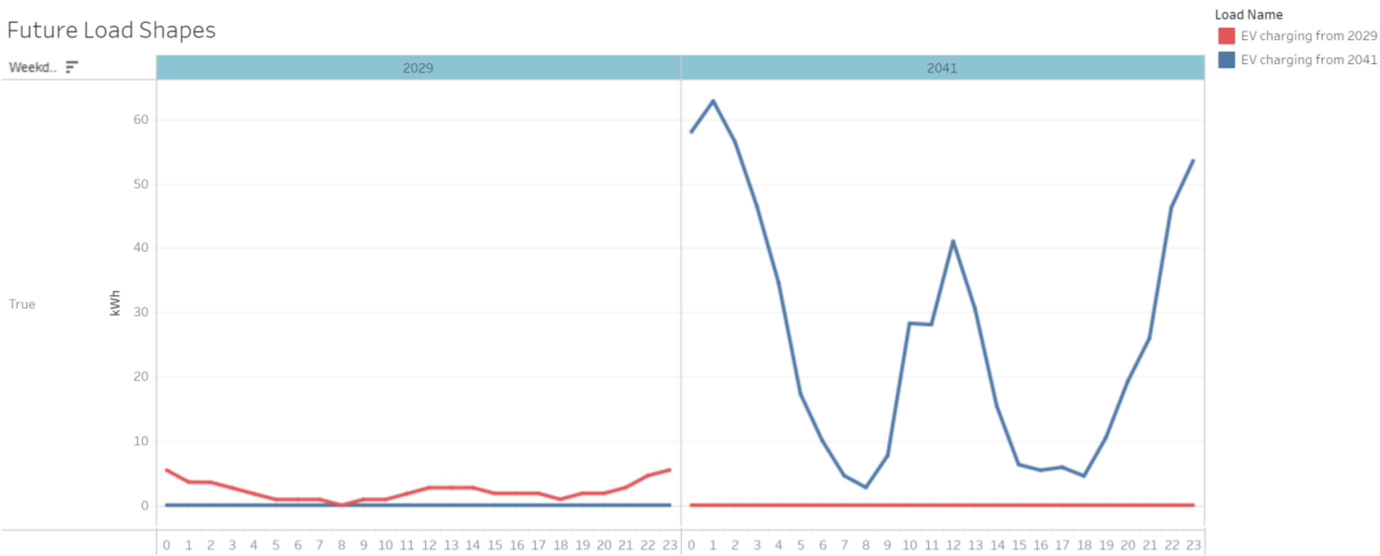


Figure 8-11: Comparison from 2029 and 2041 of modelled average daily load profile from EV charging

8.1.7 Step-Away from Decarbonisation (SAFD)

The premise of this scenario is that there is a shift from the current decarbonisation trajectory, towards maintaining the current mix of carbon and renewable energy. The assumptions resulting from this are:

- Wholesale prices get cheaper, goes down by: Scenario 1: 10% and Scenario 2: 20%
- LGC's prices trend down and go to zero after 2030 as per the following table:

Table 10: Assumed LGC prices for a future scenario based on a step-away from decarbonisation

From Year	Base Case LGC Prices, $/MWh	Revised LGC Prices for SAFD Scenario, $/MWh
2022	$50	$50
2025	$44	$40
2026	$38	$25
2027	$32	$10
2031	$15	$0

8.1.8 Variation in Wind Generation

The solar generation software data tools are accepted as being reasonably accurate and site acquired solar data is typically not required for project validation.

For wind generation however, 12 months of site acquired data is often obtained in order to validate predicted output.

Given no site data has been recorded, predicted wind input has been varied by +/-10% and +/-20% to understand the impact on the model performance.

8.1.9 Summary of Results

All of the scenarios described in preceding sections were input into GridCog based on the selected base case model with the results summarised from the perspective of the Microgrid Operator in Table 11.

Table 11: Summary of Future Scenarios Testing

<table>
<tr><th rowspan="2">Future Scenario</th><th colspan="4">Difference in Cashflow from Base Case of +$0.5m</th></tr>
<tr><th colspan="2">Scenario 1</th><th colspan="2">Scenario 2</th></tr>
<tr><td>Loss of Radial</td><td colspan="2">20% drop pa over 5 years
-$0.99m</td><td colspan="2">5% drop pa over 20 years
-$0.62m</td></tr>
<tr><td>Increase in Rooftop Solar</td><td colspan="4">Increase non-contestables approx. 20% pa over 5 yrs until approx. twice what it is today (so going from 14% of total customers to 29%)
Increase contestables approx. 20% over 3 years until approx. 1.6 times what it is today (so going from 45% of total customers to 73%)
-$0.89m</td></tr>
<tr><td>General Reduction in Load</td><td colspan="2">Decline by 10% pa over 5 years
-$2.70m</td><td colspan="2">Decline by 2% over 20 years
-$1.60m</td></tr>
<tr><td>General Increase in Load</td><td colspan="2">10% increase pa over 5 years then back to 2% for remaining years
+$2.17m</td><td colspan="2">3% increase pa over 20 years
+$0.85m</td></tr>
<tr><td>Introduction of a Constant Load 1MW Load</td><td colspan="2">Occurs after 2 years and remains for only 5 years
+$2.39m</td><td colspan="2">Occurs after 2 years and remains for life
+$16.5m</td></tr>
<tr><td>Introduction of EV Chargers</td><td colspan="4">7% of vehicles are EV's in 2029 increasing to 21% by 2033, then 43% by 2037, then 65% in 2041
+$0.22m</td></tr>
<tr><td>Step-Away from Decarbonisation (SAFD)</td><td colspan="2">LGC prices trending down with 10% reduction in wholesale prices
-$1.89m</td><td colspan="2">LGC prices trending down with 20% reduction in wholesale prices
-$2.20m</td></tr>
<tr><td>Variation in Wind Generation</td><td>10% less generation
-$0.47m</td><td>20% less generation
-$0.95m</td><td>10% more generation
+$0.46m</td><td>20% more generation
+$0.90m</td></tr>
</table>

The outcomes summarised in Table 11 demonstrates the sensitivity of the commercial outcome for this model to the microgrid load. This is as expected as the design of the EMN model means the performance is intrinsically linked to the load. This is one of the key areas where the EMN model differs from RGS+NCS model. The RGS+NCS model is decoupled from the load as all of the generation is sold via long-term contracts or in the WEM at balancing market price and so even if the microgrid load goes up or down the microgrid provider will still receive the same income for the energy generated with long-term contract. The balancing market price may be impacted by the total SWIS load, but not the local microgrid load.

This inherently means there is more risk associated with the EMN model, but the flip side is that there is also much greater opportunity to succeed commercially with the Microgrid Operator incentivised to grow the load (which in this case means grow the town of Mullewa) in order to improve commercial performance. This potential for significant growth can be attractive to investors, which are needed in order to develop such projects.

Also as would be expected it is clear any deviation in the performance of the wind resource from that estimated will impact the commercial performance of the EMN Microgrid, however not as significantly as in an RGS+NCS model where revenue is mostly based on sale of energy generation and so any variation in generation quantities will more directly impact commercial performance.

8.2 RGS+NCS Microgrid Model

With an RGS+NCS the income is independent of the microgrid load and there is little value in testing future scenarios associated with potential changes in load. Since the RGS+NCS model was selected as the model to progress based on considerations outside the commercially modelling done, the interest was to investigate mechanisms for affecting the commercial outcome of this model, the objective being to understand which of these to pursue in order to form the basis of a proposal for a feasible model. The resulting scenarios tested were:

- Scenario 1: As part of an NCS agreement for improving reliability the Microgrid Operator is not subject to a network tariff. This is a reasonable expectation given a signification portion of the generation is consumed locally and the export will reduce the line-losses on the Geraldton-Mullewa line.
- Scenario 2: there is no NAQ restriction on earning capacity credits or limiting export to 4pm-8pm every day in first 3 years.
- Scenario 3: Assigned Capacity credits increased to reflect the possibility of earning increased credits from battery capacity and from the diesel genset. Resulting estimated capacity credits income: $162k pa.
- Scenario 4: Changing the basis for the NCS service fee to Western Power based on estimated cost for current ERG. Resulting estimated NCS fee: $210k pa.
- Scenario 5: Could only get an agreement with a retailer for an off-take agreement to purchase the generation if the agreed price was based on retailer paying 30% under balancing market price.
- Scenario 6: Scenario 1+2+3+4+5

8.2.1 Summary of Results

In the original GridCog modelling the RGS+NCS model for 1000kW Solar, 1200kW and 2.3MWh battery achieved a cashflow result over 20 years of -$3.1million (ref. Figure 7-8).

The summary of results in Table 12 show the impact of the different scenarios on the cashflow for the Microgrid Operator relative to the original -$3.1 million.

Table 12: Summary of results from the different scenarios modelled for RGS+NCS Microgrid Model

Scenario	Scenario Short Description	Relative change to original RGS+NCS cashflow
1	No network tariff	+ $1.5 million
2	No NAQ	+ $0.9 Million
3	Increase in Capacity Credits	+ $2.0 million
4	Increase in NCS fee	+ $2.0 million
5	Lower than balancing marker price offered by retailer for off-take agreement	- $1.9 million
6	Combination of above scenarios	+ $4.7 million

The conclusion from these results was that if it was going to be feasible to deliver a commercially viable RGS+NCS type Microgrid model, given the downsides associated with likelihood of not being obtain balancing market price for the energy sold (Scenario 5), the measures in Scenarios 1 to 4 would need to be looked into in further detail to understand what would likely be achievable in a investment ready commercial model.

9 PHASE 4 – COMMUNITY ENGAGEMENT

9.1 Community Engagement Plan

The plan for engaging with the community involved engaging with community representatives as well as directly with the individual Mullewa residents.

Local community representatives engaged with were the City of Greater Geraldton (CGG), The Mid-West Development Commission and MEEDAC.

In terms of the overall SWIS community of which Mullewa belongs, the representatives engaged with for the SWIS were Synergy, Western Power, Energy Policy WA (EPA), the Economic Regulatory Authority (ERA) and the Minister for Mines and Petroleum; Energy; Hydrogen Industry; Industrial Relations, the Honourable Bill Johnston (noting that if a solution in Mullewa is to become a repeatable model, then these representatives would be impacted by what is implemented in Mullewa).

Engagement directly with Mullewa residents consisted of direct contact with specific landowners in relation to securing land for the Microgrid infrastructure, direct contact with specific business owners in relation to obtaining their energy consumption data and formal information session held at the local Mullewa Community Hall.

The timeline in Figure 9-1 shows the timing of the more formal engagement activities.

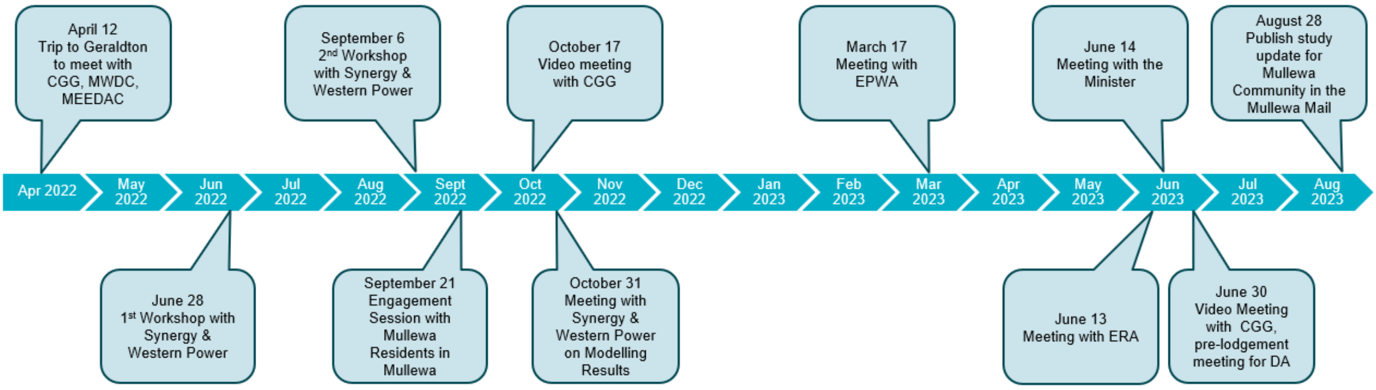


Figure 9-1: Timeline of formal engagement activities

9.2 Engagement Events and Associated Materials

All of the presentations produced for the different engagement sessions can be found in Appendix A.

The following sections summarise the engagement process for the differing forums.

9.2.1 CGG, MWDC and MEEDAC

Meetings held during April 2022 in Geraldton with CGG (ref. Figure 9-2), MWDC and MEEDAC were essentially introductory sessions to inform these organisations about the content of the feasibility study and hopefully obtain initial impressions on how a Microgrid in Mullewa might impact on the local community and surrounding areas.

Figure 9-2: Photo from the trip to Geraldton for meeting with City of Greater Geraldton representatives (while in Geraldton also met with MWDC and MEEDAC representatives)

Follow up meeting with the CGG was in the form of a general update and towards the end of the project a more specific meeting around the lodgment process for the development application.

9.2.2 Synergy and Western Power

With Synergy and Wester Power as paid contributors to the Study there has been continual engagement over the life of the Study, including weekly catch-ups with the Study appointees of these organisations. The formal engagements in the form of Workshops and review meetings have provided the Study access to insights and advice from several senior representatives.

The first workshop presented Sunrise's initial high-level screening of different commercial models, main considerations in terms of regulations, and suggestions for roles/services these organisations might play/provide in a Microgrid model applied to Mullewa, and in general, to other fringe-of-grid towns.

The second workshop presented a strawman model based around an EMN type Microgrid with the intent of testing if it would fit within the Western Power and Synergy strategy execution approach and strategy execution timing. This was considered important because solving fringe-of-grid / adopting Microgrids is not something that can be done in a vacuum. The strawman model is presented in Figure 9-3.

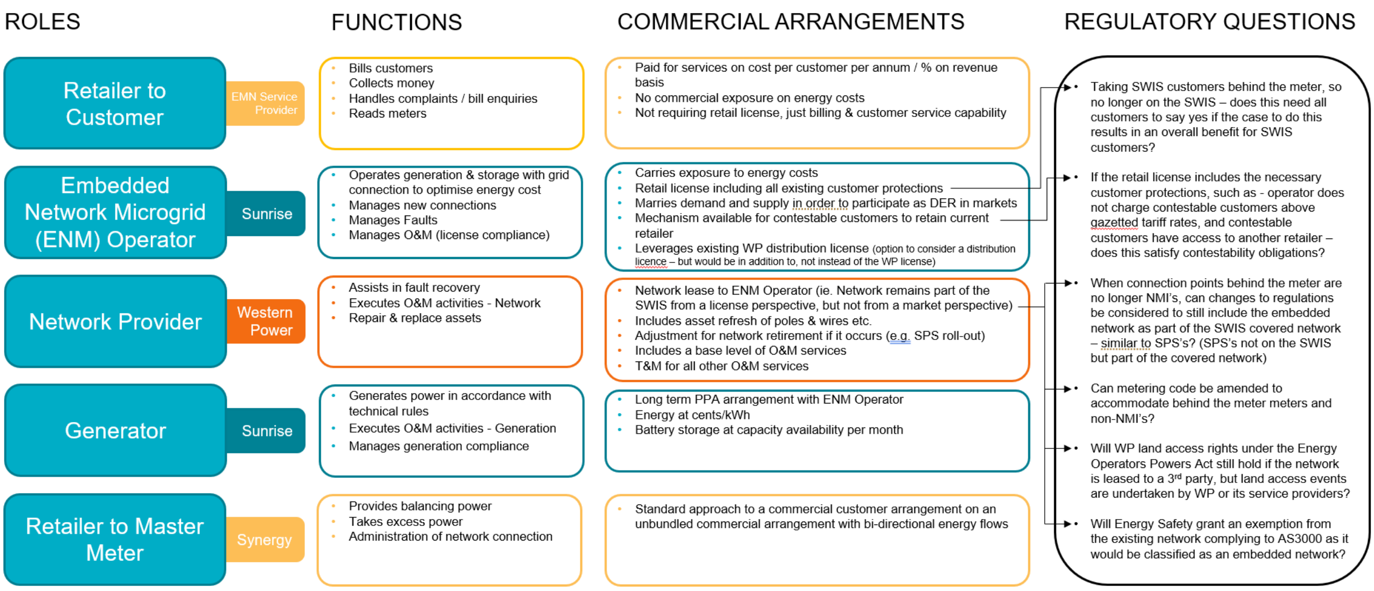


Figure 9-3: Proposed strawman model for driving regulatory reform

In the third meeting with Western Power & Synergy the results from the commercial modelling in GridCog (as described in Section 7.8) for both the RGS+NCS and EMN Microgrid Models were presented.

Sunrise also attempted to formally engage with Western Power by issuing a position paper to facilitate agreement on a set of principles, which Sunrise could then use to base the pricing of a reliability service under an Alternative Options Proposal.

9.2.3 Mullewa Township

The direct engagement with the Mullewa community was a collaborative exercise, executed together with Synergy and Western Power. The community engagement expertise within Synergy was harnessed to direct and promote the engagement process.

Advice was sought from the Mullewa Community Resource Centre, who also assisted in promoting the engagement session and providing the venue. The event was advertised in the September issue of the "Mullewa Mail" (ref. Figure 9-4) and via a letterbox drop. It was held on Wednesday evening, 21st September 2022.

Synergy, Western Power and Sunrise all presented at the event. Including a questions and answers session, it lasted over an hour. 14 residents registered their attendance at the event, which according to feedback from the community resource centre was a reasonable turnout for Mullewa.

Synergy led the introduction to the session and provided an overview of Synergy's purpose, vision and strategy with particular focus on their roadmap to zero emissions. Western Power explained what they do in relation to the overall SWIS and also provided some feedback on the performance of the ERG at Mullewa as well as some insight as to how they see the grid evolving and planned upcoming works. The Sunrise presentation (ref. Figure 9-5) was specifically focused on the Study, explaining the objectives and key activities of the study plus explaining what a Microgrid is and what it could look like (in terms of infrastructure) in Mullewa and intended outcomes from implementation of a Microgrid at Mullewa and possible opportunities. Ref. Appendix A for the complete presentation.

Mullewa District Office Update

SEPTEMBER 2022

City of Greater Geraldton
Mullewa

The month of August was a fabulous time to have been in Mullewa with the wildflowers colouring the country side and the various events that were held including the Mullewa Polocrosse Carnival, Outback Bloom (Mullewa's Wildflower Festival) and the Mullewa District Agricultural Show.

September is also a very good time to enjoy all of the wildflowers that are blooming in this Wildflower Country region that Mullewa is a part of.And especially now that the famous wreath flowers are blooming not far past the historical town of Pindar.

This year's Polocrosse Carnival in Mullewa was held on the weekend of 13 and 14 August.
While Saturday 13 August was a wet and dreary day but during the next day the Sun was shining by the time of the finals and the various teams of riders were able to display their talents. The Mullewa teams of riders were winners of the B and E Grade senior competitions.In the A grade final, the South Midlands team showed their strengths in defeating the Walkaway team.

Mullewa's four day wildflower festival called Outback Bloom was held from 25 to 28 August. This festival in its 35th year was a truly wonderful event with the Mullewa Town Hall looking like an outback bush scene with over 130 specimens of wildflowers showing the biodiversity of this region. Plus there were a number of events held each day of the festival with guest speakers, participants of the show being able to learn some new skills such as paper flower making and using the cameras on their phones to photograph wildflowers, and even guided tours of Mullewa's bush trails. A total of 1078 people visited the four day show.

Mullewa's Agricultural Show was held this year on the last Saturday in August. Over 100 volunteers were involved over four days to produce a wonderful agricultural show with a wide range of activities held inside and outside at Mullewa's Recreation Precinct with a fantastic fireworks display to finish to close out the Show. The Show's organisers are now looking for ways to improve the Show. They are seeking feedback from members of the community and visitors to make these annual show even better. Please take the time to click on the link below and fill in their survey. As they are saying, "You can help us to make the 2023 Mullewa Show even better". The survey closes Friday 24th September. https://www.surveymonkey.com/r/TW7NGFZ

MULLEWA FOOTBALL CLUB COLTS, INTO THE FINALS

Out of the Mullewa Football Clubs four teams (League, Reserve, Colts and Women) that played this season in the Great Northern Football League.

The Mullewa Colts Team in fourth position at the end of the regular season has made it to the grand final with their game against Towns to be played at 9.00am on Saturday 10 September at the Town's Oval in Geraldton.

MAIN ROAD WORKS TO RE-COMMENCE

Main Roads WA has informed the City of Greater Geraldton that while work to wi den the Geraldton-Mt Magnet Road was suspended during the winter period, road works will be re-starting in October and then the estimated completion will mid-December of this year.
The road works will occur from about 23.2 kms from Geraldton and finish about 94.6 kms from Geraldton.

SYNERGY ENERGY GROUP STUDY

There will be an opportunity during this month for community members to have a say on the future of Mullewa's Energy requirements. On Wednesday 21 September from 5.30pm in the Mullewa Community Resources Centre at 8 Jose St, Mullewa, representatives of Sunrise Energy Group will be in Mullewa for a question and answer session.

Sunrise Energy Group, an emerging renewable energy company based in Perth, is doing an initial feasibility study into potential renewable energy microgrid options for Mullewa. Synergy and Western Power are supporting Sunrise's study, as part of our support for the Western Australian State Government's commitment to reach net zero greenhouse gas emissions by 2050. Together, we're leading the way to cleaner, more decentralised energy for remote and regional energy users, and a decarbonised future for a stabler grid and more affordable electricity for all Western Australians.

Sunrise's study will perform data analysis of how Mullewa uses energy, then use that information to model technical solutions. Throughout the process, they'll share any knowledge, findings and developments with the whole community as well as investors and other stakeholders interested in improving energy reliability in Mullewa.

As a first step, Sunrise, Synergy, and Western Power representatives invite all Mullewa residents to join them in a Community Engagement Session. Come and find out more about the study's objectives and community options, and be part of Mullewa's energy future.

Rod McGrath
Mullewa District Office Manager
9956 6643

Figure 9-4: Page 3 of the September issue of the Mullewa Mail advertising the community engagement event under "Synergy Energy Group Study"

Figure 9-5: MD of Sunrise, Neil Canby, presenting on the Mullewa Microgrid Feasibility Study to residents of Mullewa

9.2.4 EPWA, ERA & The Minister

Sunrise produced a Paper for EPWA for the purpose of introducing EPWA to the Mullewa Microgrid Feasibility Study, and in doing so, test the State's support for the EMN Microgrid model – proposed by Sunrise as the most promising model to implement for solving the "problems" of fringe-of-grid towns on the SWIS.

The paper was well received by EPWA and was the means through which meetings with EPWA, the ERA and the Minister were facilitated, with the objective to understand the level of support for the EMN Microgrid model, including the support for amendments to the regulations that would be needed for it to proceed.

The paper and presentation to EPWA focused on what were considered to be the two most feasible options for a Microgrid "solution" at Mullewa (and more generally, any fringe-of-grid town with reliability issues), ie. the RGS+NCS (re-termed as "NCESS" for the EPWA Paper) Microgrid commercial model and the EMN Microgrid commercial model and why the EMN Microgrid option was the best option to pursue.

Engagement with the ERA included similar discussions to what was had with EPWA, however also focused in more detail on the regulatory versus commercial challenges between the two models and pathways for implementation with Western Power, considering the outcomes from the recently published AA5[4] in terms of reliability performance.

Engagement with the Minister was on the recommendation of EPWA, with the intent being to introduce the study findings to date, and inform the Minister of the feedback that been received from EPWA and the ERA, and ascertain whether this was reflective of the government's current position.

9.3 Feedback from Community Engagement to the Project

9.3.1 CGG, MWDC and MEEDAC

Feedback from all three organisation was positive with the CGG referring to the possibility of synergies with other commercial developments being proposed in the area, such as a prospective iron ore project that was looking to pipe iron slurry to Mullewa from a mine east of Mullewa and then decant it in Mullewa and then transport the ore from

Mullewa to Geraldton port via rail. The council also conveyed it’s willingness to contribute with community engagement in Mullewa and were the ones originally recommending the Mullewa Mail newsletter as an effective means of communicating with the residents of Mullewa. In later engagement with the CGG, particularly during pre-lodgment discussions around the development application, the CGG were very engaging and open to considering requests for locating assets in road reserves and/or other CGG land holdings (prior to settlement of the final locations) and were looking forward to receiving the application.

The MWDC noted that with a Microgrid in Mullewa resolving the energy issues, then if the access to water could also be improved it could definitely open up the potential for new industries at Mullewa, such as market gardening, which was noted would fit well with Sunrise’s agrivoltaic aspirations for the solar farm.

MEEDAC were also positive towards proposals that could improve access to energy and/or water in Mullewa and interested in the possibility of increased employment opportunities that could come with a Microgrid for Mullewa.

9.3.2 Synergy and Western Power

Feedback from the 1st workshop was that although the initial commercial screening might indicate an advantage of the EMN model, the regulatory issues associated with this model and principle, may prove challenging to overcome and so Sunrise should not discount the RGS+NCS Model at that stage. Western Power also expressed in response to the EMN Microgrid model proposition, that selling the network was an unlikely scenario. Accordingly a concept based on leasing the network was developed with future modelling work reflecting the leased network concept.

In the 2nd workshop Western Power affirmed they were not looking to solve reliability issues of fringe-of-grid towns with externally owned/managed brownfield site, behind-the-meter microgrid solutions and despite them having a high focus on the mainstream operation of the business there was still an opening for proposals from the private sector where they could be shown to be of value.

Synergy also affirmed their current focus on the immense decarbonisation transformation work to be undertaken, however that there was still room for working with the private sector to deliver feasible microgrid solutions and did not have a specific position on Synergy retaining “ownership” of the customer relationship under certain Microgrid models, beyond that which was defined by the current regulations.

In regard to feedback on support for progressing the EMN model, Synergy and Western Power re-affirmed their involvement in the study was limited to providing input to Sunrise for Sunrise’s investigation of the feasibility of different models and would not support one model over another at this stage. Despite acknowledgement of the results from the GridCog modelling presented in the 3rd meeting, this feedback did not change, including the recommendation to continue to pursue the feasibility of both models.

What Western Power did affirm was that there was no intention of disconnecting Mullewa from the grid, however some of the remote single properties that were fed from the radial line downstream of Mullewa, may be eligible at some point for inclusion in the SPS program.

Other feedback received from Western Power outside of these formal engagements was that in addition to the installation of the ERG’s, significant works had been undertaken on the feeder line from Geraldton to Mullewa and so the reliability in Mullewa 2023 had improved since the initial conception of addressing the reliability of Mullewa via a renewable microgrid towards the end of 2020. It was acknowledged however the reliability was not only related to the state of the infrastructure but also exposure to weather and accidental events, exposure to which would always be greater on long rural feeders (according to Western Power NOM2022 [6] generally less than a third of outages are directly controllable by Western Power and the remainder due to windborne debris, extreme weather events or caused by a 3rd party), and that the study for Mullewa was in the context of providing a repeatable model for fringe-of-grid towns with reliability issues and so the specific value of a Microgrid solution as a reliability service was not lost based on Mullewa's latest reliability performance.

Feedback from both organisations was also provided on their understanding of the regulatory challenges associated with implementing a EMN Microgrid model (ref. Section 10.4), together with possible avenues for addressing some of them.

Western Powers feedback to Sunrise's position paper around pricing principles for a reliability service, was that Western Power had no basis to formally respond to these outside an actual formal Alternative Options Proposal submission.

9.3.3 Mullewa Community

After the presentation there were 22 questions/statements recorded during the formal question and answers part of the engagement. Given Synergy and Western Power were present, a significant number of these were about matters related to these organisations - around current operations and future plans. Questions and statements more specific to the Microgrid Study are shown in Table 13. A lot of the participants remained after the formal part of the engagement ended with several informal discussions occurring as presenters mingled with those that stayed on for refreshments.

Table 13: Questions/statements and answers around the Microgrid Study during Mullewa Township Engagement Session

Question/Statement	Response
There's a mine site 25kms away which will be up and running in 12 month's time, why don't you do a collaboration or early trial with its battery system (Vanadium Flow)? Seeing as there are supply issues; it will take forever to get products otherwise.	It's early days for this technology & using a battery of this size. We would monitor it to see if it could be utilised and if appropriate could have a look; don't want to only focus on this battery option and throw out the other options available.
Supply chain issues will hinder the project?	Yes there are global supply issues
Wind turbines: How do you select for the area? How long do they last? How tall are they?	Turbines; 20/30/40 yrs old in market currently; Albany is 20 yrs old and just refurbished them, hoping to get another 50 years out of them. Height depends on its purpose; Warradarge; 5 MW turbine x 120 m pole & 70m blades on top. Offshore they're twice that height. Mullewa doesn't need a 5MW size; small turbine or a refurbished one (30-40 in WA) 15-20 yrs old- 600Kw size with smaller turbine blades.
Solar panels: What does this look like?	1MW farm; 2Ha of land; 2000 panels
Solar panels: life expectancy?	Residential; Poly or Commercial; Mono; 30 yrs degradation, 85%
Solar panels: do higher temps create lower efficiency?	Rooftop solar creates heated backing which traps heat and can make the panels less productive. Ground solar; tracks allow the panels to breathe and reduce the temperature behind the panels; so they can be used in hot climates.
Have you got Federal funding for this project? Who is responsible for its maintenance?	Private funding will be required to implement the project. Sunrise job to maintain and have the on-going responsibilities for the infrastructure
Many of us have paid for our own infrastructure and the costs of power are still increasing; what's to stop costs increasing again 20 years & the microgrid isn't working by then and we have to connect back to the aging network that hasn't been maintained?	There will be an incentive for the private enterprise to keep spending on power that will benefit the customers; there are regulations and license agreements that protects customers from these scenarios.
Will the project model the population decline as we have seen? What about the farming properties? Will they benefit?	Immediate plans are with the township with the hope to pick up farmers in the future. Any oversupply will go back into the grid to benefit the greater community.
Will you get Government funding for the costs to build and operating and maintaining the microgrid? Or is it private funding you require?	ARENA has a fund for renewable microgrid projects; which are repeatable e.g. can contribute funds to help de-risk first-off projects that are repeatable.
Power has improved with the ERG, but if it's not on it's no good	N/A

What we can see from the types of questions and statements and the general consensus from the Synergy, Western Power and Sunrise representatives was that the poor reliability had definitely had a detrimental impact on the community, but there was some recognition that Western Power had been making efforts to address this, however outages still occurred and if a Microgrid in Mullewa was a solution to this then it would be welcomed. There was some obvious curiosity around what a renewable microgrid would look like and function, however no specific objections.

To enable the community to continue to engage with the study an email address was created (Mullewa.engagement@synergy.net.au) giving a single point of contact for any matters related to the study. Nothing has been received via this address at time of issuing the report.

There was some interesting feedback from landowners while trying to source locations suitable for placing the Microgrid infrastructure. A number of landowners had been approached by large Australian and international companies looking for land for large scale renewable generation (wind) projects in an attempt to secure vast swathes of land and discussing levels of compensation that a small local Microgrid Operator could not compete with. This was not something that had been anticipated and hindered the process of securing land for the Microgrid. Fortunately some of the local landowners understood that a local microgrid would not be competing for the same land that would be suitable for a large scale wind farm, and appreciated how a local renewable microgrid would be in service and support of their town, and hence saw the merit in contributing through agreeing to lease areas of their land.

Feedback from local farmers in regards to the ground conditions on the lot secured for the solar farm, was used for identifying a target area in which to conduct the geotechnical survey (ref. Section 10.2.3).

9.3.4 EPWA

The feedback received from engagement with EPWA was:

- They were supportive of innovative attempts to solve reliability for fringe-of-grid towns.
- They appreciated the effort to look beyond typical NCESS solution that they agree is already doable from a regulatory standpoint.
- They accepted Sunrise preference for the EMN Microgrid model, despite the increased risk, primarily because of its attraction to investors through the potential for growth.
- They see the main hurdle for ministerial support for an embedded network (EMN) microgrid model would be the premise of making residential customers contestable.
- Based on above EPWA would suggest the “NCESS type” model would be the most workable solution to implement at this stage.
- In terms of a pathway for implementing an “NCESS type” model with Western Power, would be more appropriate to go through the Alternative Options pathway rather the NCESS process. NCESS requires certain triggers in order for WP to go out to market to procure a service, whereas the Alternative Options pathway is to allow WP to consider unsolicited proposals.
- Commented that part of the point of the Alternative Options pathway was to make it easier for WP to support/implement solutions such as the “NCESS type” model, but to date it hasn’t seemed to have had the results hoped for in terms of encouraging WP action.
- Accepted that a lease agreement with WP as the basis for the embedded network was not unreasonable and akin to any other areas of their business where lease / sub-contract agreements were used.
- Recommended engagement with the Chair of the ERA around the identified barriers for the EMN Microgrid model.
- Recommended engagement with the minister on the merits of the EMN Microgrid model, suggesting emphasising the aspects of the model where we are not looking to change established premises, such as the universal tariff, as well where changes would be required - and be able to explain the positives of these.
- Qualified that Sunrise understood that, as it currently stands, an EMN Microgrid model would require the consent of all customers in order to be implemented.
- Explained that the developing Alternative Energy Services (AES) Framework was initially going to be targeting smaller existing style embedded networks such as strata, caravan parks etc. and so probably not appropriate for operating an embedded network (of this nature) under at this stage - so agreed obtaining a retail licence was a suitable premise for EMN model proposal for now.

- Looking forward to seeing the final report given that it will include an investigation of legal/regulatory matters that others have skimmed over.
- There are further changes coming through around reliability standards (separate to what ERA are doing) that EPWA feel will help build the case for deployment of fringe-of-grid solutions.

9.3.5 ERA

The feedback received from engagement with the ERA was:

- They were interested to understand what Sunrise saw as the WP incentive for an NCESS Model. Sunrise suggested WP don't necessarily have the resources to solve reliability in the timeframe expected, and so by transferring the risk to the MO as part of NCESS agreements, could avoid reliability penalties.
- In an NCESS model where the MO would "take-over" operation of the network in an islanding scenario (ie. on loss of feeder supply) – ERA was interested in WP position on this. Sunrise explained that this had not been discussed in detail with WP at this stage, but expect WP would be amenable to this, given it would only be under fault conditions.
- Appreciated the physical aggregation achieved under an EMN Microgrid model and the benefits of this (e.g. over VPP) in terms of implementing DER.
- Saw merit in the EMN Microgrid model in how it allows the possibility of implementing tariffs that incentivised power use to match the local generation profile.
- Appreciated that renewable generation from a solar farm within an EMN Microgrid model was a more equitable application of renewable generation than rooftop solar.
- The reasons for more visibility sought by the ERA from WP, in terms of rural reliability, was to get outcomes such as that produced by this study.
- When looking at the apparent customer benefits being seen with residential greenfield microgrids, the question around can we ensure a solution that is in the best interest of the customer with brownfield microgrids, should perhaps be reframed as can we best serve the interest of customers without offering this type of service.
- Confirmed that customer protections would not be a concern for an EMN Microgrid model as they would be maintained via the MO having to have a retail licence.
- Believed there had to be thought given to new models to address the fringe-of-grid problems and that we were not going to reap the benefits of new technologies based on existing regulations/policies.
- Did not see that having to make regulatory amendments to accommodate an EMN Microgrid model as a significant impediment to the implementation of such a model – in fact the ERA was looking at ways to change the regulatory frameworks to get innovative solutions.
- The ERA is taking seriously the decision (as expressed in requirements put in place in AA5[4]) that WP are to meet the reliability requirements.

9.3.6 The Minister

The feedback received from engagement with the Minister was:

- He believed the NCESS model was a workable solution, comparing it to what is being done at Walpole (only storage/generation was solved differently).
- His feedback on the EMN Microgrid model was that it would require the purchase of the network at cost and compensation of Synergy for the loss of their customers, and so would likely be uneconomic on that basis.
- He supported more renewables, including at Mullewa.
- Given the recent AA5[4] release he could see how Western Power may be interested in an Alternative Options Proposal based on a NCESS type model.

9.4 Feedback to the Community from the Project

Weekly meetings with the Western Power and Synergy representatives for the study has provided continual feedback to both organisation throughout the study period, with this direct path for communication into both organisations proving a valuable resource.

The Mullewa Mail newsletter was again used as means of communicating to the residents of Mullewa, with an article on the current status of the Study published in the September issue. Emails were also sent to the MWDC and MEEDAC with a status update and CGG were up to date on the status based on the submission of the Development Application

9.5 Adjustments to Technical and Commercial Solution Based on Engagement Feedback

The general feedback received from all those engaged was positive to a renewable microgrid in Mullewa that could improve the reliability of power supply to the township.

In terms of the feedback that was the most impactful in terms of adjusting the technical and commercial solution, this came from the Minister. Without the minister's interest in exploring the possibilities of the EMN model, there would not be the support necessary for working through the regulatory challenges necessary to implement this model, making it unfeasible at this point in time.

Accordingly, the direction of the study was adjusted to focus on how to implement an alternative model, falling back to the NCESS (formerly RGS+NCS) commercial model (based on feedback from EPWA and acceptance from Western Power to apply for a reliability service via the Alternative Options Strategy [5], this was then re-termed to "AOS Microgrid Model"). Although the major infrastructure could be same for both models this did have some impact on the technical solution as well, with an adjustment required in relation to the connection point detail. Because the AOS Microgrid model is based on "in-front-of-the-meter" generation connection as opposed to generation co-located with the load behind a town master meter, the connection point site had to be relocated from the west side of town where it was adjacent to the incoming feeder line from Geraldton, to being co-located with the generation which had been placed east of the town.

The other feedback which had a significant impact on the technical solution, and by association the commercial feasibility, although not the commercial model, was from landowners who were engaged in regards to use of their property for locating the Microgrid infrastructure. An assessment of land around Mullewa was made based on minimising capital costs through locating Microgrid infrastructure in one location and as close as possible to a connection point. Based on this, discussions were held with a local land owner. The land owner was supportive of the Microgrid concept to improve the reliability of power supply in Mullewa, and initially positive to locating infrastructure on their land however on reviewing the terms proposed, had reconsidered what it would mean to have solar panels and a wind turbines located on their property and so decided not to proceed. The impact of this on the technical solution meant finding less than optimum locations for the infrastructure. In the terms of an EMN Microgrid model which was the basis for the commercial model at that time, it meant the connection point site and generation/storage site would not be co-located which impacted on communications technical solution between these two sites. When not co-located (or nearby located) the cost for fibre-optic communications is prohibitively expensive and so alternative solutions had to be sourced. The other impact on the alternative locations was that longer powerlines were required between the wind generation and connection point and the connection point was not nearby any existing western power powerlines and so an additional capital expenditure allowance had to be made for Western Power to extend their network up to the connection point.

9.6 Summary of Proposed Solution as an Outcome of Community Engagement

From the engagement process and resulting feedback, it was evident that the AOS model would be a lower effort, lower disruption pathway to realising a renewable microgrid project in Mullewa, hence the AOS Microgrid Model was selected as the basis for the commercial solution. This model is based on generating income through:

- Sale of the generated energy to either a retailer via a long-term offtake agreement or at the WEM balancing market price via a 3rd party.
- Sale of the LGC certificates earnt from the renewable generation.
- Charging Western Power an annual fee for a reliability service, that would involve automatic islanding of the Mullewa network and uptake of the load by the Microgrid on loss of grid supply. The fee is based on WP waiving the network tariff for the renewable generation connection point (if WP preferred, the network tariff would still apply but be added to the fee charged for the reliability service).
- Capacity credits earnt from the reserve capacity market for the combined renewable generation capacity.

The technical solution resulting from the adoption of the AOS Microgrid model and engagement with land owners, leading to the selected infrastructure location was:

- 1.1MW solar array and 3MWh* battery co-located.
  * Note the modelling work was based on multiples of a 2.3MWh battery as this was the base size available from preferred supplier, however during the course of the study the supplier updated their base size to 3MWh.
- Connection point site located adjacent to the solar array and approximately 1.5km from existing Western Power HV powerline.
- One 750kVA diesel genset located at the connection point site.
- Two 600kW wind turbines located approximately 1.3km from the connection point.
- Automated recloser for islanding of the Mullewa network and associated downstream radial line. Located approximately 3.4km by line of sight from the connection point with radio communication between the recloser and the connection point.
- Western Power Network Control Communications implemented via combination of mobile radio (4G) and satellite communications.

10 PHASE 5 – DEVELOPMENT ACTIVITIES

10.1 Plan for Development Activities

It was planned early on that prior to development activities being able to be undertaken, suitable locations would need to be sourced for where the Microgrid infrastructure would be situated. In addition to the reasons discussed in Section 9.5, there were also the practical constraints associated with locating wind and solar infrastructure. For solar this is typically land that doesn't require significant clearing and ground conditions favourable to direct piling (though this is often difficult to ascertain prior to conducting a geotechnical survey). For wind the most significant factor is proximity to noise sensitive land uses and existing infrastructure. Following the WA Governments recommendation in their position statement on renewable energy facilities [10] meant looking for sites that were at least 1.5km from noise-sensitive dwelling (e.g. residences). Other sources recommending 200m setbacks from roads and infrastructure also impacted on the search for suitable turbine locations. Because of these factors acquiring land was not straight forward and significant time was put into assessing sites and eventually securing land via signed heads of agreement so the development activities could commence.

The plan for development activities was to undertake an actual front end engineering design (FEED) study together with Sunrise's delivery partners:

- Douglas Partners: Geotechnical survey of the solar farm site
- Avora Energy: Solar farm design and construction (including battery installation), connection point site construction and wind turbine civil works
- BlairFox: Wind turbine equipment specification, procurement and installation
- Jarrah Solutions: HV design, including the connection point site design and equipment specification. Includes protection, controls, automation and communication.

The Geotechnical survey was the first activity to be initiated as the results are necessary input into the solar farm design. The other activities were conducted in parallel according to specific scopes of work, with Sunrise managing interfaces and ensuring sharing of design inputs/outputs across the various contributors as required.

The FEED study would deliver design details sufficient for:

- producing a fully costed estimate for the development, to a level of detail suitable for potential investors to review
- putting together the development application
- producing the proposal to Western Power for the reliability service
- establishing generation data an energy retailer could use as the basis for an take-off agreement.

With an EMN Microgrid model as one of the models being investigated, it was understood that if this was the model to be progressed to development it would be necessary to develop a proposal for solving the regulatory challenges associated with this specific model. Despite the EMN model not being progressed at this stage, it is still considered a viable solution and hence the plan to utilise Laval Legal to investigate the regulatory challenges was not changed. In terms of the AOS model there are no regulatory constraints stopping this being done today – the most likely reason it hasn't is due to the lack of interest from a commercial return perspective, which is the main challenge with the AOS Microgrid model.

10.2 Technical Development Activities

10.2.1 Network Connection Agreements

The network connection process typically follows three stages, the enquiry stage, the application stage and the request for approval to operate. The enquiry phase has been initiated as part of the study, which was in the form of a proposal submission under the Western Power Alternative Options Strategy [5], introduced as part of the changes made to the Access Code in September 2020 to support the delivery of the State Government's Energy Transformation Strategy which includes providing greater opportunity for third parties to provide efficient non-network solutions to Western Power.

The Alternative Options Proposal submitted (ref. Appendix I) was a proposal for the provision of a reliability service to Western Power based on the operation of a Microgrid as described in Section 9.6. The connection point will be a HV substation and the design and location of this are defined in Section 10.2.4.

An allowance for completing the second and third stages of the connection process have been included for in the cost estimate.

10.2.2 Development Approvals

A planning report (ref. Appendix H) was developed as the basis for the submission of a development application to City of Greater Geraldton and Regional JDAP and is currently under consideration by these two bodies.

The planning report explains the Mullewa Renewable Microgrid proposal and qualifies it against both local and State planning frameworks.

The submission was made on the August 25th 2023 after obtaining the written consent of the land owners on which the Microgrid infrastructure will be located.

In addition to the planning approval, an application has been submitted to the Department of Planning, Lands and Heritage (DPLH) for an easement on crown land to facilitate an access road to the wind turbines (ref. Figure 10-2). The application has been processed by the DPLH and is currently with the Midwest Gascoyne Land Management Team for review.

An Activity Notice has also been sent to the Yamatji Southern Regional Corporation (YSRC) to obtain feedback on whether there may be any Aboriginal heritage issues associated with the construction sites.

10.2.3 Geotechnical Studies

A single-axis solar array was the basis for design. This type of solar array tracks the sun from east to west by fixing the solar panels to a rotating horizontal tube, with the tube supported by a line of steel pillars (piles) embedded in the ground. Typically these piles have an embedment depth of 1-2m depending on the ground conditions. The specific ground conditions at the installation site will therefore determine the design and construction details and accordingly can have an impact on the estimated cost. In the first instance if the ground permits (e.g. non-rock conditions) the pile will be driven into the ground. If there is significant rock then typically the piles will be installed in pre-drilled holes and grouted/backfilled.

A geotechnical survey is therefore required to establish the ground conditions. A survey will typically include test pits from which an understanding of the strata can be obtained (is it sand, rock, clay etc.) as well as Dynamic Penetrometer Tests which provide feedback on loads associated with pile driving. In addition to this thermal and electrical resistivity measurements are made which are used as inputs in earthing grid design and trenched cabling design.

The general area represented by site locations in Figure 10-1 identified as proposed solar farm area and future solar farm area was chosen based on a site survey and feedback from local farmers as the location with the lowest potential for significant rock. The proposed solar farm area was initially selected as the preferred location based on an attempt to optimise the overall Microgrid infrastructure costs, including accounting for possible future expansion.

A geotechnical survey was conducted on the solar farm site with the report presented in Appendix C. As can be seen from Figure 10-1 the survey was not restricted to the preferred location as the ground conditions needed to be understood before this could be decided. The survey was planned to be conducted with an initially preliminary investigation that covered the proposed future area as well as the preferred location. The detailed survey would then be conducted in an area selected based on the feedback from the preliminary investigation. The preliminary investigation didn't conclude any significant differences between the future and preferred areas and so the detailed investigation was carried out for the preferred area.

The main finding from the survey was that there was rock present at a number of locations above a 2m depth and so this resulted in the recommendation from the tracking system designer that pre-drilling would be required for all piles (ref. Mullewa Solar FEED Report under Appendix E).

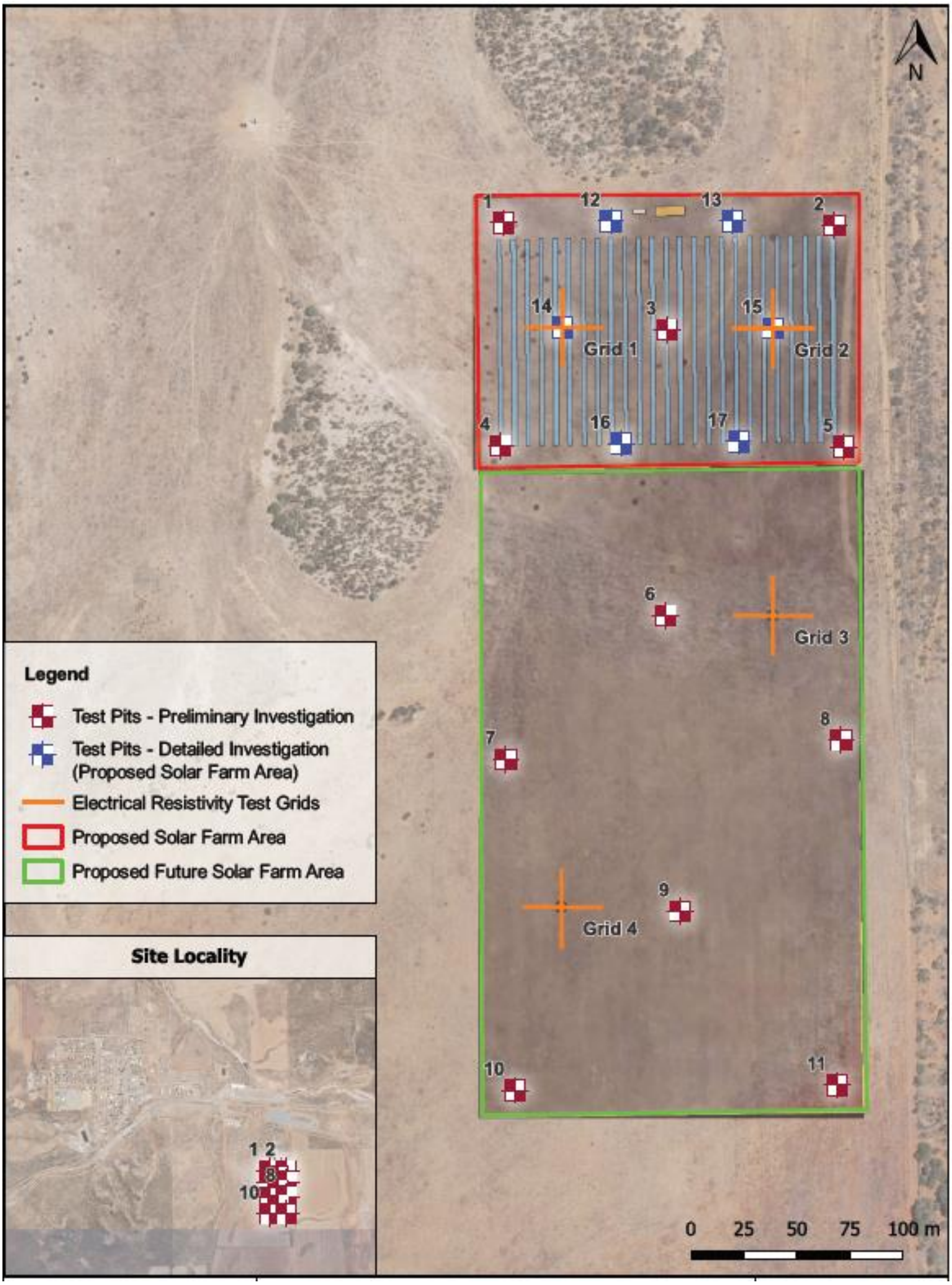


Figure 10-1: Geotechnical Site and Test Locations

10.2.4 Design

The front end engineering design of the Microgrid is presented in the FEED reports from Avora (Mullewa Solar FEED Report) and Jarrah Solutions (Mullewa Microgrid – FEED Report) with input from BlairFox on wind turbines specification, procurement and construction.

The Microgrid layout resulting from the FEED Study is shown in Figure 10-2, with a summary of the Microgrid technical details as follows:

- Solar farm installation consisting of:
  - 1.1MWDC single axis tracking solar array
  - 25 row, 81 module NEXTracker tracking system
  - 2,025 panels, 550W Longi bi-facial
  - One FIMER PVS980-CS 3.5MVA skid fitted with a 1045kVA-L+IN PVS980-58 solar inverter, 2091kVA-I type bi-directional BESS inverter and 3.5MW 33kV 2-winding transformer
  - One SAFT 3MWh BESS container
  - Underground connection to Connection Point
- Wind farm installation consisting of:
  - Two refurbished second hand Enercon E40 600kW wind turbines on 76m towers
  - Turbine transformers
  - Turbine sub metering
  - Overhead powerline from wind turbines to the Connection Point
  - Crane hardstands
  - Access road
- Connection Point / HV Substation installation (ref. Figure 10-3) consisting of:

  Overhead:
  - 3 x 33kV reclosers
  - 2 x fused switches
  - 3 x air-break switches
  - 1 x metering unit for renewable energy credits and controls
  - 1 x 63 kVA power transformer
  - Connection to the existing 33kV high voltage Western Power network via Customer Main Switch (CMS) in compliance with the ERA technical rules

  Ground:
  - 1 x protection and automation container, including Jarrah Solutions proprietary Energy Management System (EMS) with Power Park Controller (PPC), fitted out for radio communications with the automated recloser.
  - 1 x switchable neutral earthing transformer to create an earth reference when the Microgrid is supplying power to Mullewa in islanded mode (grid disconnected).
  - 1 x 1.0 MVA step-up transformer

- 1 x 750kVA Prime Power Cummins Diesel Generator
- 1 x 4,000 litre self-bunded diesel fuel tank
- Fence with access gates
- Security camera
- Access Road

Underground:

- Earthing mat
- Earthing rods
- Earth Grid

- Western Power installation works (WP Scope):
  - Extension of the existing overhead powerline network out to the Connection Point, incorporating a WP metering unit.
  - Standard NOJA type recloser at Microgrid Isolation Point (protection settings, design, configurations and interface equipment, e.g. radio communications for automation, will be by the project)

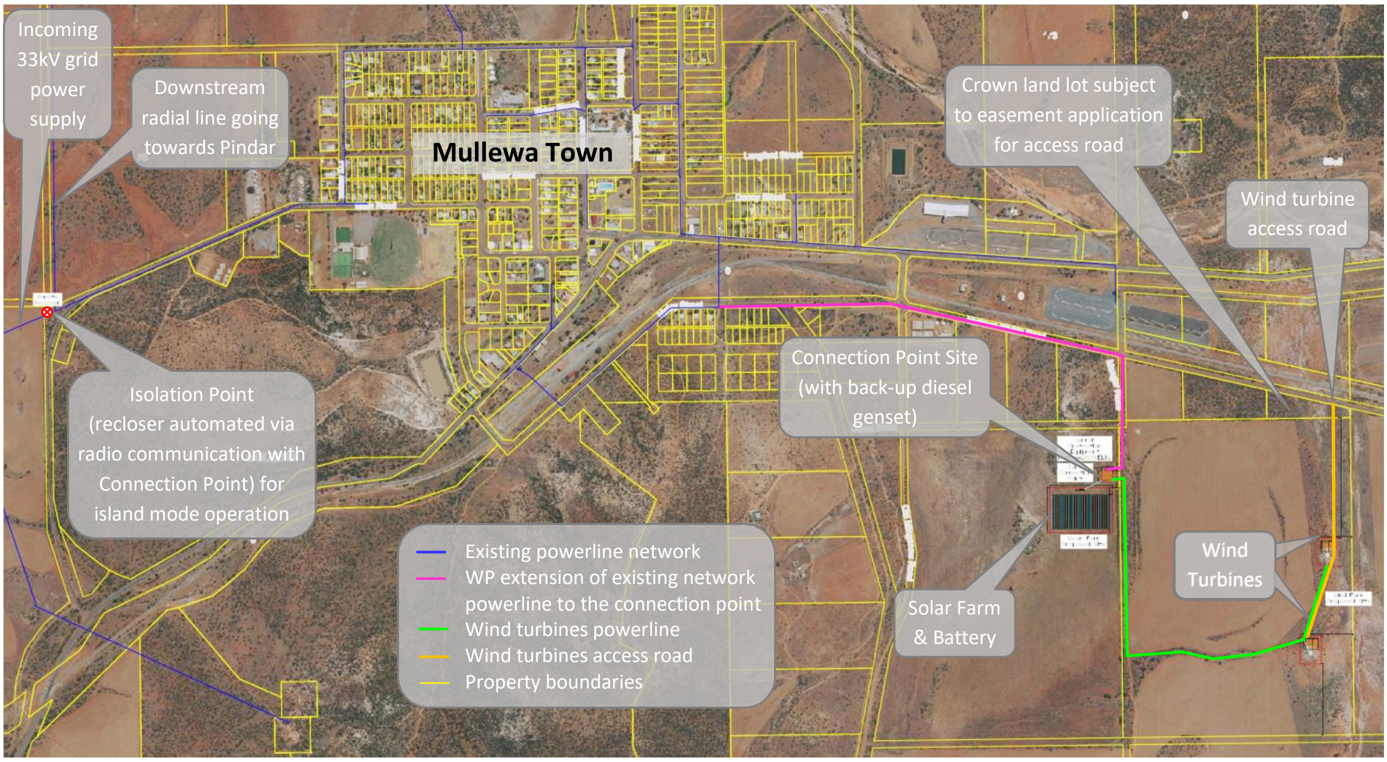


Figure 10-2: Microgrid Site Overview (ref. Appendix E for the complete drawing) – note: excludes the extent of the downstream radial network that is incorporated within the Microgrid islanded network (ref. Figure 2-2 for extent of downstream radial network)

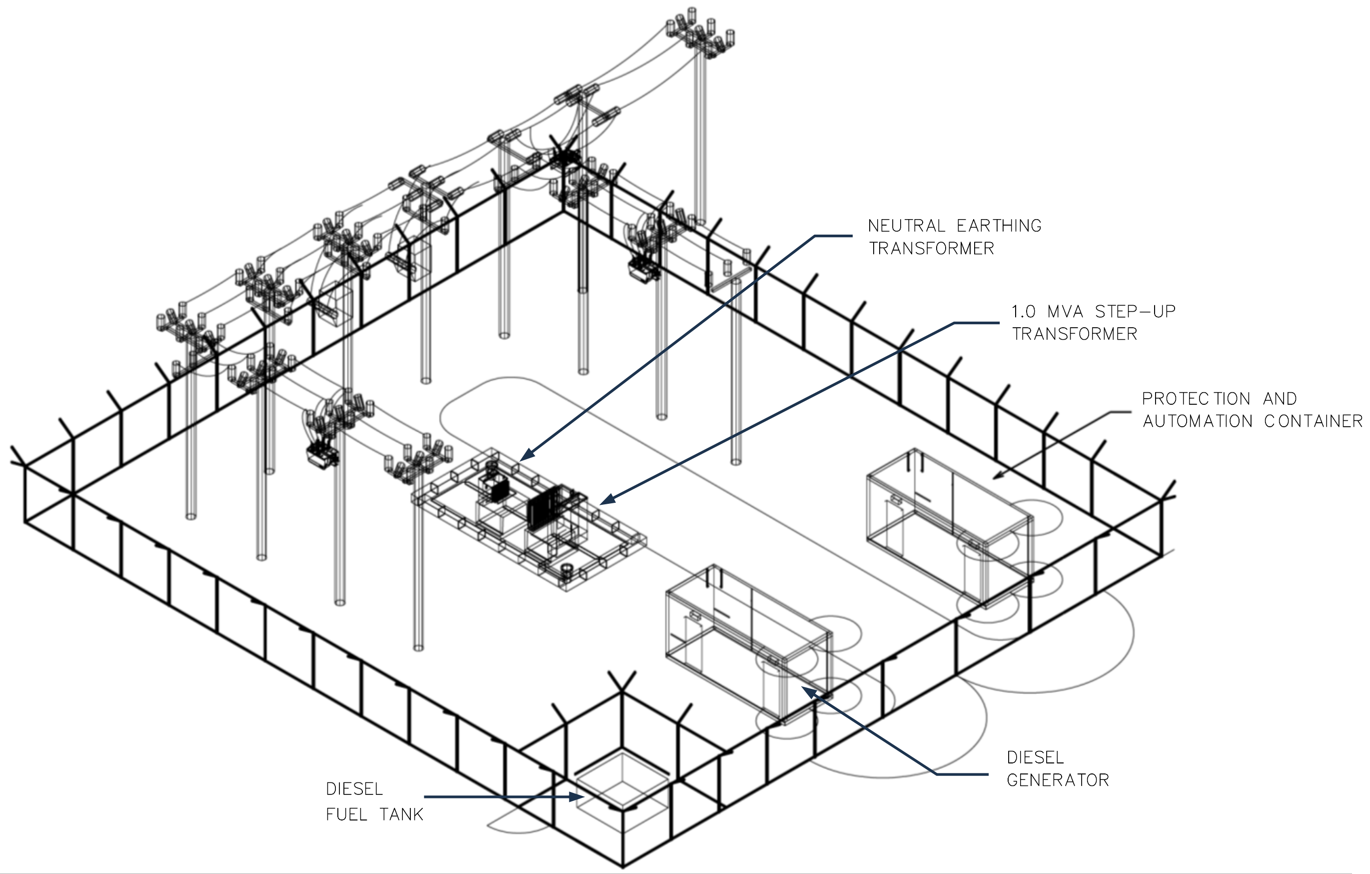


Figure 10-3: Isometric view of the Connection Point / HV Substation site (ref. Jarrah FEED Study – Appendix F)

The electrical design is defined in the Single Line Diagram (SLD) included in the Jarrah Solutions FEED Report (ref. Appendix F). The following paragraphs relating to operation, protections and communications are also extracts from the Jarrah Solutions FEED report.

Operation

The Mullewa microgrid will be designed and created to provide the following two services:

Grid Up Mode

The Mullewa microgrid will operate in an arrangement that is typical of a renewable grid-connected generation site. A connection point will be required, and the ERA technical rules requirements will apply at this grid connection. A DSOC (export limit) will be sought from WP to allow renewables from the microgrid (and on occasion, when called on by AEMO, from battery and diesel as well) to export power into the grid. Hence if there is an excess of power, over and above the town of Mullewa's needs, then this Microgrid will supply power to other customers between Mullewa and Geraldton. Neither the battery or diesel generator will be supplying (generating) power at the time of full solar and wind generation. The CMD (import limit) will be selected as a negligible amount to supply auxiliary loads at the microgrid. The CMD will not need to be selected to charge the battery as the charging of the battery will be performed by a combination of wind and solar generation. In grid-up mode, the source of power to the grid will be through a retail supply agreement. The diesel generator will not be expected to operate in Grid Up mode (except if called upon by AEMO due to generation capacity shortfall across the SWIS) and the neutral earthing transformer will not be connected in Grid Up mode.

Grid Down Mode

In the event of a power outage, the Mullewa microgrid will automatically become islanded from the grid and power will be supplied from a combination of the solar farm, wind turbines, BESS and diesel generator. The BESS will be utilised for frequency control and system stability services.

The automated detection and switching system at the connection point for the Microgrid will have the following features:

- Detection of an unplanned outage of the grid supply.
- Starting of the Microgrid and automated establishment of a 33kV earth reference.
- Disconnection of Mullewa from the grid (a new Western Power recloser will be required).
- Restoration of power to Mullewa from the Microgrid in under one minute
- Watch and wait for the restoration of supply from the grid. Following restoration, and after waiting a period of time to check for stability, the Mullewa Microgrid will automatically synchronise back onto grid supply in a seamless manner, and then isolate the 33kV local earth reference.

The "Grid Down Mode" would typically be an unplanned event however it could also be a planned event. For an unplanned event, the high level control philosophy is described within the logic diagram in Figure 10-4 below.

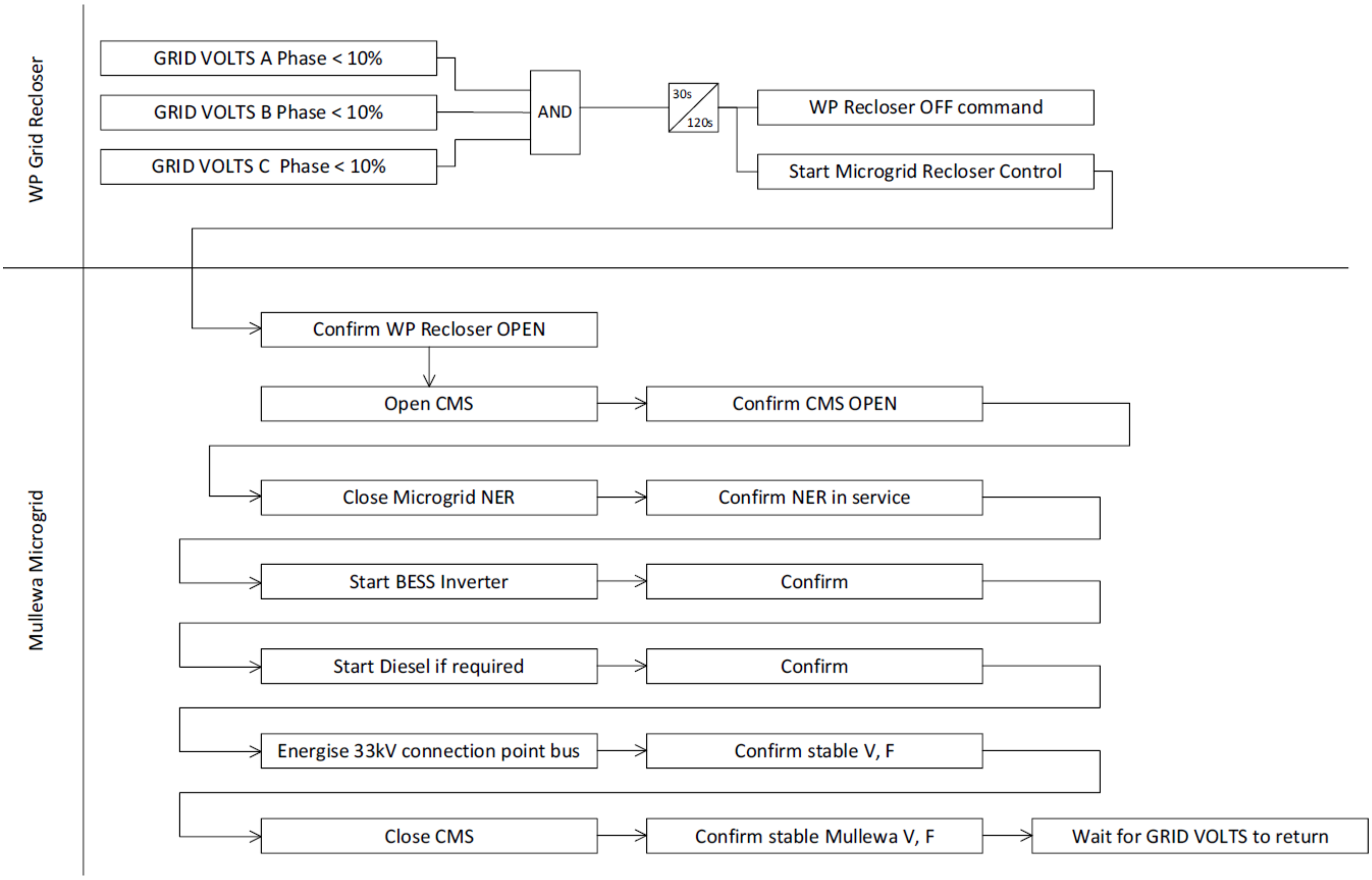


Figure 10-4: Mullewa Microgrid High Level Control Philosophy - Grid Down Mode

Microgrid Protection

Microgrid protection will be provided with connection point protections that meet ERA technical rules requirements. These protections will be located at the 33kV connection point and within the substation. When in grid-disconnected mode and the Microgrid is supplying power to Mullewa independently from Western Power, the protection system will adapt to a different mode of operation. The mode of operation (Grid Connected or Grid Disconnected) status will be provided automatically to the protection system. In Grid Disconnected mode, the fault levels will reduce, and fault detection and sensitivity requirements will become relevant and important. The protection systems will need to be designed for sensitive to short-circuit faults on the HV and LV networks. Detecting and selectively clearing for low level minimum fault currents will likely be the challenge to this project.

Directional overcurrent protections along with undervoltage backup protections will likely be required. The HV protection systems and input measurements (CTs and VTs) have been designed to allow for this flexibility. Protection studies have been allowed for in the FEED estimate, to be carried out during detailed design.

Lightning protection at the substation has not been allowed for as the overhead components (e.g. reclosers, air breaks, fuses, etc) are designed and commonly used for outdoor overhead operation. HV protection relays will be renowned international branded devices, and types SEL (USA origin) and Siemens (European origin) will be utilised.

Communications

Western Power Network Control Communications

Given the capacity of the new generation connected, it is expected that an interface will be required to communicate with the Western Power Network control centre. This will provide visibility to Western Power and also facilitate controls (ON, OFF and export limit setpoints). This type of communications is known as Remote Monitoring and Control (RMC). The most efficient means will be a combination of mobile radio (4G) and satellite communications. A serial interface will be provided through hardware installed within the Geraldton substation.

Grid Recloser Communications

A reliable communication link will be needed as the townships power system reliability will depend on its functioning at times of need.

The Western Power Grid Recloser location has been selected on high ground and to provide (close to) line-of-sight communications. A radio path analysis has been performed to check the expected reliability of this radio path (ref. Figure 10-5 and Figure 10-6).

The analysis was based on a recloser end antenna height of 7m (ie. mounted on the same pole as the grid recloser) and 5m at the connection point substation (ie. mounted on an antenna pole off the protection and automation container).

The results of the analysis concluded that Rayleigh Fade calculation yields a radio path availability of 99.98% which equates to 1hr 33m a year of unavailability in the radio link. This is considered an acceptable level of reliability for the purpose of managing Mullewa being supplied by the new Microgrid and interfacing successfully with the Western Power disconnection location (grid recloser).

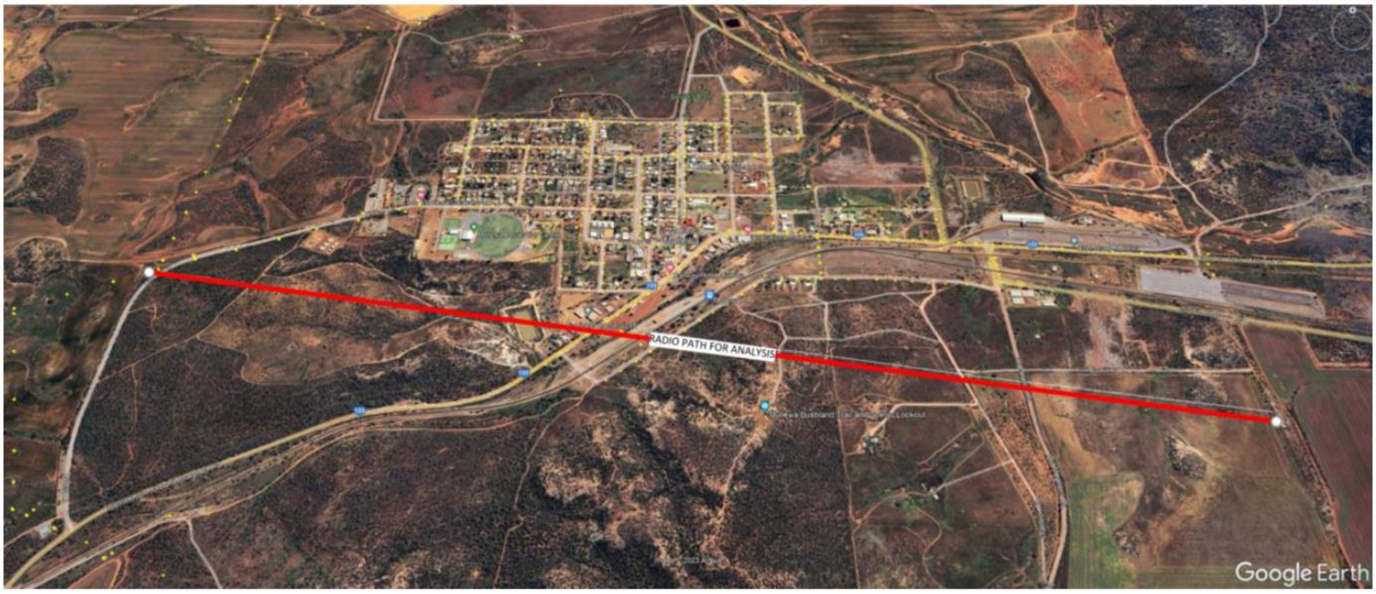


Figure 10-5: Radio path analysed for communications reliability (from Jarrah Solutions FEED Report, Appendix F)

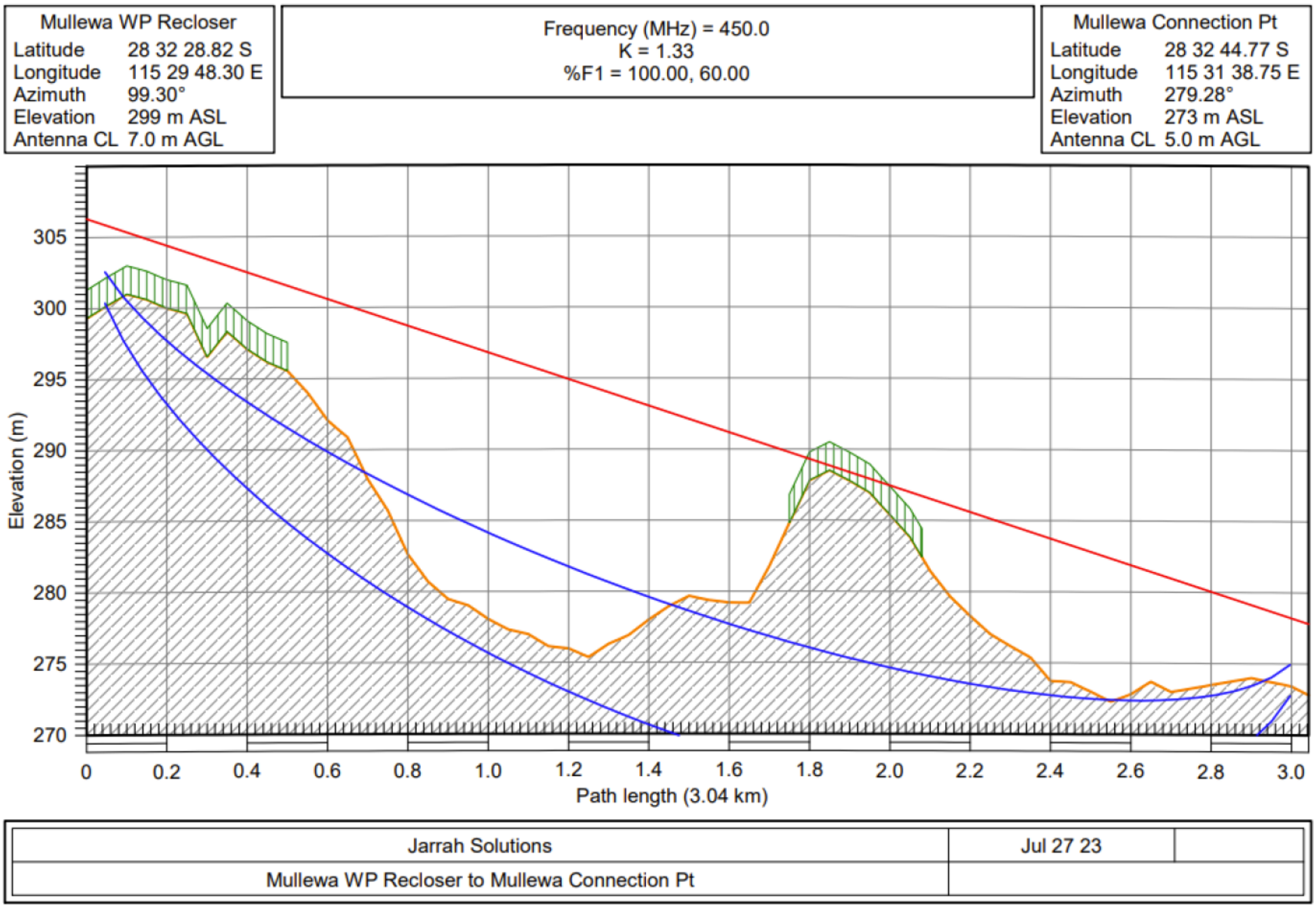


Figure 10-6: Radio path analysis (from Jarrah Solutions FEED Report, Appendix F)

10.2.5 Fully Costed Implementation

The FEED process includes a fully costed estimate based on actual equipment supplier quotations as well as quotations from design and construction sub-contractors and actual known geotechnical conditions. It also includes for a suitable margin that reflects the estimated risk associated with the “first-off” nature of the project. The estimate accounts for scope of the Microgrid up to the Western Power connection point as well as the Western Power Scope, as defined in Section 10.2.4, ie. extension of the existing Mullewa network powerline out to the connection point (ref. pink section of line in Figure 10-2) and installation of the automated recloser that enables the islanding of the microgrid (ref. Isolation Point in Figure 10-2). The project cost estimate is provided in Table 14.

Table 14: Project Cost Estimate

Cost Item	Cost Estimate
Solar Farm	$3.51m
BESS	$1.75m
Wind Turbines	$2.74m
Wind Turbines Powerline	$1.17m
Connection Point	$2.41m
Western Power Costs	$1.27m
TOTAL Project Cost	**$12.85m**

10.2.6 Project Execution Schedule

As part of the FEED work an overall project execution schedule was developed. The complete schedule can be found under Appendix E with the key milestones identified as follows (durations from project start):

- 1 month - Major Procurement orders placed
- 2 months - Geotech survey and foundation design for wind turbine commence
- 4 months - Civil works for wind turbines commence
- 6.5 months - Wind turbines received in Australia and refurbishment commences
  - Wind turbines electrical/comms work commences on site
- 8 months - Solar farm and battery long lead deliveries received on-site
  - Site works for solar farm commence
- 8.5 months - Wind turbines installation commences
- 9.5 months - Site works for connection site commence
- 11 months - Wind turbine installation complete
  - Connection site installation complete
- 12 months - Solar farm construction and battery installation complete
- 13 months - Commissioning complete

10.3 Commercial Development Activities

10.3.1 Retail Arrangements with Synergy

Sunrise provided Synergy with the estimated solar and wind generation data. Based on this Synergy provided an estimated purchase price for the Microgrid generation output on the understanding this could form the basis for negotiation of a bilateral take-off agreement should the project proceed. The pricing estimated was based on a 5 year term adjusted by 2.5% or CPI. For modelling over a 20 year period, the estimated pricing with 2.5% annual compounding was continued for the full 20 years.

In addition to a long-term agreement with Synergy or another retailer, an alternative based on using the services of a 3rd party to sell energy at the WEM balancing market price was also investigated. The costs associated with this include an initial start-up fee and then a continuing annual service charge. Based on the modelling performed according to current balancing market performance this approach shows a greater return for an investor, however has the associated increase in risk due to the greater uncertainty in pricing income.

10.3.2 Network arrangements with Western Power

As described in Section 10.2.1 Sunrise have submitted an Alternative Options Proposal (included in Appendix I) with Western Power for a reliability service that would be provided to Western Power by the Microgrid Operator. Should this proposal be accepted by Western Power then it would form the basis of the Network arrangement, which would be implemented under Western Powers standard Alternative Options Contract [8].

As per Section 9.3.2 the informal feedback from Western Power (prior to a formal access application) was that export capacity available at Mullewa was in the order of 1.5MW. A 2MW DSOC will be sought from Western Power, so that during the few occasions when called on by AEMO (as part of a capacity service agreement), generation from battery and diesel can also be exported to support a capacity shortfall in the SWIS.

10.3.3 Market arrangements with AEMO

A meeting was held with AEMO to understand what services the Microgrid would be eligible to supply to the market.

According to AEMO there is currently a conflict between terms that set the conditions for establishing whether a generation connection is defined as scheduled or non-scheduled. This conflict comes from one requirement stipulating that connections with multiple technologies (e.g. solar, battery and wind) would classify it as a scheduled service and another condition that generation connections with less than 10MW can be classified as non-scheduled. Accordingly it could be assumed that the Mullewa Microgrid would be non-scheduled and so not subject to a NAQ, and so export possible up to the assumed DSOC.

In terms of registering for the capacity market it was advised that if the Microgrid Operator registered for the capacity market but started operating prior to October 2026 it is likely the Microgrid would then be eligible for supplementary reserve capacity (SRC) credits, which supports the modelling of income from capacity credits from day 1 of Microgrid operation.

10.3.4 Policy alignment with Energy Policy WA

Given EPWA were the ones that proposed engaging with Wester Power via the Alternative Options Strategy it is clear that they are aligned with this approach as well as the project in general as confirmed in the feedback from the studies engagement with them (ref. Section 9.3.4).

As also indicated in their feedback was that they were supportive of investigating alternative models for a Microgrid (such as the EMN model) that could improve reliability in Mullewa and other fringe-of-grid towns, however conceded that it would be difficult to have alignment on a EMN type model based on the policy of making residential customers contestable, as it was expected this was not the policy of the current government, which was proven accurate during engagement with the Minister.

From Sunrise perspective this does not rule out alignment with EPWA for an EMN Microgrid type model in the future, if there is a change in government policy that is open to considering this.

10.3.5 Customer Arrangements

Given the selected Microgrid solution is based on an AOS model (ref. Section 9.6) the renewable generation will be sold to a retailer under a bilateral off-take agreement or to the market. This means there would be no change to any of the contestable or non-contestable customer arrangements.

Customer arrangements were however investigated for an EMN Microgrid model. The premise of the EMN model is that non-contestable customers would still be subject to the same Uniform Tariff Policy as the rest of the SWIS and so there would be no change from their perspective. The purpose of the Microgrid is not to offer cheaper energy but more reliable energy.

Contestable customers under an EMN model would still be offered a level of contestability. As per the legal review of the regulatory challenges (ref. Section 10.4) the Microgrid Operator would likely be required to offer open access on the basis of Western Power's standard Electricity Transfer Access Contract (ETAC), meaning non-contestable customers would have the right to choose a retailer other than the Microgrid Operator.

The premise for the EMN model, in terms of operating the Microgrid network, is that the Microgrid Operator would obtain a distribution license. Under this mode of operation customers would experience the same level of protections as they currently do as customers of the SWIS.

Under and EMN model it is in the commercial interest of the Microgrid Operator to match the load as closely as possible to the generation profiles and so this could result in customers being incentivised to alter their energy consumption habits in order to achieve this. Some of the possibilities for achieving this are mobile phone based applications that can provide information on best times for performing energy intensive activities, empowering customers with the knowledge to make decisions on energy usage that delivers the best results for them, and as a result, the best outcome for the Microgrid Operator.

10.4 Regulatory Activities

The selected AOS model for a Microgrid in Mullewa can be implemented today under the current regulations without any necessary amendments. In essence it is no different, from a regulatory point of view, than any other renewable generation currently connected to the SWIS in front of the meter.

The EMN model however, has not been implemented in a brownfields environment to date and so there are several regulatory challenges that would need to be navigated. As the EMN model is still considered a viable option for future brownfield Microgrids the study has investigated these regulatory challenges. Expert legal advise was sought on how to:

- best fit the EMN Microgrid model into existing regulations where possible, and where necessary;
- define in more detail the regulatory reforms that would be required to accommodate the "agreed in principle" features of the EMN Microgrid model.

Sunrise's summary of the resulting paper is given in the following sections.

10.4.1 Basis for the Review

The basis for the review is testing a model for the establishment of a “brownfield” EMN Microgrid, the characteristics of which are:

- The infrastructure of the network (Target Network) would be a discrete part of Western Power’s network (WPN) at “the fringe-of-grid”.
- The operator of the EMN Microgrid (EMNOP) would lease the Target Network from Western Power (WP).
- A master meter is installed at the single entrance point into the Target Network. This master meter then has all the loads in the Target Network as its load as well as any generation installed behind the master meter.
- The EMNOP acts a vertically integrated network operator, generator and retailer similar to other more typical embedded network operations.

10.4.2 A Covered Network and its Implications

The Western Power network became a “covered network” on commencement of the Access Code and all augmentations to the Western Power network are similarly part of that “covered network” under the terms of the Access Code.

Western Power is the sole “service provider” in respect of the Western Power network under the Access Code.

A “service provider” is defined to mean a person that owns or operates a network, and the access code makes provision for multiple service providers, including where a network is owned by one person and operated by another person. An EMNOP would become a “service provider” in relation to a Target Network on entering a lease agreement with WP for the Target Network.

Coverage under the Access Code gives rise to a very broad range of obligations on a “service provider”, which for an EMNOP as a “service provider”, would be too onerous to meet in the context of sustaining a commercially viable enterprise.

10.4.3 Addressing the Covered Network Challenges

The approach to addressing the challenges of an EMNOP becoming a “service provider” for a Target Network that will continue as part of a broader WPN under the Access Code and Western Power’s access arrangement (WPAA), ie. maintaining its coverage within the existing covered network, is based on Western Power seeking an amendment to its access arrangement (WPAA) to reflect an allocation of responsibilities between the EMNOP and Western Power in relation to the Target Network.

This allocation, if approved by the ERA, would enable a clear delineation of responsibilities between the parties and may also address the financial impact of the arrangement from a regulatory perspective, without the need for extensive contractual arrangements between the parties.

Some of the tasks associated with this approach (apart from the specific task of developing the operating lease and the WPAA amendments) would include:

- The EMNOP obtaining from the ERA an exemption from the ring-fencing requirements under the Access Code. Without such an exemption the ringfencing obligation would essentially undermine the core characteristics of the EMN model.
- Reaching a consensus with ERA that non-network operations (for example generation and retail operations) will not be “services” or “covered services” under the Access Code and therefore not subject to Access Code and/or WPAA regulation, ie. the price control / allowable revenue and related principles of economic regulation

that apply to WP would not apply to non-network operations – meaning development of the Operating Lease and amendments to the WPAA would need to incorporate this.

- Obtaining de-registration exemptions from the WEM Rules (in the first instance – and longer term possibly seeking applicable amendments to the WEM Rules in relation to developing a repeatable ENM model).
- Obtaining consent from users (ie. Synergy and existing contestable retailers, a total of five for Mullewa) to re-assign Western Power Electricity Transfer Access Contracts (ETAC's) from Western Power to the EMNOP.

10.4.4 Specific Issues

Will existing NMI meters become non-NMI meters after moving behind the meter?

Given the Target Network will remain a "covered network" the only way, under current regulations, that existing meters could become "non-NMI" (ie. excluded from WEM settlement calculations under the WEM Rules) is by AEMO granting exemption from registration requirements. This is a reasonable approach, particularly for a trial or pilot project, however may not provide the certainty for an EMNOP if the objective is to achieve a repeatable model – in that instance a longer term approach may be to seek amendment to the WEM Rules.

How is the requirement that a WPN connected load shall comply with AS/NZS3000 to be addressed?

The Western Australian Services and Installation Requirements (WASIR) 2022 requirement to comply with AS/NZS3000 is applicable to "consumer electrical installations", which start at the lot boundary. This is not the Target Network, which is a leased portion of the WPN and so still owned by WP and so not subject to complying with AS/NZS 3000 requirements and there are no grounds for why installation of a master meter upstream the Target Network should change this. Given the infrastructure connecting the WPN and Target Network would be owned by the EMNOP then that infrastructure would be required to comply and in addition any Target Network "consumer electrical installations". Regardless, for sake of clarity it would be appropriate for the WASIR to recognise the ENM model, and in doing so, exclude the Target Network as a separately owned and operated (from the SWIS) infrastructure.

When customers become "non-NMI" how are their rights and obligations associated with metering services maintained?

The obligation (in the absence of an exemption) of the EMNOP to hold a retail license will require compliance with the metering code. As mentioned in point a) an exemption from WEM rules would be required, meaning metering obligations applicable to a network under the WEM rules would not apply, but all other metering obligations would apply.
There are two possible ways of approaching metering in the ENM model, the first could be to appoint WP as the "metering data agent", in which case the meter would still remain a "NMI" just not a "WEM speaking NMI". This would be the least disruptive approach. Appointing an entity other than WP as the "metering data agent" is still a workable requirement that would not alleviate the requirement to meet all the obligations under the metering code (other than those under the WEM rules) but it would be more work and require some exemptions.

How can retailers other than Synergy supply electricity to "prescribed customers"?

Retailing of electricity by the EMNOP as the "service provider" in the Target Network and offering open access under the Customer Transfer Code would not offend against the prescribed customers or amount to WP contravening the Electricity Corporations Act. Care however needs to be taken in how the EMNOP and WP agreement is structured to ensure that WP can in no way be deemed to be providing a service, as this would then invoke the WP obligation to only distribute energy to non-contestable customers via Synergy.

Non-contestable customers would have the option to retain Synergy as their retailer and so implementation of an EMN model would not require consent of every customer in the Target Network.

How can Western Power's rights under the Energy Operators (Powers) Act 1979 (WA), EOPA, be used by the EMNOP?

The EOPA is out of date as it applies to electricity and so in the first instance the best route for dealing with this is for the EOPA to be updated to solve this for the entire industry not just this project – as has been done in relation to gas distributors and retailers under the Energy Coordination Act 1994 (WA).

As a fallback option in terms of how to ensure powers to access existing assets for operation (not for locating new assets) are afforded to the EMNOP in an EMN model, the EOPA already provides for a range of powers that may be delegated to third party contractors of WP, and so would be available to the EMNOP. The details around this would have to incorporated into the structure of the operating lease.

Is the Microgrid deemed to have an unfair advantage in terms of offering true contestability?

Given that the Target Network will remain a "covered network" under the Access Contract, it is highly likely even with an amended WPAA that the EMNOP will be required to offer access to the Target Network on the basis of Western Power's standard Electricity Transfer Access Contract. As such, there would not be an unfair advantage in connection with offering true contestability.

11 PHASE 6 – DOCUMENT AND SEEK INVESTORS

11.1 Financing Data to Support Due Diligence by Potential Financier

For producing the predicted financial performance of the final Renewable Microgrid Proposal, the GridCog model was updated with the following data coming out of the completed study work:

- Solar generation data output from PVSyst for the actual solar design (as opposed to less accurate GridCog internal estimate)
- Total wind generation output (generated by GridCog internal wind generation) adjusted based on the total annual energy yield estimated by BlairFox (ref. Section 5.6 and Appendix D)
- Battery storage size updated to supplier revised base size of 3MWh
- Update of estimated capacity credits income based on AEMO recent issue of the 2023 WEM ESOO [13]. In the 2023 ESOO the Cunderdin Solar Farm Project was assigned 48.7MW of capacity credits for 2024-25. Cunderdin is a 100MW solar farm with a 55MW/220MWh battery with 44.8MW assigned to the storage component and 3.8MW to the solar component. Taking this as an example of what would apply to the Mullewa Microgrid battery, it is expected the 1.5MW/3MWh battery could be assigned 0.6MW of credits (even with 50% reserved for the reliability service). The Cunderdin Solar has DC-DC connection to the battery and so output capacity from the battery and solar is limited to the battery inverter capacity which would explain why the credits assigned to solar are so small. For Mullewa, the solar and wind will be connected independent of the battery and so it is estimated that 15% of the installed 2.2MW capacity could be assigned capacity credits, meaning another 0.3MW. Assuming the 600kW of diesel generation would be in addition to this, the total capacity at Mullewa that could be assigned capacity credits is assumed to be 1.5MW. With the reserve price assigned for 2024-25 as $194,783/MW that equates to a capacity credits income of $290k per annum. A 2MW DSOC will be sought from Western Power so it is possible to export from the battery and diesel genset on the few occasions this service would be called on.
- Fully costed project capex as per Section 10.2.5
- Constraint on export between 4pm and 8pm assumed for first 3 years removed based on discussions with AEMO suggesting the project would not be subject to NAQ, ref. Section 10.3.3.
- Sale prices for renewable generation based on:

  Scenario a) Synergy estimate a per Section 10.3.1

  Scenario b) balancing market price as per Section 10.3.1
- Reliability service fee based on Alternative Options Proposal submitted to Western Power (Ref. Appendix I)
- Funding request to ARENA in order to de-risk the project, ref. Section 11.2

The output from the updated GridCog model is shown in Figure 11-1, giving the resulting IRR as 8.3% for Scenario a) and 9.6% for Scenario b)

Site Name:	Mullewa Township
Scenario:	Scenario a) - Synergy based pricing
Site Variation:	s6_Mullewa Township_var-1
Solar Specs:	1100+248.8kW, 0+0 , 0+10
Wind Specs:	1200kW
Battery Specs:	3000kWh, 2hrs, Co-optimised
Genset Specs:	0kW
Relative Cashflow:	$8,236,771
Relative Cashflow Min:	
Relative Cashflow Max:	
Simple Payback:	9.7
IRR:	8.3%
ROI:	103.6%
ROI Min:	
ROI Max:	
Emissions Reduction:	40,433
Emissions Units:	Grid MWh

Site Name:	Mullewa Township
Scenario:	Scenario b) - Balancing Market based pricing
Site Variation:	s7_Mullewa Township_var-1
Solar Specs:	248.8+1100kW, 0+0 , 10+0
Wind Specs:	1200kW
Battery Specs:	3000kWh, 2hrs, Co-optimised
Genset Specs:	0kW
Relative Cashflow:	$9,266,208
Relative Cashflow Min:	
Relative Cashflow Max:	
Simple Payback:	8.4
IRR:	9.6%
ROI:	116.2%
ROI Min:	
ROI Max:	
Emissions Reduction:	20,118
Emissions Units:	Tonnes CO2e

Figure 11-1: GridCog output from updated model, Scenario a) on the left and Scenario b) on the right

11.2 Investment Entities Who Have Expressed Interest in Microgrid Projects

11.2.1 ARENA

ARENA have a Regional Australia Microgrid Pilots Program [11] which is a $50million six year program that aims to improve the resilience and reliability of power supply for regional and remote communities, of which the funding is available to projects that have successfully completed a feasibility study.

Sunrise has already briefed ARENA on the Mullewa Renewable Microgrid Study. Comments from ARENA were that they are looking for projects that can demonstrate a repeatable model, and that a pilot project in Mullewa could be a suitable candidate. The main feedback however, was that key to obtaining serious consideration was to secure Western Powers participation. Accordingly, Sunrise have not proceeded with a formal grant application and are waiting on Western Powers response to the Alternative Options Proposal. Given the ARENA fund is for pilot programs with the emphasis on projects that have a repeatable a model, it is expected that the level of funding that could be expected would be tied to the estimated capital cost for the first-off pilot project (which would need to account for the associated unknowns and elevated risk level) compared to the estimate for future repeatable models after they have been de-risked from the pilot project and lessons learnt applied. Sunrise assessment of the cost for future brownfield microgrid projects in fringe-of-grid towns and the estimated cost reduction that could be achieved compared to a Mullewa pilot project is $3.7million. The main contributions to this figure are:

- A reduction in the Jarrah Solutions cost for the connection point scope. This scope carries the biggest risk because of the first-off nature of combining all the different generation sources and connecting and controlling it in a brownfield setting. This risk has been priced into the cost of this work and once it has been proven in practice it is expected a $0.3million in savings could be achieved.
- A reduction in powerline scope. Based on the lessons learnt (ref. Section 13), site selection will be done to ensure an agreement is put in place with a landowner for a site based on lowest capital cost, by minimising the distance between assets thereby minimising powerline costs. The estimated saving based on this is $1million.
- A reduction in cost for the Solar Farm. Fringe-of-grid towns are by definition remote and the cost of construction in these locations is increased and so the unit cost for installing solar increases substantially for smaller installations. Mullewa township is typically smaller than other towns that are likely to be targeted as candidates for future microgrids. This implies a larger solar installation that can be achieved at a lower unit rate with estimated savings being $0.4million.

- A reduction in cost for the wind turbines civilworks. The assumption is that locations for wind turbines can be found that have better existing access, such that cost allocated for access roads can be reduced, with estimated saving of $0.1million.
- A reduction in cost based on future cost of batteries. As can be seen from the plot of CSIRO data in Figure 11-2, the predicted cost of batteries is expected to nearly halve in the next 5 years based on the more conservative net zero emissions (NZE) post 2050 scenario, and even more than half in that time according to a NZE by 2050 scenario. The estimated saving based on this is $0.7million.

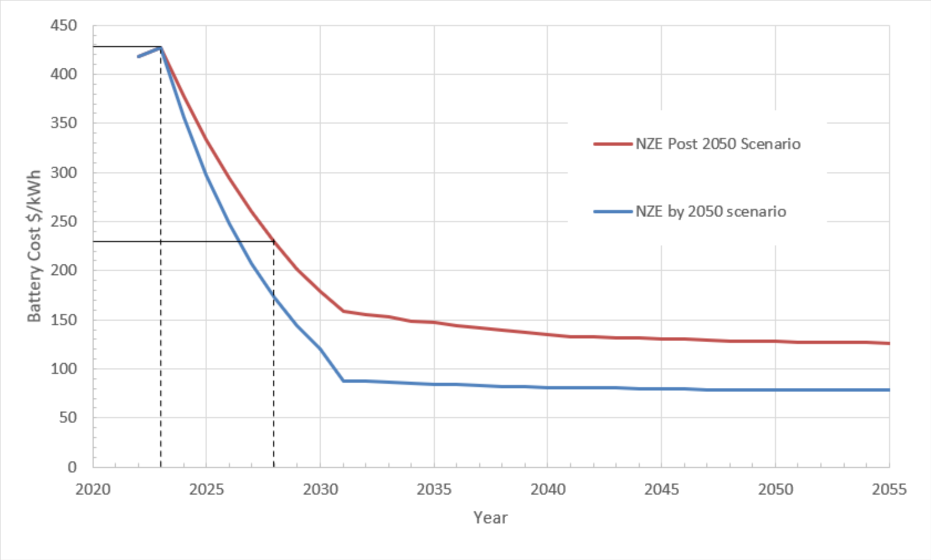


Figure 11-2: Plot of reduction in battery costs according to CSIRO GenCost Report [12]

- A reduction in the contingencies for most of the project areas to reflect the overall reduction in risk as a result of having proven the model via the Mullewa pilot. Estimated savings based on this is $0.5million.
- A reduction in Western Power design and administration costs after Mullewa proof of concept has been demonstrated in Mullewa. The decommissioning of the ERG's which is specific to Mullewa can also be excluded. Estimated saving based on this is $0.1million.
- A reduction in overall cost through synergies derived from executing future repeatable projects under a single portfolio. With this approach significant savings can be extracted from synergies in minor procurement and equipment hire as well as project management costs. Would also expect gains in design and construction efficiency via continuity of project personnel and sub-contractors would contribute to reduced costs. The estimated savings from this is based on a 10% reduction in non-major equipment costs, giving a saving of $0.6million

In addition to this $3.7million, a further $1.2million would help reduce the barrier to attracting investor interest. For a first-off pilot project such as Mullewa a reasonable IRR is required to attract an investor. To make the Mullewa Renewable Microgrid Pilot Project attractive to an investor and look beyond the inherently greater risk with a pilot project, it is likely to require a greater IRR than would be necessary to garner interest in a proven concept where investors could see the potential of a repeatable model that can be applied to a number of towns, executed as a portfolio of projects. Reducing the capital cost of a Mullewa pilot project by $1.2million in grant funding is expected to increase the IRR for the Mullewa pilot project somewhere in the order of 2%.

The Sunrise funding application to ARENA will therefore be looking for a grant for the Mullewa Renewable Microgrid Pilot Project, in the order of $4.9million.

11.2.2 Potential Investors

Sunrise have been in discussions with investors in relation to supporting a portfolio of Sunrise projects, which has included discussion of Mullewa as one of the projects for possible inclusion in this portfolio. Negotiations are still ongoing and subject to confidentiality agreements at this stage. This does not rule out possible engagement with investors looking specifically at the Mullewa Project, as given the current climate in the renewable energy sector, there is not a shortage of investors looking to put capital into renewable energy projects.

In order to approach investors specifically for the Mullewa Microgrid Pilot Project it is first considered necessary to have planning approval, acceptance from Western Power of the Alternative Options Proposal for the reliability service and confirmation of estimated capacity credit assignment. Ideally approval for ARENA funding would also be available, however the submission for ARENA funding suggest it may require evidence of co-funding commitments and financial capacity and so it is likely that these two parts of the project funding are progressed in parallel.

11.3 Commercial Offers for Select Investors and Preferred Investor

To date a commercial offer has not been received for investment in the Mullewa Renewable Microgrid. Discussions have been held with potential investors, however not solely or specifically around Mullewa. Sunrise do not expect to receive an offer from an investor until the confirmations noted in Section 11.2.2 above have been settled.

12 Risks & Opportunities

12.1 Risks

Identified risks for a Renewable Microgrid Project in Mullewa are presented in Table 15.

Table 15: Project Risks

Event	Risk	Mitigation Options	Residual Risk Level
Estimated Risks to Western Power (WP)			
Project Delays	Would delay timeframe in which reliability improvements would be seen and potentially impact on WP's ability to sufficiently demonstrate improvements sufficient to avoid penalties	Set realistic execution schedule with sufficient contingency to manage unforeseen events. Set commitment based on agreed FID date that allows time for pre-execution activities to be completed.	Low
Service Fails to Perform when called on	WP may incur penalties by not being able to demonstrate sufficient reliability improvements	Ensure designers have suitable qualification and experience to complete a robust design and conduct design review	Low
Service Provider Operates at a Loss	Risk of increase costs for the service in response to ultimatum from service provider that service costs must increase or risk losing the service altogether if the service provider goes out of business	Set WP as the operator of last resort so they can continue operation of the service in the event the Service Provider goes out of business	Low
Incident Occurs in Mullewa Network while operating is islanded mode	Arguments over responsible party when WP not in operational control leading to litigation	Ensure assignment of responsibilities under these scenarios are thought through and captured in the service agreement contract	Low
WP reject the Reliability Service Proposal	WP don't meet their obligations under AA5[4] to demonstrate improvement in reliability in pilot areas exposing WP to the possibility of commercial (and potentially reputational) penalties	Seek out alternative solutions for improving reliability for fringe-of-grid towns	Medium
WP seek out competitive reliability solutions via a tender process	Risk not receiving an offer with any improvement in price or performance over this proposal and have lost that time and money associated with a tender process	Proceed with the Mullewa Renewable Microgrid Proposal pilot and consider a second pilot to be sought via expressions of interest and tender process	Low
WP propose to do in house	With the current WP work load may lack the resources to execute in an acceptable timeframe	Proceed with the Mullewa Renewable Microgrid Proposal pilot and consider a second pilot executed in house	Low

Event	Risk	Mitigation Options	Residual Risk Level
Project Risks – Pre FID			
WP reject the reliability service proposal	Project no longer viable	Put the project on-hold until the environment is more open to an embedded network commercial model	High
WP insist on a radio communications link back to Geraldton substation	Project no longer viable due to excessive capital cost	Enter discussions with Western Power to understand what is driving this requirement and investigate viable alternative solutions that satisfy the same requirements	Medium
Can't get an off-take agreement with Synergy	Unable to sell the energy, such that the project is no longer viable	Seek offtake agreements with other retailers Look at selling to WEM at balancing market price via 3rd party service	Low
Not accepted by ARENA for funding	Unable to de-risk the project to a sufficient degree to attract a financier	Look at other funding options	High
Can't secure an investor	Project is no longer viable	Put the project on-hold until the environment is more open to an embedded network commercial model	Low
Can't secure a reasonable DSOC	Reduces commercial return expectation such that can't secure an investor	Look at other means of grant funding to compensate for this. If related to line capacity investigate with WP possibility of dynamic capacity rating	Medium
Aren't assigned capacity credits in line with expectations	Reduced commercial performance	Submit application to AEMO as soon as possible. Look for expressions of interest for Supplementary Reserve Capacity that could be applied for	Low
Project Risks - Execution			
Site access delays	Schedule delays, cost overruns, unable to meet the target date	Coordinate site access with land owners	Low

Event	Risk	Mitigation Options	Residual Risk Level
Western power delays for connection approvals and/or construction of the extension of the WP network to the connection point	Schedule delays, cost overruns, unable to meet the target date	Start approval process well in advance of required date. WP consider sub-contracting construction of the extension to the project, given the project will already have assets on-site to build the projects powerline scope	Low
Project Estimate for WP network extension exceeded	Greater than expected costs impacting commercial performance	Allow for additional contingency. Discuss possibility of project executing the work on behalf of WP in order to keep costs down	Low
Aboriginal Heritage	Evidence of Aboriginal heritage discovered during site works requiring works to stop	Organise Aboriginal heritage assessment of the sites (and possible survey if required) prior to project commitment	Low
Loss of key personnel	Schedule delays, cost overruns, unable to meet the target date, market conditions currently resource constrained	Maintain healthy working environment so personnel are happy to remain engaged with project, replace key personnel with alternative personnel as required	Low
Project Risks - Design			
Delays in detailed design of system	Schedule delays due to delays in placing procurement orders	Start detailed design well in advance of required date so procurement is not impacted	Low
2nd Hand Wind Turbines	Older 2nd hand turbines may pose challenges in meeting new technical rules and obtaining approval to connect them to the network	Select turbines that comply with the required rules and regulations and has a proven track record. Check the selected turbine with Western Power. With battery incorporated into the overall system this can assist in meeting necessary technical requirements	Low
Project Risks - Procurement			
Volatility of currency exchange rates	Australian Dollar continue to fall below $0.60 to USD, cost escalation	Hedge USD or EUR	High
Volatility of panel pricing	Currently volatile due to world conditions	Place order when possible and manage closely	Medium
Volatility of cable pricing	Currently volatile due to world conditions	Place order when possible and manage closely	Medium

Event	Risk	Mitigation Options	Residual Risk Level
Logistics pricing and delays	Currently volatile due to world conditions and overseas items subject to delays. Procurement items with highest risks include: Panels, Tracking System, Inverter Stations, HV switchgear and. Transformers	Place order when possible and manage closely	High
2nd Hand Wind Turbines	Used turbines typically lack guarantees and manufacturer support. Purchasing used turbines from overseas involves responsibility for dismantling them which can lead to runaway costs.	Look for Turbines that have been operated under a manufacturers service agreement to ensure reliability and support. Conduct thorough due diligence by performing inspections on the turbines. Purchase operating turbines and identify worn components that may require refurbishment while they are on the ground. Visit the site in person to meet the owners and gain a comprehensive understanding of the turbine service history. Choose a trusted partner with a proven track record in selecting, purchasing and dismantling used turbines	Medium
Wind Turbine Transport	Significant logistical challenges as well risk of biosecurity issues as the turbines may be contaminated from agricultural properties and navigating through different countries permits and transport rules	Use partners with a proven track record who are familiar with the potential challenges that may arise. Initial early planning and ensure a proactive presence on the ground	Medium
Project Risks - Construction			
Rock Present	Piling and trenching delays	Piling will require pre-drilling, trenching will be trialled	Low
Contamination	Risk of dieback or fungal contamination when brining vehicles and imported fill into site	Establish appropriate measures for vehicle and material entry to site	Low
Manual Handling	Personal injury	Experienced installers and purpose built installation aids will be used to handle racking, panels and cable	Low
Electrical	Personnel injury & plant/equipment damage	Experienced electricians will be used to install electrical system	Low

Event	Risk	Mitigation Options	Residual Risk Level
Lifting	Crane overload/collapse, Personal Injury, & damage to plant, equipment, environment	Experienced crane operator and riggers will be used, minimal number of lifts	Low
Rubbish	Control of rubbish from site, in particular panel packing	Establish separate panel staging area to unpack panels in order to control and contain rubbish	Low
Dust	Airborne dust interferes with construction operations	Appropriate PPE, depends on time of year	Low
Labour Market	Labour difficult to find and retain given current market	Use known personnel and sub-contractors to maintain experienced personnel	Low
Vandalism/theft	Construction close to town will require additional security provisions for materials and equipment	Cameras, security guards	Low
Weather	Risk of Solar panel damage from extreme weather events (beyond design limits), e.g. hail, flooding etc. In particular during construction before tracking system has come on-line	Put in place appropriate insurance. During construction ensure panels are secured in “stowed” position.	Low
2nd Hand Wind Turbines	Degree of uncertainty during construction when 2nd hand turbines involved	Involve the team who dismantled the turbine.	Low
Project Risks - Operations			
Fail to meet service obligations when called on	Commercial risks due to penalties associated with not meeting obligations	Use experience and qualified design and construction personnel Ensure thorough commissioning process	Low
Wind Generation does not perform as expected	Commercial risks as income will be reduced		Medium
Vandalism	Damage to assets that prevent the service from meeting its obligations	Limit access through fencing and implement deterrents such as video surveillance Have insurance in place to cover this possibility	Low

Event	Risk	Mitigation Options	Residual Risk Level
Change in contract prices at end of initial contract terms	Commercial risk as may not be able to renew reliability service contracts and energy take-offs for the same prices as the initial terms.	Allow for reduced return in the commercial model for the period after the initial terms contracts	Low
Microgrid Instability	This is a complex network with integration of diesel, batteries and renewables in an islanded (off-grid) remotely located context. There is a risk of unplanned outages caused by Microgrid instability.	Use Experienced design, construction and commissioning personnel Electrical system protections will be in place to ensure that Mullewa customers are disconnected and isolated if the Microgrid does not meet the required power quality requirements Monitoring over time will be provided and compliance monitoring can be performed.	Low
Equipment Failures	Commercial risks due to possible penalties associated with not meeting service obligations and cost injections associated with breakdowns.	Procure equipment from reputable manufacturer's with proven service records. Put in place planned maintenance schedule in accordance with manufacturers recommendations. Monitor equipment performance to identify potential issues so they can be rectified prior to resulting in breakdowns	Low

12.2 Opportunities

Opportunities identified for a Renewable Microgrid Project in Mullewa are presented in Table 16.

Table 16: Project Opportunities

Opportunity	Description	How to Advance	Relative Benefit
Future change to operate under an EMN Microgrid Model	If the future government policy was more receptive to an EMN Microgrid model, it doesn't require a significant change to Microgrid infrastructure to go from AOS model to EMN model. The connection point protection and automation container needs to be relocated to where the grid isolation point is located. The container is designed as re-deployable. Under an EMN model there would be the opportunity to explore the benefits of this model such as the Microgrid Operator (MO) delivering some of the network operations services, via local Mullewa employees, the incentive for the MO to attract new business to the town in order to grow the load, enable the marriage of demand and supply to participate as DER in the market. Would provide an opportunity to demonstrate the model and given it is successful, incentivise investment in this Microgrid model in other fringe of grid towns.	Continue to lobby the government and its agencies about the potential benefits of the EMN Microgrid model. Continue to work with Western Power around the delivery model. Continue to develop the details around the regulation changes required	High for the Project, Mullewa and SWIS
Reduce the cost of the Western Power project scope	If Western Power can find a point in the existing network from which is closer to the Connection Point and so require a short powerline, cost of the powerline could be less.	Challenge Western Power to find the cheapest solution for extending the existing network to the Connection Point	Medium for the Project
Attract new business to the town	With local generation available and improved reliability of supply there is the opportunity to attract more energy intensive business to the town	Discuss with CGG the possibility of doing a marketing campaign	High for Mullewa
Develop agrivoltaics	The solar farm provides the opportunity to develop an agrivoltaics project.	Look into organisations currently investigating agrivoltaics and offer the Mullewa solar farm as possible testing ground for new agrivoltaics pilot projects Look for grants from funds that are looking to develop agrivoltaics projects	Medium for Mullewa

Opportunity	Description	How to Advance	Relative Benefit
Extend the extent of the islanded Microgrid towards Geraldton	If several automated reclosers could be positioned back along the Geraldton feeder line as you head away Mullewa, then for the AOS model, depending on where the fault occurred, this could enable the Microgrid to extend its support further West when grid supply is interrupted.	Advise Western Power and let them examine the cost-benefit value of this proposal	High for customers West of Mullewa, low for the project
Upgrade the Microgrid Network by adding equipment that can locate local faults	At present if the Mullewa network is islanded and operated by the Microgrid and a fault occurs within the Mullewa Network the Microgrid would have to shutdown causing an outage. If the local fault could be located so that it could potentially be isolated this would allow the remainder of the islanded network to come on line again.	Look at the cost-benefit value	Medium for Mullewa, Low for the project
Capacity Market at Peak	In addition to estimated income from assigned capacity credits could also sell excess generation during peak demand events. With solar and wind generation at peak capacity combined with battery and diesel have potentially up to 4.3MW of capacity (3.2MW with wind and solar at 50%) that could be dispatched when called on by AEMO during peak events.	Secure the necessary DSOC with Western Power	Low for the Project, Low for the SWIS
Extra Capacity in Mullewa	The local generation in Mullewa will increase Western Power capacity available in Mullewa and so will open up opportunities for the community, for example in pursuing an “electrification of everything” objective	Western Power to consider the value of this	Medium for Mullewa

13 LESSONS LEARNT

Lessons learnt throughout the completion of the Study include the following:

- It can take a considerable time to reach an agreement with a network provider and State retailer in order to obtain access to actual load data for modelling and so this should be accounted for when considering project timing. Also if significant loads come from contestable customers that have other retailers, the permissions and time required to obtain this data should also be accounted for.

- The impact on capital costs of the location for the microgrid can be significant, which highlight the criticality of securing suitable land early on in a project.

- There are large companies looking into acquiring rural land for large renewable energy based projects, which can potentially be in competition for land for small town microgrids. It can be difficult to compete with such companies on price, so have to be prepared to engage with land owners and discuss the upsides of committing land to a renewable microgrid project that can directly benefit the town.

- Need to get a heads-of-agreement signed before assuming offers for land have been secured.

- If considering investing in a digital twin, make sure there is already a working framework for it that can be reviewed prior to proceeding.

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https://www.csiro.au/en/research/technology-space/energy/energy-data-modelling/gencost

13. 2023 Wholesale Electricity Market Electricity Statement of Opportunities, AEMO, August 2023
https://aemo.com.au/en/energy-systems/electricity/wholesale-electricity-market-wem/wem-forecasting-and-planning/wem-electricity-statement-of-opportunities-wem-esoo

APPENDIX A

Sunrise Engagement Presentations

Includes:

1. CGG, MWDC and MEEDAC Engagement Presentation, April 2022
2. Western Power and Synergy Workshop Presentation, June 2022
3. Western Power and Synergy Workshop Presentation, September 2022
4. Mullewa Community Engagement Presentation, September 2022
5. Western Power and Synergy Modelling Results Presentation, October 2022
6. EPWA Engagement Presentation, March 2023
7. ERA Engagement Presentation, June 2023
8. Presentation for Engagement with the Minister, June 2023

Mullewa Microgrid Feasibility Study Project

Mullewa Site Visit, April 2022

AGENDA

- Recap of the project scope and phases
- A look at the project participants / stakeholders
- Update on the current status
- Detailed look at Phase 4 – Community Engagement
- An opening to future opportunities
  - Agrivoltaics
  - Leveraging Mullewa’s unique location
- Selecting a power generation site – key considerations
- Project relevance to CGG / MWDC / MEEDAC
- Discussion

FEASIBILITY STUDY RECAP

- The Mullewa Microgrid Feasibility Study Project involves a 21-month examination into the viability of deploying a renewable energy microgrid in the fringe-of-grid town of Mullewa, in WA's Mid-West region

- Mullewa is located at the end of a 100km radial feeder, which has suffered from poor reliability, has large line losses in addition to being dated infrastructure.

- The Project aims to develop a commercially sound, technically and economically feasible solution to significantly improve energy reliability, improve amenity for Mullewa residents and to retain and attract business to the town.

FEASIBILITY STUDY RECAP – SCOPE

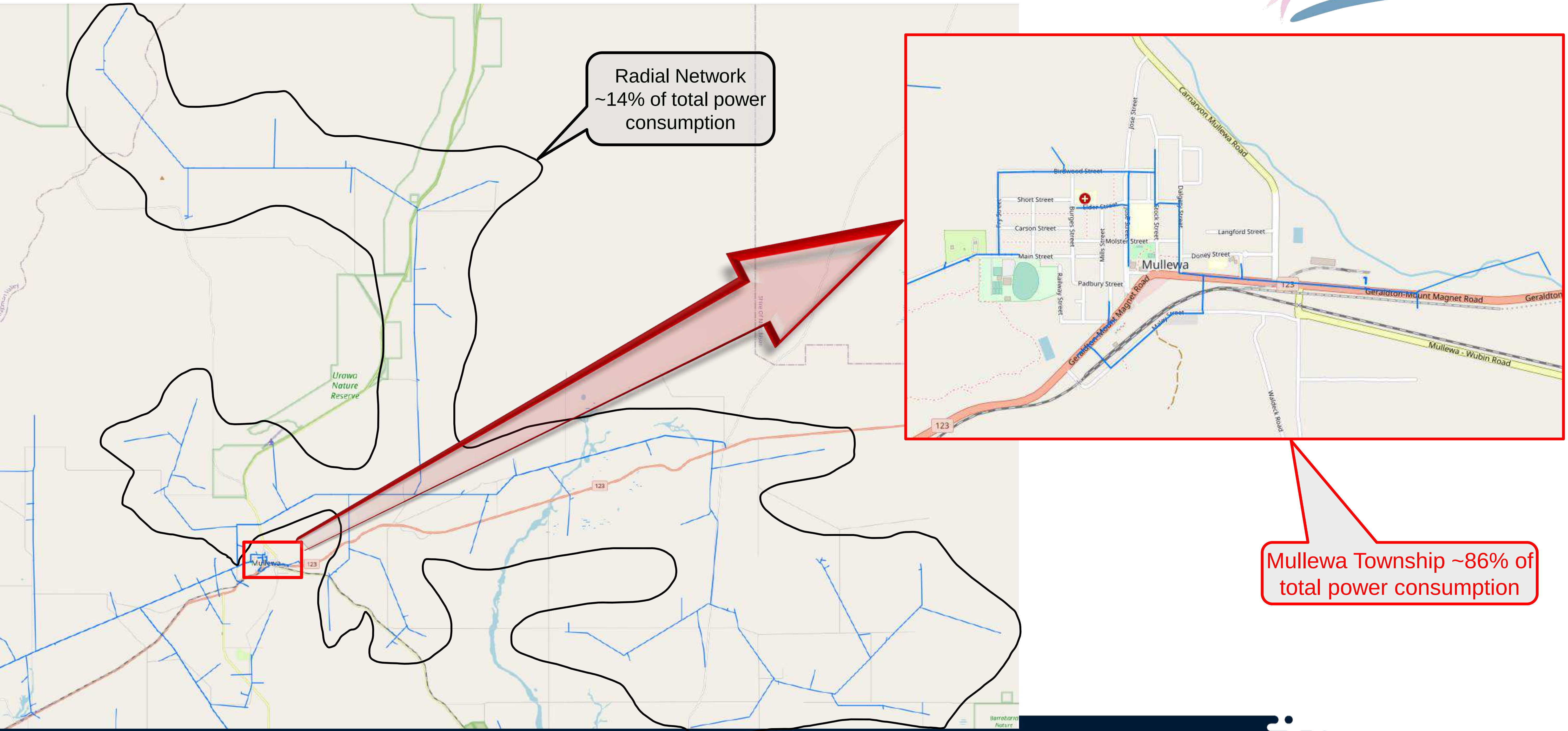
- The Project scope includes modelling the use of renewable energy generation such as solar panels or wind, supported by battery energy storage systems (BESS), which would be distributed to the town via the microgrid solution. Innovative technology and software will play a key role in ensuring that demand and supply are linked.

- The Project scope key activities focus on engaging with the Mullewa community to develop the best solution for its needs, while equally ensuring that the solution is technically, commercially, and financially feasible and viable, supported by engagement with Western Power and Synergy.

- The microgrid concept would allow Mullewa to maintain a grid connection, while significantly improving reliability.

- The feasibility study aims to develop a model which is replicable at other fringe-of-grid and potentially off-grid sites around WA and Australia, with key learnings and knowledge disseminated as part of the Project.

FEASIBILITY STUDY – EXTENT OF SCOPE



PROJECT PHASES

The Mullewa Microgrid Feasibility Study Project will be executed in 6 phases. These are:

- Phase 1 – Establish a Digital Twin
- Phase 2 – Model Technical & Commercial Solutions
- Phase 3 – Test Future Scenarios on Proposed Solution
- Phase 4 – Community Engagement
- Phase 5 – Finalise Proposed Base Case Solution and Undertake Development Activities
- Phase 6 – Document Results & Seek Investors

The project is at the end of phase 1, heading into phase 2

PROJECT PARTICIPANTS

Project participants working together with Sunrise Energy will include :

- Western Power – Network Operator
- Synergy – Energy Retailer
- Enzen – Digital Twin Development
- Grid Cognition – Energy Modelling Solutions
- Avora Energy – Renewable Energy EPC Services
- Jarrah Solutions – Network Integration

PROJECT STAKEHOLDERS

Project stakeholder with an interest in the project include:

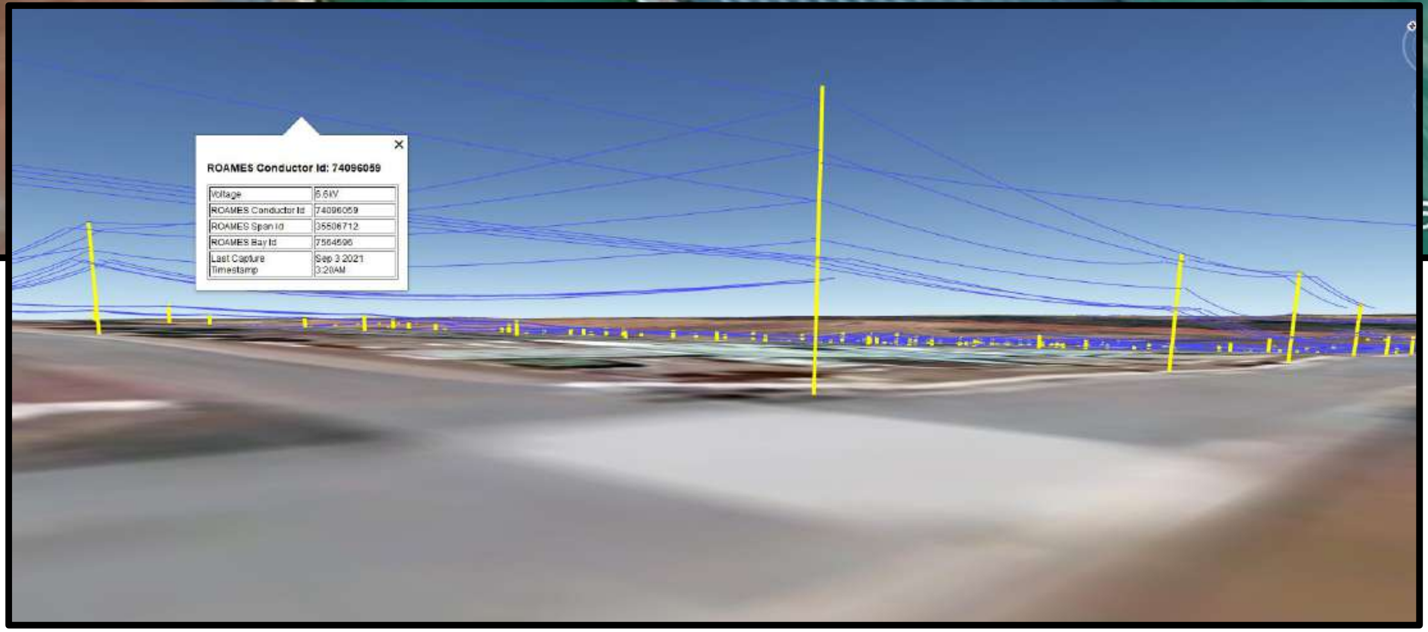
- Mullewa Township and local businesses
- City of Greater Geraldton (CGG)
- Mid West Development Commission (MWDC)
- Midwest Employment and Enterprise Development Aboriginal Corporation (MEEDAC)
- Western Power – Network Operator
- Synergy – Energy Retailer
- WA State Government
- Federal Government
- Potential Investors

PHASE 1 HIGHLIGHTS

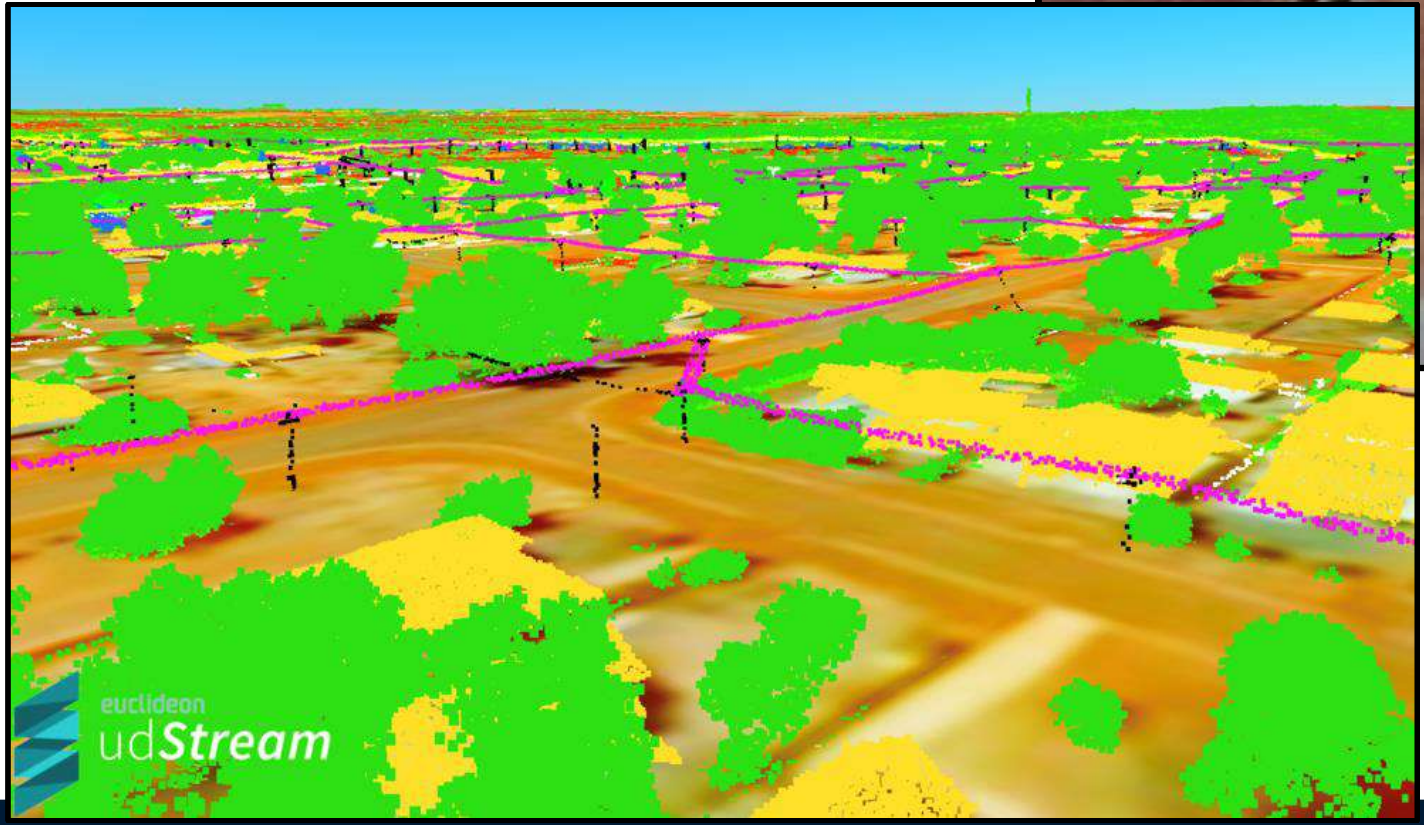
- Signing of a Collaboration Agreement between Sunrise Energy, Western Power, Synergy and Enzen
- Receipt of initial Western Power asset data
- Receipt of point cloud data for the Mullewa region
- Development of the 3D model that will form the basis of the digital twin interface
- Development of the “Dashboard” used for presenting the asset data
- Receipt of Mullewa baseline energy consumption data from Synergy

DIGITAL TWIN

Point cloud and asset data combined and displayed in 3D environment



Point cloud data from Mullewa
(note power poles in black and power lines in pink



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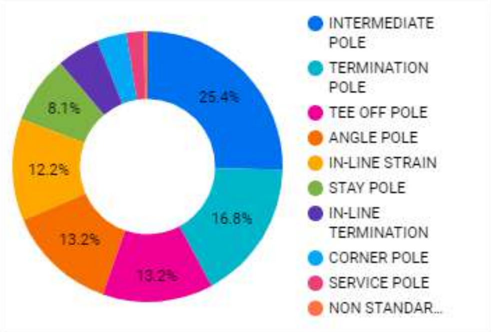
DIGITAL TWIN

- Examples from the “dashboard” used for presentation of the asset data

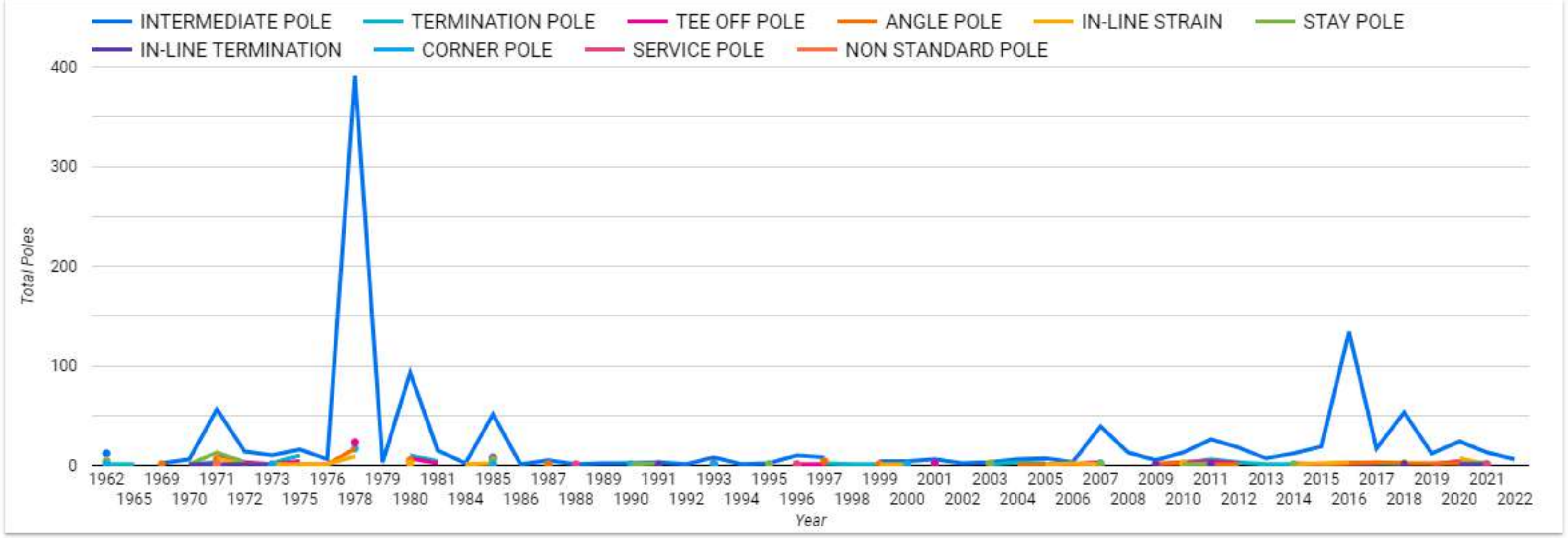
Poles Data Overview

Total Poles in captured network
1,544



	Pole Type ▲	Count	Percentage
1.	ANGLE POLE	66	4.27%
2.	CORNER POLE	7	0.45%
3.	IN-LINE STRAIN	56	3.63%
4.	IN-LINE TERMINATION	10	0.65%
5.	INTERMEDIATE POLE	1,167	75.58%
6.	NON STANDARD POLE	1	0.06%
7.	SERVICE POLE	4	0.26%
8.	STAY POLE	43	2.79%
9.	TEE OFF POLE	92	5.96%
10.	TERMINATION POLE	[illegible]	[illegible]

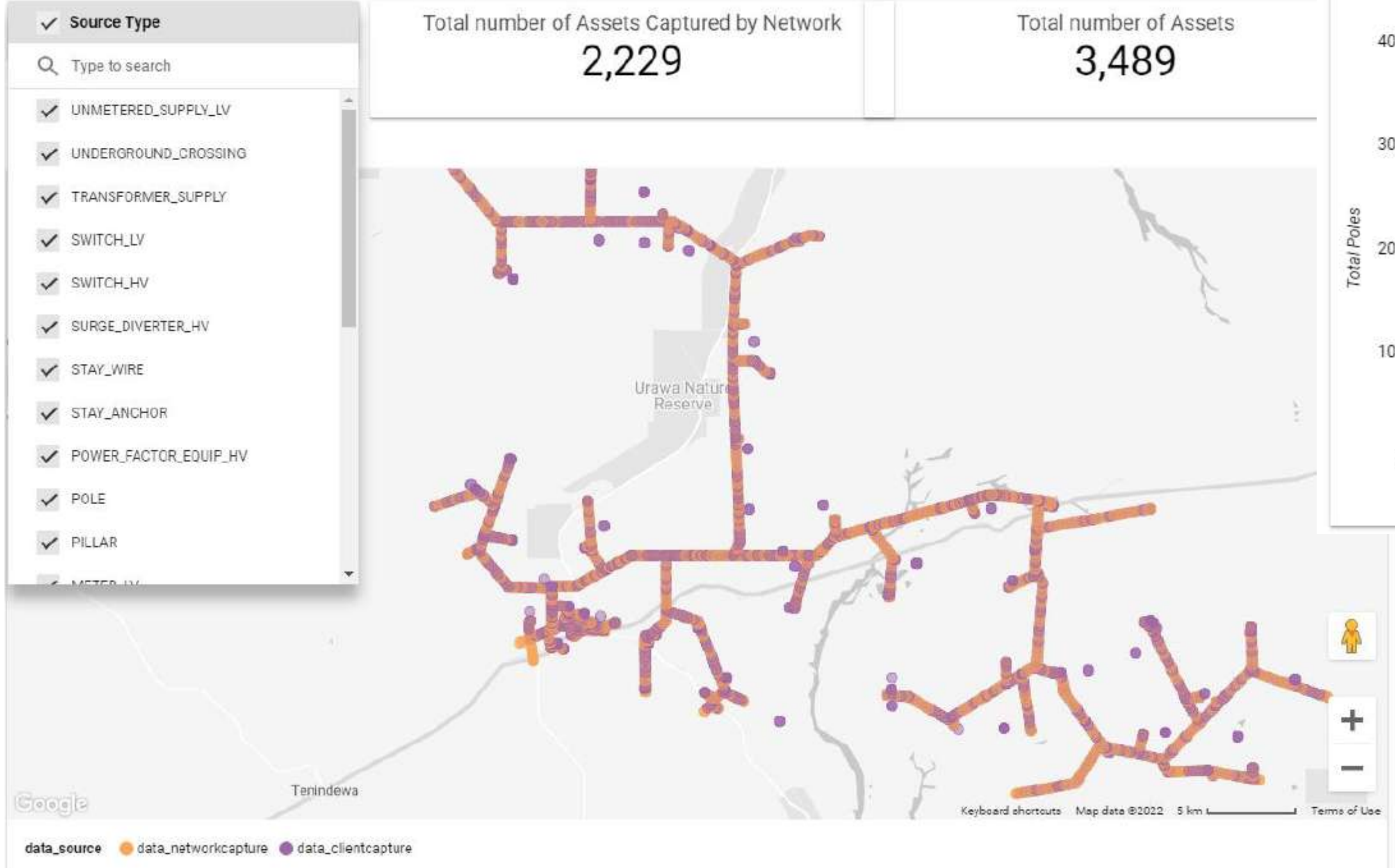
1 - 10 / 10



Assets data

Total number of Assets Captured by Network
2,229

Total number of Assets
3,489



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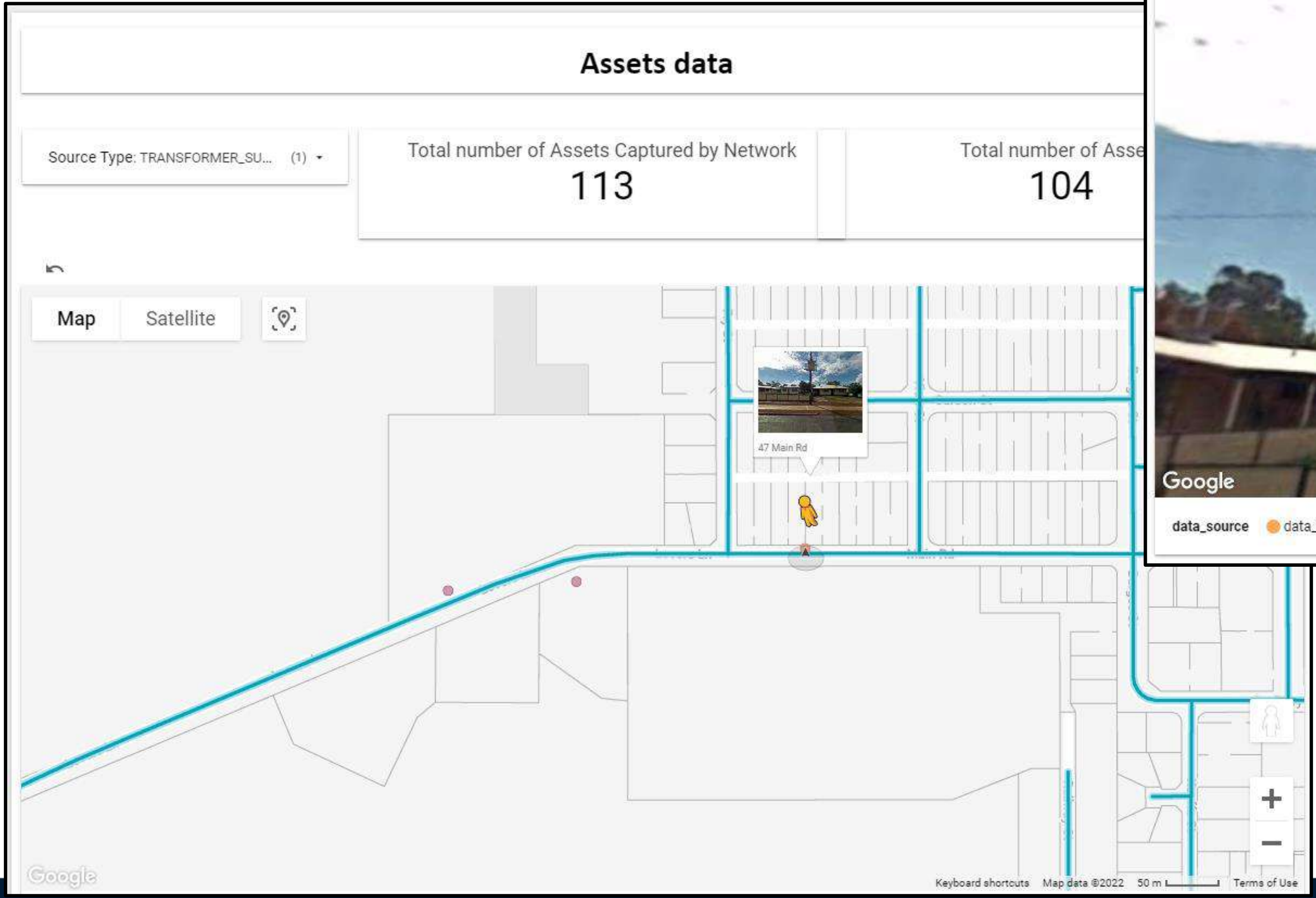
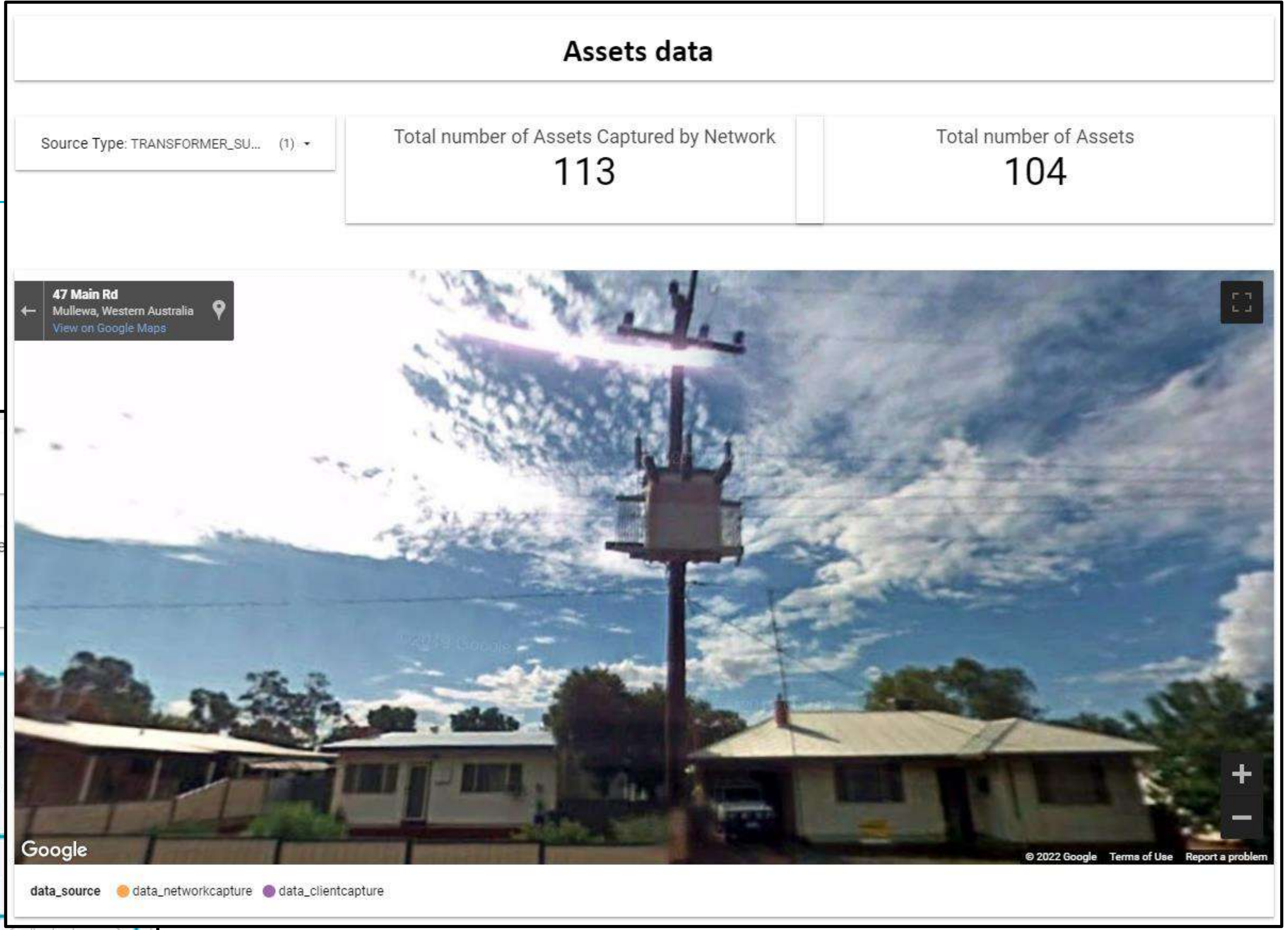
DIGITAL TWIN

- Locating a specific asset using Google Streetview

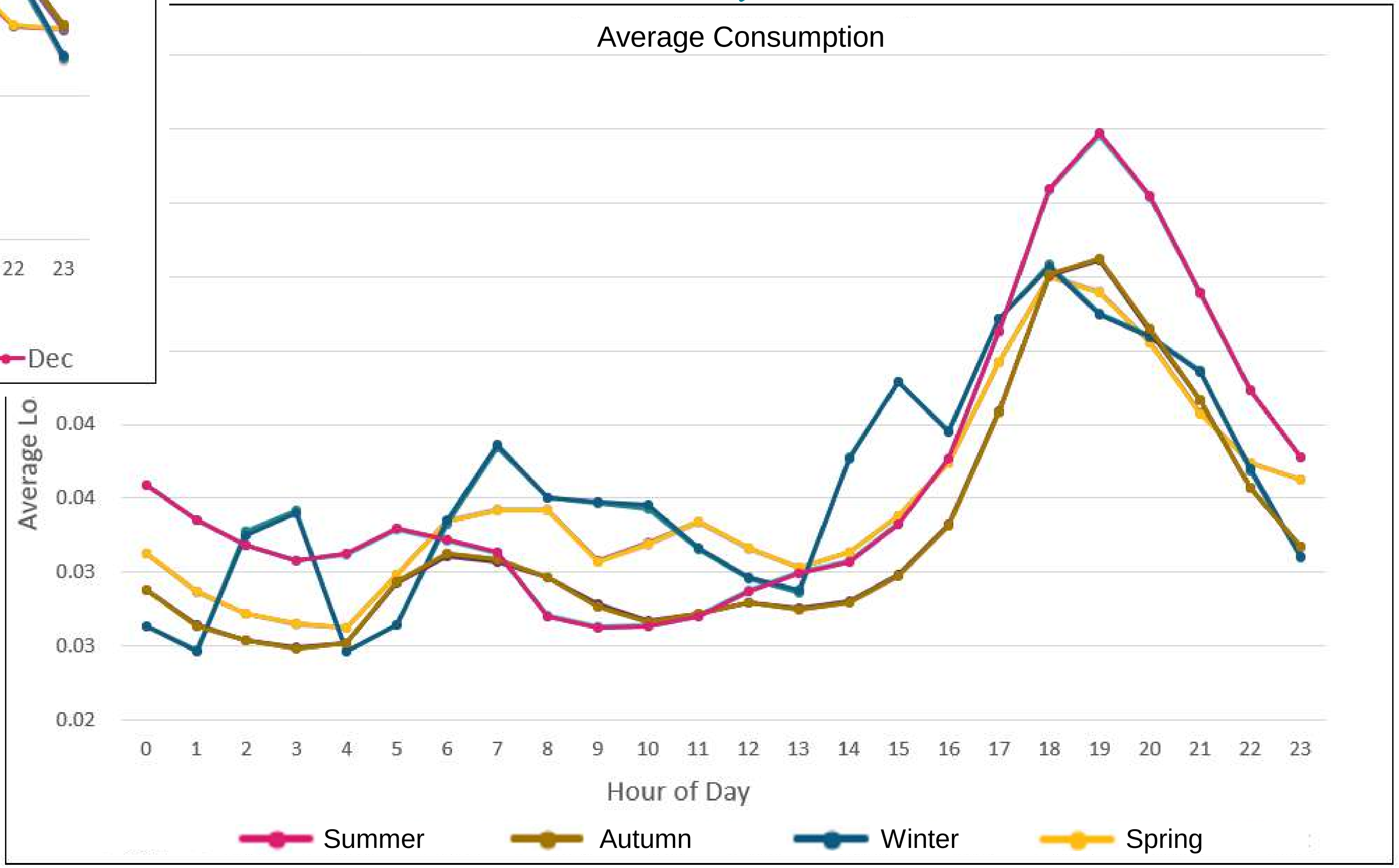


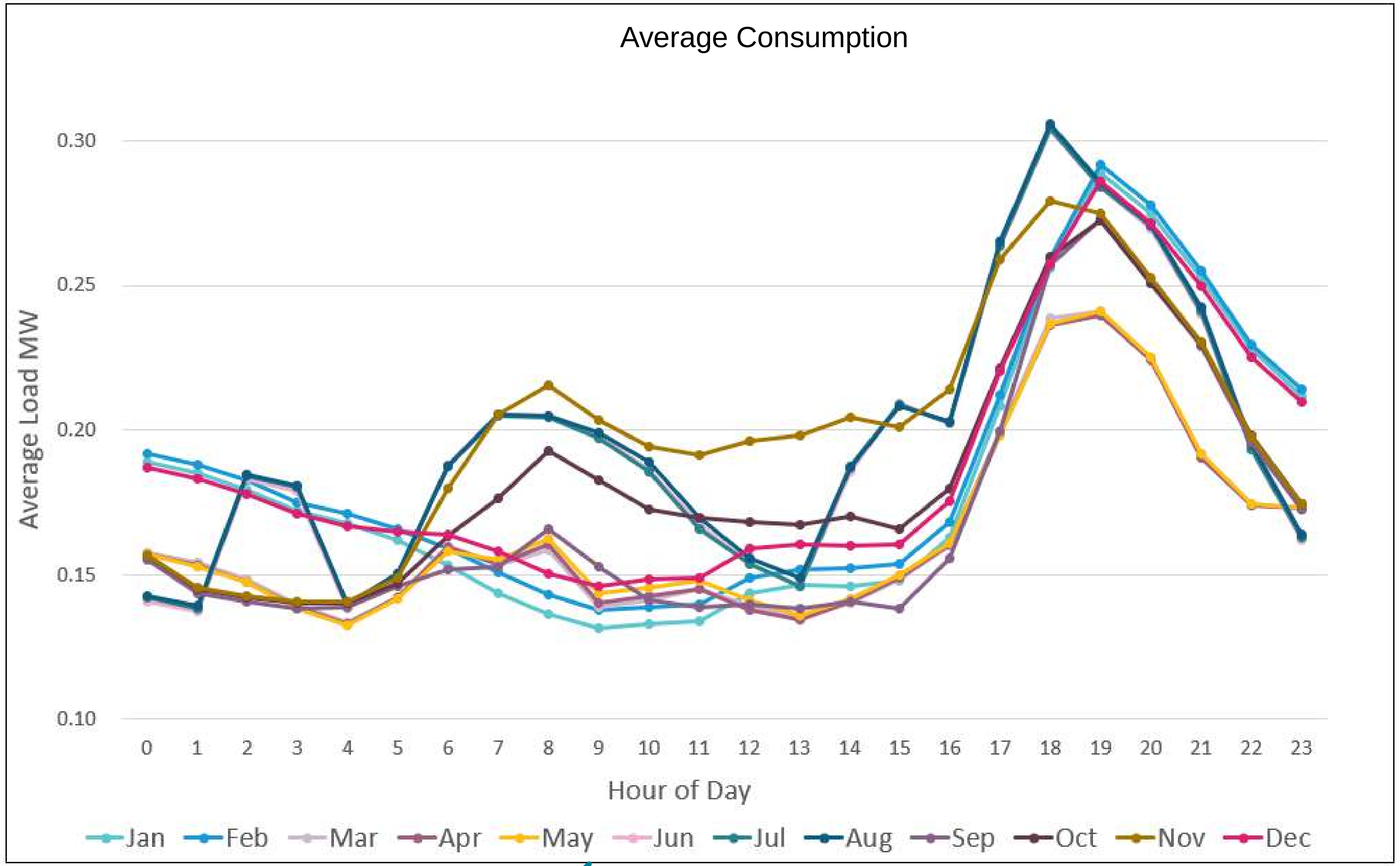


PHASE 2 BEGINNINGS

- Phase 2 has kicked off with a workshop with Grid Cognition to establish the structure of the model for analysing the existing Mullewa energy system and testing proposed microgrid solutions.
- Load profiles being developed based on the meter data for input to the model.
- Base case for model and the test case scenarios being developed in Grid Cognition.

Preliminary Load Profile for Mullewa Radial Network





Preliminary Load Profile for Mullewa Town

PHASE 4 – COMMUNITY ENGAGEMENT

- Aim:

  To engage with the community to gather feedback on the proposed solution and improve understanding of their priorities

- Activities:

  Run community engagement sessions in conjunction with CGG, MWDC and Synergy to test community priorities including:
  - Reliability (all of the time or key times)
  - Cost
  - Self-supply capability (solar and battery)
  - Equity for all electricity users
  - Feed in tariffs earned from excess solar
  - Unbundled tariff options.

  Use feedback from sessions to validate or adjust solution to align with community expectations.

- Outcomes:

  Gathering data and feedback from the community that will be used to improve the proposed solution to better align with community priorities

FUTURE OPPORTUNITIES - AGRIVOLTAICS

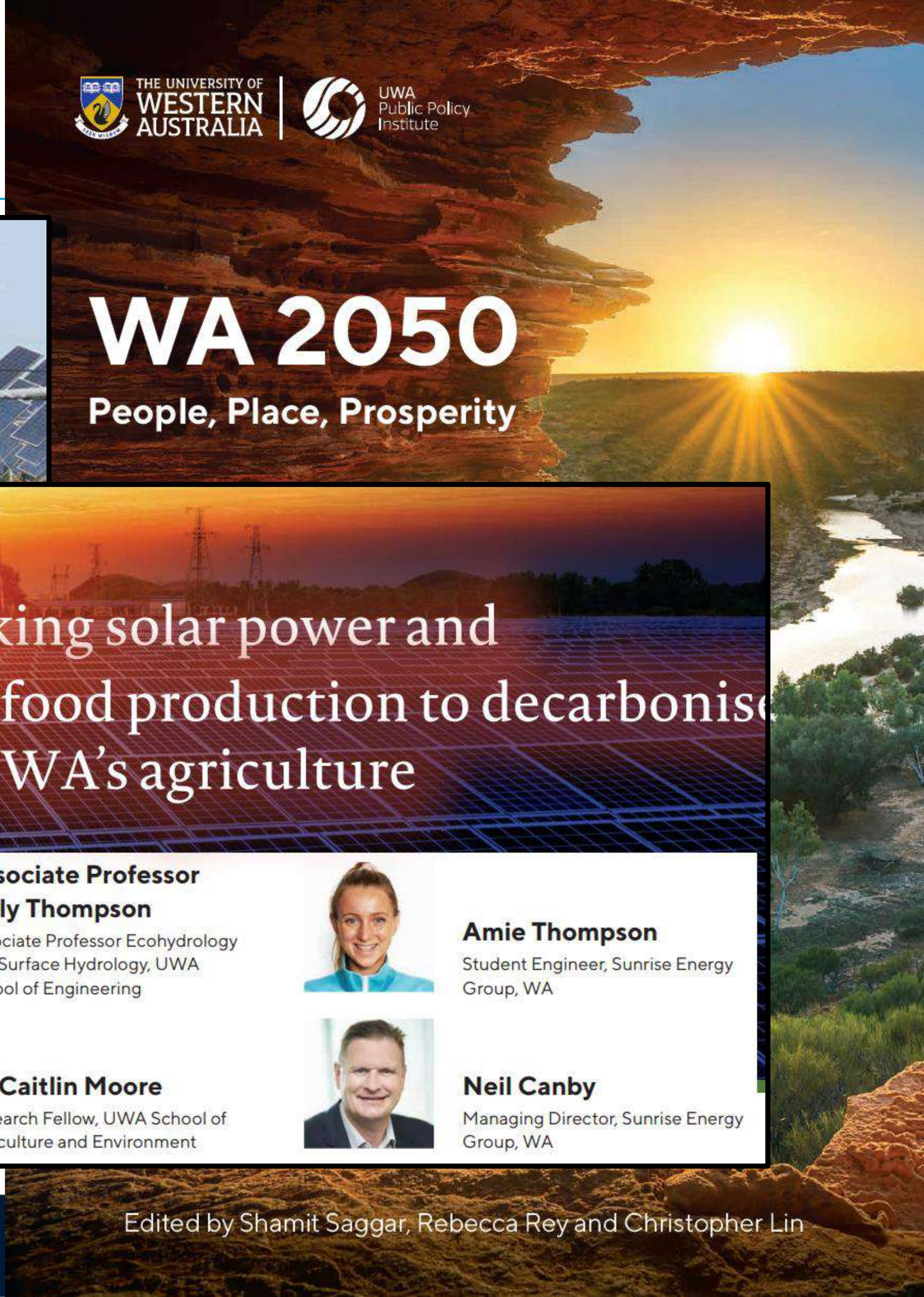
mullewa

What is Agrivoltaics?

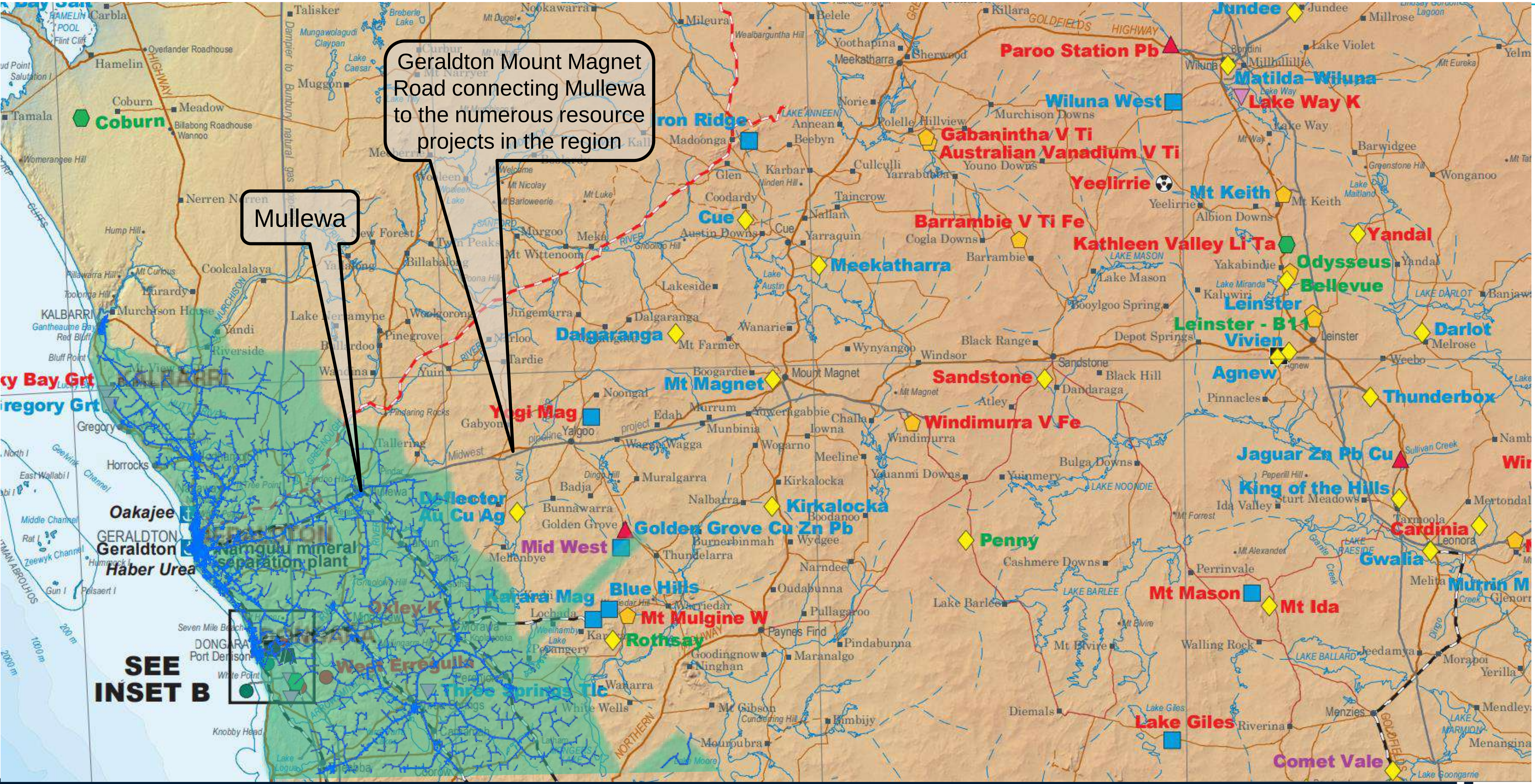
- Solar power production which is incorporated into agricultural land.
- Texts below are extracts from UWA Public Policy Institute Publication, “WA 2050 People, Place, Prosperity”

The potential for transformation of the power grid, climate risks to agricultural production, and food stress are not evenly distributed in WA (Figure 1). Instead, areas with high potential for transformation of the energy system coincide with higher food stress indices and areas of known climate risks to agriculture. These coincidences suggest that adopting AV at the fringes of the WA electricity grid could be transformative.

AV offers the prospect of not only sharing land between agriculture and power production, but also of engineering microclimates that enhance agricultural production, resilience and climate-preparedness.



FUTURE OPPORTUNITES – LEVERAGING MULLEWA'S UNIQUE LOCATION



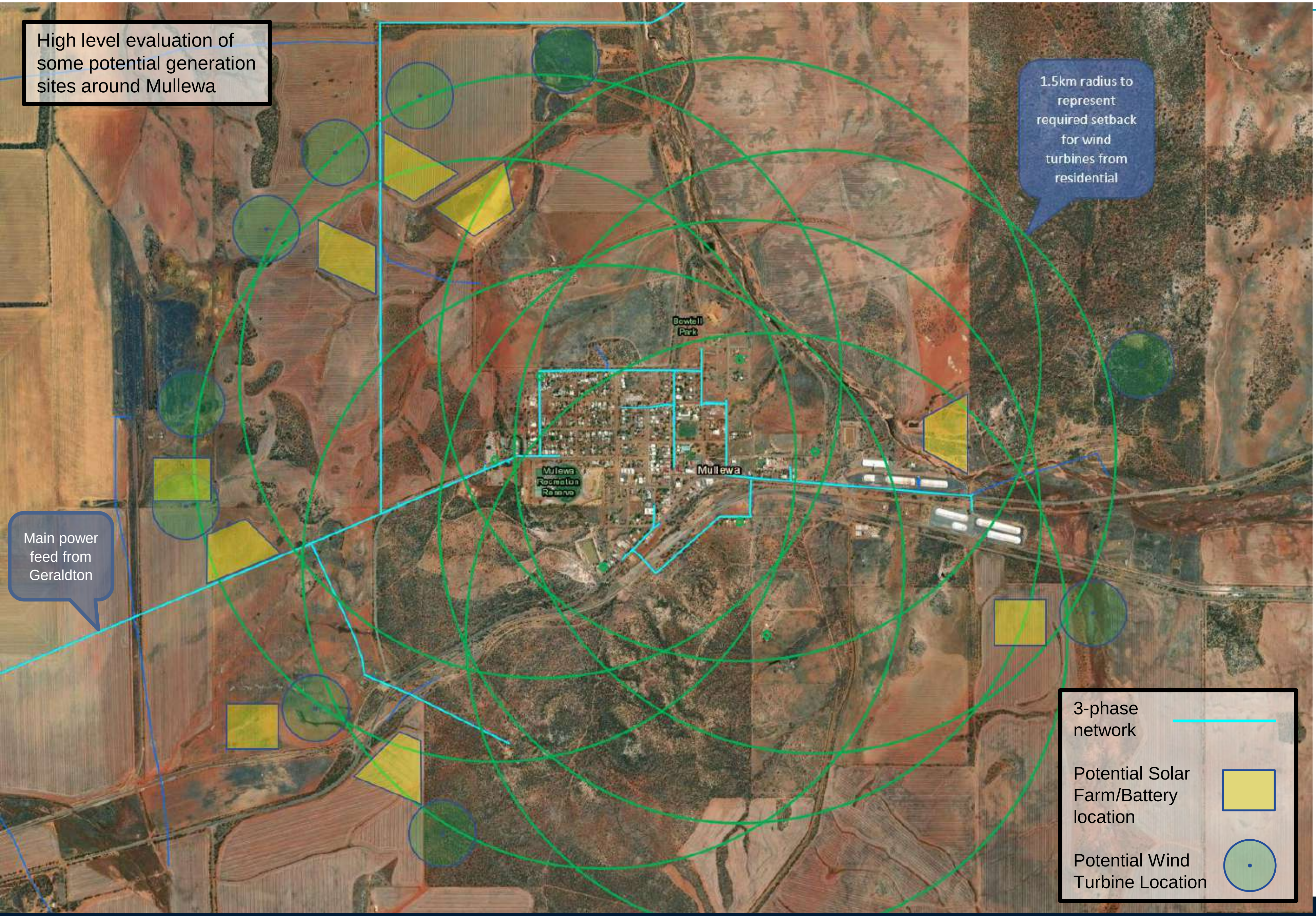
Extract from Major Resource Projects WA Map – Oct 2021 overlayed with the extent of the Western Power Electrical Grid (in green)

MINERAL SYMBOLS
- Precious mineral — Dmd (or as shown)
- Precious metal — Au (or as shown)
- Steel alloy metal — Ni (or as shown)
- Speciality metal — Ti–Zr (or as shown)
- Base metal — (as shown)
- Iron — Fe (or as shown)
- Bauxite
- Coal or lignite
- Uranium
- Industrial mineral — (as shown)

FUTURE OPPORTUNITES – LEVERAGING MULLEWA'S UNIQUE LOCATION

- Mullewa's location is unique in that it is the last grid connected town on the main road heading east towards the many mining/resource projects in the Mid West/Goldfields region of WA.
- The grid connection combined with Mullewa's location on a major transport route for the mining sector would make it a prime location for a future hydrogen supply station servicing the mining industry directly and the transportation industry supplying the numerous sites.
- A grid connection is relevant as it typically improves the economics of a green hydrogen production facility.

SELECTING A POWER GENERATION SITE – KEY CONSIDERATIONS



Key considerations when evaluating potential sites for renewable generation (ie. solar farms / wind turbines)

- Relatively flat cleared land for solar farm (potential to sustain agrivoltaics also favourable)
- Preference for square/rectangular areas for solar farm, orientated perpendicular to north-south, east-west (alternatives acceptable however will have less efficient land use)
- Solar Farm/Battery close to connection point (to keep line losses and cabling costs down). Connection is preferrable on the main feed from Geraldton but potentially could be elsewhere within the 3-phase network
- Wind turbine relatively close to solar farm/battery
- Minimum 1.5km setback from a residence (dwelling) for wind turbines
- Wind turbines within 2 x tip height from e.g. infrastructure / public roads / non-involved property boundary
- Avoidance of environmentally sensitive areas
- Enough area to cater for potential future growth in solar and/or wind generation
- Close to major transport routes (to cater for potential future hydrogen production and refueling stations / electric vehicle charging stations)
- Land ownership

CITY OF GREATER GERALDTON (CGG)

How does the project align with CGG interests? The understanding is that CGG is keen for projects that align with the goals of it's 2020-2023 Geraldton Jobs & Growth Plan - including:

- Increased collaboration between private sector, public sector and local communities to drive success and economic growth in the region, via the following platforms:
  - **Quality infrastructure (one of the "game changer" strategies being expansion of energy transmission capacity to enable regional development of innovative and renewable energy solutions and secure power supply)**
    - The project aligns with this because: The project seeks to improve energy capacity in the region and facilitate development of innovative and renewable energy solutions to secure power supply. This, in turn, provides a platform for industry to grow and to attract investment in the region. Economic participation (particularly expanded job opportunities for Aboriginal people).
  - **Positive reputation**
    - The project aligns with this because : Improved reliability and affordability of power will make Mullewa a more attractive place to live, do business and to visit.
  - **Innovation and entrepreneurship**
    - The project aligns with this because : Sunrise and its Project partners all have a strategic focus on innovation and this theme underpins the Project, including the technologies to be used during the feasibility study, as well as potential technologies to be included in future solutions for deployment, e.g. Agrivoltaics and looking at possible diesel displacement through local hydrogen production.

CITY OF GREATER GERALDTON (CGG)

- **Investment attraction**
  - The project aligns with this because: Unreliable and expensive energy supply has historically been an inhibitor for businesses to invest in the Mullewa region. The Project therefore represents an opportunity to remove this inhibitor and encourage greater investment in the region.
- **Economic participation:**
  - The project aligns with this because: The Project provides an opportunity to increase economic participation not only during the deployment phase but also through the increased economic activity in the region as a result of more affordable and reliable power, ensuring that the economic benefits are spread widely amongst the community. This is particularly important in Mullewa, where there is a significant Aboriginal population and data has shown relatively high unemployment and persistent labour market disadvantage for this group within the community. Sunrise has engaged with MEEDAC to ensure that Aboriginal community engagement is a strategic priority in Project planning. Additionally, as MEEDAC own a number of assets in Mullewa, including a motel and aged care facility, and are also embarking on innovative micro-agriculture business concepts based on renewable power, the group has expressed strong support in the Project and its endeavour to determine how more reliable, affordable and greener power can drive economic activity in Mullewa.

CITY OF GREATER GERALDTON (CGG)

CGG Interfaces with the Project

- Possible use of CGG land for an installation site
- City Development Approvals
- Environmental Approvals
- Assistance with Community Engagement
- Input on possible local investment interest

MID WEST DEVELOPMENT COMMISSION (MWDC)

How does the project align with MWDC interests? The understanding is that the MWDC is keen for projects that supports its core objectives which are understood to be:

- Attracting population to the region
- Growing and diversifying the economy
- Growing private investment
- Addressing priority community amenity needs
- Delivering service effectiveness to communities and efficiencies to government.

Consistent with these themes, the Project would provide innovative renewable energy generation solutions that enhance the community's quality of life and attractiveness through more affordable, secure and reliable connectivity to the electricity network for the region.

In addition, current and future businesses would benefit from reduced blackout events and power system outages and improve the liveability for the local community. The Project would assist with infrastructure and connectivity issues to help address increasing population and help create jobs and promote sustained economic growth for the region.

MIDWEST EMPLOYMENT AND ENTERPRISE DEVELOPMENT ABORIGINAL CORPORATION (MEEDAC)

How does the project align with MEEDAC interests? The Expectation is that the MEEDAC is keen for projects that support it's Purpose & Vision which are understood to include:

- To improve the lives of our people in regional and remote Australia
- Deliver sustainable and relevant programs
- Create sustainable commercial Enterprises
- Social inclusion and economic independence
- Lead with innovation in all our projects and employment creation

The project supports these objectives and can contribute to their realization by providing an opportunity to increase economic participation not only during the deployment phase but also through the increased economic activity in the region as a result of more affordable and reliable power, ensuring that the economic benefits are spread widely amongst the community.

An increase in energy reliability would also support MEEDAC directly as an owner of a number of assets in Mullewa (e.g. motel and aged care facility).

Agrivoltaics is an example of one avenue for new investment and employment that could be opened up from a successful outcome to the project. It is understood MEEDAC are already investigating innovative micro-agriculture business concepts based on renewable power and so there is an obvious synergy between this and the project.

Mullewa Microgrid Feasibility Study Project

Tuesday June 28th, 2022

Synergy/WP/SEG Worksop

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AGENDA

- 2:00-2:15pm Introductions and outline of meeting purpose & objectives
- 2:15-2:40pm Commercial Models
- 2:40-3:00pm Regulations
- 3:00-3:20pm Western Power Roles/Service
- 3:20-3:40pm Synergy Roles/Service
- 3:40-4:00pm General Considerations

WHY ARE WE MEETING – STUDY ORIGINS

- This meeting is the outcome of what started with the question “how do we solve the “problems” of fringe-of-grid towns on the SWIS with a replicable model”? The problems being:
    - the low reliability of these towns, typically on long radial feeders
    - the subsidisation of these towns by the rest of the SWIS
    - the uncertainty surrounding long term sustainability of a grid supply (given WP identifying fringe disconnection as part of their “Grid Evolution” discussions.
- This led to the agreement between WP, Synergy and Sunrise to apply for federal funding from the “Regional and Remote Community Reliability Fund Microgrids 2020-21 grant opportunity” to complete a Microgrid Feasibility Study at a specific location.
- Western Power provided a list of ten worst performing locations, which included Mullewa. From this list Mullewa was selected as the location for the study.
- The premise on which grant funding was received was for a microgrid that incorporated renewable generation, with the aim of the study being to develop a commercially sound, technically and economically feasible solution to significantly improve energy reliability, improve amenity for Mullewa residents and to retain and attract business to the town.
- The level of commitment at this stage is completion of the feasibility study.

GRANT OBJECTIVE AND OUTCOMES

Extract from Grant Opportunity Guidelines:

The objective of the program is to:

- support regional and remote communities to investigate whether replacing, upgrading or supplementing a microgrid or upgrading existing off-grid and fringe-of-grid supply with microgrid or related new energy technologies would be cost effective.

The intended outcomes of the program are:

- improved regional business, community services and emergency resilience through innovative microgrid solutions
- scaled-up and improved microgrid systems in regional and remote communities
- increased human capital (skills/knowledge) in the design and deployment of microgrids
- demonstrated commerciality and/or reliability and security benefits of deploying and upgrading microgrids
- reduced barriers to microgrid uptake in remote and regional communities
- increased dissemination of technology and/or project knowledge regarding the deployment and upgrading of microgrids.

WORKSHOP OBJECTIVES

- Test key assumptions and sensitivities of the commercial models with key partner stakeholders and subject matter experts.
- Move towards selecting the baseline commercial model for the rest of the feasibility study.
- We are not expecting to settle on solutions but come to an understanding of what are the options to be considered/investigated, decisions required and the hierarchy involved in making those decisions etc.
- We need to understand what areas require further investigation in order to make a decision on the commercial model at our next workshop.

COMMERCIAL MODELS

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COMMERCIAL MODELS

Four commercial models under consideration:

- **Model 1 – "As-Is" Model:**

  Current arrangement with local solar generation & battery connected to the network. Solar/Battery Operator revenue from PPA agreement with retailer for energy supplied, sale of LGC's & Generation Capacity Credits.

- **Model 2 – "As-Is + Network Control Services (NCS's)" Model:**

  Same as Model 1 with addition of payment to solar/battery operator for some NCS's (e.g. UPS via battery)

- **Model 3 – "Microgrid Embedded Network (MEN)" Model:**

  Solar generation & battery connected behind a master meter located on incoming line to the town. Microgrid Operator revenue from direct sale of energy to town customers, via retailer (retailer receives a %), sale of LGC's, sale of excess generation to the grid and control of the network tariffs and market costs, through active management of the battery. Aggregated load able to participate in various market services.

- **Model 4 – Geographical VPP Model:**

  "Smart" Solar and battery adopted by all the individual consumers and managed as a local VPP, by a VPP service provider (ie. no "communal Solar Farm", however "large" central grid forming battery included for). Aggregated load able to participate in various market services.

RESULTS FROM HIGH LEVEL ANALYSIS

Scenarios		Model 1 "As-IS"			Model 2 "As-Is + NCS"			Model 3 "Microgrid"			Model 4 "Geographical VPP"			
Solar Farm Size	Battery Size	Capital Cost	Net Revenue	**Simple Payback**	Capital Cost	Net Revenue	**Simple Payback**	Capital Cost	Net Revenue	**Simple Payback**	No. of 5kW Systems to give equivalent output to stated Solar Farm Size	Capital Cost	Net Revenue	**Simple Payback**
MW	Mwh	$million	$1000's	**Years**	$million	$1000's	**Years**	$million	$1000's	**Years**		$million	$1000's	**Years**
0.5	**0**	$ 1.9	$8	**219**	$ 1.9	$8	**219**	$ 3.9	$217	**18**	140	$ 1.9	$82	**24**
1	**0**	$ 2.9	$92	**32**	$ 2.9	$92	**32**	$ 4.9	$305	**16**	280	$ 2.6	$81	**33**
2	**0**	$ 5.0	$130	**38**	$ 5.0	$130	**38**	$ 7.0	$408	**17**				
3	**0**	$ 6.9	$170	**41**	$ 6.9	$170	**41**	$ 8.9	$428	**21**				
4	**0**	$ 8.8	$211	**41**	$ 8.8	$211	**41**	$ 10.8	$449	**24**				
0.5	**1**	$ 2.4	$21	**116**	$ 2.4	$12	**202**	$ 4.4	$289	**15**	140	$ 2.9	$125	**24**
1	**1**	$ 3.7	$107	**34**	$ 3.7	$98	**37**	$ 5.7	$368	**15**	280	$ 3.6	$129	**28**
2	**1**	$ 6.1	$137	**45**	$ 6.1	$128	**48**	$ 8.1	$458	**18**				
3	**1**	$ 8.5	$172	**49**	$ 8.5	$163	**52**	$ 10.5	$474	**22**				
4	**1**	$ 10.7	$209	**51**	$ 10.7	$200	**53**	$ 12.7	$491	**26**				
0.5	**2**	$ 2.7	$35	**78**	$ 2.7	$42	**65**	$ 4.7	$299	**16**	140	$ 3.9	$160	**25**
1	**2**	$ 4.0	$146	**27**	$ 4.0	$153	**26**	$ 6.0	$378	**16**	280	$ 4.6	$178	**26**
2	**2**	$ 6.4	$161	**40**	$ 6.4	$168	**38**	$ 8.4	$460	**18**				
3	**2**	$ 8.8	$187	**47**	$ 8.8	$194	**45**	$ 10.8	$476	**23**				
4	**2**	$ 11.0	$224	**49**	$ 11.0	$231	**48**	$ 13.0	$493	**26**				
0.5	**3**	$ 3.1	$50	**62**	$ 3.1	$60	**51**	$ 5.1	$306	**17**	140	$ 4.9	$107	**46**
1	**3**	$ 4.3	$186	**23**	$ 4.3	$196	**22**	$ 6.3	$386	**16**	280	$ 5.6	$252	**22**
2	**3**	$ 6.8	$200	**34**	$ 6.8	$211	**32**	$ 8.8	$459	**19**				
3	**3**	$ 9.1	$216	**42**	$ 9.1	$227	**40**	$ 11.1	$475	**23**				
4	**3**	$ 11.4	$238	**48**	$ 11.4	$249	**46**	$ 13.4	$492	**27**				
0.5	**4**	$ 3.4	$64	**53**	$ 3.4	$79	**43**	$ 5.4	$314	**17**	140	$ 5.9	$126	**47**
1	**4**	$ 4.7	$225	**21**	$ 4.7	$240	**19**	$ 6.7	$394	**17**	280	$ 6.6	$271	**25**
2	**4**	$ 7.1	$240	**30**	$ 7.1	$254	**28**	$ 9.1	$458	**20**				
3	**4**	$ 9.5	$256	**37**	$ 9.5	$270	**35**	$ 11.5	$474	**24**				
4	**4**	$ 11.7	$273	**43**	$ 11.7	$287	**41**	$ 13.7	$491	**28**				

SENSITIVITIES – MODELS 1/2 VS MODEL 3

Sensitivity to Network Sale Price & O&M Costs

- Current Assumption $2m Sale & $55k pa O&M
- Prices these would need to increase to in order to raise payback years to same as lowest payback for Model 2 is:
  - Sale price alone would have to increase to $3.25m (160% increase)
  - O&M costs alone would have to increase to $115k pa (288% increase)
  - Example of Combined price/cost increases of $3m (150% increase) and O&M $55k (138% increase)

Sensitivity to NCS income for Model 2 (current assumption $25k/MWh(battery)/per annum

- Would have to increase to $58k/MWh/pa to equate to same lowest payback as Model 3

Sensitivity to Contestable customers revenue. Currently based on rate of $250/MWh

- For contestable rate of $200/MWh, lowest Model 3 payback would increase to 18 years.

Sensitivity to LGC Price

LGC Price	Payback Years Model 1/2	Payback Years Model 3
$40 (current)	**19**	**15**
$35	21	15
$30	22	16
$20	25	16
$10	30	17
$0	36	17
$106	9	9

SENSITIVITIES - MODELS 1/2 VS MODEL 3

Sensitivity to Peak & Off-Peak Energy Sale prices for Models 1&2 / Peak & Off-Peak Grid Purchased Energy for Model 3 (assumed to be the same)

- Current Assumption $26 Off-Peak (9pm-6pm) and $87 Peak (6pm-9pm)
- Prices these would need to increase to in order to drive lowest payback years between models 1/2 and 3 to equalise:
  - Off-Peak price alone would have to increase to $45 (173% increase)
  - Peak price alone would have to increase to $145 (167% increase)
  - Example of combined price increase of Off-Peak to $34 (131% increase) and Peak to $130 (149% increase)

Sensitivity to price earned for Generation Capacity Credits:

- Current assumption is that generating capacity credits is earnt at a rated of $100k/MW
- If this was reduced to $70k/MW then this would add approx. 3 years to Model1/2 payback time
- In order to reach payback time equivalent to Model 3, the price would have to reach approx. $165k/MW

Sensitivity to increased capital cost of Model 3, due to an allowance for replacement of metering infrastructure:

- Assuming 290 NMI’s at $2000 each, would increase lowest payback in Model 3 from 14 to 16 years.
- A capital cost of $6500 per NMI would be required to increase the lowest payback in Model 3 equivalent to that for Model 2.

SENSITIVITIES - MODEL 4 VS MODEL 3

Sensitivity to Customers receiving no compensation for use of their property for solar/battery installation:

- Current Assumption is a reduced price for power from $250/MWh to $200/MWh (equating to approx. $130-$450 rebate per annum)
- With no compensation the payback time reduced from 22 years to 17 years, still greater than that for Model 3

Sensitivity to Capital Costs:

- Assuming no grid forming battery required (ie. reduction in capital of $750k) the best payback scenario drops to 13 years, however this is for scenario with no batteries in the system at all – not realistic given the objective of improving reliability. Next best payback scenario (incl. battery) is 17 years, still greater than Model 3.
- If we look at reducing capital further (assumed up front lump sump cost for establishing VPP of $500k, and $2000 per system for smart hardware installation/configuration), in order to achieve equivalent lowest payback time to Model 3, then this would require a reduction to:
    - $345k alone for lump sum cost
    - or $900 per system alone for smart hardware installation/configuration costs
    - or for example combination of reduction to $415k for lump sump and $1500 per system

MODEL 1 – "AS-IS" MODEL

Pros:

- Easy - no regulatory changes required / status quo maintained
- Western Power revenue increase from new Solar Farm connection

Cons:

- No significant improvement in reliability – if grid connection is lost no mechanism for the solar farm / battery to provide back-up
- Difficult to implement as not attractive to investors because:
  - High risk – no certainty over future of grid connection (required to export excess generation)
  - Longer payback period compared to Microgrid model
  - Unlikely to gain approval above 1MVA DSOC
- Most commercially viable scenarios require larger batteries – with inherently greater commercial exposure (e.g. Batteries have limited life and replacement costs have not been accounted for in the analysis).
- Requires a retailer to underwrite, of which they have little incentive to do (uncontracted solar power already available today – likely at lower cost as at larger scale).

Assumptions:

- PPA price based on other existing agreements with Synergy
- RT11 Network Tariff for Solar Farm
- $40 for LGC's
- Earn capacity fees for solar & battery participation in the capacity market based on 20% solar capacity and 4hr battery at $100k/MW

MODEL 2 – "AS-IS" MODEL + NCS

Pros:

- Same as "As-Is" Model, plus can support the town during outages and slight commercial improvement due to increased revenue from NCS's

Cons:

- Same as "As-Is" model, except that as this scenario can support the town during outages, reliability issues is no longer a con.
- Western Power have already installed diesel generators to do this (ie. support town during outages) – so may be better suited to towns with no emergency generation.
- Western Power costs increase to fund the NCS service.

Assumptions:

- Network Control Service Fee based on providing a UPS service paid at a rate of $25,000 per MWh of reserved nominal battery storage capacity (min 1MWh)
- 50% of nominal battery storage capacity reserved for UPS service
- Earn capacity fees for solar & battery participation in the capacity market based on 20% solar capacity and 4hr battery at $100k/MW

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MODEL 3 – "MICROGRID EMBEDDED NETWORK"

Pros:

- Increase reliability of power supply in Mullewa
- Most attractive commercial model for investors (demand & supply combined)
- Positioned to enable disconnection from the grid in the future, should that occur.
- Reduces Synergy commercial risk & aligns with Synergy's move into embedded networks
- Reduces Western Power exposure to maintaining ageing infrastructure, if network sold. If leased WP would be paid for the upkeep.
- Aligns with Western Powers future grid transformation (disconnected towns / skinny network connected towns)

Cons:

- Some challenges to navigate on some regulatory requirements
- Synergy uses less wholesale energy to supply Mullewa
- Reduces Western Power tariff revenue (offset by embedded network services income & asset sale/lease)
- May be constrained to a 1.5MVA CMD & 1MVA DSOC

Assumptions:

- Embedded Network purchase price of $2m (for info on network age ref. last slide).
- Embedded Network O&M servicing expenses of $55k pa (of which $15k is allocated for streetlights)
- Energy sold at flat rate of $250/MWh (intended to generally reflect current costs for Mullewa - which are not intended to change)
- Energy imported and exported from/to grid at same $ rates as PPA from Model 1
- 10% of local energy sales paid to retailer
- Streetlights income of $27k pa & expenses of $15k pa
- Applied Network Tariff is maximum of RT5 or RT11
- Battery managed to reduce DSOC and hence RT5 Network Tariff expenses
- Battery managed to avoid IRCR charges
- $40 for LGC's & $38 for STC's (for income and liabilities)
- No Market Services Sold

MODEL 4 – "GEOGRAPHICAL VPP"

Pros:

- Increase reliability of power supply in Mullewa

Cons:

- Difficult to implement as not attractive to investors because:
  - VPP model relies on selling services to the market – however currently only Synergy can sell services to residential customers.
  - High risk – no certainty over future of grid connection (required for services to support VPP model)
  - High risk - uncertainty over future revenue opportunities, e.g. FFR/FCAS/ESS, Wholesale Demand Response Mechanism
  - Longer payback period compared to Microgrid model
- Some challenges to navigate on some regulatory requirements
- Reduces Synergy revenue – with no reduction in commercial risk
- Reduces Western Power tariff revenue – with no reduction in responsibility
- Not proven (e.g. for grid forming, meaning centralized battery/inverter may still be required to provide these services) and no obvious provider in the market

Assumptions:

- VPP pays for / owns all rooftop solar/battery systems
- Rooftop Solar size 140% of tracking commercial solar farm for same output
- 1MW/1MWh central battery for grid forming at cost of $750k
- $500k for overall VPP set-up + $2k per system
- Annual $250 per system for VPP software license fee
- Annual $200 per system for O&M, incl. billing/metering
- % of power exported during peak pricing based on battery size
- Export rates of $100 peak, $27.5 off-peak (based on Synergy DEB Scheme)
- Customer pays reduced tariff (reduced from $250 to $200 per MWh) to compensate for use of property for installation. Equates to ~$130-$450 rebate per year.
- No Market Services Sold

SUNRISE HYPOTHESIS

Model 3 – "Microgrid Embedded Network" is the model best placed to pursue as a "solution" for Mullewa and in general most other similar "fringe of grid" towns on the SWIS.

- Best financial return
- Best aligned to future network direction
- Proven in greenfields application
- Doesn't require additional subsidy from Synergy/Western Power

There will be challenges to navigate based on Model 3 (as alluded to in the "considerations" stated in the following slides) – some of the key ones being:

- Extent of consent required from customers and contestable retailers
- Mechanism for implementing "true" contestability

REGULATIONS

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REGULATIONS

Considerations:

- Maintaining customer protections, Network & Retail
- Customer connection arrangements
- Regulations governing Network – do any changes to regulations need to be considered
- Regulations governing retail pricing – do any changes need to be considered.
- Extent of consent required from customers & contestable retailers
- Distribution License Options – Western Powers / 3rd Party / Exemption

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WESTERN POWER ROLES/SERVICE

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WESTERN POWER ROLES/SERVICE

Considerations:

- Form of Involvement in terms of network ownership, O&M services, Conditions of Sale/Lease
- Form of Services – if any (leverage Energy Operators Powers Act)
- Inspectorate Services – WP / 3rd Party
- Provision of Metering Services – WP / Synergy / 3rd Party (handling of contestable customers)
- Network Provider of last resort

SYNERGY POWER ROLES/SERVICE

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SYNERGY POWER ROLES/SERVICE

Considerations:

- Retail arrangements with Synergy – residential, non-contestable commercial, contestable commercial.
- 3rd Party retail arrangements (for contestables) and how to maintain contestables access to alternative retailers.

GENERAL

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GENERAL CONSIDERATIONS

- Isolation point - include/exclude the radial beyond Mullewa? (see over)
- Expectation for improvements in outages as a result of implementing a Microgrid
- Customer Self Supply Guidelines
- Market Arrangements with AEMO
- Policy Alignment with Energy Policy WA
- Benefit of discussions with ERA & EPWA prior to Sep 21st Community Engagement – can we reach an internal consensus in time to achieve this?

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REFERENCE MATERIAL

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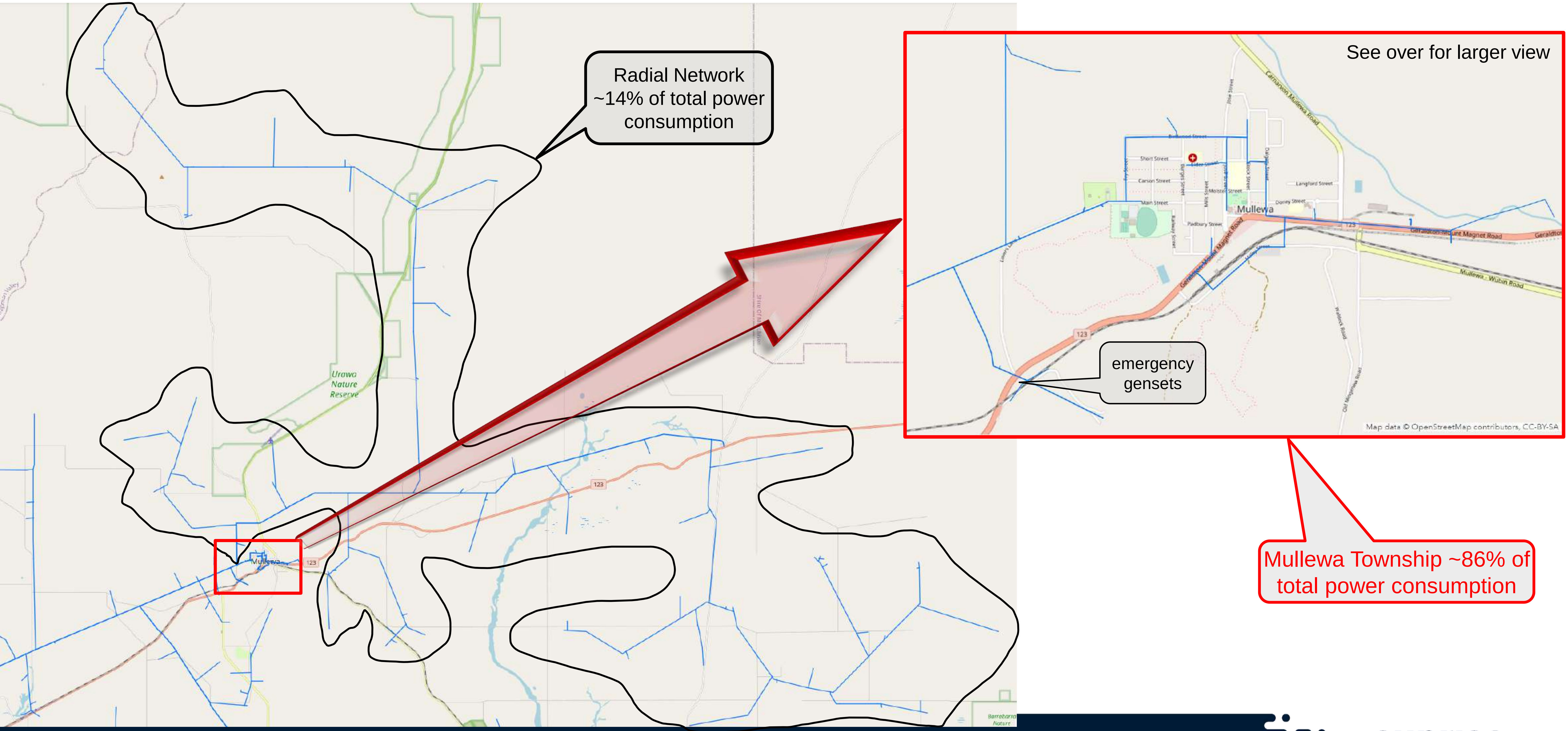
MULLEWA NETWORK



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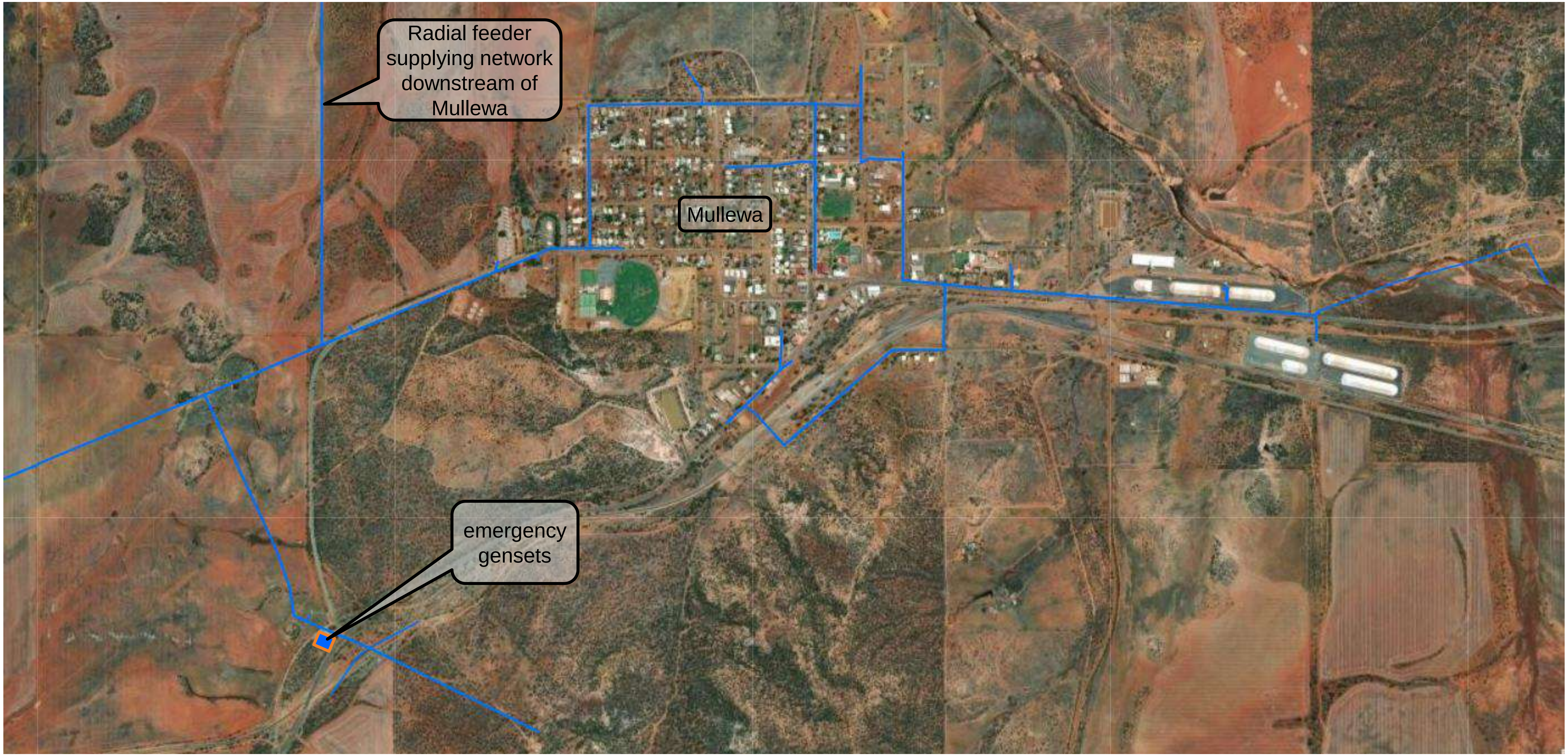
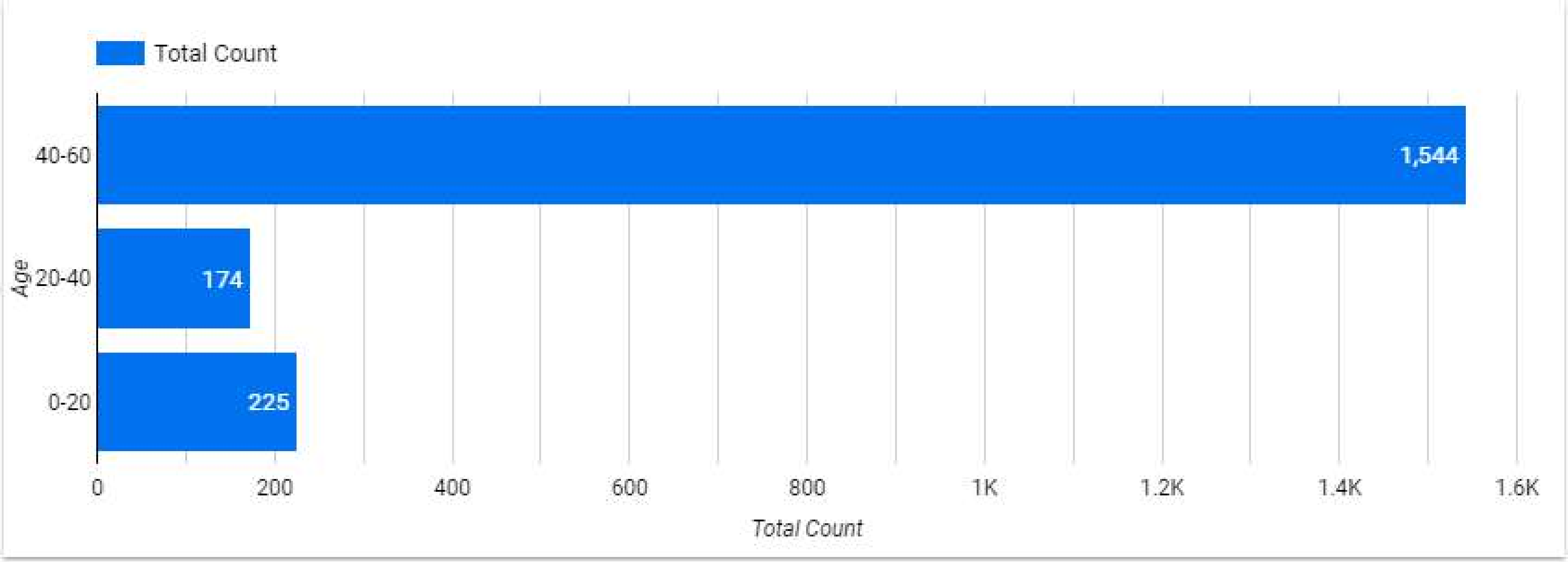
MULLEWA NETWORK

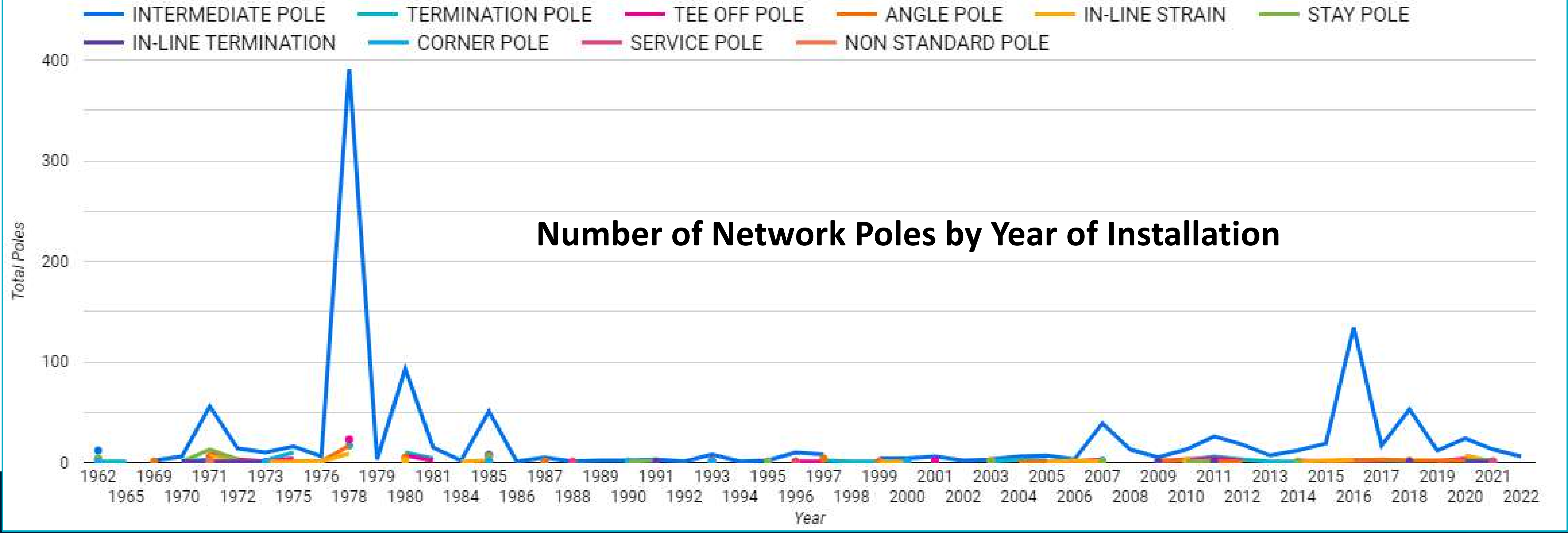


NETWORK AGE DATA

Conductors segregation based on Age (Years)



Number of Network Poles by Year of Installation



Mullewa Microgrid Feasibility Study Project

Tuesday September 6th, 2022

Synergy/WP/SEG Worksop

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AGENDA

- 2:00-2:05, Introductions

Part 1 – Embedded Networks and Microgrids Strategic Position

- 2:05-2:10, Context - Sunrise Energy
- 2:10-2:25, Western Power Discussion
- 2:25-2:40, Synergy Discussion

Part 2 – Strawman Model and Regulatory Reform

- 2:40-2:50, Walk through strawman
- 2:50-3:10, Open discussion
- 3:10-3:30, Boundaries – what options/variants also fit within the strawman components/roles?
- 3:30-3:50, Key Issues – what is addressed by the strawman, what remains and becomes the focus of regulatory reform.
- 3:50-4:00, Review and summarise conclusions

PART 1
Embedded Networks and Microgrids Strategic Position

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PART 1 –
EMBEDDED NETWORKS AND MICROGRIDS STRATEGIC POSITION

- The strawman model presented is a hypothesis we want to test with EPWA/ERA
- But first we want to test if it fits in within the Western Power & Synergy strategy execution approach and strategy execution timing
- The intent is not to be confrontational but to have an honest conversation

MICROGRIDS STRATEGY –
WESTERN POWER STRATEGY EXECUTION APPROACH

- It is clear that Western Power supports Microgrids, and that we're aligned on wanting Microgrids that: solve reliability, incorporate renewable generation, maintain customer protections, reduce overall costs for the SWIS etc.
- But where does this support sit in terms of execution strategy and execution timing?
- Why is this important – because solving fringe-of-grid / adopting Microgrids is not done in a Vacuum
- In terms of execution strategy – do Western Power want partners, do they want to do it alone, do they want a lead role or just a support role?

MICROGRIDS STRATEGY –
WESTERN POWER STRATEGY EXECUTION APPROACH (CONT.)

- Has Western Power Strategy shifted since it's submission to the 2018 Inquiry into Microgrids where it stated:

> - As the incumbent network operator, **Western Power is best placed to construct and manage microgrids, SPS, and other emerging network technologies** as a regulated network activity within the area of the South West Interconnected System (SWIS). Not only do we have the knowledge, experience, and existing core capability for designing, managing and maintaining associated grid infrastructure; but we also have the most compelling business case to utilise these alternative grids solutions to lower the cost of essential service provision and improve the customer experience.

> - Empowering Western Power to invest in and manage microgrids in the SWIS would allow us to **avoid investing capital expenditure in ageing infrastructure, which keeps costs down while continuing to maintain reliability for customers**. Western Power also has an existing workforce (which other market participants do not) located throughout the south west of the state that can be deployed to work involving microgrids. Additional benefits include:
>   - Creating **economies of scale** (through using a sole provider for this service);
>   - Providing **certainty of efficiency** by using an independently regulated agency; and
>   - Offering a **safety net to customers** by empowering a government owned entity to perform the task.

MICROGRIDS STRATEGY –
WESTERN POWER STRATEGY EXECUTION TIMING

- In terms of execution timing is it the right time to do this now – is there space?
- Is there funding in AA5 for this - It seems there is some funding in AA5 for a couple of small disconnected microgrids, but none for Microgrid type batteries.
- Is there funding in Western Power to solve this in the next 5 years?

MICROGRIDS STRATEGY – SYNERGY STRATEGY EXECUTION APPROACH

- There is no question that we're aligned with Synergy on the need for decarbonisation, reliability, customer choice and customer participation.
- We can see that Synergy support a strategy where others step-in with a retail licence in a greenfield setting, where Synergy are not "losing" existing customers. However, what is Synergy's position in a brownfield setting?
- Can Synergy step-back from owning the customer relationship (ie. defend it's non-contestable customers) and instead participate in the customer relationship?
- Are Synergy willing to not be the final decision makers of tariff structures in an embedded microgrid model, opening the opportunity to test new tariffs in order to reduce costs for customers and operators (assuming a "no worse off" clause), e.g. through incentivising changes in energy use behaviour?

MICROGRIDS STRATEGY –
SYNERGY STRATEGY EXECUTION TIMING

- Embedded Network products are commercially available, so from a service position standpoint we know there is the ability to execute now.
- But, given the $3.8 billion renewable investment, Project Symphony, market reforms and a host of other initiatives, e.g VPP for schools, EV charging networks, energy efficiency programs etc. – is there space for microgrids in the next few years?

PART 2
Strawman Model and Regulatory Reform

PROPOSED STRAWMAN MODEL FOR DRIVING REGULATORY REFORM

ROLES		FUNCTIONS	COMMERCIAL ARRANGEMENTS
Retailer to Customer	EMN Service Provider	• Bills customers • Collects money • Handles complaints / bill enquiries • Reads meters	• Paid for services on cost per customer per annum / % on revenue basis • No commercial exposure on energy costs • Not leveraging retail license, just billing & customer service capability
Embedded Network Microgrid (ENM) Operator	Sunrise	• Operates generation & storage with grid connection to optimise energy cost • Manages new connections • Manages Faults • Manages O&M (license compliance)	• Carries exposure to energy costs • Retail license including all existing customer protections • Marries demand and supply in order to participate as DER in markets • Mechanism available for contestable customers to retain current retailer • Leverages existing WP distribution license (option to consider a distribution licence – but would be in addition to, not instead of the WP license)
Network Provider	Western Power	• Assists in fault recovery • Executes O&M activities - Network • Repair & replace assets	• Network lease to ENM Operator (ie. Network remains part of the SWIS from a license perspective, but not from a market perspective) • Includes asset refresh of poles & wires etc. • Adjustment for network retirement if it occurs (e.g. SPS roll-out) • Includes a base level of O&M services • T&M for all other O&M services
Generator	Sunrise	• Generates power in accordance with technical rules • Executes O&M activities - Generation • Manages generation compliance	• Long term PPA arrangement with ENM Operator • Energy at cents/kWh • Battery storage at capacity availability per month
Retailer to Master Meter	Synergy	• Provides balancing power • Takes excess power • Administration of network connection	• Standard approach to a commercial customer arrangement on an unbundled commercial arrangement with bi-directional energy flows

REGULATORY QUESTIONS

- Taking SWIS customers behind the meter, so no longer on the SWIS – does this need all customers to say yes if the case to do this results in an overall benefit for SWIS customers?
- If the retail license includes the necessary customer protections, such as - operator does not charge contestable customers above gazetted tariff rates, and contestable customers have access to another retailer – does this satisfy contestability obligations?
- When connection points behind the meter are no longer NMI's, can changes to regulations be considered to still include the embedded network as part of the SWIS covered network – similar to SPS's? (SPS's not on the SWIS but part of the covered network)
- Can metering code be amended to accommodate behind the meter meters and non-NMI's?
- Will WP land access rights under the Energy Operators Powers Act still hold if the network is leased to a 3rd party, but land access events are undertaken by WP or its service providers?
- Will Energy Safety grant an exemption from the existing network complying to AS3000 as it would be classified as an embedded network?

KEY ISSUES

What is and isn't addressed by the Strawman and hence what remains as the focus points for regulatory reform:

ADDRESSED

- Access arrangement maintained under lease agreement
- WP remain as 'Service Provider' under lease agreement (from WP perspective, just a change in revenue stream)
- Customer protections remain
- Retail licence would be obtained by ENM Operator
- ENM Operator would leverage WP existing distribution licence – in addition could also obtain own distribution licence if found necessary
- Obligation to connect remains
- Network operator of last resort is WP, with conditions for implementing defined with the lease agreement

- Note: Adoption of the Alternative Energy Framework (AEF) could be a more elegant solution to licensing, customer protections & last resort powers, ie. but would be subject to timing

REMAINING – Focus of Regulatory Reform

- Taking SWIS behind the meter do we need all customers to say yes?
- Can we resolve contestability requirements in similar fashion to PEEL?
- Can embedded network still be part of the SWIS covered network?
- Can metering code be amended to accommodate non NMI behind the meter meters?
- Are WP land access rights maintained when network leased to 3rd party?
- Will Energy Safety grant exemption for AS3000 compliance of existing network when it converts to embedded network

- Related to an AEF approach – where would the responsibility for inspectorate and investigation function reside for the embedded network and connected loads?

Mullewa Community Engagement Forum

Wednesday September 21st 2022

Acknowledgement of Country

"We'd like to start by acknowledging the Traditional Owners of the land on which we meet today. We pay our respects to their elders, both past and present."

Welcome

Mullewa Community Engagement

Who are we?

- Synergy
  - Ella Dennis: Growth and Solutions; Retail
  - Steve Boyle: Growth and Solutions; Retail
- Western Power
  - Mark Timson: Product Development Manager
- Sunrise Energy Group
  - Neil Canby: Managing Director
  - Matthew Stewart: Project Manager

Background context

Feasibility Study;

Sunrise has secured funding to develop a feasibility study over 23 months, commencing October 1st 2021.

The feasibility study focusses on examining microgrid technology and its ability to address reliability challenges in regional towns and remote fringe-of-grid locations such as Mullewa.

The study includes various components including; data capture and analysis, scenario modelling, testing proposed solutions, community and stakeholder engagement.

Roles & Responsibilities;

Western Power and Synergy are assisting Sunrise to capture data for the study and provide input into the commercial arrangement options, as the relevant customer relationship and network owners respectively

What is the aim of this engagement?

synergy

The aim of this engagement session is to:

- Inform community of **Synergy's** strategy & business direction
- Introduce **Western Power's** strategy & role in feasibility study
- Introduce **Sunrise** to discuss feasibility study key components
- Increase community awareness of the study and its aims
- Encourage on-going engagement with community stakeholders
- Inform the community of next steps and timeframes for the feasibility study
- Allow for Q&A

Leading Western Australians to their intelligent energy future

Supply 66%
of the electricity to homes and business

6,300 GWh
of electricity generation

990+
employees

1.1 million +
Residential and business customers

Legend

- South West Interconnected System (SWIS)
- Thermal power station
- Wind farm
- Gas turbine
- Battery
- BEI renewable assets
  Albany Wind Farm, Warradarge Wind Farm and Greenough River Solar Farm

*Battery under construction

evolution 2030

OUR PURPOSE – This is why we exist

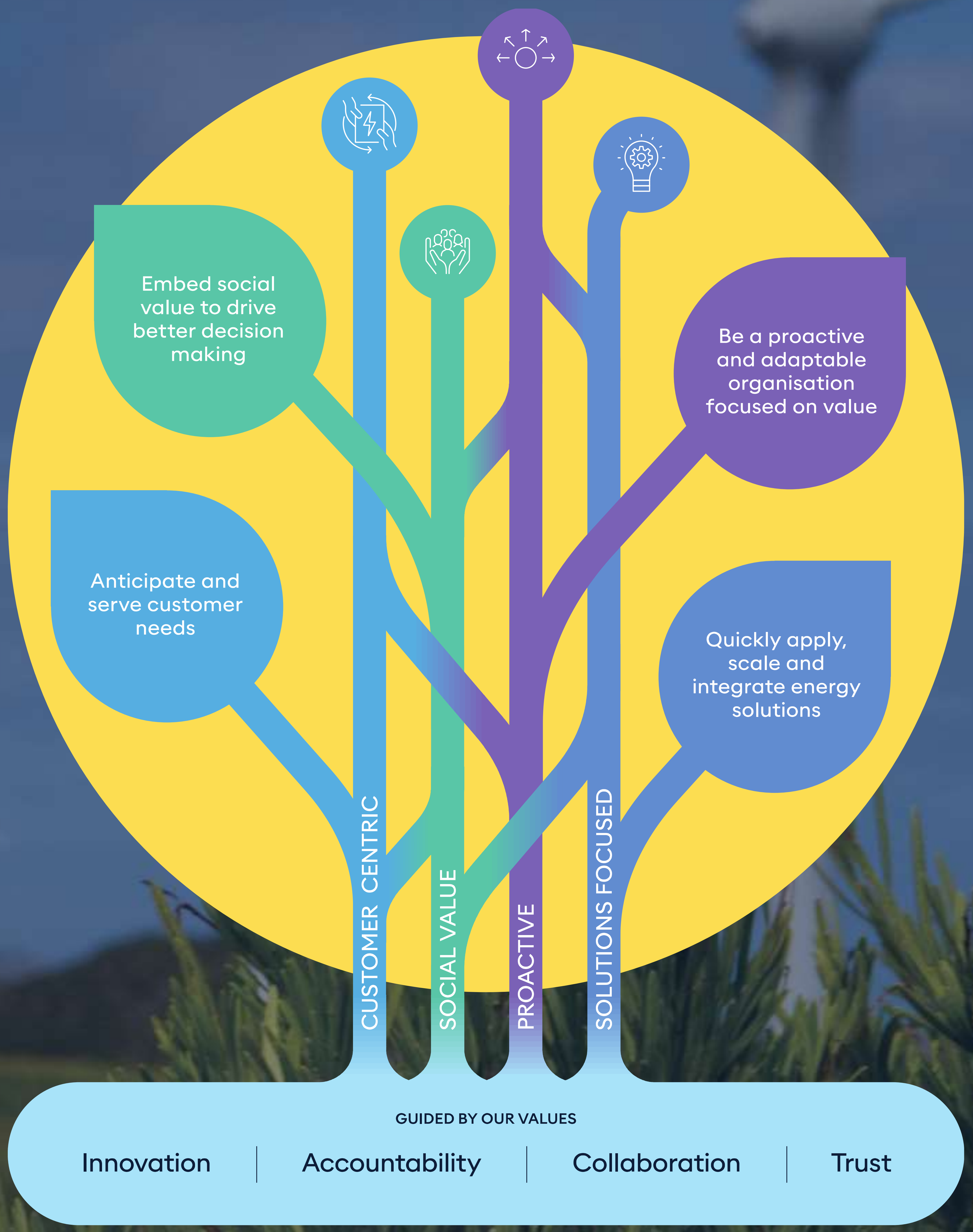
To lead Western Australians to their intelligent energy future

OUR VISION – This is our desired future state

To be the first choice for energy

STRATEGY OVERVIEW – This is how we'll accomplish our purpose and vision

To evolve into a sustainable energy provider, for the benefit of all Western Australians



synergy

Synergy's roadmap to net zero emissions

synergy

>50% below 2005
Paris Agreement

80% below
2021 levels by 2030

1987
Esperance
wind farm

Greenough River
Solar Farm

2020
Warradarge Wind
Farm

2020
VPP4
Schools

2021
Project
Symphony

2022
Synergy 'Big
Battery'

2022/24
Muja 5&6
decommission

2027
Collie PS

2029
Muja PS

Pathway to Net Zero by 2050
- No new gas post 2030
- More wind and storage
- Distributed energy resources
- Carbon offsets

1966 | 2022 | 2030 | 2040 | 2050

- 1966 Muja Power Station
- 1999 Collie Power Station
- 2001 Albany Wind Farm
- 2018 Muja A&B decommission
- Coal*
- DER*
- Wind and storage*
- Gas*
- Windfarms*
- Pumped hydro*
- Carbon offsets*

* Potential generation portfolio


synergy

Introduction

About Western Power

3,000+
strong workforce

2+ million
people connected

1.7GW
grid connected solar

13 community batteries

100+ stand-alone power systems

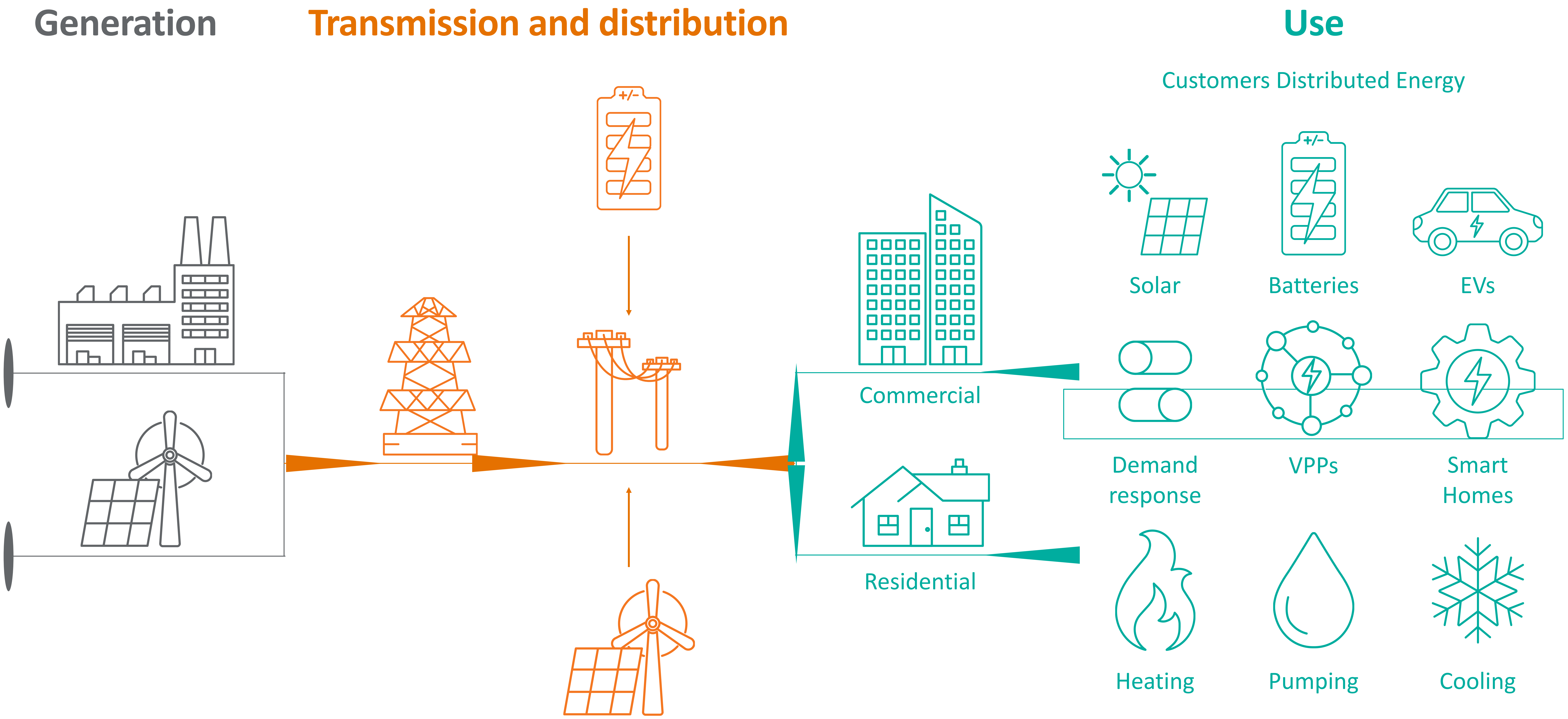
104,000km
of power lines

277,000
streetlights

$299.8M
dividend to Government

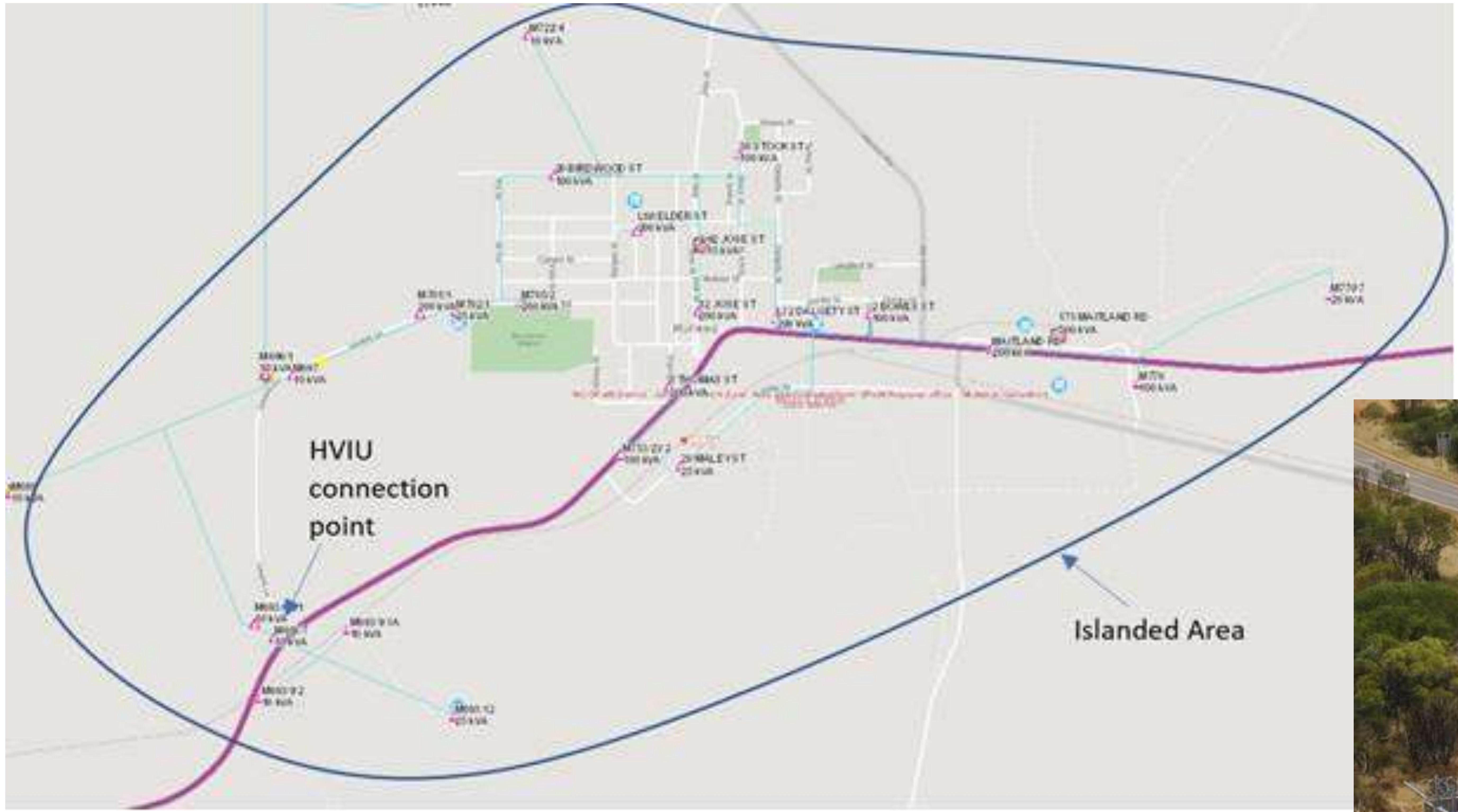
Figures current as of February 2022

What we do

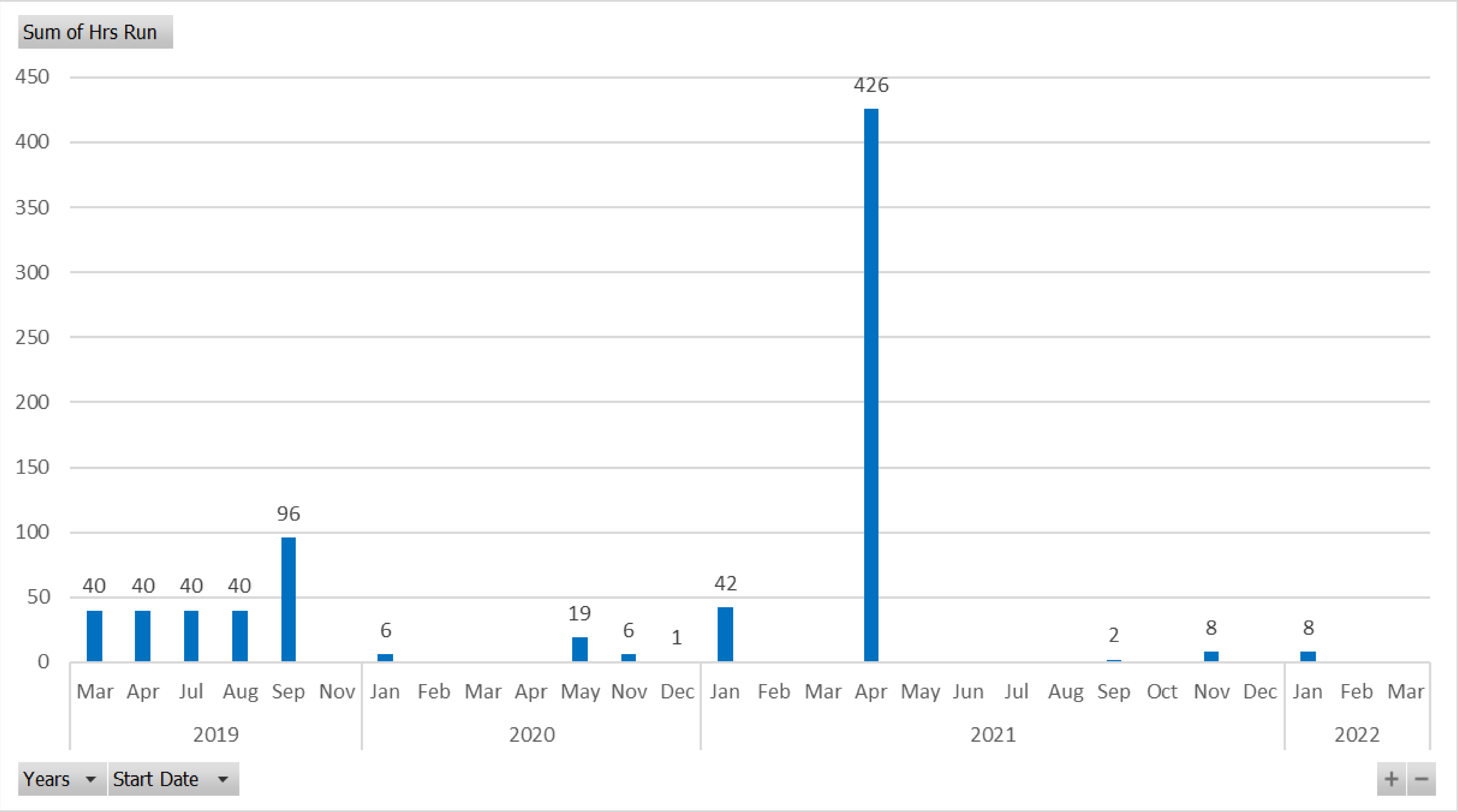

Generation
Transmission and distribution
Use
Customers Distributed Energy
+/-
Commercial
Residential
Solar
Batteries
EVs
Demand response
VPPs
Smart Homes
Heating
Pumping
Cooling

Your network

Your Network - Mullewa



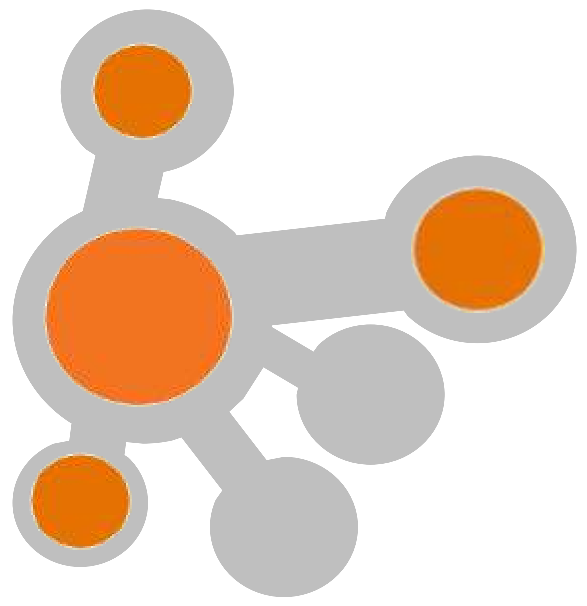
Generator performance



Why we're evolving our grid

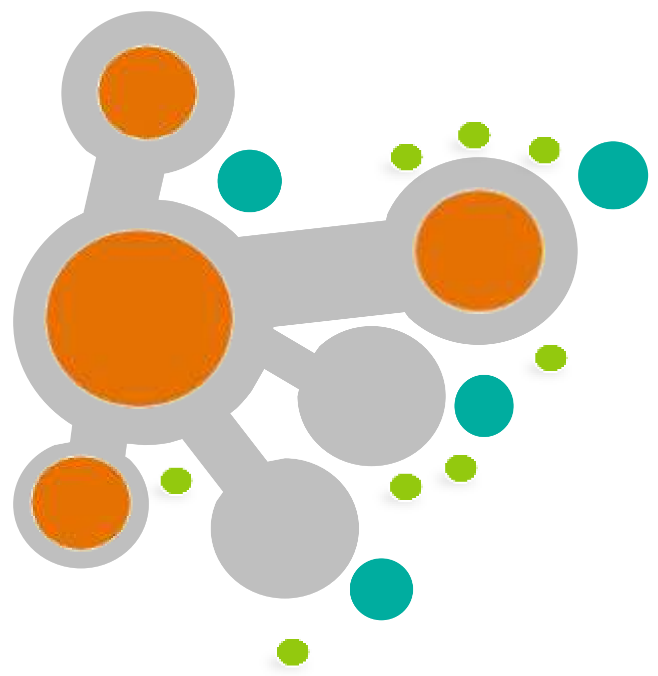
A more flexible grid will support our customers to adopt changing generation and storage options. Grid evolution relies on community behaviour, technology advancement rates, regulation and policy.

Integrated Network



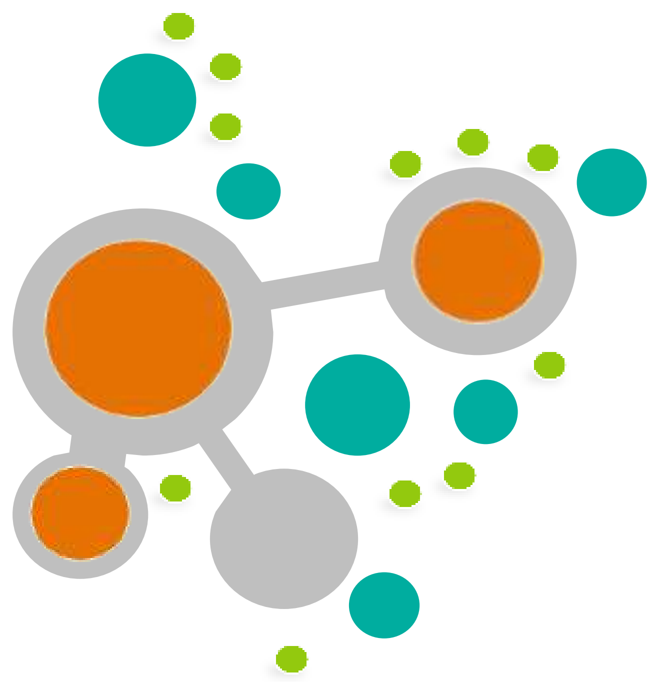
Our traditional interconnected network of poles and wires

Fringe Disconnection



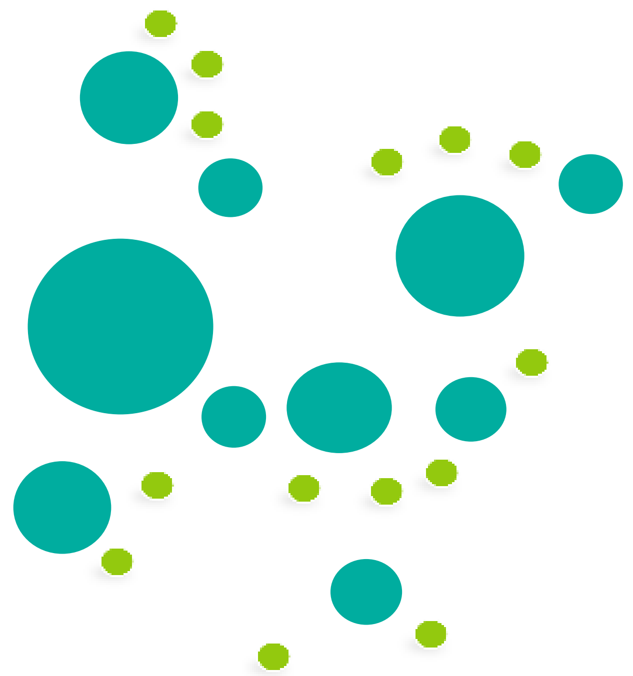
A centralised network with consumers at the edge of the network on island systems

Modular Network



A flexible model with a centralised grid that embraces SPS, microgrids, VPPs and other new technologies

Fully Decentralised

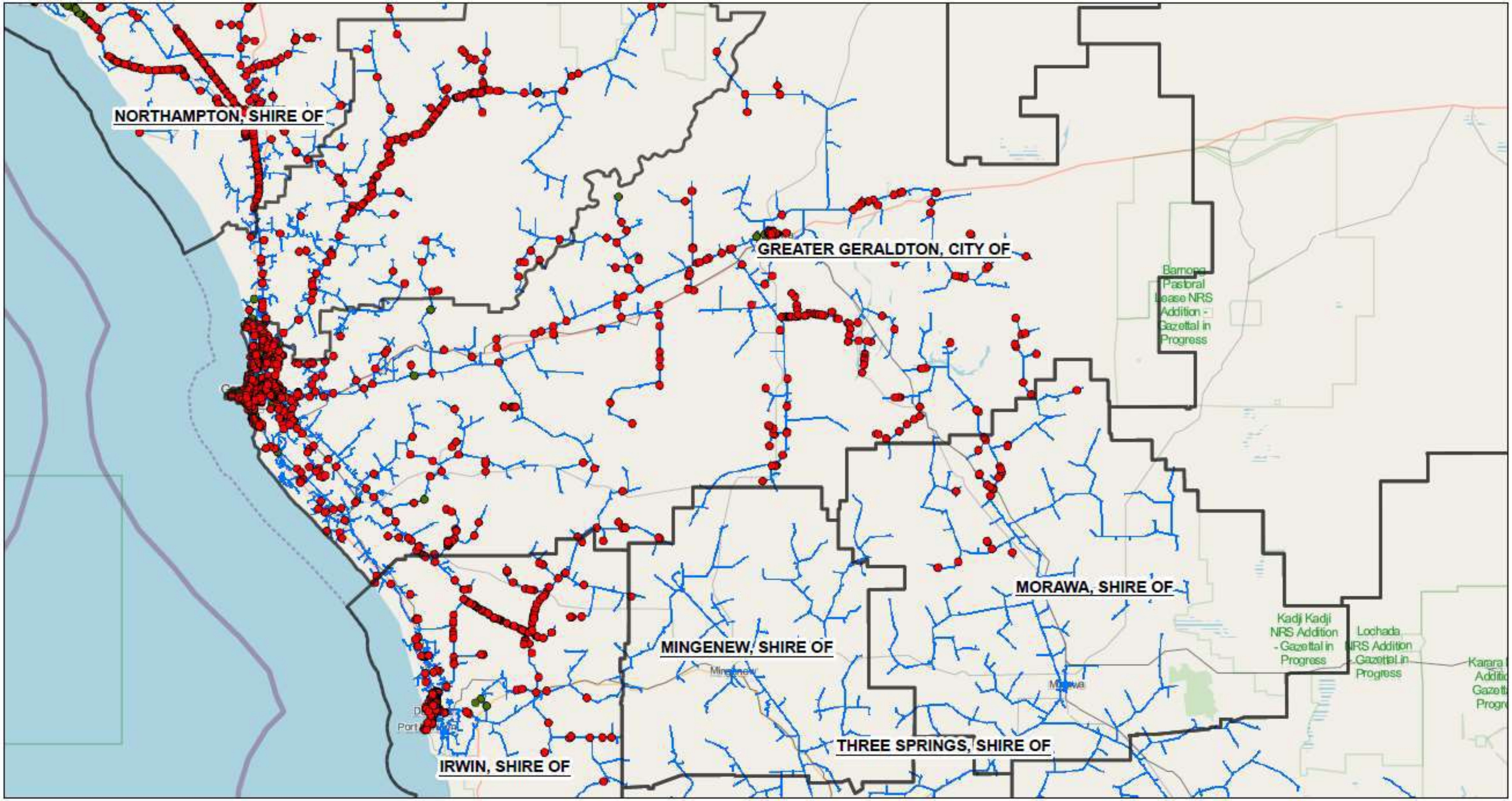


An extreme model with no centralised network

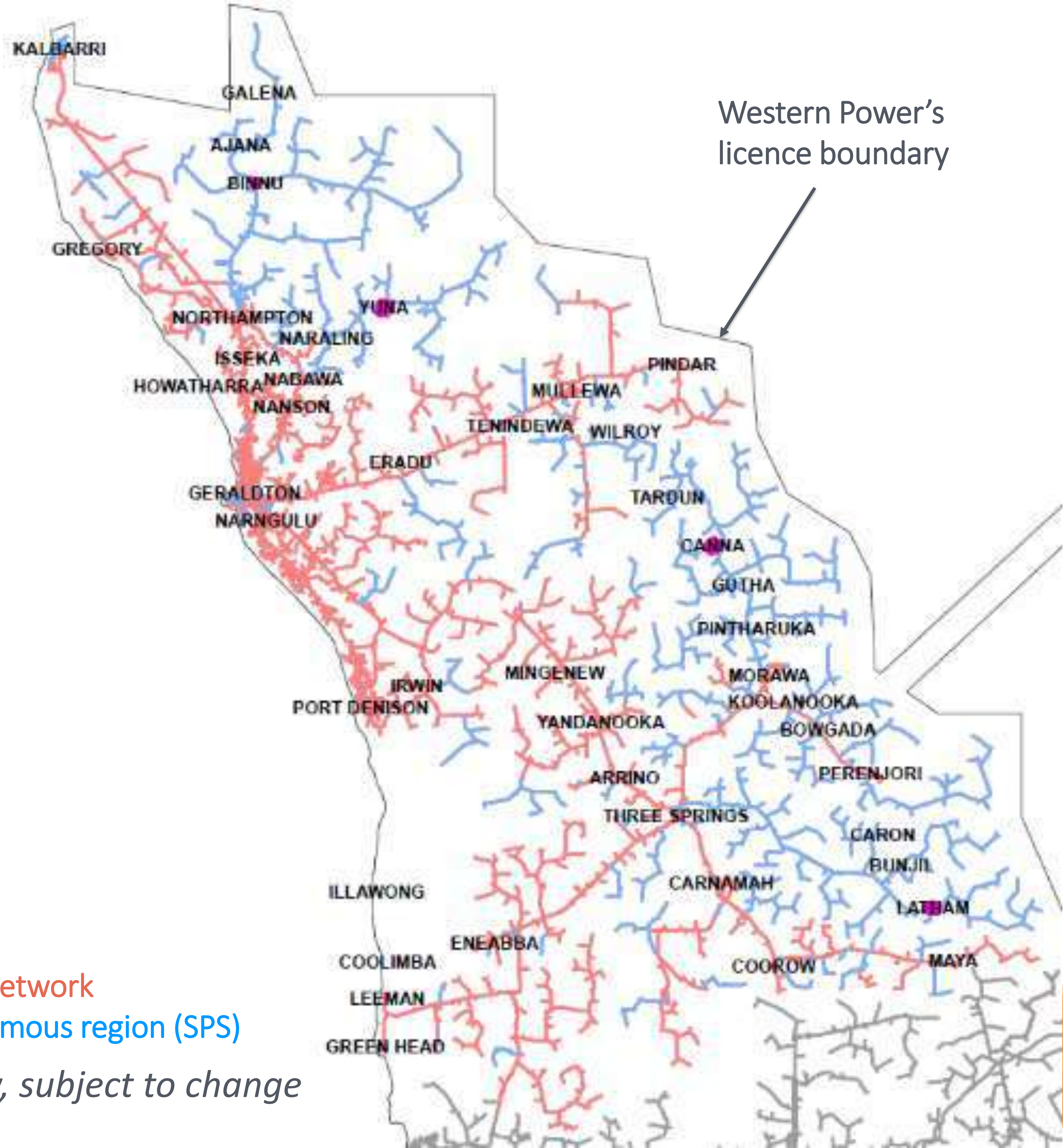
Radial Network
Mesh Network
Microgrid
Stand-alone Power Systems (SPS)

Upcoming work

Greater Geraldton AWP FY22/23 Map



Future Network



Legend
Mesh network
Autonomous region (SPS)

**Indicative only, subject to change*

Mullewa Microgrid Feasibility Study Project

Wednesday September 21st, 2022

Mullewa Customer Engagement

sunrise energy group

WHAT IS THE MULLEWA MICROGRID FEASIBILITY STUDY?

- The Mullewa Microgrid Feasibility Study Project involves an examination into the viability of deploying a renewable energy microgrid in Mullewa.

- The objective of the study is to identify commercial arrangements, both existing and new, that could improve energy reliability and amenity for Mullewa residents and could retain and attract business to the town through development of a commercially sound, technically and economically feasible microgrid solution (repeatable for other fringe-of-grid towns).

- Key activities in achieving this objective include working with study partners, Synergy and Western Power and engaging with the Mullewa community.

WHAT IS A MICROGRID?

- The term Microgrid does not have a unique/fixed definition and has widely been used to describe a number of different small electrical grid configurations.
- For the purpose of this study we have settled on a relatively loose definition as follows:

In the SWIS, a microgrid is a section of the Western Power network that:

a) is still connected to the meshed network (grid)
b) has the ability to be islanded as an autonomous system, and
c) Includes local renewable generation and storage

WHAT COULD A MICROGRID LOOK LIKE IN MULLEWA?

In terms of hardware, a microgrid in Mullewa could include:

a) "Large" Battery - why:
   - primary purpose being short term storage for improving reliability

b) Renewable generation from a solar farm and possibly wind turbines – why:
   - to charge the battery and support a significant proportion of the towns load under normal operation
   - when the grid connection is down for longer periods, support continued operation of the town up to battery maximum storage capacity
   - for the energy supply to be at a lower delivered cost, enabling the commercial investment necessary to build the microgrid
   - Enhancing reliability by reducing the power that has to be carried on the Geraldton to Mullewa power line.

c) Diesel generator - why:
   - Provides longer term energy storage, aiding reliability for medium to long duration grid outages, when local supply options (e.g. solar/wind/battery) are exhausted.

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HOW MIGHT A MICROGRID DIFFER FROM CURRENT DIESEL GENSETS

The reliability provided by the current diesel gensets would be enhanced by the addition of local renewable generation and battery storage. It should offer:

- More seamless transfer of control and operation of the load from the grid to the microgrid on loss of grid connection, meaning:
  - less short terms outages as currently occur when transferring to diesel operation, which result from the time delay between grid fault event and diesel start-up/switch-over time.
- Certainty over reliability solution long-term. Existing diesel gensets are currently on periodical review and approval process for use at Mullewa.
- Possible increase in reliability of operation when called on for use. Battery will be in operation daily, whereas on occasion diesel genset may not start when required.

Note: If diesel gensets were not incorporated in the microgrid, then potential exposure to longer duration outages, ie. once battery storage depleted and no renewable generation available.

WHY NOT ROOFTOP

What could be an alternative to a single solar farm with a large battery?

- Installation of rooftop solar with small battery at the majority of homes/businesses.

What are potential drawbacks with this approach:

- Technology to integrate these individual elements (rooftop solar & home batteries) into single controllable system to support the town in a grid outage event is still being proven.
- Who pays for the equipment and installation – is this affordable for individual property owners, how are rental properties dealt with? If paid for by others, what would be the incentive to invest that capital?

- Will a microgrid with solar farm prevent the private installation of rooftop solar – No, customers would still retain the ability to install their own rooftop solar.

INTENDED OUTCOMES FROM A MICROGRID IN MULLEWA

Mullewa customer perspective:

- Enhanced Reliability
- No higher costs than they would otherwise incur
- No loss of customer protections

Western Power perspective:

- Reduction in overall line losses
- Reduction in overall network costs

West Australian energy consumer perspective:

- Increase in the renewable content of energy supply

TYPICAL OPPORTUNITIES THAT MICROGRIDS IN GENERAL MAY BE ABLE TO PROVIDE

What are the types of opportunities, that could potentially be realised by a Microgrid, that would be of interest to residents/businesses:

- Opportunity to be better informed on energy usage and it's cost.
- Opportunity to reduce the cost of electricity by managing when it is consumed.
- Opportunity to attract/develop/grow energy demanding businesses based on access to reliable supply of affordable power.
- Opportunity for local employment from roles associated with operation/management of a microgrid.
- Opportunity to develop a more circular economy with ideas such as agrivoltaics.

Next steps

synergy

Data collation

On-going collation of data, load modelling, reliability stat examination, cost analysis

Scenario mapping

Creation of solutions & modelling of benefits, costs, technical capability

Completion of study

Compilation of above into study, including development activities; Geotech assessment

Submission of study

Submission of feasibility study by August 31st 2023.

Questions:

Thank you for attending.

Please sign the attendance sheet and indicate if you would like on-going engagement.

Mullewa Microgrid Feasibility Study Project

Grid Cognition Modelling Summary
WP & Synergy Presentation
Monday 31st October

sunrise energy group

GRID COGNITION MODELLING

Section 1 – Overview

Section 2 – Modelling in Grid Cognition, the basics

Section 3 – Model Inputs

Section 4 – Model Output

Section 5 – Questions and examination of the live model

Section 1 – Overview

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MODELLING OBJECTIVE

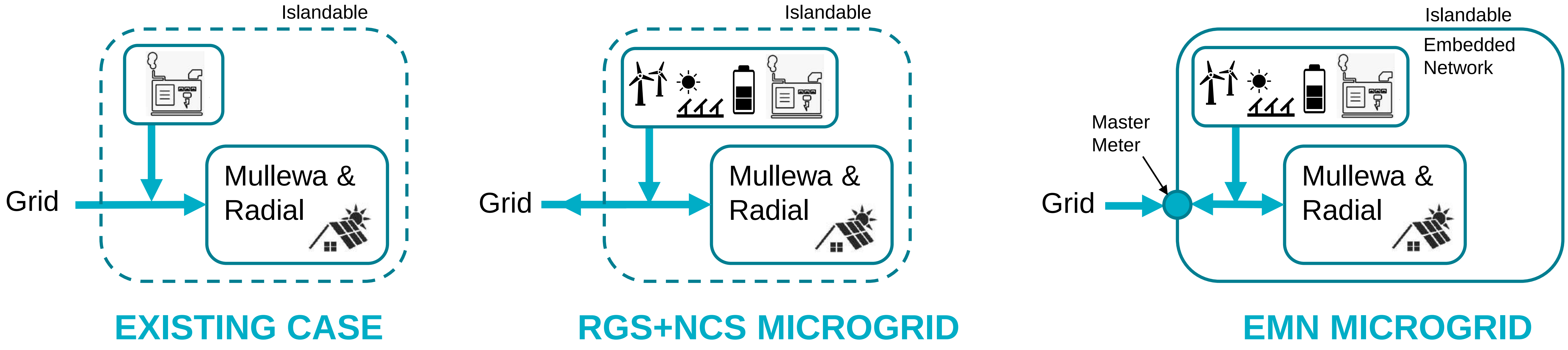
Model different Microgrid arrangements and various solar, wind and battery sizes within those arrangements, with the objective of selecting the "best" configuration as base case for:

- "stress testing" against different future scenarios and,
- study development works

CASES MODELLED

3 cases (scenarios) have been modelled in Grid Cognition for the town of Mullewa and it's downstream radial network

1. Existing Case – Mullewa operation as of today
2. Renewable Generation & Storage + Network Control Service (RGS+NCS) Microgrid
3. Embedded Network (EMN) Microgrid



ASSET SIZES MODELLED

For each of the two Microgrid cases the following asset sizes were modelled

- Solar: 500kW, 750kW, 1000kW, 2000kW, 3000kW
- Wind: 0, 600kW, 1200kW
- Battery (2hrs): 0, 2300MWh, 4600MWh

MODELLING PARAMETERS

- Model Lifetime: 20 Years
- Assumed Load Growth: 1.33% per annum (based on projections for Geraldton of 8% over 6 years) after 1st year.
- 245 Non-contestable NMI's, 11 Contestable NMI's
- Existing 249kW rooftop split equally between contestable and non-contestable customers
- Time constraint (between 4&8pm) on 1.5MW export limit only applicable in first 3 years of operation.
- Generating Capacity Credits available to RGS+NCS scenario after first 3 years of operation.
- For EMN scenario, no reduction in Synergy revenue for non-contestable customers compared to existing case.
- For EMN scenario, no reduction in contestable retailer revenue compared to existing case.
- For EMN scenario, no reduction in revenue for Western Power from RT5 tariff and network lease income, compared to existing case of RT1/RT2 tariffs less NCS cost of existing diesel gensets.

MODELLING OUTCOME

Selected model configuration to take forward as base case moving forward:

- Embedded Network Microgrid
- 1000 kW Solar Array
- 1200 kW of Wind Generation (2 x 600kW wind turbines)
- 2300 MWh / 2hr Battery Storage
- 750kVA Diesel Genset

This is based on an ROI of 6% before Corporate Costs

Section 2 – Modelling in Grid Cognition, the Basics

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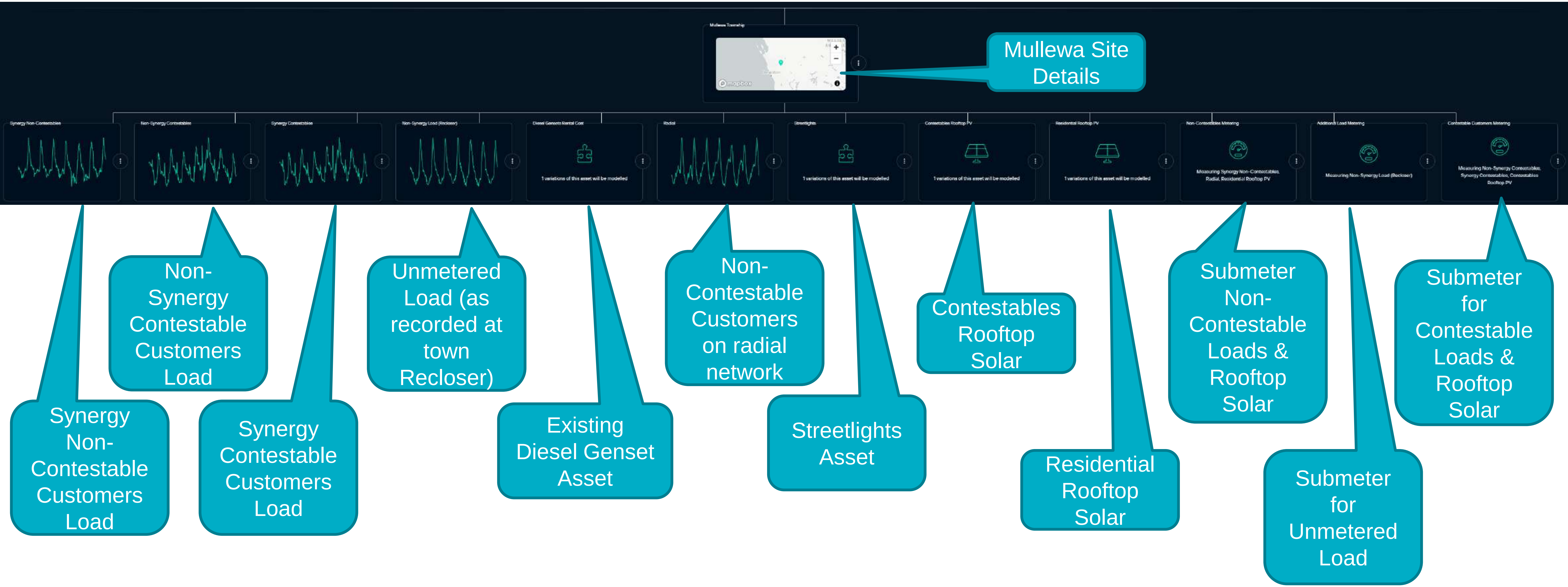
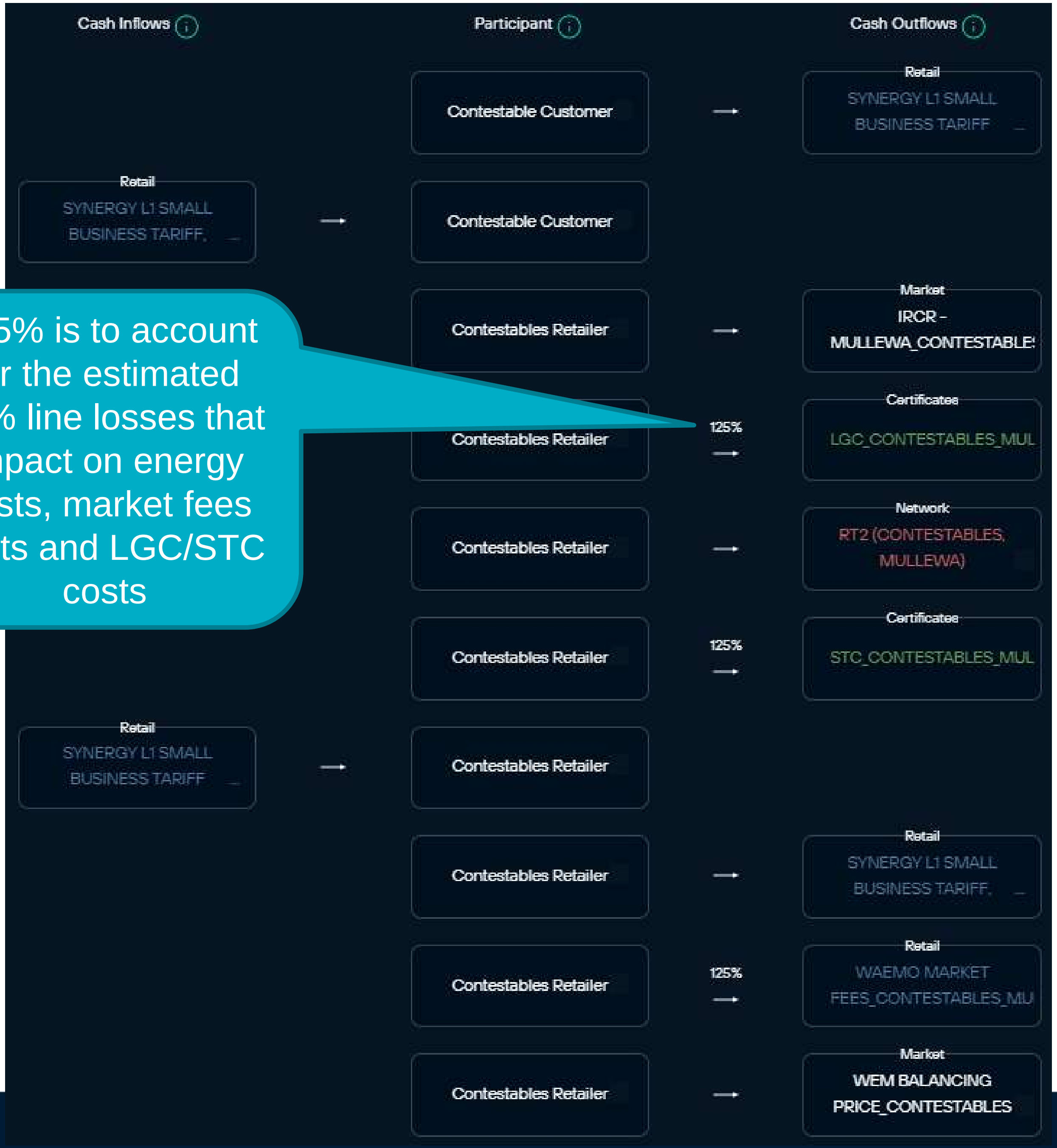
EXISTING CASE – MODEL STRUCTURE DESIGN

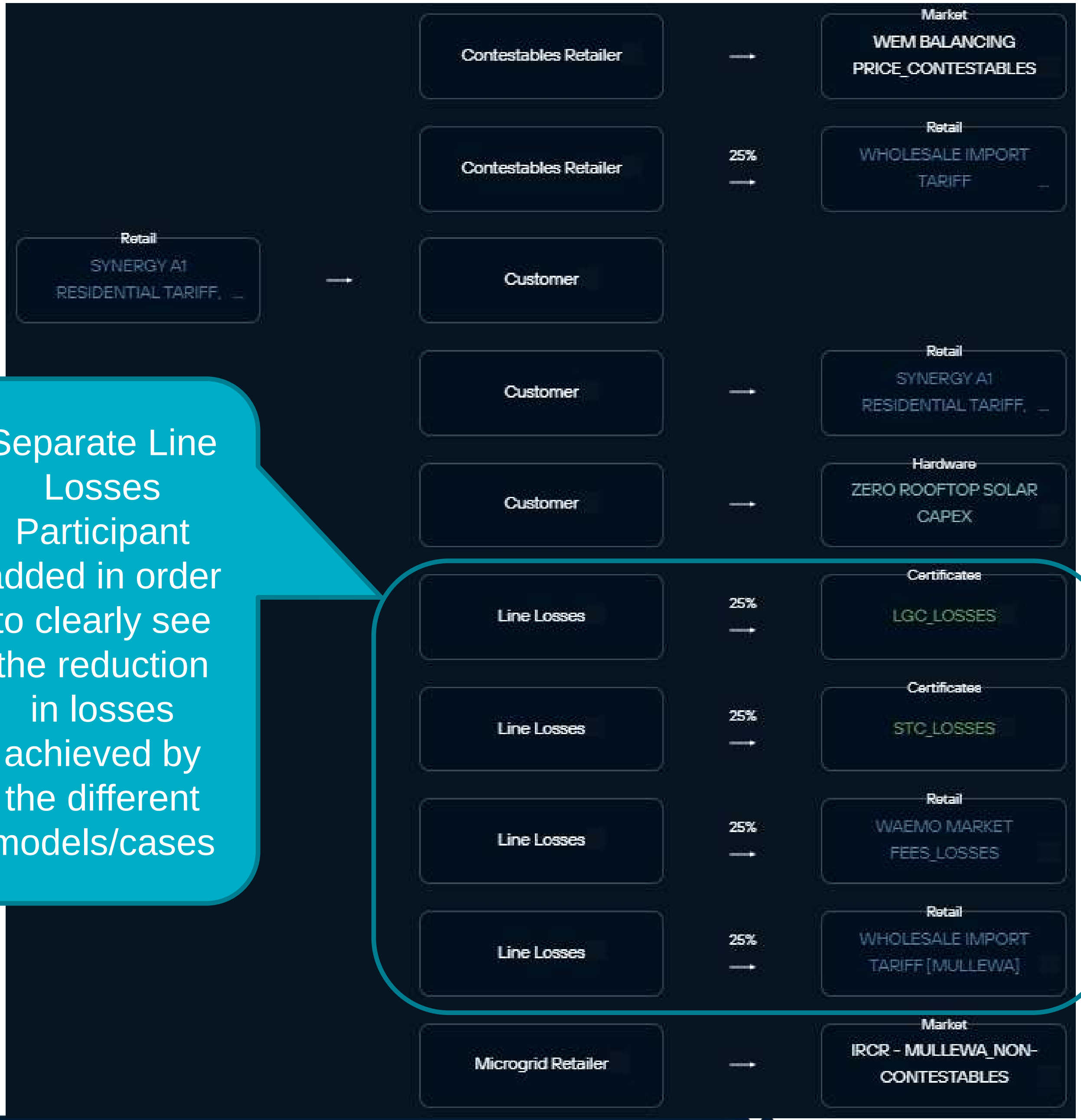


The two microgrid cases modelled are also designed similarly with solar farm, wind turbines, permanent diesel genset, grid connection and network lease (for EMN model) added as additional assets.

EXISTING CASE – MODEL PARTICIPANT VALUE FLOW DESIGN



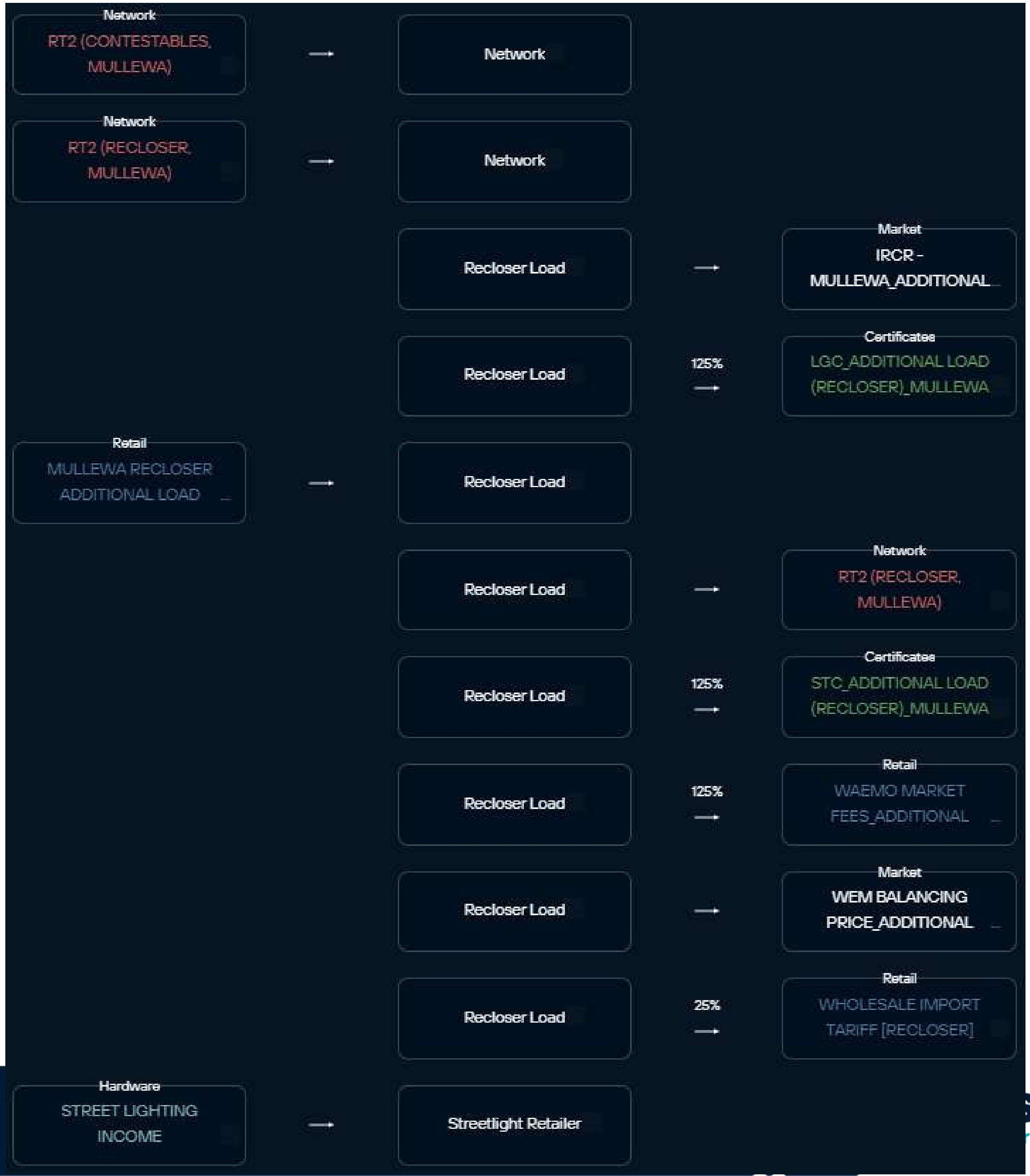
125% is to account for the estimated 25% line losses that impact on energy costs, market fees costs and LGC/STC costs



Separate Line Losses Participant added in order to clearly see the reduction in losses achieved by the different models/cases

EXISTING CASE – MODEL PARTICIPANT VALUE FLOW DESIGN

Microgrid Retailer is the retailer (Synergy) for the non-contestable customers



MODEL PARTICIPANT VALUE FLOW DESIGN FOR EMN & RGS+NCS CASES

The participant value flows for the two microgrid models are built on top of this existing case with the following changes:

EMN Microgrid Model

- Customer A1 & L1 rates are paid to the Microgrid Operator with a % of this income then paid by the Microgrid Operator to the different retailers (ie. 12% to contestables and 15.2% to non-contestables).
- Streetlights income paid to Microgrid Operator with a % then paid to non-contestables retailer (15.2%)
- LGC income is earnt by the Microgrid Operator on the renewable energy that is generated (ie. that which is consumed within the Microgrid and exported).
- Microgrid Operator pays for the net energy consumed based on energy measured (import/export) at the master meter according to the WEM balancing price
- Network fees, market fees, IRCR charges, LGC/STC fees are calculated at the master meter and paid for by the Microgrid Operator.
- As an aggregated load the Network fees are now based on an RT5 tariff
- Capex & Opex for new generation, storage & lease of the embedded network paid for by Microgrid Operator
- Network Operator no longer has NCS cost for rented diesel gensets
- Network Operator earns income from lease of the embedded network

RGS+NCS Microgrid Model

- Customer and Retailer arrangements remain the same
- Microgrid Operator is paid WEM balancing price for export of energy to the grid (independent of town load)
- Microgrid Operator is paid NCS to reserve 50% of battery capacity and make available to Network Operator
- LGC income is earnt by the Microgrid Operator for all renewable generation
- Microgrid Operator pays network fees at RT11 tariff for all generation export
- Microgrid Operator pay market fees (excluding those for ancillary services) for all generation export
- Capex & Opex for new generation & storage paid for by Microgrid Operator
- Network Operator no longer has NCS cost for rented diesel gensets but pays instead for battery NCS service from Microgrid Operator

Section 3 – Model Inputs

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LOADS & GENERATION

LOADS

- **Non-Contestable Customers: 1221 MWh first year**
  - Town: 866 MWh per year
  - Radial: 355 MWh per year

- **Contestable Customers: 982 MWh first year**
  - Synergy: 542 MWh per year
  - Non-Synergy: 440 MWh per year

- **Unmetered Load (recorded at incoming recloser): 491 MWh first year**

- **TOWN + RADIAL TOTAL: 2694 MWh first year**

- **Peak Load, 522kW**

GENERATION

- **Existing Rooftop Solar (249kW DC)**
  - 428 MWh first year
  - Capacity Factor: 19.6%

- **Solar Farm (per MW DC)**
  - 2289 MWh first year (based on GC internal calc, will do update with PVSyst estimate based on selected configuration)
  - Capacity Factor: 26.1%

- **Wind (per 600kW Turbine)**
  - 1630 MWh first year (based on internal GC calc)
    Capacity Factor: 30.9%

INPUT VALUES FOR ASSETS

Existing Diesel Genset:

- 2x500kVA diesel generators and transformer
- Annual rental cost: $210k per year – which is used as estimated NCS cost to the Network operator for the existing case

Existing Rooftop Solar:

- 249kW, 89% derating factor, 0.4% degradation per year
- Already installed so zero capital cost

Streetlights:

- Approximately 160 streetlights in Mullewa
- Estimated annual income of $27k based on Synergy streetlight rates (this would be income for Synergy "microgrid retailer" however has been differentiated in the participant flow as "streetlight retailer" so that a direct comparison of the "microgrid retailer" income between existing case and EMN model can be made independent of streetlight income.
- Estimated annual operating cost of $15k based on Western Power streetlight rates
- Modelled as net income of $12k (ie. $27k-$15k)

INPUT VALUES FOR ASSETS

Microgrid Diesel Genset:

- 1x750kVA diesel generators and transformer
- Capex: $360k (genset: $250k, diesel tank: $40k, Transformer: $40k, Installation: $30k)
- Opex: $4.6k pa + Insurance based on 1% of Capex

Solar Array:

- Single axis tracking, 89% derating factor, 0.4% degradation per year
- Capex: $2.16m/MW
- Opex: $16000k pa ($4k/qtr) + Insurance based on 1% of Capex + Land Lease based on $5k per ha (500kW)

Wind Turbines:

- Refurbished 2nd hand turbines, 600kW each, 1.6% degradation per year
- Capex: $1.863m/MW
- Opex: $30k pa for connection point + $35k pa per turbine + Insurance based on 1% of Capex + Land Lease based on $5k per turbine

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INPUT VALUES FOR ASSETS

Battery:

- Lithium battery, 90% depth of discharge, 85% round trip efficiency, 2% degradation per year, 2 or 4hr duration
- Capex: 2300kWh @ $826/kWh ($1.9m), 4600kWh @ $717/kWh ($3.3m)
- Opex: Insurance based on 1% of Capex

Grid Connection:

- 1.5MW export constraint (export between 4pm-8pm only, first 3 years only)
- Capex: $1m
- Opex: $25k pa grid connection + $20k pa general + Insurance based on 1% of Capex

Embedded Network (for EMN model only)

- Capex: N/A – ownership retained by Western Power
- Opex: Lease of $56k pa (for town + radial) + $40k pa (nominal operating costs) – paid to network operator

NETWORK TARIFFS

- Non-Contestable Customer: RT1 (applied to each NMI)
- Contestable Customers / Unmetered Load: RT2 (applied to each NMI)

- RGS+NCS Model: RT11 (based on 1.5MW DSOC and 92km to Geraldton substation)

- EMN Model: RT5 (based on <1kVA half hourly CMD and so distance charges don’t apply)

ENERGY COSTS & RETAIL TARIFFS

- Non-Contestable Customer: Synergy A1, applied to each NMI

- Contestable Customers / Unmetered Load: Synergy L1 (for loads <50MWh/yr), applied to each NMI
  - (Note: Contestable customers generally use >50MWh/year, which would mean in terms of standard Synergy tariff L3 would apply. L3 tariffs however are considered to be significantly higher than what is realistically available to contestable customers in the market, and so the L1 tariff is adopted as a better reflection of realistic prices for contestable customers.

- RGS+NCS Model: Sale of energy based on the balancing market price

- EMN Model: Sale and purchase of energy based on the balancing market price

CERTIFICATES, MARKET FEES IRCR CHARGES

- LGC Certificates:
  - From 2022: $50 per certificate
  - From 2025: $44 per certificate
  - From 2026: $38 per certificate
  - From 2027: $32 per certificate
  - From 2031: $15 per certificate equivalent (this is based on there being a replacement scheme after 2030, or if not, then to reflect the expected resulting increase in the wholesale energy price if no replacement scheme)
- LGC Obligations: 18.54% of certificate price
- STC Obligations: 28.8% based on STC price of $38
- Market Fees: $6/MWh ($1.4004 towards Admin fees, remainder towards ancillary services)
- IRCR Charges: $114,134.15/MW with TDL ratio of 1.6 (based on published rate for 2020-21 capacity year – expected to remain at this level for the foreseeable future)

LINE LOSSES

- Line Losses estimated at 25% based on 92km radial distribution feeder from Geraldton substation
- Lines Losses applied to WEM balancing price, market fees and LGC/STC obligation fees per unit of energy imported from the grid
- Line loss costs are included in the overall cashflows however are also calculated on their own in order to see directly the reduction in line loss costs achieved in the microgrid models compared to todays existing case
- Line Losses for the different retailers in RGS+NCS scenario are assigned based on ratio of their individual loads relative to the total load [ie. 44% for Non-Contestables, 34% for Contestables (based on even split between rooftop solar) and 22% for the unmetered load]

NETWORK CONTROL SERVICES (NCS)

Existing Case

- Rental of existing back-up diesel gensets by Western Power is deemed an NCS for current existing case ($210k pa)

RGS+NCS Microgrid

- The Microgrid would operate an NCS in the form of access to reserved 50% of battery capacity (paid at $95k/MWh pa for reserved storage) and permanent back-up diesel to support the town in event of grid failure. Western Power could therefore demobe their diesel genset installation.

EMN Microgrid

- The microgrid will manage their resources (including permanent diesel back-up) to support the town+radial in event of grid failure and so no formal NCS service required. Western Power could demobe their diesel genset installation

CAPACITY CREDITS

- At this location the network is currently congested and so because of the NAQ (Network Access Quantity) regime capacity credits are deemed to not be applicable for the first 3 years of operation. (ref. ERA Triennnial review of the effectiveness of the Wholesale Electricity Market 2022, discussion paper).

- Beyond the first 3 years of operation Generation Capacity Credits are available to for the RGS+NCS scenario and calculated as follows:

<table>
<tr><td colspan="3">Wind + Solar < 1MW, Battery < 4MWh or < 1MW</td><td>0</td></tr>
<tr><td>Wind + Solar > 1MW</td><td colspan="2">20% of Capacity Sum</td><td rowspan="3">Maximum of these x $100,000 pa</td></tr>
<tr><td>Battery Storage > 4MWh*</td><td>¼ of Size MWh</td><td rowspan="2">Minimum of these two</td></tr>
<tr><td>Battery Inverter > 1MW</td><td>Size MW</td></tr>
</table>

* Where an NCS service reserves % of the battery, then only unreserved portion of this storage is considered in terms of being available for earning capacity credits

- It is not possible to include an algorithm that defines this logic in a single GC model. Therefore have to run 3 separate projects in GC to allow comparisons between the different cases based on the correct application of Capacity Credits.

Section 4 – Model output

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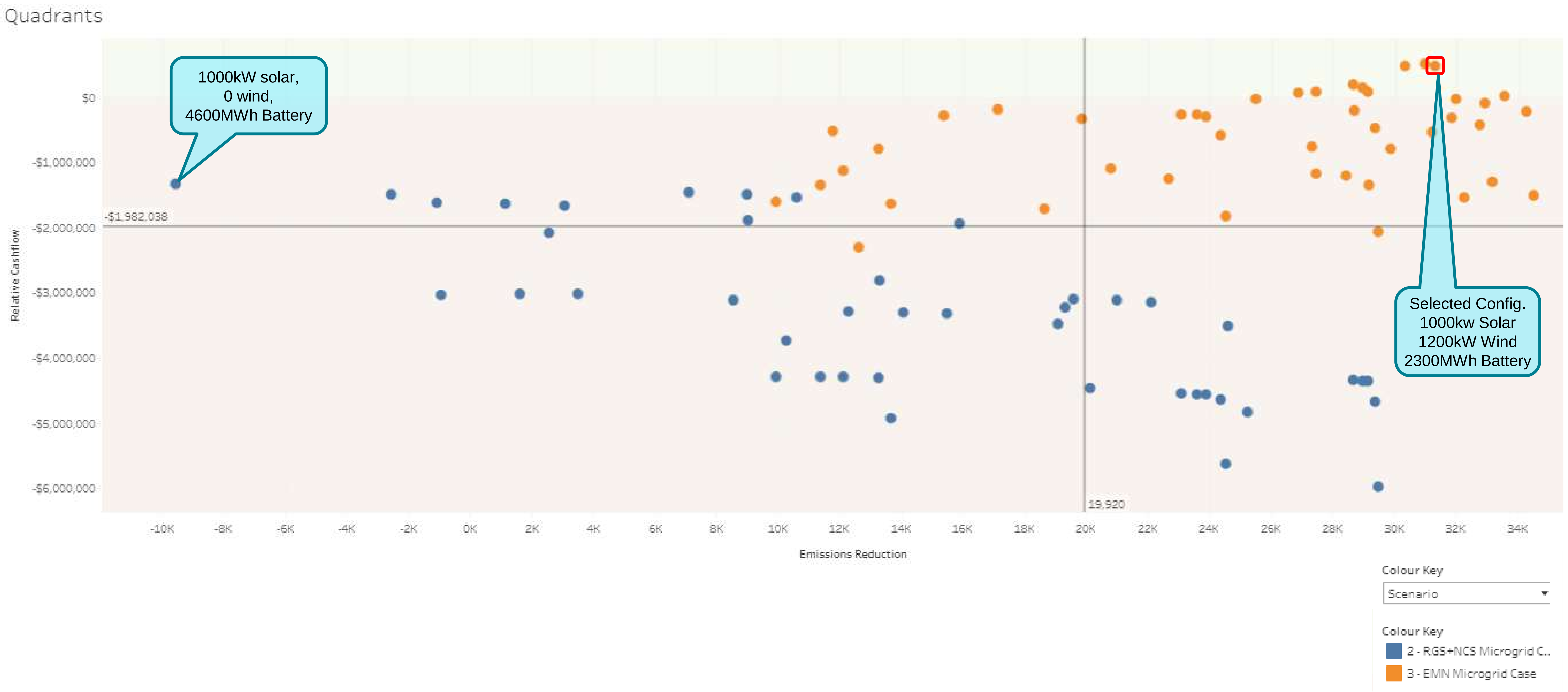
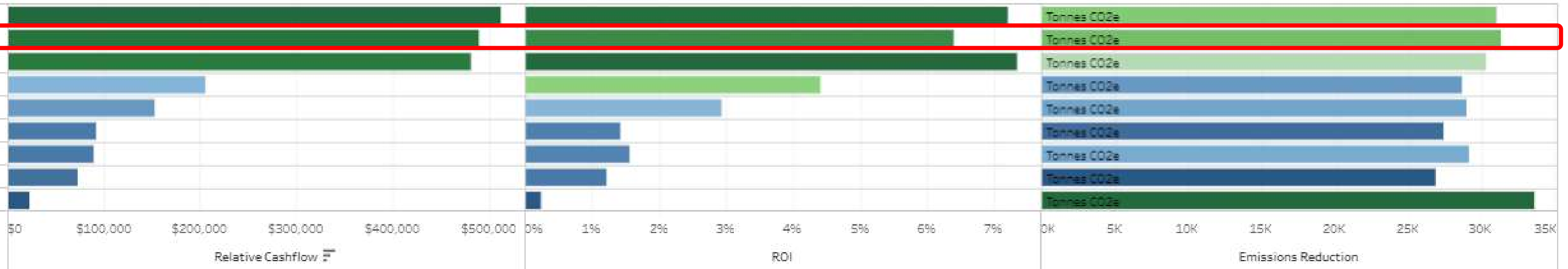
CASHFLOW & EMISSIONS COMPARISON BETWEEN EMN & RGS+NCS MODELS



RANKINGS FOR POSITIVE CASHFLOW CASES

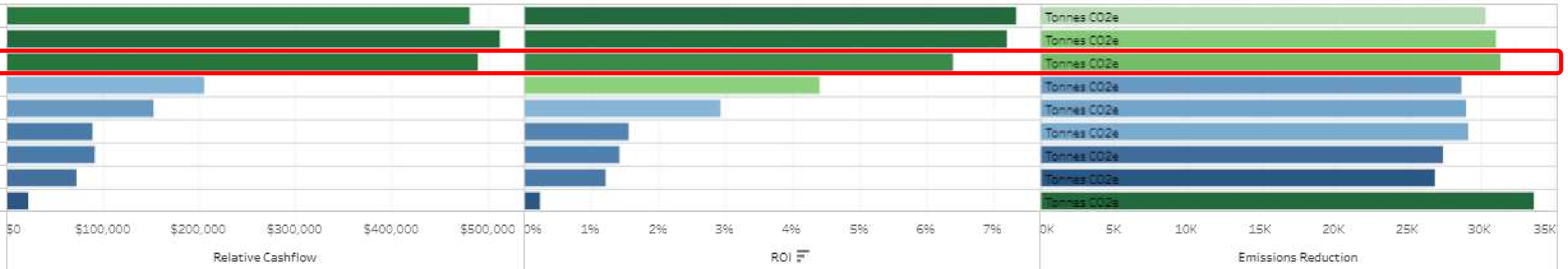
Rankings by Cashflow

Site Name	Scenario	Solar Specs	Wind Specs	Battery Specs	Genset Specs
Mullewa Township	3 - EMN Microgrid Case	750+124.4+124...	600+600kW	2300kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	1000+124.4+124..	600+600kW	2300kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	500+124.4+124...	600+600kW	2300kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	500+124.4+124...	600+600kW	0kWh	0kW
	3 - EMN Microgrid Case	750+124.4+124...	600+600kW	0kWh	0kW
	3 - EMN Microgrid Case	1000+124.4+124..	0+600kW	2300kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	1000+124.4+124..	600+600kW	0kWh	0kW
	3 - EMN Microgrid Case	750+124.4+124...	0+600kW	2300kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	1000+124.4+124..	600+600kW	4600kWh, 2hrs, Co-op..	0kW



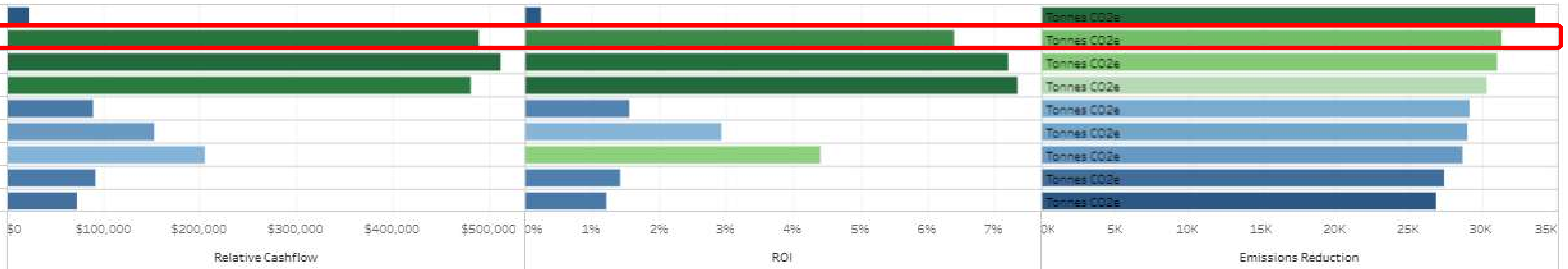
Rankings by ROI

Site Name	Scenario	Solar Specs	Wind Specs	Battery Specs	Genset Specs
Mullewa Township	3 - EMN Microgrid Case	500+124.4+124...	600+600kW	2300kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	750+124.4+124...	600+600kW	2300kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	1000+124.4+124..	600+600kW	2300kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	500+124.4+124...	600+600kW	0kWh	0kW
	3 - EMN Microgrid Case	750+124.4+124...	600+600kW	0kWh	0kW
	3 - EMN Microgrid Case	1000+124.4+124..	600+600kW	0kWh	0kW
	3 - EMN Microgrid Case	1000+124.4+124..	0+600kW	2300kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	750+124.4+124...	0+600kW	2300kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	1000+124.4+124..	600+600kW	4600kWh, 2hrs, Co-op..	0kW



Rankings by Emissions Reduction

Site Name	Scenario	Solar Specs	Wind Specs	Battery Specs	Genset Specs
Mullewa Township	3 - EMN Microgrid Case	1000+124.4+124..	600+600kW	4600kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	1000+124.4+124..	600+600kW	2300kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	750+124.4+124...	600+600kW	2300kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	500+124.4+124...	600+600kW	2300kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	1000+124.4+124..	600+600kW	0kWh	0kW
	3 - EMN Microgrid Case	750+124.4+124...	600+600kW	0kWh	0kW
	3 - EMN Microgrid Case	500+124.4+124...	600+600kW	0kWh	0kW
	3 - EMN Microgrid Case	1000+124.4+124..	0+600kW	2300kWh, 2hrs, Co-op..	0kW
	3 - EMN Microgrid Case	750+124.4+124...	0+600kW	2300kWh, 2hrs, Co-op..	0kW



GENERATION PROFILE FOR SELECTED CONFIGURATION

EMN Microgrid with 1000kW Solar, 1200kW Wind & 2300MWh Battery

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IMPORT/EXPORT HEAT MAPS FOR SELECTED CONFIGURATION - FIRST YEAR (TIME RESTRICTED EXPORT)

EMN Microgrid with 1000kW Solar, 1200kW Wind & 2300MWh Battery

Import Heatmap

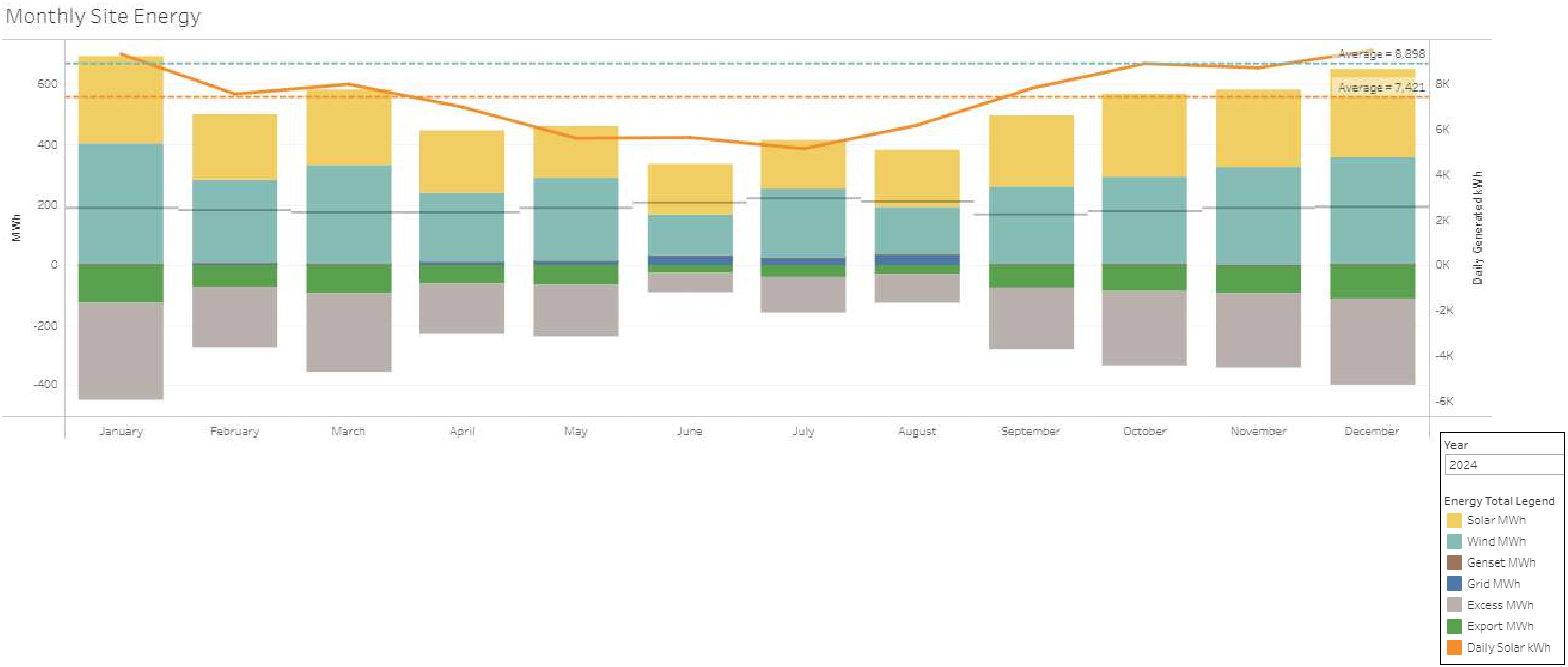
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Monday	32	32	36	33	27	24	9	2	0	0	0	0	2	2	5	4	2	4	5	16	18	29	34	35
Tuesday	33	37	39	37	30	28	14	4	1	1	3	5	1	5	5	2	0	3	3	9	13	16	25	25
Wednesday	20	20	21	23	20	18	10	3	3	3	3	5	6	6	4	3	2	12	16	22	24	23	23	21
Thursday	21	22	26	23	18	16	14	8	3	3	7	9	5	9	3	3	4	13	16	22	28	29	34	34
Friday	34	34	35	35	32	29	19	3	1	2	6	9	5	2	3	1	5	15	14	17	20	24	33	39
Saturday	41	40	44	44	40	38	34	1	0	0	0	0	0	0	0	0	0	19	23	30	33	33	34	39
Sunday	2	5	14	7	7	10	1	0	0	0	0	0	0	0	1	0	3	9	13	23	26	29	31	29

Export Heatmap

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Monday	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	730	741	654	390	0	0	0	0
Tuesday	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	716	671	736	548	0	0	0	0
Wednesday	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	722	723	756	404	0	0	0	0
Thursday	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	727	702	655	404	0	0	0	0
Friday	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	614	557	664	425	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	597	539	576	404	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	697	646	677	401	0	0	0	0

MONTHLY SITE ENERGY FOR SELECTED CONFIGURATION - FIRST YEAR (TIME RESTRICTED EXPORT)

EMN Microgrid with 1000kW Solar, 1200kW Wind & 2300MWh Battery

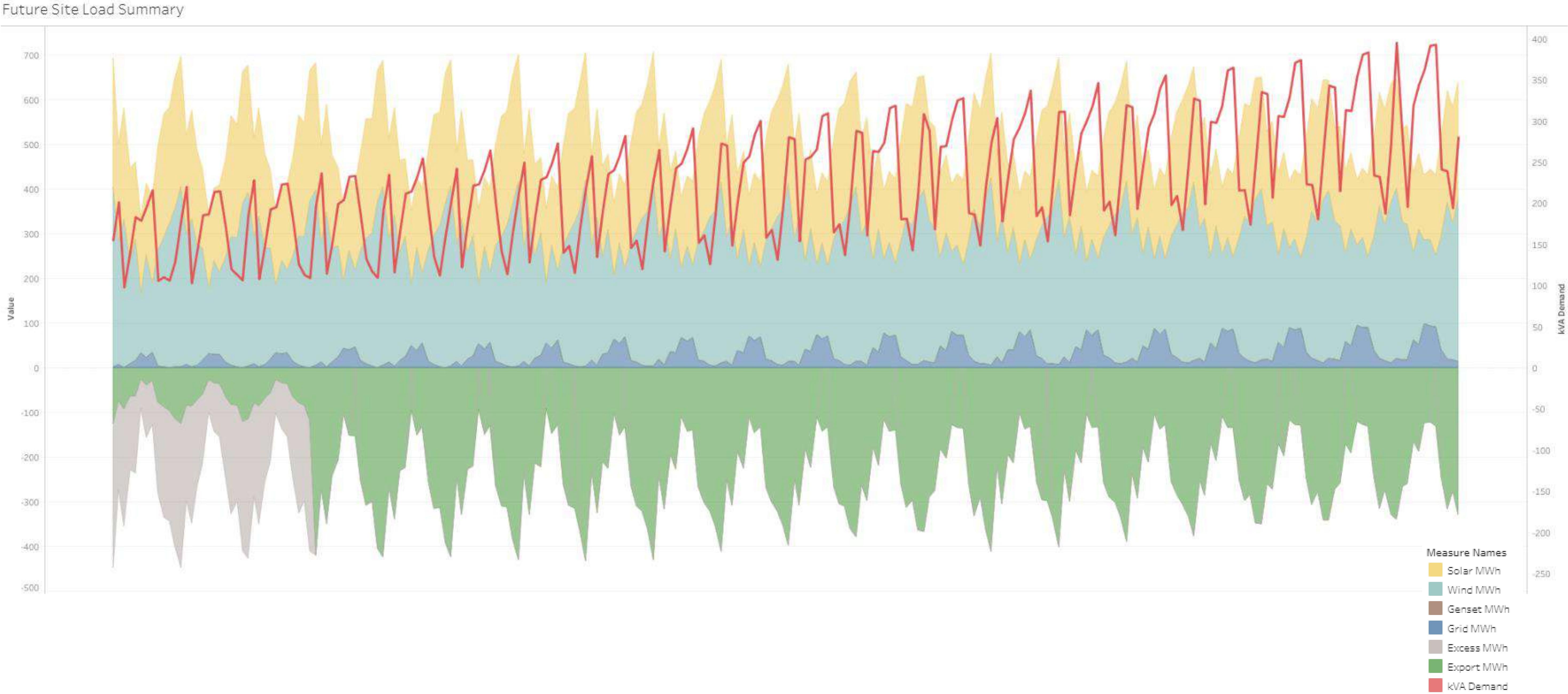


MONTHLY SITE ENERGY FOR SELECTED CONFIGURATION - 4TH YEAR (AFTER TIME RESTRICTED EXPORT CONSTRAINT REMOVED)

EMN Microgrid with 1000kW Solar, 1200kW Wind & 2300MWh Battery

SITE ENERGY OVER 20 YEARS FOR SELECTED CONFIGURATION

EMN Microgrid with 1000kW Solar, 1200kW Wind & 2300MWh Battery



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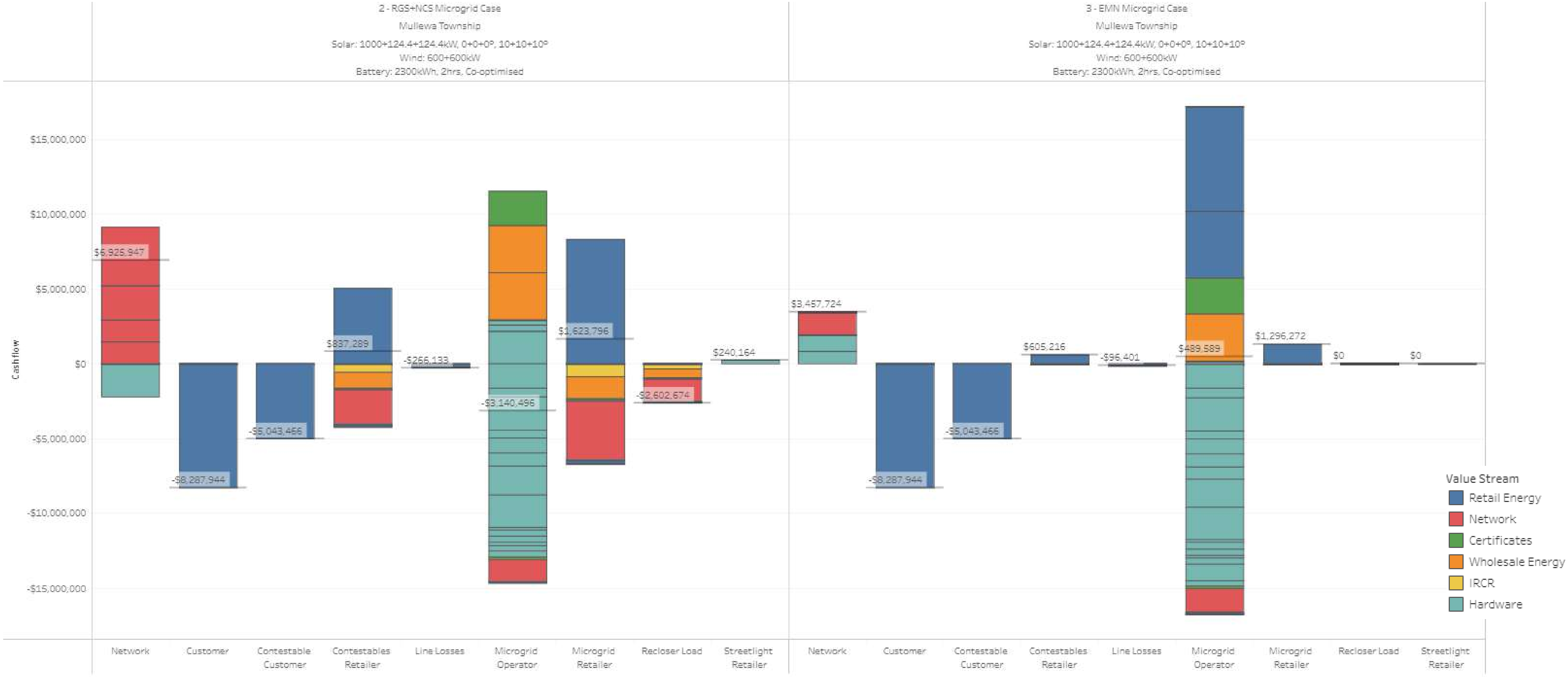
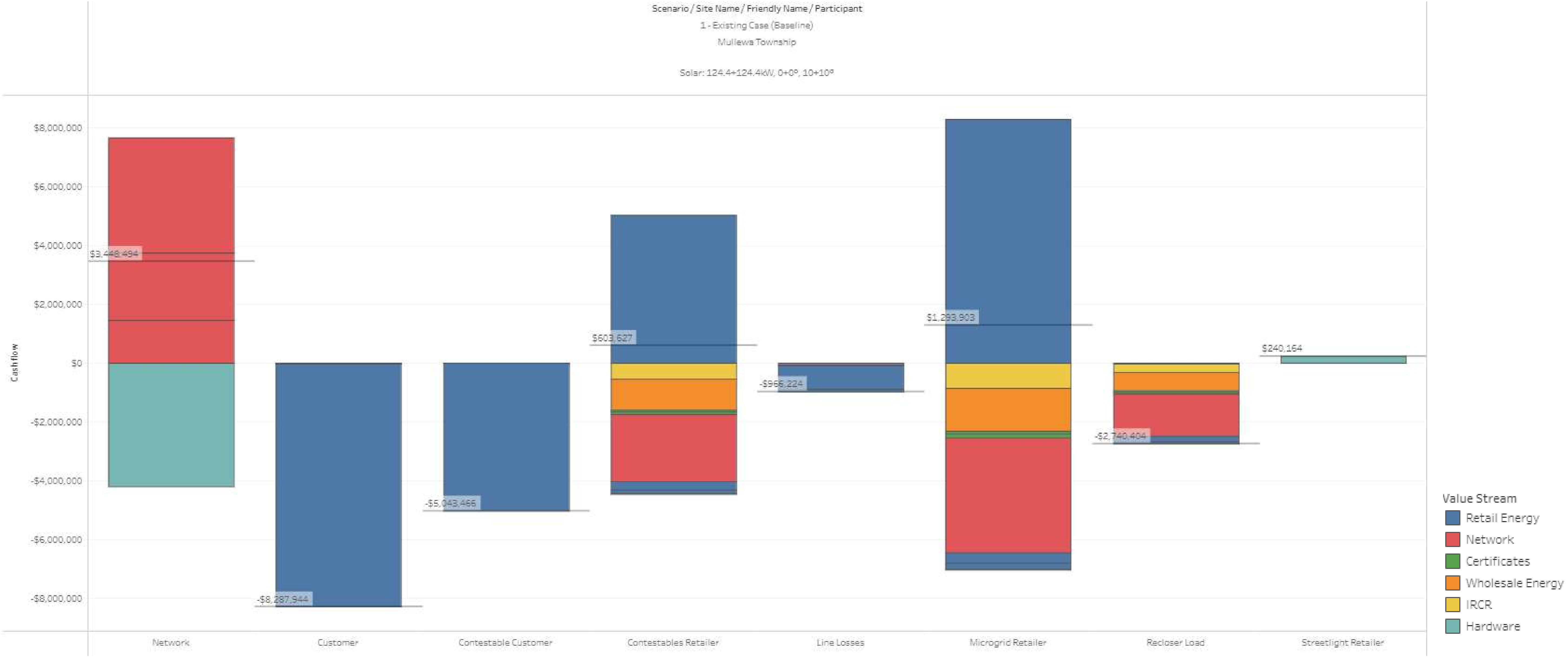
CASHFLOWS (OVER 20 YEARS)

EMN and RGS+NCS Microgrids with 1000kW Solar, 1200kW Wind & 2300MWh Battery



BASELINE (EXISTING CASE) CASHFLOWS (OVER 20 YEARS)

249kW Rooftop Solar



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RELATIVE CASHFLOWS (OVER 20 YEARS)

EMN and RGS+NCS Microgrids with 1000kW Solar, 1200kW Wind & 2300MWh Battery

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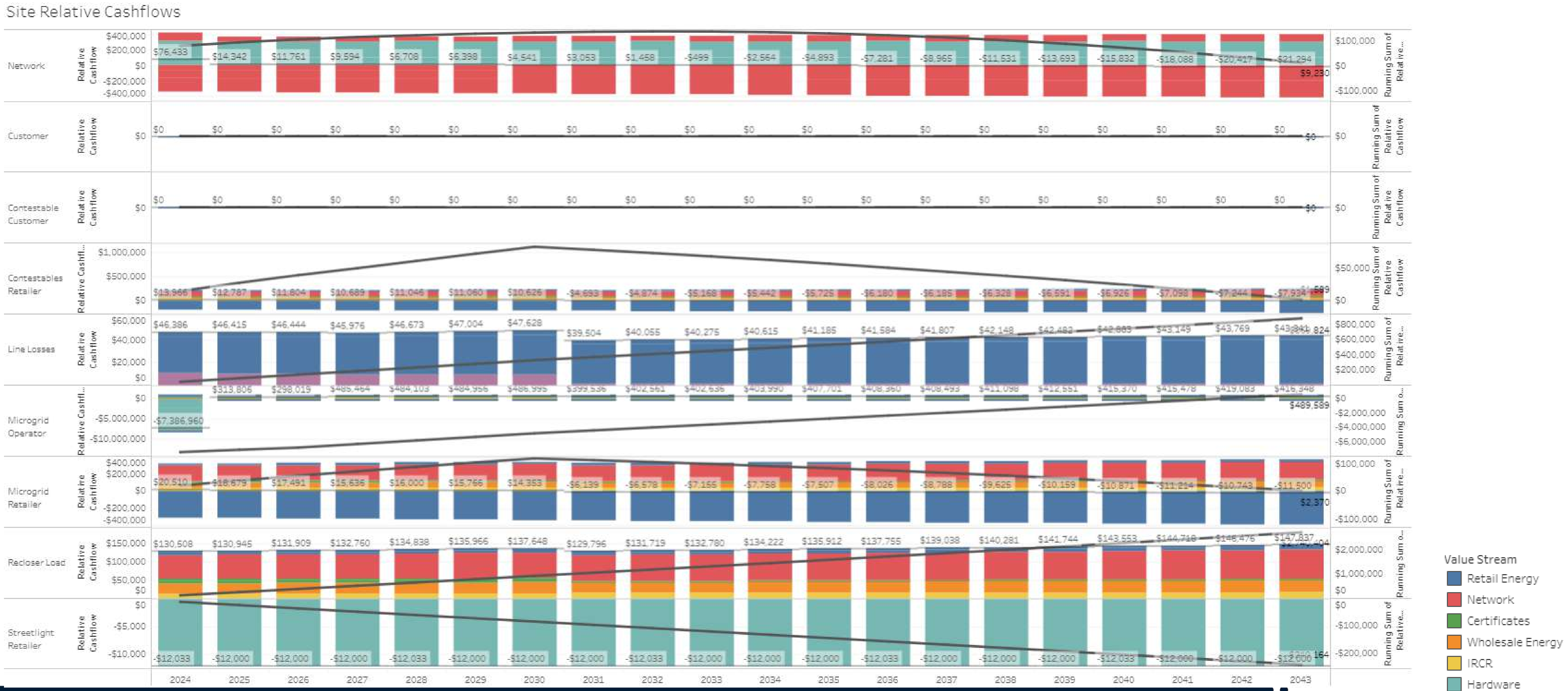
RELATIVE CASHFLOWS (PER YEAR OVER 20 YEARS)

EMN Microgrid with 1000kW Solar, 1200kW Wind & 2300MWh Battery



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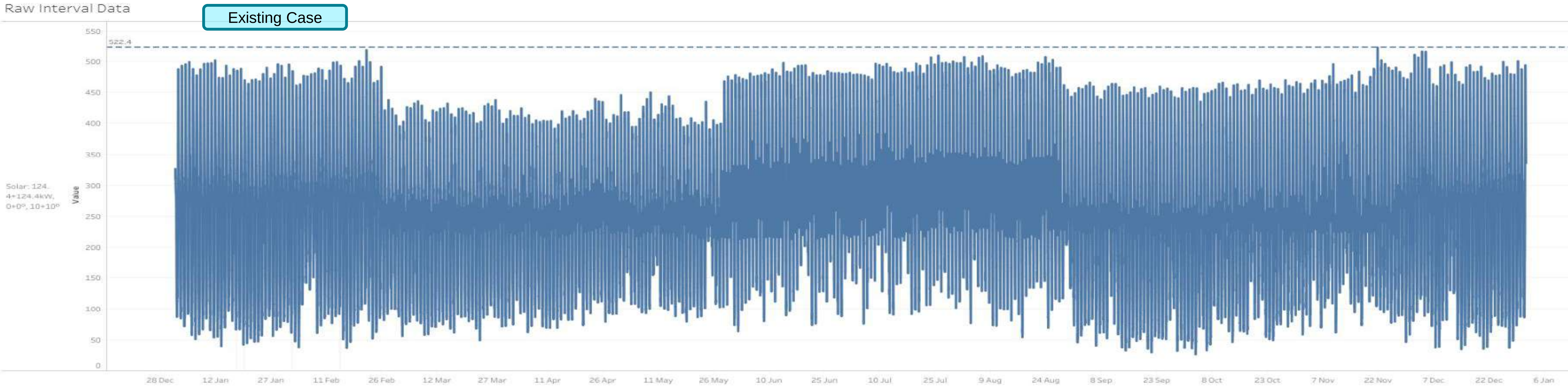
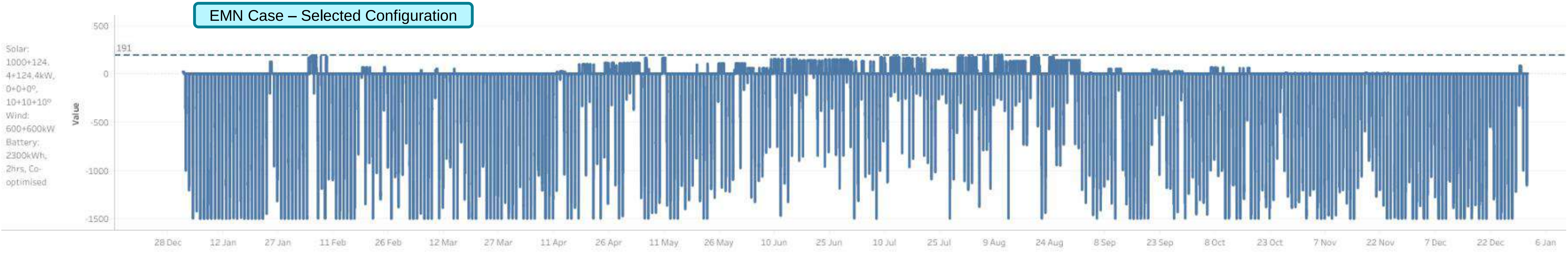
GRID CONSUMPTION OVER A YEAR

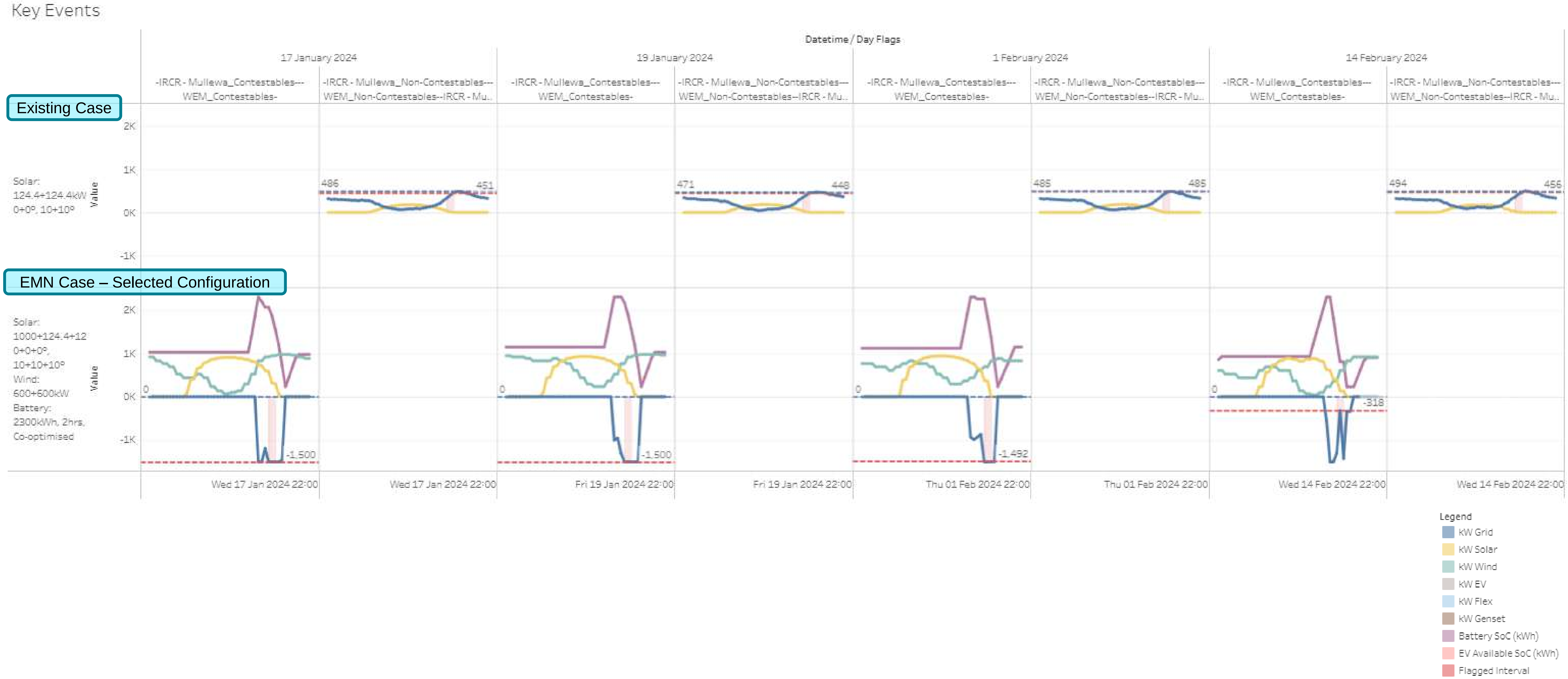
EMN Microgrid with 1000kW Solar, 1200kW Wind & 2300MWh Battery





IRCR CHARGES

EMN Microgrid with 1000kW Solar, 1200kW Wind & 2300MWh Battery



Section 5 – Questions and examination of the live model

Mullewa Microgrid Feasibility Study Project

EPWA Presentation

Friday, 17th March 2023

sunrise energy group

STUDY ORIGINS

- The study is looking into “how do we solve the ‘problems’ of fringe-of-grid towns on the SWIS with a replicable model”.
- Sunrise Energy applied for funding to complete a Renewable Microgrid Feasibility Study for Mullewa, and entered into a Collaboration Agreement with Enzen, Western Power and Synergy.
- The premise on which grant funding was received was for a microgrid that incorporated renewable generation, with the aim of the study being to develop a commercially sound, technically and economically feasible solution to significantly improve energy reliability, improve amenity for Mullewa residents and to retain and attract business to the town.
- The Study is being executed in six phases, concluding by August 2023:
    - 1 – Establish a Digital Twin, 2 – Model Technical & Commercial Solutions, 3 – Test Future Scenarios on Proposed Solution, 4 – Community Engagement, 5 – Undertake Development Activities, 6 – Document Results & Seek Investors
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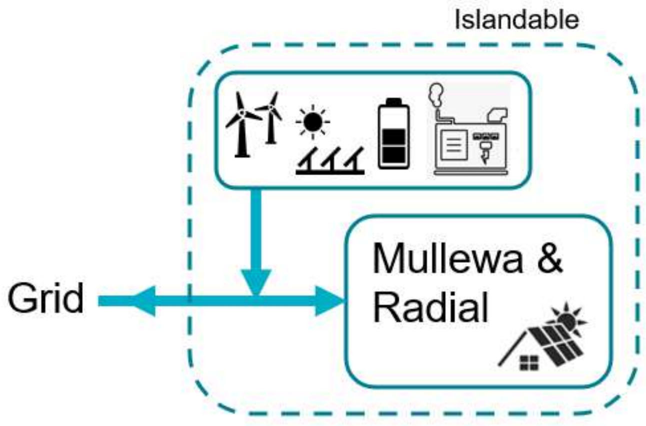
BINDING OFFTAKE AND ESSENTIAL SERVICES (NCESS) MICROGRID OPTION

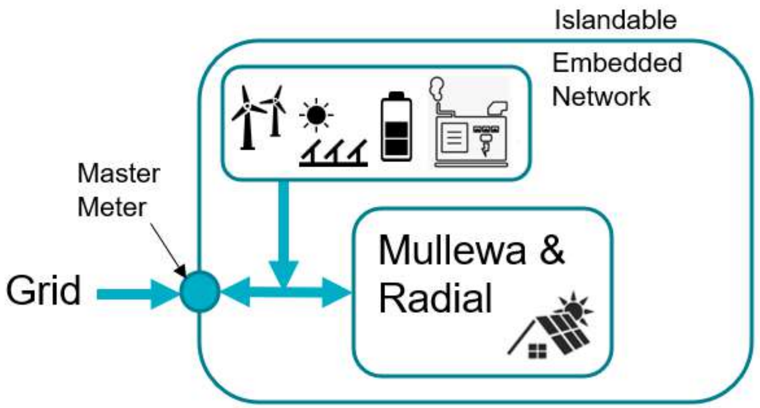


- In-front-of-the-meter connection of independent renewable generation and storage with the ability to provide contracted network services.

- **Three core characteristics:**
  - ➢ Retailer contract long term for the output of the microgrid
  - ➢ Western Power contract long term for provision of a reliability service
  - ➢ Renewable microgrid provider is provided with a high degree of revenue certainty, limited to construction costs risks and operating performance risks.

EMBEDDED NETWORK MICROGRID (ENM) OPTION

- Master meter installed at single entrance point into the microgrid. This master meter has all the loads in the microgrid as its load as well as the generation.



- **Three core characteristics:**
  - Renewable microgrid provider takes a much higher level of risk as there is no revenue guarantee and exposed to much higher costs base. Motivation is to optimise generation with consumption and manage its network, generation capacity, balance of energy and market costs.
  - A retailer would provide retail services to the master meter with revenue a fixed amount per customer (or similar model) – so not exposed to revenues and cost of the microgrid.
  - Western Power would earn an income from the network tariff for the master meter and from leasing the network (now part of the embedded network run by the renewable microgrid provider). Western Power would also either pay for an NCESS service or reflect the requirement for an NCESS in the lease agreement.

WHY ENM OPTION?

- **Pathway to self funding**
  - Best possibility of making fringe-of-grid microgrids commercially viable in their own right – ie. without the need for ongoing subsidies/support from the State.
- **DER participation**
  - Marries demand and supply so can participate as DER in markets, more suited to its size.
- **Local content/involvement**
  - Employment for both generation and network assets in Mullewa
- **Incentive to grow the Town**
  - Renewable microgrids performs better commercially with more load.
- **Proven appetite in Greenfields**
  - Private sector investment in microgrids in WA.

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Mullewa Microgrid Feasibility Study Project

ERA Presentation

Tuesday, 13th June 2023

sunrise energy group

STUDY ORIGINS

- The study is looking into "how do we solve the 'problems' of fringe-of-grid towns on the SWIS with a replicable model".
- Sunrise Energy applied for funding to complete a Renewable Microgrid Feasibility Study for Mullewa, and entered into a Collaboration Agreement with Enzen, Western Power and Synergy.
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- This engagement with ERA falls under phase 5, Development Activities

sunrise energy group

SYNERGY WITH RECENT AA5 DECISIONS

- In terms of the ‘problems’ to be solved for Mullewa, reliability is the main one.
- Western Power have addressed this today with the installation of Emergency Diesel Generators.
- This does not resolve all the reliability issues and is not considered a long-term solution.
- We see from the AA5 decision to raise the reliability benchmark for rural and long feeders, that there is an expectation for an increase in reliability for these cases.
- The renewable microgrid solution being studied, since before the commencement of the Access Arrangement revision, has been focussed on reliability and supports this expectation for greater reliability.
- Given long rural feeders will always remain ‘radial’ networks, the use of renewable generation in a distributed manner provides an alternative approach to improve reliability.

STUDY UPDATE

MILESTONE 1 – Digital Twin

90%

- Presentation of final digital twin model and corresponding reports to be held.

MILESTONE 2 – Modelling

95%

- Modelling update based on Alternative Options approach to be completed

MILESTONE 3 – Test Solutions

90%

- Testing scenario variations of Alternative Options approach model to be completed

MILESTONE 4 – Community Engmnt

75%

- Follow-up engagement to be held when development works complete / nearing completion

MILESTONE 5 – Development

60%

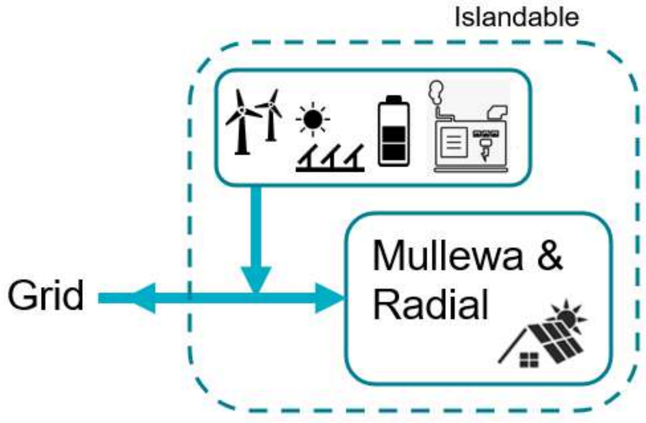
- Connection point land to be secured to enable submission of planning applications
- Pricing on major equipment for solar, battery, powerline and connection container to be received
- Legal review of regulations to be finalised
- Western Power enquiry to be submitted

MILESTONE 6 – Document & Investors

30%

- Finalise commercial model based on development works
- Engage with ARENA on grant funding support
- Are in advanced discussions with investors on broader funding for Sunrise – to include Mullewa on completion of two points above
- Complete write up of study report

BINDING OFFTAKE AND ESSENTIAL SERVICES (NCESS) MICROGRID OPTION



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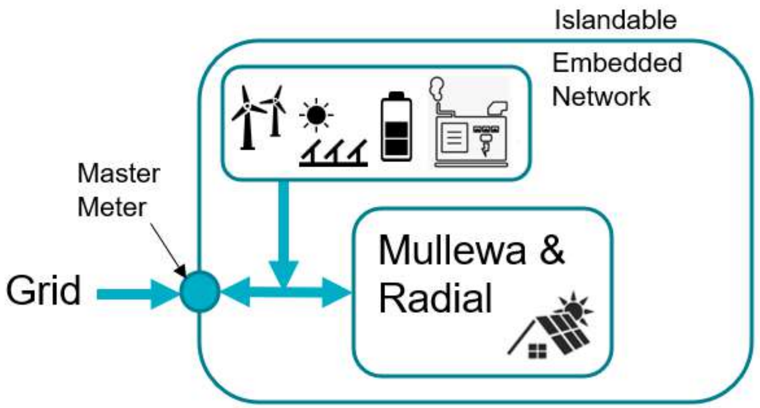
EMBEDDED NETWORK MICROGRID (ENM) OPTION



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  - A retailer would provide retail services to the master meter, with revenue based on a fixed amount per customer (or similar model) – so not exposed to revenues and cost of the microgrid.
  - Western Power would earn an income from the network tariff for the master meter and from leasing the network (now part of the embedded network run by the renewable microgrid provider). Western Power would also either pay for an NCESS service or reflect the requirement for an NCESS in the lease agreement.

WHY THE ENM OPTION?

- **Pathway to self funding**
  - Best possibility of making fringe-of-grid microgrids commercially viable in their own right – ie. without the need for ongoing subsidies/support from the State.
- **DER participation**
  - Marries demand and supply so can participate as DER in markets, more suited to its size.
- **Local content/involvement**
  - Employment for both generation and network assets in Mullewa
- **Incentive to grow the Town**
  - Renewable microgrids perform better commercially with more load.
- **Proven appetite in Greenfields**
  - Private sector investment in microgrids in WA.

REGULATORY CHALLENGES – ENM OPTION

- **Network Access Code 2004 (WA), "Covered Network"**
  - Treatment of the ENM model under this code is the most significant challenge. There is provision for multiple "service providers" under the access code, however they would be subject to the same broad range of obligations as WP, and so not tenable for a "small" microgrid operator.
  - There are a few possible pathways to solving this, with the most feasible considered to be a variation to WP's access arrangement. Coverage of the target network would be maintained but WP would seek an amendment to reflect an allocation of responsibilities between the MO and WP in relation to the target network and any comparable network where the ENM model was to be adopted (the repeatability piece).
  - This allocation of responsibilities would need to be approved by the ERA.
- **Metering Code, "Customer Protections"**
  - When customer meters become non NMI's how are Customer rights, obligations and responsibilities associated with metering services maintained.
- **Electricity Corporations Act 2005 (WA)**
  - Only Synergy can supply electricity to 'prescribed customers'.
- **Energy Operators (Powers) Act 1979 (WA)**
  - Only provides Western Power with the ability to access land for the purposes of maintaining the network and supply system.
- **Provisions for Contestable Customers**
  - Is the Microgrid Operator deemed to have an unfair advantage in terms of offering true contestability.
- **Obtaining Consent to take SWIS customers behind the meter**
  - Is there an alternative to all customers giving consent, assuming there is an overall benefit to the SWIS.

COMMERCIAL CHALLENGES – NCESS OPTION

- **Establishing Commercial Arrangements with Western Power for NCESS Services**
  - How do we agree the value of the reliability service provided by local generation supported by BESS and back-up diesel generation?
  - How do we agree the value of other services available from the microgrid such as voltage regulation?
  - How do we agree on the value of reduced load on the Geraldton-Mullewa feeder?
  - Can we agree on values that will be sufficient to enable the Microgrid to operate commercially and ensure WP is no worse off than they currently are?
- **Waiving Network Export Tariffs for local Renewable Generation**
  - We do not see a means of achieving a commercially viable microgrid while Western Power continue to collect a tariff from the individual users in Mullewa and on top of that collect a tariff for all the new local generation.
- **Securing long terms off-take contracts with Synergy for the renewable generation**
  - Synergy likely to be able to secure renewable generation elsewhere from a large scale provider at a rate a small Microgrid Operator could not compete with via a typical tender process. Is it possible to negotiate an off-take above market rates, that accounts for Synergy's line loss reduction savings in order that Synergy is no worse off than today and that can provide a commercially viable return for the Microgrid Operator?

TECHNICAL CHALLENGES

- **Working within Western Power Constraints**
  - Western Power require visibility and control over renewable generation.
  - Innovative cost-cutting technology solutions, even those proven in successful trials with Western Power, are being overlooked in favour of older style methods.
  - Being able to use such cost saving technologies In these “frontier style” microgrid developments can make the difference to their commercial viability – particularly where generation and grid connection/isolation points are not co-located.

PATHWAYS FOR IMPLEMENTATION WITH WESTERN POWER

- **NCESS Contract**
  - the typical means by which WP would seek to secure reliability services
  - typically a market tender process, with requirement for a short time until availability (within 12 months)
  - typically a short to medium term contract (2-5 years)
  - typically technology agnostic

  These are all features that do not favour a renewable microgrid development at the fringe-of-grid.

- **Alternative Options Strategy**
  - This pathway allows Western Power to consider unsolicited proposals for network solutions and so would enable a Microgrid developer to offer NCESS services in the form of an overall Microgrid solution.
  - To date Western Power has not received any proposals under this framework and so actual means of handling this within WP is not fully developed.

INNOVATIVE SOLUTIONS

The implementation of a Microgrid at Mullewa would provide an opportunity to demonstrate some of the innovative solutions possible, and those that would support a repeatable model for other fringe-of-grid towns. Some of these are:

- Generation and connection/isolation point not co-located. Possible through radio communications technology. Securing suitable land for generation around a town is one of the difficulties to overcome – freeing this task from the constraint of it having to be located at the grid connection/isolation, increases the feasibility of adopting this solution at other locations.
- Provision of a Digital Twin of the microgrid distribution network. This will enable a data driven approach to the operation and maintenance of the network in order to optimise these activities and drive down costs over time.
- If Western Power can be convinced to accept it - use of 3G technology to control renewable generation in DER.
- Delivered by the private sector:
  - lower demand on Western Power staff
  - capital secured from private sector – Western Power NCESS is an operating cost
  - tailored to the individual communities
  - supports the electrification of everything enabling growth in consumption at fringe-of-grid

Mullewa Microgrid Feasibility Study Project

Presentation to the Minster for Mines and Petroleum; Energy; Hydrogen Industry; Industrial Relations

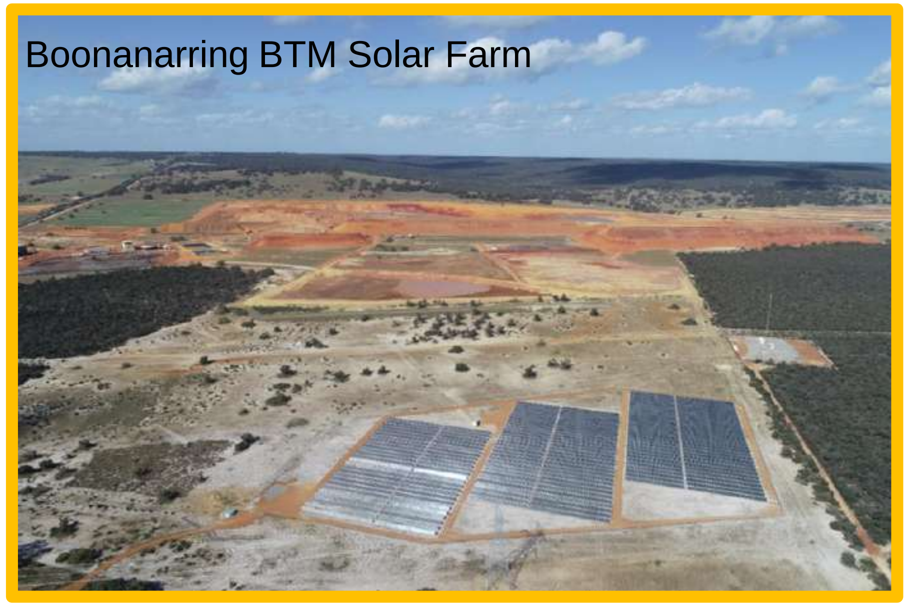
Wednesday, 14th June 2023

sunrise energy group

INTRODUCING SUNRISE ENERGY GROUP

- Sunrise Energy Group (Sunrise) was established 7 years ago by managing director Neil Canby. Neil is an ex-Western Power employee and during his time at WP saw the value in distributed energy and recognised there was a huge potential there that wasn't being realised, hence his drive to start Sunrise.
- Sunrise is a renewable energy project developer, but unlike most project developers, Sunrise seeks to have a "whole of Life" relationship with its customer.
- We provide full end-to-end value chain services which begin with pre-contract works such as planning, modelling, design, through to construction, supervision, and commissioning services.
- We have a history of delivering innovative first-offs in the renewable energy and microgrid space, such as the PEEL Business Park Microgrid and Image Resources behind the meter solar farm.


PEEL Microgrid Solar Array & Battery


Boonanarring BTM Solar Farm


Koobeja Estate Off-Grid System

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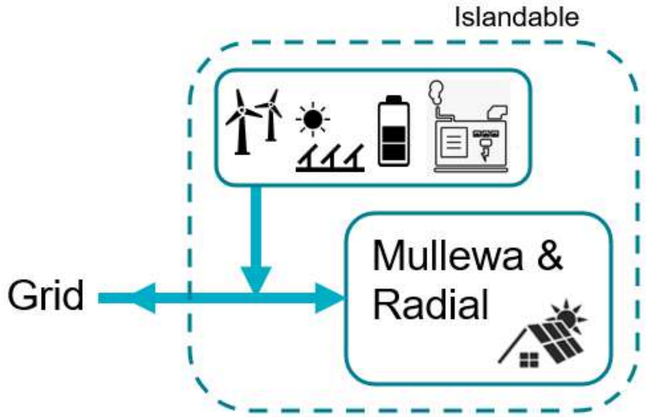

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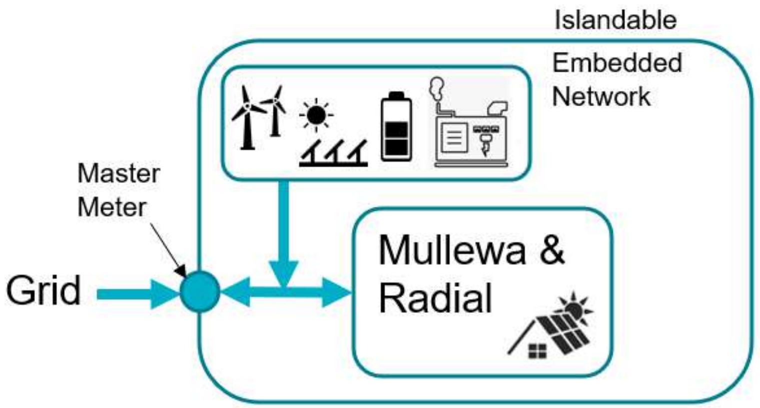

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CHALLENGES

ENM Option Regulatory Challenges

- How to deal with an embedded network microgrid operator under the context of maintaining a “covered network”.
- Maintaining Customer rights, obligations and responsibilities associated with metering services
- Someone other than Synergy supplying electricity to ‘prescribed customers’.
- Only Western Power have the ability to access land for the purposes of maintaining the network and supply system.
- Is the Microgrid Operator deemed to have an unfair advantage in terms of offering true contestability.

NCESS Option Commercial Challenges

- Establishing Commercial Arrangements with Western Power for NCESS Services
- Waiving Network Export Tariffs for local Renewable Generation
- Securing long term off-take contracts with Synergy for the renewable generation

CHALLENGES

Technical Challenges

- Working within Western Power Constraints
  - Western Power require visibility and control over renewable generation.
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EPWA FEEDBACK

- Supportive of innovative attempts to solve reliability for fringe-of-grid towns.
- Appreciated the effort to look beyond typical NCESS solution that they agree is already doable from a regulatory standpoint.
- Accepted Sunrise Energy preference for the EMN model, despite the increased risk, primarily because of its attraction to investors through the potential for growth.
- Interested in understanding level of ministerial support for the premise that an ENM model would essentially make residential customers contestable
- Based on above EPWA would suggest the “NCESS type” model would be the most workable solution to implement at this stage.
- In terms of a pathway for implementing an “NCESS type” model with Western Power - the Alternative Options pathway would be a more appropriate process the NCESS process.
- The point of the Alternative Options pathway was to make it easier for WP to support/implement solutions such as the “NCESS type” model, but to date it hasn’t seemed to have had the results hoped for in terms of encouraging WP action.
- Accepted that a lease agreement with WP as the basis for the embedded network was not unreasonable and akin to any other areas of their business where lease / sub-contract agreements were used.
- Appreciated the aspects of the ENM model where we are not looking to change established premises, such as the uniform tariff.
- Confirmed, as it currently stands, an ENM model would require the consent of all customers in order to be implemented.
- Looking forward to seeing the final report given that it will include an investigation of legal/regulatory matters that others have skimmed over.
- There are further changes coming through around reliability standards (separate to what ERA are doing) that EPWA feel will help build the case for deployment of fringe-of-grid solutions.

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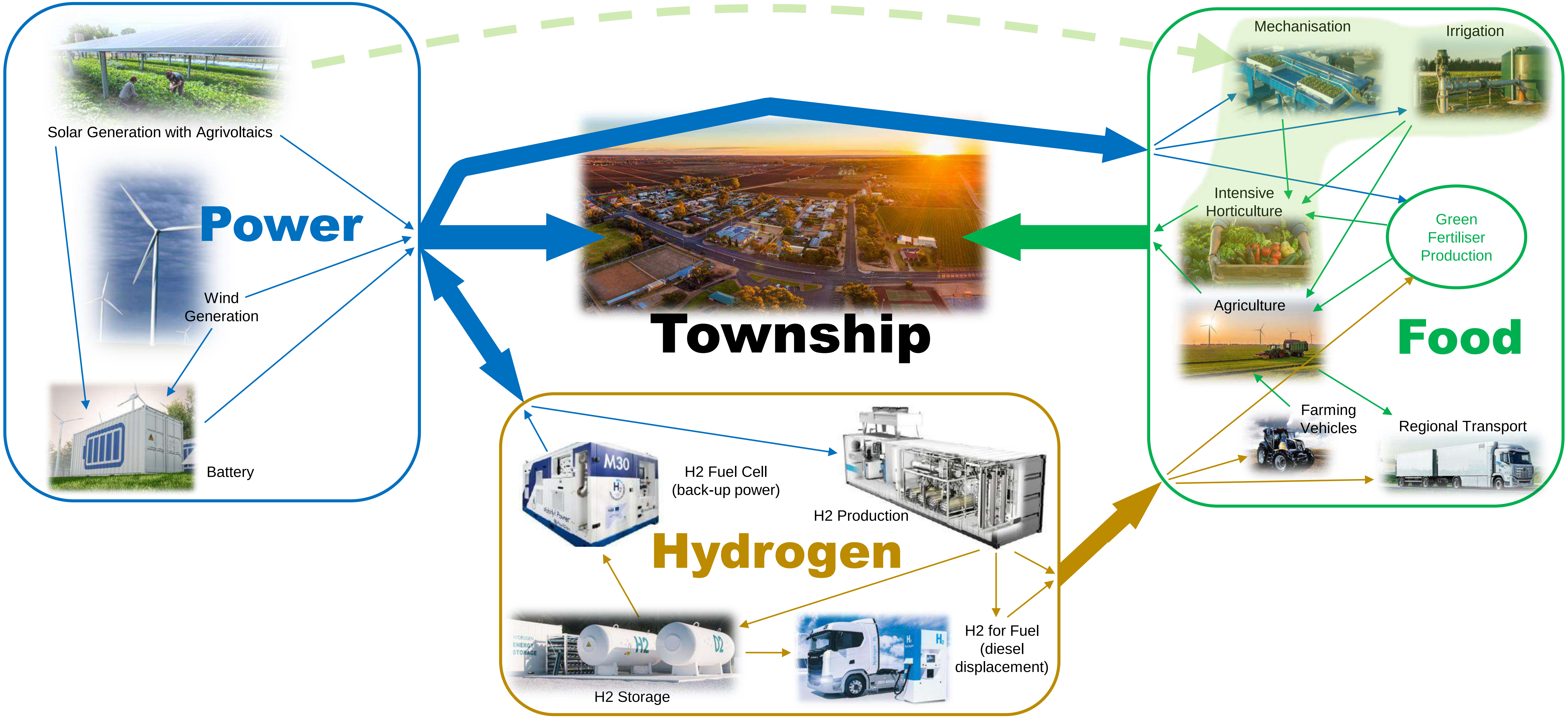
ERA FEEDBACK

- Saw merit in the ENM model in how it could allow the possibility of implementing tariffs that incentivised power use to match the local generation profile.
- Appreciated that renewable generation from a solar farm within an ENM model was a more equitable application of renewable generation than rooftop solar.
- The reasons for more visibility sought by the ERA from WP, in terms of rural reliability, was to get outcomes such as that produced by this study.
- Were interested in what WP and Synergy feedback on the study had been like to date. Sunrise perspective was that feedback from our study counterparts in WP and Synergy was positive, however our perception was that it had not attracted significant attention at the higher levels in those organisations, from which support would be necessary in order to make real progress in implementing a solution.
- When looking at the apparent customer benefits being seen with residential greenfield microgrids, the question around can we ensure a solution that is in the best interest of the customer with brownfield microgrids, should perhaps be reframed as can we best serve the interest of customers without offering this type of service.
- “NCESS option sounds sub-optimal”, but understood suggestion of a staged approach to a pilot whereby we get the infrastructure in place via the easiest regulatory path (ie. NCESS model vial WP Alternative Options Strategy) and prove the technology and reliability improvements before trying to transition to an ENM model.
- Confirmed that customer protections would not be a concern for an ENM model as they would be maintained via the MO having to have a retail licence.
- Believed there had to be thought given to new models to address the fringe-of-grid problems and that we were not going to reap the benefits of new technologies based on existing regulations/policies.
- Did not see that having to make regulatory amendments to accommodate an ENM model as a significant impediment to the implementation of such a model – in fact the ERA was looking at ways to change the regulatory frameworks to get innovative solutions.
- The ERA is taking seriously the decision (as expressed in requirements put in place in AA5) that WP are to meet the reliability requirements.

A VISION FOR THE FUTURE



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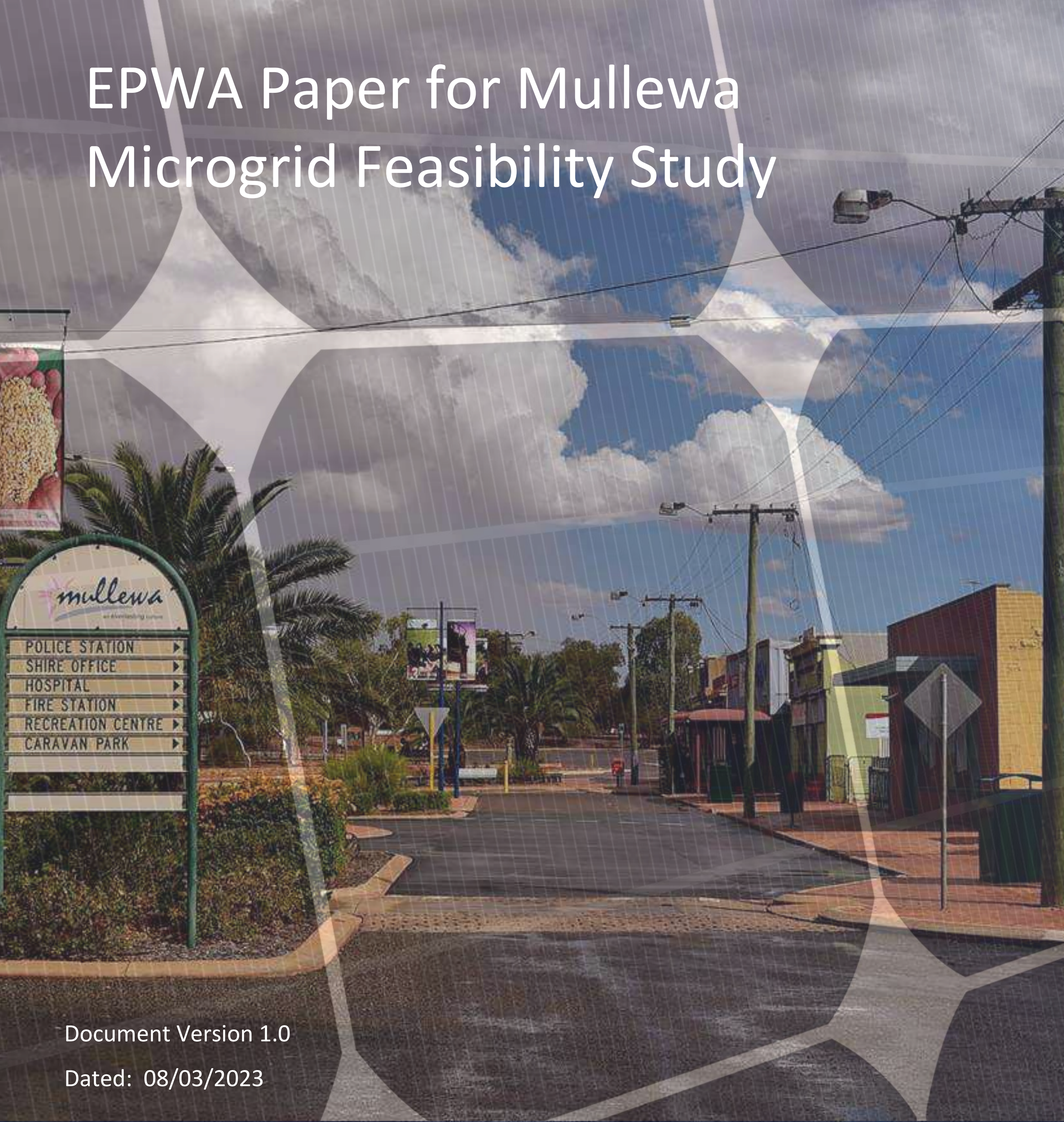
APPENDIX B

EPWA Paper

EPWA Paper for Mullewa Microgrid Feasibility Study



Document Version 1.0

Dated: 08/03/2023

sunrise energy group

Contents

1. Purpose

The purpose of this paper is to introduce EPWA to the Mullewa Microgrid Feasibility Study, and in doing so, test the State's support for the approach proposed within, that aims to solve the 'problems' of fringe of grid towns on the SWIS through application of an innovative renewable based microgrid model.

2. Feasibility Study Background

The Mullewa Microgrid Feasibility Study Project involves a 21 month examination into the viability of deploying a renewable energy microgrid in the fringe of grid town of Mullewa, in WA's Mid-West region (the **Project**).

The location (relative to the SWIS) and the network connections of the Mullewa township can be seen in Figure 2-1.

The Project is being completed by Sunrise Energy Group Pty Ltd (**Sunrise Energy**), in collaboration with Enzen Australia Pty Limited (**Enzen**), a developer of a digital twin for the Mullewa network.

The Electricity Networks Corporation, trading as Western Power (**Western Power**) and the Electricity Generation and Retail Corporation, trading as Synergy (**Synergy**) are also supporting the Project.

Collaborating and providing support to the Project is in no way a commercial commitment or solution preference on Western Power's part, particularly given it's work on other regional reliability and network augmentation projects. Similarly, Synergy is not a party to the Project and has made no commercial commitment. Its role in the Project is only to provide data, engage the community (as requested), and to provide support to Sunrise Energy.

The Project was initiated as a result of the initial question of: "*How do we solve the 'problems' of fringe-of-grid towns on the SWIS with a replicable model*"? The problems being:

- the low reliability of these towns, typically on long radial feeders
- the subsidisation of these towns by the rest of the SWIS
- the uncertainty surrounding long term sustainability of a grid supply (given Western Power identifying fringe disconnection as part of their "Grid Evolution" discussions).

This led to Sunrise Energy applying for funding to complete a Microgrid Feasibility Study at a specific location, and entering into a Collaboration Agreement with Enzen, Western Power and Synergy in respect to the nature and scope those parties have agreed to collaborate and provide support to the Project.

Western Power provided a list of ten worst performing locations, which included Mullewa. From this list Mullewa was selected as the location for the Study. Mullewa is located at the end of a 100km radial feeder, which has suffered from poor reliability, has large line losses and dated infrastructure.

The Project aims to develop a commercially sound, technically and economically feasible solution to significantly improve energy reliability, improve amenity for Mullewa residents and to retain and attract business to the town. The objective is that the model is replicable at other fringe of grid and potentially off-grid sites around WA and Australia, with key learnings and knowledge disseminated as part of the Project.

The Project scope includes modelling the use of renewable energy generation such as solar panels or wind, supported by battery energy storage systems (BESS), which would be distributed to the town via the microgrid solution. Innovative technology and software will play a key role in ensuring that demand and supply are linked. Key activities focus on engaging with the Mullewa community to develop the best solution for its needs, while equally ensuring that the solution is technically, commercially, and financially feasible and viable.

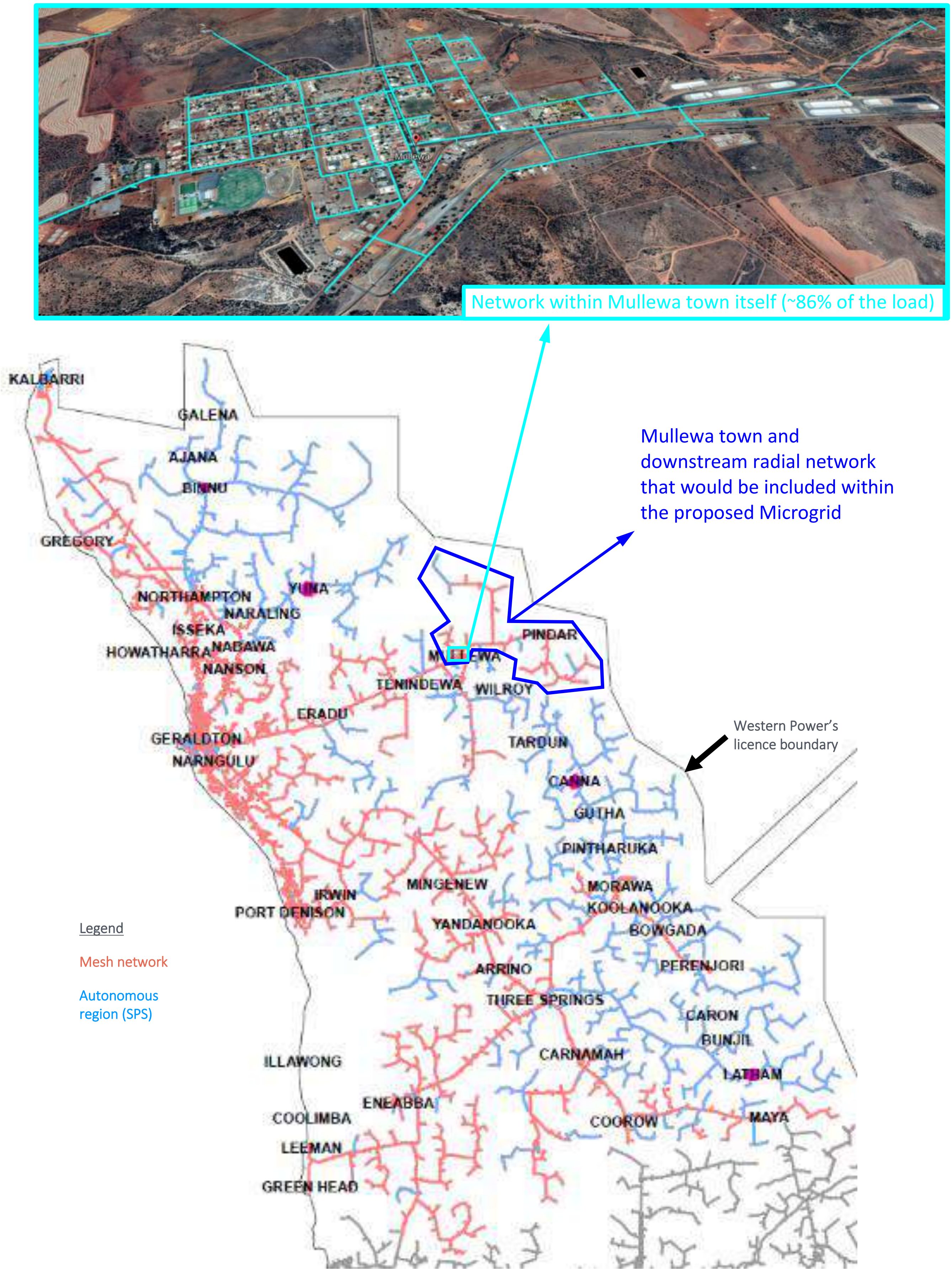


Figure 2-1: Mullewa town and network in relation to the SWIS

3. Definition of Microgrid

The term Microgrid does not have a unique/fixed definition and has widely been used to describe several different small electrical grid configurations. For the purpose of this study the following, relatively loose definition, has been selected:

In the SWIS, a microgrid is a section of the Western Power network that:

a) is still connected to the meshed network (grid)
b) has the ability to be islanded as an autonomous system, and
c) Includes local renewable generation and storage

4. Current State and Barriers

The key component of a fringe of grid renewable microgrid is the presence of renewable generation and storage at a suitable connection location near the town/load at the fringe of the grid.

Currently though there are 4 major barriers that exist for these fringe of grid renewable microgrids:

1. Revenue sufficiency. In a report published by the ERA in December 2022, the forecast analysis completed indicated that there is insufficient revenue available to both renewable generation (solar and wind) as well as battery storage from the Wholesale Energy Market under its current structure. This is not unique to a fringe of grid located system, rather is a characteristic of the whole WEM.
2. Diseconomies of size. The fringe of grid network where these renewable microgrids will typically be located are on long radial distribution networks. They inherently do not need to be large scale generation or storage. As a result they will have a higher unit cost than their large scale equivalents.
3. Offtake Counterparty. At present in the WEM there is little demand from either Retailers or end customers for renewable supply via long term PPAs. Retailers are typically building their own projects and only a handful of customers have purchased direct from a renewable generator.
4. Network Uncertainty. There is limited information readily available about the state of the fringe of grid network. Unknown matters include level of reliability, size of available connection, network charging model and loss allocation. This puts these developments at a significant knowledge disadvantage compared to a transmission level development where this information is published by Western Power.

It is extremely unlikely that a commercial project developer would choose to develop a fringe of grid project as an independently connected renewable microgrid on the SWIS.

So in order to see the establishment of renewable microgrids these barriers need to be addressed. In the study analysis two options to address these barriers were identified. These options are:

- Independently connected renewable microgrid with a PPA with a Retailer and a NCESS with Western Power (as Network Operator); (Binding offtake and Essential Services); and
- Embedded Network Microgrid

These options are discussed further below.

5. The Binding Offtake and Essential Services (NCESS) Option

This option is based around in-front-of-the-meter connection of independent generation and storage with the ability to provide contracted network services.

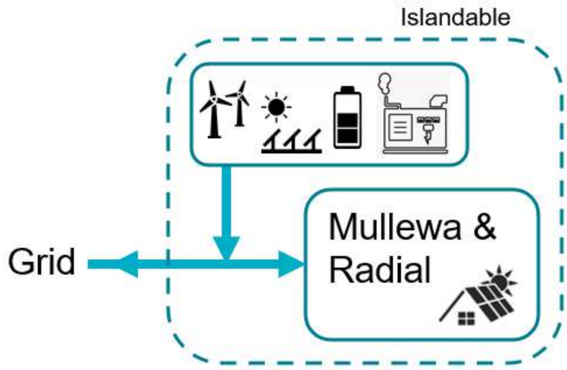


Figure 5-1: Simple representation of the NCESS option

This option has 3 core characteristics:

1. Retailer contract long term for the output of the renewable microgrid. This output is in 3 components:
   a) The energy generated
   b) The renewable certificates produced
   c) The generation capacity provided (participation in the Capacity Reserve Market)
2. Western Power contract long term for the provision of a reliability service for the fringe of grid, where the renewable microgrid can be activated in an island mode to maintain electricity supply to customers in the microgrid. This would see a proportion of the battery storage "reserved" to provide power if there is an outage.
3. The renewable microgrid provider is provided with a high degree of revenue certainty, with its risk limited to construction cost risks and operations performance risks.

Essentially the renewable microgrid provider has the previously described barriers removed through contractual certainty with a Retailer and Western Power.

However, this model in turn has its own barriers in the form of the practicalities of actually implementing this option, as described later in this paper.

6. Embedded Network Microgrid (ENM) Option

This option is based around a master meter being installed at the single entrance point into the microgrid. This master meter then has all the loads in the microgrid as its load as well as all the generation.

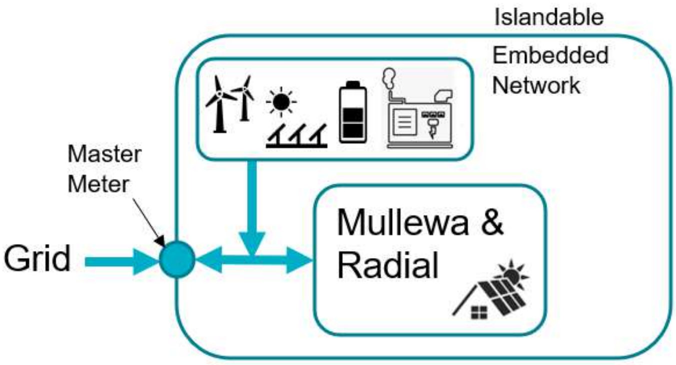


Figure 6-1: Simple representation of the ENM Option

This option has 3 core characteristics:

1. The renewable microgrid provider now takes a much higher level of risk in the project, as there is no revenue guarantee, and it is exposed to a much higher cost base. The motivation for the renewable microgrid provider is now to optimise generation with consumption and to manage its network, generation capacity, balance of energy and market costs.
2. A Retailer would provide retail services to the master meter and dependant on the internal system capabilities of the renewable microgrid provider could also be the provider of services for an embedded network such as metering, billing and customer service - but would no longer be exposed to the revenues and costs of the microgrid, instead its revenue would be a fixed amount per customer or similar model.
3. Western Power would earn an income from both the network tariff for the master meter and lease income from leasing the network, now part of the embedded network, run by the renewable microgrid provider. Western Power would either pay for an NCESS service or reflect the requirement for an NCESS in the lease arrangement.

Through the lease arrangement between Western Power and the renewable microgrid provider, it would be possible to structure some of Western Power's routine activities as undertaken by the renewable microgrid provider utilising local resources in the town. This could cover activities such as vegetation inspections, inspections for flora or fauna strikes causing outages, video streaming of information around faults reported back to a depot to allow a root cause to be determined prior to visiting site and the like.

In order for the renewable microgrid provider to operate this embedded network it would require either a distribution license, license exemption or be code participant under the proposed Alternate Energy Services (AES) regulatory framework, on the basis that these embedded network microgrids would be a service covered by the framework. Whilst there are a growing number of embedded network microgrids emerging on the SWIS they are all being driven from a greenfields perspective. This would be the first on a brownfields basis, which has its own barriers, mostly in the form of regulation challenges to navigate, as described later in this paper.

7. Commercial Comparison

Commercial models for both the NCESS and ENM options have been built in Gridcog. Gridcog is a software platform for modelling and analysing energy systems and associated emissions. For each option different Microgrid arrangements were modelled with variations in solar generation (0.5MW, 0.75MW, 1MW, 2MW & 3MW), wind (0.6MW & 1.2MW) and battery (2.3MWh & 4.6MWh) configurations. The model was based on a 20 year lifetime. The cashflow and emissions outcomes from Gridcog for each option indicate a distinct advantage for the Microgrid Operator of the ENM option over the NCESS option, as shown in Figure 7-1.

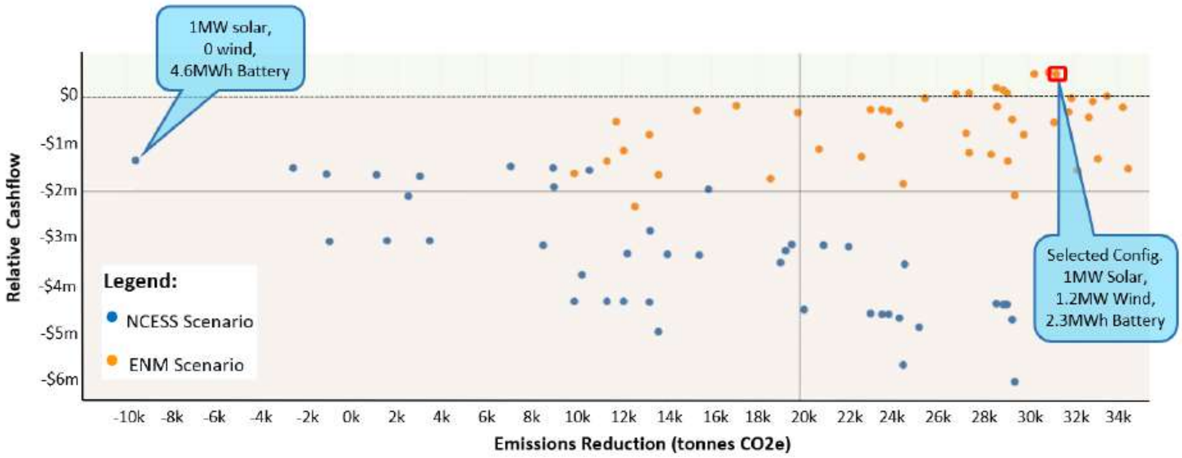


Figure 7-1: Relative Cashflow and Emissions Reduction Outcomes of NCESS versus ENM models for varying combinations of Solar, Wind and Battery.

From the relative cashflows (relative to the existing Mullewa baseline model), as shown in Figure 7-2 for the selected configuration, it can be seen that the poorer cashflow performance for the microgrid operator in the NCESS scenario is mostly a result of the increase in Network costs that need to be paid over that for the ENM scenario. This is basically because when the generation is in front of the meter, as in the NCESS scenario, all of it will be subject to network fees.

The relative cashflows also highlight how there is no change in the outcomes for the customers for either scenario, which was one of the core conditions set for the model.

It can also be seen that the retailers and Network Operator are essentially no worse off under the ENM scenario than what they are currently, which is reflected in the (close to zero) relative cashflows shown. This can be achieved in the ENM model as there is the flexibility for the Microgrid operator to be able to set the % of the revenue stream paid to the retailers, and agree a lease value with the Network Operator, that achieves this outcome.

Regardless of the relative performance of NCESS versus ENM, Figure 7-1 shows that overall there are actually only very few scenarios (all ENM) with an actual positive cashflow, which includes the selected configuration of 1000kW of Solar, 1200kW of Wind and a 2300kWh battery. The return on investment (ROI) calculated in Gridcog for this configuration is in the order of 6%, before corporate costs.

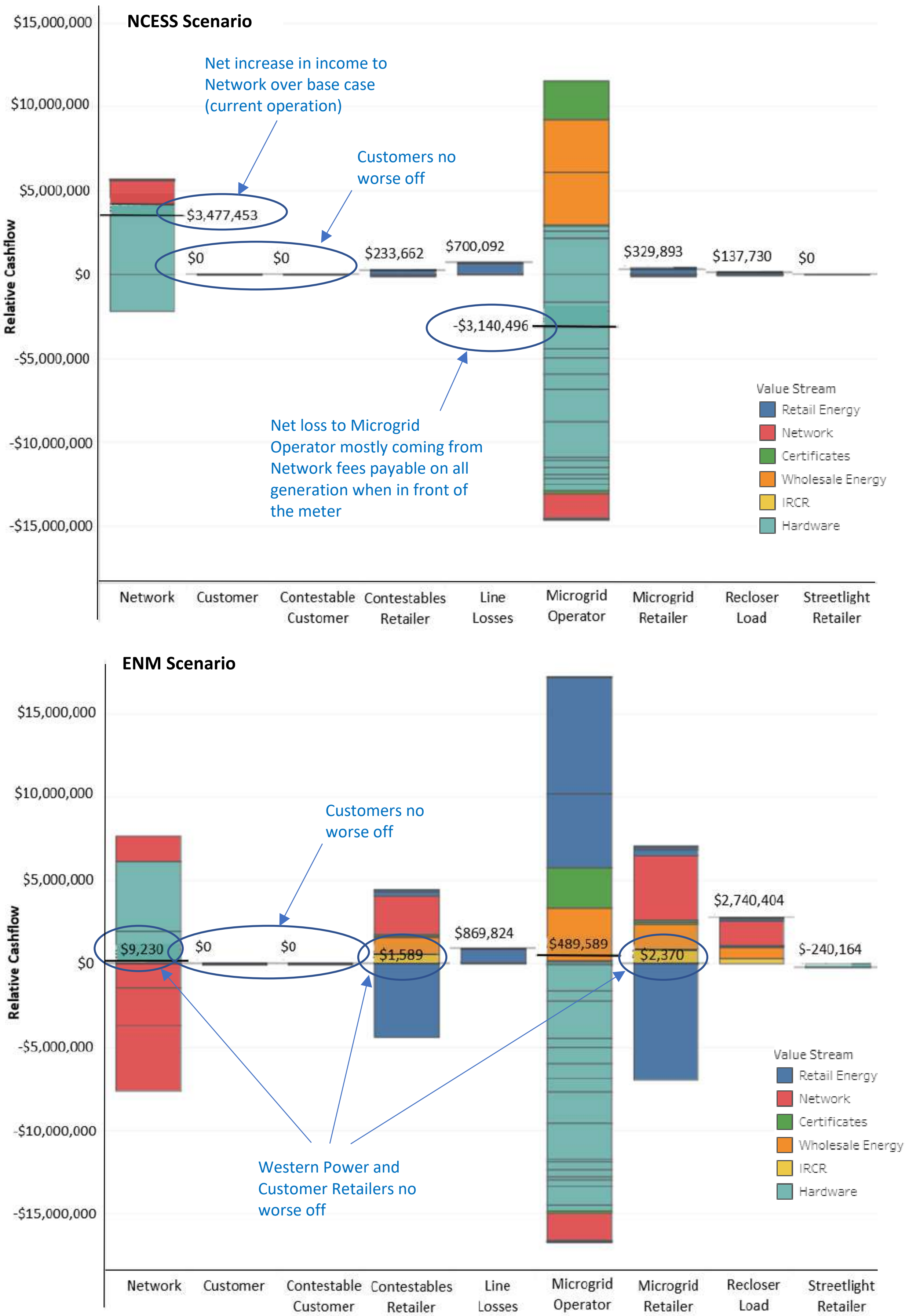


Figure 7-2: Cashflows over 20 years for NCESS and ENM Scenarios with Configuration: 1000kW Solar, 1200kW Wind & 2300MWh Battery

8. Regulatory Comparison

The NCESS option for a Microgrid in Mullewa could be implemented today under the current regulations without any necessary amendments. In essence it is no different, from a regulatory point of view, than any other solar farm currently connected to the SWIS in front of the meter. The ENM option however has not been implemented in a brownfields environment to date and so there are several regulatory challenges that would need to be navigated.

Regulations which would need to be addressed and their impact on the NCESS and ENM options are identified in Table 1.

Table 1: Regulations that are applicable to Brownfield Microgrid Solutions

Regulation	NCESS challenges	ENM challenges
Network Access Code 2004, 'Covered Network'	None	Existing NMI meters that would become non-NMI's after moving behind the meter
Network Access Code 2004, 'Compliance with Technical Rules'	None	Requirement for service providers to ensure their network complies to AS3000 (WP have an exemption for the SWIS)
Metering Code **'Customer Protections'**	None	When customer meters become non NMI's how are Customer rights, obligations and responsibilities associated with metering services maintained
Electricity Corporations Act 2005 (WA)	None	Only Synergy can supply electricity to 'prescribed customers'
Energy Operators (Powers) Act 1979 (WA)	None	Only provides Western Power with the ability to access land for the purposes of maintaining the network and supply system
Provision for Contestable Customers	None	Is the Microgrid Operator deemed to have an unfair advantage in terms of offering true contestability

9. Practicalities Around Renewable Development

The practicalities around Renewable Development are typically governed by the following factors:

- Access to renewable resources which generally means access to “suitable land” (ie. proximity to the load and/or network) that can support renewables, e.g. solar/wind farms. This includes a significant amount of time to validate renewable resources at specific locations. e.g. SODAR measurements over 12 months.
- Grid connectivity in terms of physical location, the capacity of the grid, and time/cost to connect.
- Regulations and policy: The regulatory framework and policies surrounding renewable energy development in Western Australia can play a significant role in determining the feasibility of new projects.
- Financing: Developing renewable energy projects can be expensive, and securing financing can be a challenge. The availability of government incentives and subsidies can sometimes help to offset some of the costs.
- Public Acceptance: Public acceptance of renewable energy projects can also impact their feasibility, as some communities may have concerns about the impact of new developments on the local area.
- Offtakes required due to the high capital investment and fixed nature of the assets.

Addressing all of these factors in order to develop renewable projects is not a simple or easy process and for the NCESS option which is formed on the basis of acquiring long terms contracts from a Retailer for the energy and from Western Power for NCES Services, likely prohibitive.

A Retailer would typically seek to secure renewable generation, LGCs and capacity via a market tender process. It is reasonable to expect that a fringe of grid renewable microgrid project would not be selected through a competitive tender process because:

- Its diseconomies of scale will make it uncompetitive with large scale projects;
- Its location is likely to result in revenue uncertainty in earning capacity from the capacity reserve market (NAQ is likely to be zero if in the north or east of the SWIS); and
- It would attract a relatively high transaction and administration cost for a very small value contract

Western Power would also typically seek to secure reliability services via a market tender process. In this process Western Power will typically remain technology agnostic, and will also contract for a short to medium term arrangement (2-5 years). Further the tender process would usually occur less than a year prior to the service being required. It is reasonable to expect that a fringe of grid renewable microgrid project would not be selected through a competitive tender process because:

- The short to medium term contract life would be unattractive for renewable technologies (high capital costs, low operating costs) but attractive to diesel generators (low capital costs, high operating costs)
- The short timeframe from selection to implementation would make it highly unachievable for a new renewable project to be built in time following selection

It is unlikely that the revenue from one of the two contracts outlined above with a Retailer and Western Power would be sufficient to support a project. To gain both contracts would either require a Retailer and Western Power to work collectively in sourcing these services or for a Retailer to contract for the power output and take the risk on securing a reliability service.

Even in the instance where both a Retailer and Western Power collaborate to tender for these services, it is unlikely that many renewable developers would tender to provide the service. The relative investments are small and tender transaction costs high, pre-tender activities such as securing land and assessing generation resources etc. are significant, and there is little upside in securing the business as the size of the asset is unlikely to change over time. It will not be commercially attractive for renewable developers to pursue.

10. Sunrise Energy Proposed Model and Rationale

The Sunrise proposed model has been derived in the attempt to make fringe-of-grid microgrids commercially attractive for developers in their own right – so without the need for ongoing subsidies/support from the State, yet still in partnership with Western Power and a Retailer (preferably Synergy given the projects Sunrise Energy and Synergy have worked on together). Based on the discussions in preceding section, the proposed model is a brownfields embedded network microgrid (ENM) model and the key components are outlined in Figure 10-1.

Features of this model that address some of the issues with establishing a brownfield Embedded Network Microgrid include:

- Access arrangement maintained under lease agreement
- Western Power remain as 'Service Provider' under lease agreement (from WP perspective, just a change in revenue stream)
- Customer protections remain
- Retail licence obtained by ENM Operator
- ENM Operator leverages Western Power existing distribution licence – in addition could also obtain own distribution licence if found necessary
- Obligation to connect remains
- Network operator of last resort is Western Power, with conditions for implementing defined within the lease agreement

Note: Adoption of the Alternative Energy Services (AES) regulatory framework could be a more elegant solution to licensing, customer protections & last resort powers, ie. but would be subject to timing.

As indicated in section 8, there are some regulatory challenges with the ENM model and so the questions related to regulatory reform arising from this model would be:

- Taking SWIS behind the meter – it would currently require all customers in the microgrid to agree to their NMI being aggregated, an administrative burden that could see something that was in the interest of all SWIS users not proceeding because of the view of one customer – does it need all customers to say yes, if the case for doing it results in an overall benefit for all SWIS customers?
- Can contestability requirements be resolved in a similar fashion to PEEL Renewable Energy Microgrid?
- Can the embedded network still be part of the SWIS covered network (similar to SPS's – SPS's are not on the SWIS but are part of the covered network)?
- Can the metering code be amended to accommodate non NMI behind the meter meters?
- Are Western Power land access rights maintained when network leased to 3rd party?
- Will Energy Safety grant exemption for AS3000 compliance of existing network when it converts to embedded network?
- Related to an AES approach – where would the electrical safety responsibility for inspectorate and investigation function reside for the embedded network and connected loads?

ROLES		FUNCTIONS	COMMERCIAL ARRANGEMENTS
Retailer to Customer	Sunrise Energy + Retailer	• Bills customers • Collects money • Handles complaints / bill enquiries • Reads meters	• Paid for services on cost per customer per annum / % on revenue basis • No commercial exposure on energy costs • Not leveraging retail license, just billing & customer service capability
Embedded Network Microgrid (ENM) Operator	Sunrise Energy	• Operates generation & storage with grid connection to optimise energy cost • Manages new connections • Manages Faults • Manages O&M (license compliance)	• Carries exposure to energy costs • Retail license including all existing customer protections • Marries demand and supply in order to participate as DER in markets • Mechanism available for contestable customers to retain current retailer • Leverages existing WP distribution license (option to consider a distribution license – but would be in addition to, not instead of the WP license)
Network Provider	Western Power	• Assists in fault recovery • Executes O&M activities - Network • Repair & replace assets	• Network lease to ENM Operator (ie. Network remains part of the SWIS from a license perspective, but not from a market perspective) • Includes asset refresh of poles & wires etc. • Adjustment for network retirement if it occurs (e.g. SPS roll-out) • Includes a base level of O&M services • T&M for all other O&M services
Generator	Sunrise Energy	• Generates power in accordance with technical rules • Executes O&M activities - Generation • Manages generation compliance	• Long term PPA arrangement with ENM Operator • Energy at cents/kWh • Battery storage at capacity availability per month
Retailer to Master Meter	Retailer	• Provides balancing power • Takes excess power • Administration of network connection	• Standard approach to a commercial customer arrangement on an unbundled commercial arrangement with bi-directional energy flows

Figure 10-1:Proposed Model for a Brownfield Embedded Network Microgrid

As suggested the prime rationale to this model is to make it commercially interesting to attract the attention of developers in this space, through investment of renewable generation and storage at the fringe of grid without costing all SWIS users (customers, retailers and network provider), as this is seen as key to solving the fringe of grid "problems".

It is expected there would be investment interest in the proposed ENM model due to the potential for growth, through load growth in the microgrid. Although having said this, the estimated return from the proposed ENM model is relatively small (with a degree of uncertainty), given the level of risk involved, and so it is likely there would need to be a "bundle" of microgrid towns to make the economics attractive for a developer and this would require a different approach to "sourcing" a provider for these renewable microgrids.

In addition to the prime rationale, there are also more specific sub-rationales that are driving the components from which the model is constructed, some of which are defined as follows:

- Rationale for embedded network:
    - Marries demand and supply so can participate as DER in markets
    - Enables local involvement in operation of the network
    - Enables Western Power to relinquish responsibility for the reliability of supply
- Rationale for leasing the network and not buying it outright
    - Reduces the up-front capital investment required
    - Simpler process than trying to negotiate a sale price
    - Provide a mechanism for Western Power to outsource some of its responsibilities while still maintaining its current income from the network and some level of control/security
    - Leverages existing Western Power distribution licence (although Microgrid Operator obtaining their own distribution licence in addition may also be considered)
- Rationale for Microgrid Operator obtaining a retail license:
    - A mechanism for ensuring customer protections are maintained
- Rationale for local generation:
    - Co-locating generation with load is overall better for SWIS customers as it reduces line losses and wear on the network
    - Inherent to improved reliability
    - Longer term it assists with renewable generation diversification
- Rationale for renewable generation:
    - In-line with State objectives for transitioning to net zero
    - Lowest cost alternative for local generation
- Rationale for battery:
    - Increases reliability associated with short-term feeder outages
    - enables a reduction in imported energy via assisting in matching generation to load
    - Makes the microgrid better equipped to participate as DER
- Rational for diesel generation:
    - Increases reliability associated with long-term feeder outages

11. Actions to Complete Feasibility Study

The objective of this engagement with EPWA, in terms of what is needed to complete the Feasibility study, is to:

a) Test the appetite for support in pursuing the model presented.
b) Receive guidance on the regulatory questions presented, such that the model may be refined to a level suitable for implementation as a pilot program.

The study will also be engaging a lawyer to provide expert advice on how to:

- best fit this model into existing regulations where possible, and where necessary;
- define in more detail the regulatory reforms that would be required to accommodate the "agreed in principle" features of the ENM model.

It is recognised however, that implementation of the AES regulatory framework could address the majority of the reforms required.

12. Progressing Past a Feasibility Study (ARENA and EPWA Support)

From Sunrise Energy's perspective, the extent of Sunrise Energy's interest in the fringe of grid "problem" was never just a feasibility study, but to develop a feasible solution that could be implemented by Sunrise Energy.

To this end, Sunrise Energy has already looked towards what will be needed beyond the completion of the feasibility study to progress a project in Mullewa. Two objectives of Sunrise Energy in this regard are defined as key to this:

a) Obtaining EPWA endorsement for implementation of this model as a pilot program for the town of Mullewa.

   Implementing a Microgrid in Mullewa on the basis of a pilot case will provide the opportunity to demonstrate the successful performance of this model. This would then support the implementation of the regulatory reforms necessary to make a success in Mullewa, repeatable to other fringe-of-grid towns.

b) De-risking the initial implementation at Mullewa. This is seen as necessary to attract investors given there is no proof of concept for a "first of its kind" such as this. An effective means of doing this is through securing funding from the ARENA Regional Australia Microgrid Pilots Program. It is a $50million six year program that aims to improve the resilience and reliability of power supply for regional and remote communities, of which the funding is available to projects that have successfully completed a feasibility study.

   The reduction in a developers commercial risk provided by ARENA funding would enable the developer to focus on refining the execution/operation of the model. The learnings taken from Mullewa could mean the implementation of this model in the next fringe-of-grid town would then be sustainable under its own commercial execution.

APPENDIX C

Geotechnical Survey Report

Douglas Partners
Geotechnics | Environment | Groundwater

Integrated Practical Solutions

Report on Geotechnical Investigation

Microgrid Solar Farm
Darlot Road, Mullewa, WA

Prepared for
Sunrise Energy Group Pty Ltd

Project 222100.00
July 2023

Document History

Document details

Project No.	222100.00	Document No.	R.001.Rev0
Document title	Report on Geotechnical Investigation Microgrid Solar Farm		
Site address	Darlot Road, Mullewa, WA		
Report prepared for	Sunrise Energy Group Pty Ltd		
File name	222100.00.R.001.Rev0.Mullewa Microgrid Solar Farm		

Document status and review

Status	Prepared by	Reviewed by	Date issued
Revision 0	David Rubenis	Chris Crowe	5 July 2023

Distribution of copies

Status	Electronic	Paper	Issued to
Revision 0	1	0	Matthew Stewart, Sunrise Energy Group Pty Ltd

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		5 July 2023
Reviewer		5 July 2023

Douglas Partners acknowledges Australia's First Peoples as the Traditional Owners of the Land and Sea on which we operate. We pay our respects to Elders past and present and to all Aboriginal and Torres Strait Islander peoples across the many communities in which we live, visit and work. We recognise and respect their ongoing cultural and spiritual connection to Country.

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Appendix E: Lateral Capacity and Deflection of Piles Using Broms

Report on Geotechnical Investigation
Microgrid Solar Farm
Darlot Road, Mullewa, WA

1. Introduction

This report presents the results of a geotechnical investigation undertaken for a proposed microgrid solar farm at Darlot Road, Mullewa, WA. The investigation was commissioned with a Services Order dated 24 April 2023 signed by Neil Canby on behalf of Sunrise Energy Group Pty Ltd and was undertaken in accordance with Douglas Partners' proposal P222100.00 dated 19 April 2023.

The aim of the investigation was to assess the subsurface soil and groundwater conditions across the site in order to provide comments on:

- ground conditions and its suitability for the proposed solar farms construction, including depth to top of rock, if encountered, and identification of problematic soils;
- earthquake site factor in accordance with AS 1170.4;
- excavation conditions in soil and plant required for bulk excavations, and excavatability in rock and plant required for excavating/ripping, or the requirement for explosives, and recommendations on batter slopes;
- allowable bearing pressures and estimated settlements for shallow footings (if appropriate);
- ultimate unfactored vertical bearing, shaft adhesion (compression and tension), lateral yield pressure for the design of any proposed pile foundation systems;
- geotechnical reduction factor as per AS 2159-2009;
- soil aggressivity (corrosivity) to concrete and steel in accordance with AS 2159-2009, based upon limited sampling and analysis;
- geotechnical parameters for external pavements, including California bearing ratio (CBR) of the subgrade encountered;
- provide soil electrical and thermal resistivity values; and
- the depth to groundwater, if encountered.

The investigation included the excavation of 17 test pits, electrical resistivity testing, thermal resistivity testing and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the items listed above.

2. Site Description

The proposed microgrid solar farm is located within a rural grazing paddock accessed via a 400 m long dirt track, running north-south, off Wubin-Mullewa Road. The paddock is located approximately 1.6 km south-east of the town of Mullewa.

The site is delineated into two rectangular areas, 130 m by 180 m (2.34 ha) for the proposed solar farm in the north and 300 m by 180 m (5.4 ha) for the proposed future solar in the south.

At the time of investigation, the site generally comprised a relatively flat fenced paddock with some shrubs to 1.5 m tall, the paddock was cleared and tyned in the southern part of the site (from test pit 6 and south). Outcropping rock was observed within the paddock, north of the site and along the boundary fence. Drawing 1 in Appendix B shows the above along with the test pit locations.

Surface elevations for the site were interpolated from the Department of Primary Industries and Regional Development (DPIRD) natural resource information (WA) online topographic contour maps (2 m contour intervals). The site slopes gently (gradient of 2%) down towards the north-east from around 288 m to 276 m AHD.

The Yalgoo 1:250,000 scale geological map sheet indicates that shallow subsurface conditions comprise Quaternary-aged colluvial soils comprising rock fragments, gravel sand and silt underlain by deeply weathered Archaean-aged porphyritic granite to adamellite, outcropping in the north-west of the site.

3. Field Work Methods

Field work was carried out between 22 and 25 May 2023 and comprised:

- The excavation of 17 test pits;
- DCP testing adjacent to each test pit;
- Electrical resistivity testing at four locations; and
- Thermal resistivity testing within ten selected test pits.

Test pits were excavated using a 20 tonne excavator fitted with a 750 mm wide toothed bucket on 23 and 24 May to depths of between 0.65 m and 2.4 m depth, with test pits terminated due to excavator refusal on granitic bedrock. Soils were logged to AS1726:2017 by a geotechnical engineer and soil samples were recovered from selected locations for subsequent laboratory testing.

Dynamic cone penetrometer (DCP) tests were carried out at each test location in accordance with AS 1289.6.3.2 to assess the in-situ density of the soils.

In situ thermal resistivity testing was undertaken on 23 May 2023 using a KD2 Pro within 10 test pit locations (test locations 2 to 11) in accordance with IEEE 442 and ASTM D5334 at a depth of 0.6 m.

Electrical resistivity (ER) testing was undertaken on the 22 and 25 May using the ABEM Terrameter and comprised four tests, each consisting of an orthogonal pair of vertical electrical soundings (VES1 and VES2) with common midpoint a-spacings of 0.5 m, 1.0 m, 2.0 m, 4.0 m, 8.0 m and 12.0 m used. Orthogonal arrays were all oriented east-west (VES1) and north-south (VES2). Results are presented in Appendix C.

Test pit locations and ER test centres were recorded using a hand-held GPS accurate to +/- 5 m and are marked on Drawing 1, Appendix B. Surface levels at the test pits locations were interpolated from the Department of Primary Industries and Regional Development (DPIRD) natural resource information (WA) online topographic contour maps (2 m contour intervals) and are indicated on the test pit logs in Appendix C.

4. Field Work Results

4.1 Ground Conditions

Detailed logs of the ground conditions are presented in Appendix C, and should be read in conjunction with the notes defining descriptive terms and classification methods provided in Appendix A. A test location plan is provided in Appendix B.

The ground conditions encountered beneath the site comprised colluvial soils primarily fine to coarse gravels and sands with variable fines content, overlying Archean granite bedrock. The rock encountered during the field work varied in strength from very low to extremely high strength and was encountered from depths of between 0.55 m and 2.15 m at the test locations.

Encountered ground conditions at the site can be summarised as such:

- **Unit 1: GRAVEL to Clayey Gravelly SAND (GP-GM, SP-SM GC)** – dense to very dense, sandy gravelly colluvium with variable fines content. Unit 1 soils included variable gravel, sand, silt and clay content from the surface to depths up to 2.15 m at the test locations. Gravel particles are generally sub-rounded to sub-angular laterite. At most of the test locations the fines were noted to be non-plastic, exceptions to this were noted around the north-western corner of the site at pits 4 and 14 potentially associated with residual granite.

  The upper 0.1 m to 0.3 m of this unit was logged as a topsoil due to the observed organic content and colour, however this may represent tyned (disturbed) soils during agricultural activities on site and may not be a true representation of topsoil.

- **Unit 2: GRANITE** – variably weathered, very low to extremely high strength granite rock underlying the colluvial soils to test termination depths. The 20 tonne excavator used during the investigation was only able to penetrate 0.1 m to 0.3 m into the rock, as such observed properties of the rock are largely limited to surficial observations rather than generally properties of the underlying rock mass. Table 1 summarised the depth to rock observed during the geotechnical investigation, noting that reported elevations are only approximate due to the lack of a detailed feature survey for the site. For the present development area the depth to rock is noted to increase in depth from the north-west to the south-east.

Table 1: Summary of Depth to Rock

Test Location	Approximate Surface Elevation (m AHD)	Depth to Rock (m)	Approximate Rock Elevation (m AHD)	Development Area
1	279	0.55	278.5	Current Development Area
2	280	1.2	279.0	
3	281	1.4	279.5	
4	282	1.0	281.0	
5	281	2.15	279.0	
6	283	1.6	281.5	Future Development Area
7	285	1.35	283.5	
8	283	1.4	281.5	
9	285	1.45	283.5	
10	287	1.35	285.5	
11	284	0.95	283	
12	279	1.25	277.5	Current Development Area
13	280	1.15	279.0	
14	280	0.6	279.5	
15	281	2.1	279.0	
16	282	0.9	281.0	
17	282	1.95	280.0	

4.2 Groundwater

No free groundwater was observed in any of the test pits excavated to maximum depths of 2.4 m below the existing surface level.

Groundwater levels can vary seasonally, following periods of rainfall and due to local factors, such as permeability of the soil and rock, changes in drainage conditions and dewatering activities associated with nearby developments.

4.3 Earth Thermal Resistivity

In situ earth thermal resistivity testing was attempted within 10 test pits, these tests were undertaken at depths of 0.6 m below the surface using a KD2 Pro.

Results of the earth thermal resistivity are summarised in Table 2.

Table 2: Summary of Thermal Resistivity Results

Test Location	Depth (m)	Temperature (C)	Thermal Resistivity (K.m/W)
2	0.6	22.92	1.517
3	0.6	22.30	1.507
4	0.6	22.44	1.200
5	0.6	20.02	1.611
5 (retest)	0.6	21.08	2.311
6	0.6	22.61	1.173
7	0.6	23.34	0.661
8	0.6	23.32	1.454
9	0.6	22.32	1.216
10	0.6	22.52	1.436
11	0.6	23.71	0.847

4.4 Earth Electrical Resistivity

Earth electrical resistivity testing was undertaken using a Terrameter LS2 (ABEM) resistivity meter at four locations (Grid 1 to 4) in accordance with AS 1768, employing the Wenner alpha array, with equal inter-electrode spacings (0.5 m, 1 m, 2 m, 4 m, 8 m and 12 m).

Testing was undertaken in accordance with AS 1768 along both east-west and north-south electrode orientations. Test results and apparent resistivity plots are presented in Appendix C.

5. Laboratory Testing

A geotechnical laboratory testing programme was undertaken by NATA registered laboratories and comprised the determination of:

- The particle size distribution of eight samples (AS 1289.3.6.1);
- The Atterberg limits and linear shrinkage of five samples (AS 1289.3.1.1, AS 1289.3.2.1, AS 1289.3.3.1 and AS 1289.3.4.1);
- The maximum modified dry density and optimum moisture content (AS 1289.5.2.1) of four samples;
- The chloride, sulfate and pH levels on four soil samples;

- Thermal resistivity measurements on six soil samples at moisture content similar to that encountered in the field (IEEE Standard 442, ASTM D5334, AS 1289.2.1.1 and AS 1289.5.2.1); and
- Point load test on 16 rock samples (AS 4133.4.1).

The detailed test certificates are presented in Appendix D with the results summarised in Tables 3 to 6 next pages.

Table 3: Summary of Laboratory Testing Results on Soil Identification

Test Location	Depth (m)	Fines (%)	Sand (%)	Gravel & Cobbles (%)	LL (%)	PL (%)	PI (%)	LS (%)	CBR (%)	MMDD (t/m^3)	OMC (%)	Material
4	0.2	28	39	33	23	13	10	3.5	-	-	-	Clayey Gravelly SAND (SC)
4	0.8	24	34	42	-	-	-	-	-	-	-	Clayey Sandy GRAVEL (GC)
5	0.5	7	33	60	NO	NP	NP	0.5	40	2.14	6.0	Sandy GRAVEL (GP-GM) with silt
8	0.5	8	20	72	-	-	-	-	-	-	-	GRAVEL (GP-GM) with sand and silt
9	0.5	13	29	58	NO	NP	NP	1.5	60	2.34	7.0	Silty GRAVEL (GM) with sand
11	0.5	24	44	32	NO	NP	NP	2.0	50	2.27	7.5	Silty Gravelly SAND (SM)
13	0.5	9	25	66	-	-	-	-	-	-	-	GRAVEL (GP-GM) with sand and silt
14	0.5	30	35	35	25	13	12	5.0	35	2.13	8.0	Clayey Sandy GRAVEL (GC)

Notes to Table 3:

The % fines is the amount of particles smaller than 75 µm.
The % sand is the amount of particles larger than 75 µm and smaller than 2.36 mm.
The % gravel is the amount of particles larger than 2.36 mm and smaller than 63 mm.
LL: liquid limit.
PL: plastic limit.
PI: plasticity Index.
LS: linear shrinkage.
CBR: California bearing ratio.
MMDD: modified maximum dry density
OMC: optimum moisture content.
"-" indicates that the test was not undertaken for this sample.

Table 4: Laboratory Results on Soil Aggressivity and Chemical Concentrations

Test Location	Depth (m)	Exposure Classification				Material
		Concrete		Steel		
		pH	SO4 (mg/kg)	pH	Cl (mg/kg)	
4	0.8	4.6	28	4.6	<10	Clayey Sandy GRAVEL (GC)
8	0.5	5.1	22	5.1	<10	GRAVEL (GP-GM) with sand and silt
11	0.5	5.3	28	5.3	17	Silty Gravelly SAND (SM)
13	0.5	4.7	20	4.7	20	GRAVEL (GP-GM) with sand and silt

Notes: [1]: Soil Type based on guideline presented in AS 2159-2009 and summarised below:
Soil Type A – High permeability soils (e.g. sands and gravels) and soils below water table
Soil Type B – Low permeability soils (e.g. silts and clays) and soils above water table

Scale of aggressivity based on threshold values given in AS 2159-2009

Non-aggressive	Mild	Moderate	Severe	Very Severe

Table 5: Summary of Laboratory Results on Rock

Test Location	Depth (m)	Point Load Index $I_{s(50)}$ (MPa)	Rock Strength	Rock Type
1	0.6	1.32	High	Granite
2	1.25	8.27	Very High	
4	1.2	0.08	Very Low	
5	2.2	0.76	Medium	
6	1.65	1.06	High	
7	1.4	4.99	Very High	
8	1.45	3.67	Very High	
9	1.45	2.31	High	
10	1.4	3.91	Very High	
11	1.0	11.41	Extremely High	
12	1.3	0.26	Low	
13	1.2	3.48	Very High	
14	0.7	4.44	Very High	
15	2.15	0.51	Medium	
16	0.95	1.93	High	
17	2.0	2.66	High	

Table 6: Summary of Thermal Resistivity Testing

Test Location	Depth (m)	Moisture Content (%)	Thermal Resistivity (K.m/W)	Material
5	0.5	0.4	2.830	Sandy GRAVEL (GP-GM) with silt
		2.2	1.230	
		4.3	0.674	
		6.0	0.587	
8	0.5	0.1	2.700	GRAVEL (GP-GM) with sand and silt
		2.7	0.892	
		5.1	0.477	
		7.6	0.083	
9	0.5	0.2	2.087	Silty GRAVEL (GM) with sand
		2.6	0.997	
		5.1	0.693	
		6.9	0.335	
11	0.5	0.3	1.980	Silty Gravelly SAND (SM)
		2.5	0.933	
		5.1	0.692	
		7.8	0.401	
13	0.5	0.2	2.370	GRAVEL (GP-GM) with sand and silt
		2.6	0.973	
		5.2	0.642	
		7.1	0.431	
14	0.5	0.2	2.410	Clayey Sandy GRAVEL (GC)
		3.2	0.860	
		6.2	0.495	
		7.9	0.237	

6. Proposed Development

The proposed development is understood to comprise an initial 1 MW solar farm development across an approximately 2.3 ha site, designated as the "proposed solar farm area" on Drawing 1 in Appendix B. Foundations for the single axis tracking panels are understood to comprise piles founded within rock. The present investigation has also been conducted across a proposed future solar farm development area covering an area of approximately 5.4 ha immediately to the south of the initial area.

No information on finished design level or loading has been provided to Douglas Partners at the time of reporting, however it is assumed that surface levels within the solar array areas will remain relatively unchanged.

7. Comments

7.1 Ground Appreciation and Site Suitability

The results of the investigation indicate that ground conditions across the site generally comprise sandy and gravelly colluvial soils overlying relatively shallow granite bedrock (e.g. typically from between 0.5 m and 2.0 m depth). Clayey soil within the matrix of the surficial gravel, cobbles and boulders is of low reactivity and at a proportion anticipated to result in marginal seasonal surface movements, of less than 5 mm. The soils are non-collapsible and soil dispersity is not considered to form a risk owing to the predominant proportion of coarse particles. Given the absence of groundwater, the risk of soil liquefaction is nil for the encountered ground conditions.

The ground conditions are considered geotechnically suitable for the proposed development.

Based on the results of the investigation, it is anticipated that primary geotechnical constraint is the shallow strong bedrock. This is generally high strength and stronger (up to extremely high strength) and typically was encountered at shallow depth. The nature of the fracturing could only be broadly assessed based on the method of investigation, the shallow refusal (0.1 m to 0.3 m into the rock) suggests that the underlying rock is likely relatively competent. Based on the results of the investigation, strong rock is considered to underly the entire site and will be suitable for the anticipated compressive loads imposed by the proposed structures, however tension and lateral loads will require some embedment into the rock. Depending on final design levels shallow bedrock may impact proposed excavation and will need consideration in bulk earthworks design and construction, and civil design (e.g. trenching for services). The piling contractor will also need to ensure that the equipment mobilised to site is capable of dealing with high to extremely high strength rock. It is noted that localised weaker zones of extremely weathered bedrock were also encountered at shallow depth, including some very low strength rock at some locations.

The strong ground conditions are anticipated to generally be suitable for shallow footing systems for proposed buildings and structures, provided uplift and lateral forces are addressed in the design. Either large footings or the use of rock anchors could be considered to resist uplift forces for small structures on shallow footings.

Typical piled foundation systems for solar arrays comprise driven piles, screw piles, drilled and grouted piles. Owing to the shallow rock at this site, it is considered likely that a drilled and grouted (or concreted) pile system, which includes the predrilling of holes and installation of the solar array poles (e.g. steel beam) grouted or concreted in their respective hole, would form a suitable solution at this site. Driven piles and screw piles are not suitable owing to the shallow coarse soil condition and shallow strong bedrock.

An alternative to a piled foundation system, a ballast foundation system (eg in situ poured shallow footings) could be considered for the proposed solar arrays provided uplift forces can be addressed in the design. A shallow footing system anchored into the underlying rock could also be considered to resist uplift forces, but would need to be financially balanced against a conventional drilled and grouted piled system aforementioned.

7.2 Site Preparation

7.2.1 Surface Stripping

Topsoil was logged on site with depths of between 0.1 m and 0.3 m recorded, however, this assessment was largely based on the colour rather than organic content and depths may have been exaggerated by historic farming activities on the site such as tyning of the soils.

It is proposed that all vegetation and deleterious materials should be stripped from the proposed development areas. Following the removal of the existing vegetation and associated roots, it is considered the surficial soils are likely to be suitable to remain in place, however, this should be confirmed on site by a suitably experienced geotechnical engineer.

Removal of large cobbles and boulders near the surface is also recommended to facilitate compaction operations and allow for a suitably smooth finished surface suitable for trafficking of vehicles.

7.2.2 Site Preparation in Proposed Solar Array

Ground conditions across the solar array areas include dense to very dense sandy and gravelly soils overlying rock from depths of between 0.5 m and 2.0 m. As such the ground conditions in their current state are suitable for support of foundations for the solar arrays and no specific improvement or preparation of the ground would be required.

Stripping of vegetation and surficial oversized particles is expected to create some disturbance to the surface and therefore, some relevelling using a dozer blade or front end loader bucket, followed by the re-compaction of the ground using a heavy pad foot roller (say 15 t or heavier) is recommended to create a suitable surface.

It is anticipated that some minor cut and fill will possibly be required to produce terraced levels within the solar array areas. If required, fill should be placed and compacted in layers. Suitable structural fill materials and compaction is further discussed in Section 7.2.3.

7.2.3 Suitable Fill and Compaction

While not identified by the laboratory testing, site photos suggest soils of Unit 1 excavated from the site may contain oversized particles greater than 150 mm in size, which would typically exclude the material from reuse as structural fill. Treatment of on-site soils to produce a material suitable for reuse as structural fill would require screening the on-site material to remove oversized particles greater than 150 mm and then blending of the screened material with imported soil fill to produce a well graded material, with no risk of voids between coarse particles following placement.

Suitable material for blending could comprise soil with:

- less than 30% by weight of soil fraction finer than 0.075 mm;
- not more than 10% by weight of soil fraction greater than 2.63 mm;
- no particles greater than 37.5 mm in size;
- liquid limit not greater than 30% (when assessed in accordance with AS 1289.3.1.1); and
- free of organic content.

Alternatively other material locally available could be suitable following review and approval by a geotechnical engineer.

A blending trial should be undertaken on site to confirm suitability of the blending materials, appropriate fill lift thickness and to assess a suitable blending ratio, however a preliminary blending ratio of 2:1 (import:on-site) is suggested. It is emphasised that owing to the large particle sizes within the blended material, nuclear density testing or penetration testing (i.e. dynamic penetrometer testing or cone penetration testing) would not be suitable for assessment of the compaction of the fill. Therefore, assessment of the reuse of on-site materials should be supervised by a geotechnical engineer.

If imported fill (ie without blending with onsite soils) is used directly as structural fill, the following specification is recommended:

- less than 15% by weight of soil fraction finer than 0.075 mm;
- not more than 30% by weight of soil fraction greater than 2.63 mm;
- no particles greater than 37.5 mm in size;
- liquid limit not greater than 20%;
- plasticity index not greater than 10%: and
- free of organic content.

Other material than specified above could be suitable following assessment and approval by a geotechnical engineer.

If granular, non-cohesive imported fill is used (for instance, the locally termed '*river sand*' or '*dune sand*'), it should be placed in loose lift thickness within 2% of its optimum moisture content with each layer compacted to achieve a dry density ratio of not less than 95% relative to modified compaction. Fill lift thickness should be adjusted to suit the compaction plant on site, however, lift heights of 0.3 m for granular fill is typically suitable. Lightweight compaction equipment may require thinner lifts. Such granular fill is anticipated to have a significantly greater permeability than the in situ ground and other types of commonly available fill and therefore possible impact on project drainage should be considered if it is proposed to be used.

If cohesive imported fill is proposed, it should be placed in loose lift thickness within 2% of its optimum moisture content with each layer compacted to achieve a dry density ratio of not less than 92% relative to modified compaction. Fill lift thickness should be adjusted to suit the compaction plant on site, however, lift heights of 0.15 m for cohesive fill is typically suitable. Lightweight compaction equipment may require thinner lifts.

Compaction control of the imported fills discussed above could be carried out using a nuclear surface moisture-density gauge, in accordance with AS 1289.5.8. Alternatively, assessment with a Perth sand penetrometer (PSP) or dynamic cone penetrometer (DCP) by a geotechnical engineer for granular and cohesive fill respectively, could supplement or reduce the testing frequency for nuclear density testing.

7.3 Batter Slopes

It is recommended that batter slopes in soils (Unit 1) and very low strength (typically fragmented) rock are not steeper than:

- 1.5H:1V (horizontal:vertical) for temporary excavations; and
- 2H:1V for permanent slopes.

For excavations creating slopes up to 4 m high in stronger rock, a batter slope not steeper than 0.5H:1V for temporary cutting and 1H:1V for permanent cutting are recommended. Steeper slopes might be achievable during construction following assessment of the exposed rock and acceptance by an experienced geotechnical engineer during the earthworks, however, the above values are recommended for planning and design. It should be noted that stability of slopes in rock will be governed by a combination of rock strength, joint spacing and joint orientation.

If loads are applied at the top of the batter (for example, excavated soil, equipment or permanent structures), or if there is any groundwater influence, then a site specific assessment of stability should be undertaken.

7.4 Excavation Conditions

Excavations on site will encounter predominantly very dense colluvial soils overlying high strength granite. Standard excavation equipment such as tracked excavators are considered appropriate for the soils. Rock excavation, if required, will at a minimum require large excavators with rock breaking attachments, noting the 20 tonne excavator utilised for the investigation typically refused within 0.1 m to 0.3 m of the top of rock.

Information on the rock strength and fracturing pertinent to large scale excavation is not available from the present mode of investigation. If significant excavation into rock is proposed it is recommended that further investigation utilising boreholes is considered. Based on the high to extremely high strength of the rock and typical fracturing for this rock type blasting may be required for bulk excavations.

7.5 Soil Classification for Earthquake Design

Ground conditions encountered beneath the site generally comprise dense to very dense colluvial soils overlying high strength rock.

It is considered that an earthquake design soil sub-class of B_e is appropriate for this site in accordance with AS 1170.4-2007.

The project location is allocated an Earthquake Hazard Factor (Z) of 0.09, and a probability factor (k_p) of 1.0 based on an event with a recurrence interval of greater than 1 every 500 years, in accordance with AS 1170.4-2007.

7.6 Foundation Design

Lateral and uplift loads are anticipated to govern the pile design rather than the normal compressive loads that the foundation system will support for the proposed solar arrays. Resisting uplift forces will require either shallow footings of suitable weight or else anchored into the rock, or piers (typically posts grouted or concreted in drilled holes) with suitable embedment into the underlying soil and rock.

7.6.1 Shallow Foundation Design

Shallow foundation systems comprising slab, pad and strip footings will be suitable at this site for proposed buildings and structures. Shallow footings could be founded on either soil (colluvial soils of Unit 1 or structural fill) or rock (Unit 2), however it is recommended that differential settlement is minimised by ensuring all footings for each structure are founded into the same material.

Shallow foundation systems founded in soil at a depth of 0.5 m or greater below surrounding finished level, should be suitable to support the allowable bearing pressures shown in the Table 7.

Table 7: Recommended Net Allowable Bearing Pressure for Shallow Footings on Granular Soil

Footing Type and Size (m)		Net Allowable Bearing Pressure (kPa)	
		For settlement up to 10 mm	For settlement up to 25 mm
Pad	1.0	280[1]	280[1]
	2.0	260	370[1]
	3.0	200	380[1]
Strip	0.5	200[1]	200[1]
	1.0	240	250[1]
	1.5	200	310[1]

Note [1]: These allowable net bearing pressures are controlled by soil failure criteria (rather than settlement criteria) using a factor of safety of 2.5.

Recommended bearing pressures provided in Table 7 are applicable for footings founded in fill or within natural soils provided site preparation is undertaken as per the comments in Section 7.2.

An allowable bearing pressure of 1000 kPa is recommended for shallow footings founded directly on medium strength or stronger rock. Footing excavations should be inspected by a geotechnical engineer to confirm that the ground conditions encountered during construction meets design assumptions. Footing in weaker rock, typically in extremely weathered rock, should be designed based on the values in Table 7.

Most of the settlement included in Table 7 is anticipated to occur during first loading. Differential settlement for footings founded in similar ground (ie all in in-situ soil or all in fill) is expected to be no greater than half the total estimated settlement. Settlement in rock is estimated to be less than 1% of the footing maximum size.

A deep foundation system discussed in Section 7.6.2 is considered the most likely suitable foundation system for solar arrays at this site, however, a ballast foundation system (e.g. in situ poured shallow footings) could be considered for the proposed solar arrays provided uplift forces can be addressed in the design, using either sufficient concrete weight or rock anchors.

7.6.2 Piled Foundations

7.6.2.1 Construction

Owing to the occurrence of shallow rock, bored piles (such as posts grouted or concreted in drilled holes) are considered the most suitable deep foundation system for proposed solar arrays if a shallow ballast option (i.e. shallow footing) is not preferred.

It is suggested that casing for the overlying colluvial soils could likely be avoided, however provision for casing (or other pile hole support) by the contractor is considered prudent.

It is anticipated that uplift resistance (tension) will be a governing factor in design of pile lengths and therefore, logging the ground conditions at the pile locations during construction is recommended to confirm design assumptions.

7.6.2.2 Pile Design Parameters and Preliminary Pile Dimensions

The ultimate parameters shown in Table 8 are suggested for the design of bored piles subject to vertical compressive and uplift loads, with pile length to diameter ratios of at least four into the targeted bearing layer.

The shaft adhesion should be assumed to be null within 0.5 m of the ground surface owing to ground disturbance during construction.

Ground failure by ‘cone pull-out’ mechanism, of the inverted cone of soil or fragmented rock around the pile should also be assessed for short piles resisting tension loads, such as the piles for proposed solar arrays. This mode of failure should be considered as well as the possibility of failure along the rock/pile grout interface. A 60° included angle is recommended for the inverted cone within the encountered shallow colluvial soil and granite. Soil and rock bulk weight indicated in Table 10 (Section 7.6.2.3) can be adopted to derive the cone weight.

Table 8: Ultimate Unfactored Design Parameters - Bored Piles (Cast In Situ)

Unit	Material	Indicative UCS (MPa)	Ultimate Unfactored Pressure (kPa)		
			End Bearing f_b	Average Skin Friction $f_{m,s}$	
				Compression	Tension
Unit 1	Colluvial Soils (sandy gravel)	NA	600	10[1]	8[1]
Unit 2	Extremely weathered granite (up to very low strength rock)	<2	1,800	60[1]	50[1]
	Granite (low strength)	2-6	8,000	250	200
	Granite (medium strength)	6-20	12,000	450	350
	Granite (high strength or stronger)	>20	20,000	850	675

Notes: [1] value applicable deeper than 0.5 m. Shallower soils and extremely weathered granite assumed to be disturbed during the boring process and therefore are recommended to be assumed to not contribute to uplift resistance.

Based on completed similar prior projects it is understood that vertical posts for the panel arrays may be grouted into 200 mm diameter bored holes drilled either 1.2 m, 2.0 m and 2.3 m deep. Based on a 200 mm pile diameter, Table 9 provides indicative unfactored ultimate capacity for the proposed piles in both compression and tension. These calculations suggest that some embedment into rock will likely be required.

Two scenarios are provided in Table 9:

- Scenario 1: piles are entirely founded into either colluvial soils and/or extremely weathered granite (of varied strengths between soil strength to very low rock strength). This scenario is suggested to be assumed site-wide, because it covers the worst ground conditions encountered across the site.
- Scenario 2: piles penetrate some underlying bedrock of medium strength and stronger. Additional pile capacity resulting from penetrating strong bedrock is provided under this scenario, to consider the opportunity to shorten piles during construction if strong bedrock is encountered at a shallow depth. With reference to Table 8 and limited information on rock gradation with depth, it is suggested that "*medium strength*" granite is assumed as a site-wide conservative assumption on shallow rock strength for pile design purpose for the proposed solar arrays.

Table 9: Unfactored[1] Ultimate Pile Capacities - 200 mm Diameter Bored Piles (Cast In Situ)

Pile Length (m)	Scenario 1 Ultimate unfactored[1] pile capacity in colluvial soils and extremely weathered granite (up to very low strength) (kN)		Scenario 2 Additional pile capacity over ultimate unfactored pile capacity (Scenario 1) if pile extends into medium strength and stronger rock (kN)	
	Compression	Tension [2] = Min {pile shaft friction in tension; weight of inverted cone of ground}	Compression	Tension(3)
1.2	22 kN	Min{4;12}=4 kN	Add 275 kN + 279 kN per metre of pile into rock	45
2.0	27 kN	Min{8;56}=8 kN		56
2.3	29 kN	Min{9;85)=9 kN		85

Notes to Table 9:

[1] The ultimate pile capacity values in Table 10 are unfactored and therefore need to be multiplied by a suitable geotechnical strength reduction factor (ϕ_g) in accordance with AS2159 to derive a design ultimate pile capacity (design geotechnical strength $R_{d,ug}$ in AS2159 terminology). Geotechnical strength reduction factors (ϕ_g) are further discussed in the text below.

[2] The pile capacity in tension is the minimum between the resistance from the pile shaft friction in tension and the weight of the inverted cone of ground resisting a 'cone pull out' failure.

[3] Assumes minimum 0.5 m into rock and therefore cone pull out is the controlling failure mechanism in tension for short piles, resulting in significantly lower pile tension capacities than considering the criteria about pile shaft friction alone, noting the average shaft friction in medium strength stronger and rock is 220 kN per metre length of pile assuming a 200 mm diameter pile. For less than 0.5 m embedment, use scenario 1.

A preliminary basic geotechnical strength reduction factor (ϕ_g) of 0.48 is recommended for limit state design of piles in accordance with AS 2159 – 2009. This is based on the data presented in this report, the method of soil strength assessment used in this investigation and after assessing the overall design average risk rating (ARR) for the site, design and installation risk factors anticipated for a low redundancy piling system. Higher values of ϕ_g may be applied if additional investigation is carried out at the site, or higher geotechnical strength reduction factor (ϕ_g) may be adopted if selected piles are subjected to confirmatory load testing. The pile designer should ultimately assess this factor ϕ_g in accordance with AS2159 at detailed design, based on the knowledge about pile design, pile installation and pile testing available at that stage.

7.6.2.3 Lateral Load

The response of piles to lateral load can be assessed using p-y curves, elastic continuum or finite element methods, using the design parameters in Table 10.

Lateral capacity of piles can also be estimated using Broms' Theory and the parameters indicated in Table 10. Information on the use of the parameters given in Table 10 is given in Appendix E, in order to calculate the lateral capacity and lateral deflection of piles.

Table 10: Ultimate Unfactored Lateral Design Parameters

Unit	Material	Unit Weight (kN/m^3)	Soil Undrained Cohesion, Cu (kPa)	Soil Angle of Friction (°)	Passive Earth Pressure Coefficient K_p	Ultimate Passive Pressure (kPa)
Unit 1	Colluvial Soils (sandy gravel)	20	0	40	4.5	-
Unit 2	Granite Extremely weathered	22	200	0	2.5	-
	Granite (very low to low strength)	25	N/A	N/A	-	400
	Granite (medium strength and stronger)	25	N/A	N/A	-	6,000

It should also be noted that the above parameters regarding passive earth pressure coefficients and values (two last columns of Table 10) are ultimate values and do not incorporate a factor of safety. Because the stress-strain relationship curve for lateral loading is not linear, relatively large strains are required to mobilise full passive pressure but only relatively small strains are required to mobilise half the passive pressure, therefore it would be prudent to incorporate a factor of safety of at least two, to derive design values from the ultimate values.

As for vertical loading, the upper 0.5 m depth of soil should be ignored due disturbance during installation.

7.6.2.4 Pile and Soil Jacking

Soil jacking is a heave phenomenon that occurs in reactive clay profiles in areas with significant seasonal soil moisture variations. Uplift is generated on the shaft of piles over the upper part of the soil profile when soil swelling occurs during the latter part of the wetting part of the shrink-swell moisture change cycle. Where the piles are not of sufficient depth, the piles can be 'jacked' upwards over several seasons.

Owing to the mostly granular nature of the soils and the low reactivity of the limited fines component, pile jacking is not considered to form a risk at this site.

It is noted that shrink-swell index testing could not be undertaken owing to the gravelly nature of the soils that prevented suitable sampling. Indicatively, correlation with laboratory testing results on Atterberg limits and considering the low fines content of the encountered soils, the shrink-swell index (Iss) for the shallow soils is inferred to be marginal and with an upper bound in the order of 0.1% to 0.2%. Based on previous experience by Douglas Partners, the potential swell pressure for a soil may be crudely estimated as 100 times the Iss value (in kPa). For the typical Iss values given above and considering the relatively low fines content of the soils, upper bound swell pressures of less than 10 kPa for the surface soils could be considered for preliminary design purposes if required.

7.6.3 Rock Anchors

Passive anchors are discussed in this section in the event they are proposed to resist uplift in proposed pads or strip footings. The geotechnical modes of failure of anchors include grout/rock failure and 'cone pull-out' failure (the other two non-geotechnical modes are strand failure and grout/strand failure). A minimum bond length of 3 m is generally recommended for anchors. Owing to the shallow depth of the rock across the site, it is suggested that the bond length of proposed anchors targets the bedrock.

With regards to grout/rock failure, a preliminary average ultimate bond stress value $f_{d,ug}$ of 450 kPa is considered appropriate at the grout-rock interface over the bond length of the anchors in highly to slightly weathered, medium strength and stronger bedrock inferred to be underlying the site, and a $f_{d,ug}$ of 60 kPa is recommended in extremely weathered bedrock of very low strength. These values could potentially be increased subject to the results of on site load testing, if considered warranted. As mentioned in section 7.6.2.2 a geotechnical strength reduction factor of 0.48 is considered appropriate. Given the limited information presently available on rock gradation with depth, should rock anchors be proposed geotechnical boreholes would need to be drilled into the rock to confirm the properties applicable to the rock anchors. Also, logging the rock conditions by a geotechnical engineer during the drilling for rock anchors is recommended to confirm that the ground conditions encountered during construction meet design assumptions. Bond stresses are highly dependent on contractor skill and drilling technique. The aforementioned values are suggested for preliminary sizing and the actual capacity is best evaluated by proof testing of installed anchors on site.

To check against failure of the ground from a 'cone pull-out' failure, a 60 degree included angle is recommended within the encountered shallow colluvial soil and generally fractured to fragmented bedrock. Soil and rock bulk weight indicated in Table 10 can be adopted to derive the cone weight. Possible anchor interaction (possible intersections of cones) should be considered in the event of adjacent anchors.

7.7 External Pavements

The subgrade material external pavements is expected to typically comprise dense to very dense sandy gravel colluvium. Based on the results of laboratory testing and similar materials, a design CBR value of 10 %, or a modulus of subgrade reaction of 52 kPa/mm is suggested. These values should not be adopted for other than wheel loading without first confirming their suitability with DP.

Prior to construction of the pavement, the exposed subgrade should be proof rolled using a 6 t/m width static weight roller and a minimum of 6 passes to observe the subgrade deflection and check for soft spots. Zones that undergo excessive deflection or are unstable would require additional treatment, the extent of which is best assessed at the time of construction. The treatment may involve further compaction or removal and replacement with controlled fill.

7.8 Soil Aggressivity

Results of the testing performed on samples for pH, chloride and sulfate ion concentrations, were compared with the exposure classifications in AS 2159 – 2009. The results indicate a mild classification for concrete and non-aggressive for steel within soils above groundwater.

7.9 Thermal Resistivity

The results of the in situ thermal resistivity testing were considered to be broadly consistent with laboratory analysis on samples prepared to emulate in situ conditions.

Laboratory testing was undertaken between soil moisture contents approximately of 0% and 8% to match the typical moisture content encountered in the field at the time of the investigation. Moisture condition measurements were not recorded in the field, however, where both in situ and laboratory data was available the results showed the best correlation between the soil moisture content range of approximately 0% to 3%.

In situ test results indicate resistivity values of between 0.661 K.m/W and 2.311 K.m/W for soils tested on site. Adopted design values should consider both the natural variation observed based on the soil composition as well as the likely soil moisture conditions expected to be experienced during the design life of the structures.

7.10 Proposed Further Testing

Based on the information collected as part of the ground investigation and our understanding of the proposed development, further information on the following could possibly be beneficial to the project to increase the understanding of the ground conditions at the site:

- Undertake borehole drilling to obtain more information on the rock profile, typical strength and fracturing. This would assist in better estimating the likely rock socket material properties for pile design, anchor design, excavatability assessment and equipment requirements for the piling contractor.
- Installation of groundwater monitoring wells. While no groundwater observations were noted during the investigation the installation of groundwater monitoring wells to confirm this to a depth of the likely foundations would reduce construction and material durability risks for the project.

8. References

1. AS 3798-2007, *Guidelines on Earthworks for Commercial and Residential Developments*, Standards Australia
2. AS 1289-2000, *Methods of Testing Soils for Engineering Purposes*, Standards Australia
3. AS 1289.6.3.2:1999, *Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Dynamic Cone Penetrometer Test,* Standards Australia
4. AS 1726-2017, *Geotechnical Site Investigation*, Standards Australia
5. IEEE 422:2017, *Guide for Thermal Resistivity Measurements of Soils and Backfilled Materials*, IEEE Standards Association
6. ASTM D5334-14, *Standard Test Method for Determination of Thermal Conductivity of Soil and Soft Rock by Thermal Needle Probe Procedure*, ASTM International

7. AS 2159-2009, *Piling – Design and Installation*, Standards Australia

9. Limitations

Douglas Partners (DP) has prepared this report (or services) for this project at Darlot Road, Mullewa, WA in accordance with DP's proposal dated 19 April 2023 and acceptance received via a signed services order by Neil Canby on behalf Sunrise Energy Group Pty Ltd dated 24 April 2023. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Sunrise Energy Group Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations.

The assessment of atypical safety hazards arising from this advice is restricted to the geotechnical components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd

Appendix A

About This Report

Soil Descriptions

Douglas Partners

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

The soil group symbol classifications are given as follows based on two major soil divisions:

- Coarse-grained soils
- Fine-grained soils

<table>
<tr><th colspan="4" rowspan="2">Major Divisions</th><th colspan="2">Description</th></tr>
<tr><th>Group Symbol*</th><th>Typical Name</th></tr>
<tr><td rowspan="8">COARSE-GRAINED SOILS</td><td rowspan="8">More than 65% by dry mass, (excluding that larger than 63 mm) is greater than 0.075 mm</td><td rowspan="2">GRAVEL</td><td rowspan="4">More than 50% of coarse grains are greater than 2.36 mm</td><td>GW</td><td>Well graded gravels and gravel-sand mixtures, little or no fines.</td></tr>
<tr><td>GP</td><td>Poorly graded gravels and gravel-sand mixtures, little or no fines.</td></tr>
<tr><td rowspan="2">GRAVELLY SOILS</td><td>GM</td><td>Silty gravels, gravel-sand-silt mixtures.</td></tr>
<tr><td>GC</td><td>Clay gravels, gravel-sand-clay mixtures.</td></tr>
<tr><td rowspan="2">SAND</td><td rowspan="4">More than 50% of coarse grains are less than 2.36 mm</td><td>SW</td><td>Well graded sands and gravelly sands, little or no fines.</td></tr>
<tr><td>SP</td><td>Poorly graded sands and gravelly sands, little or no fines.</td></tr>
<tr><td rowspan="2">SANDY SOILS</td><td>SM</td><td>Silty sand, sand-silt mixtures.</td></tr>
<tr><td>SC</td><td>Clayey sands, sand-clay mixtures.</td></tr>
</table>

* For coarse grained soils where the fines content is between 5% and 12%, the soil shall be given a dual classification eg GP-GM.

<table>
<tr><td rowspan="7">FINE-GRAINED SOILS</td><td rowspan="7">More than 35% by dry mass, (excluding that larger than 63 mm) is less than 0.075 mm</td><td rowspan="3">Liquid Limit less than 35%</td><td>ML</td><td>Inorganic silts, very fine sands, rock flour, silty or clayey fine sands.</td></tr>
<tr><td>CL</td><td>Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.</td></tr>
<tr><td>OL</td><td>Organic silts and organic silty clays of low plasticity</td></tr>
<tr><td>35% <LL< 50%</td><td>CI</td><td>Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.</td></tr>
<tr><td rowspan="3">Liquid Limit greater than 50%</td><td>MH</td><td>Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts.</td></tr>
<tr><td>CH</td><td>Inorganic clays of high plasticity, fat clays.</td></tr>
<tr><td>OH</td><td>Organic clays of medium to high plasticity.</td></tr>
<tr><td colspan="3"></td><td>Pt</td><td>Peat muck and other highly organic soils.</td></tr>
</table>

Soil Descriptions

Douglas Partners

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

The proportions of secondary constituents of soils are described as follows:

In fine grained soils (>35% fines)

Term	Proportion of sand or gravel	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	>30%	Sandy Clay
With	15 – 30%	Clay with sand
Trace	0 - 15%	Clay with trace sand

In coarse grained soils (>65% coarse)
- with clays or silts

Term	Proportion of fines	Example
And	Specify	Sand (70%) and Clay (30%)
Adjective	>12%	Clayey Sand
With	5 - 12%	Sand with clay
Trace	0 - 5%	Sand with trace clay

In coarse grained soils (>65% coarse)
- with coarser fraction

Term	Proportion of coarser fraction	Example
And	Specify	Sand (60%) and Gravel (40%)
Adjective	>30%	Gravelly Sand
With	15 - 30%	Sand with gravel
Trace	0 - 15%	Sand with trace gravel

The presence of cobbles and boulders shall be specifically noted by beginning the description with 'Mix of Soil and Cobbles/Boulders' with the word order indicating the dominant first and the proportion of cobbles and boulders described together.

Soil Descriptions

Douglas Partners

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	VS	<12
Soft	S	12 - 25
Firm	F	25 - 50
Stiff	St	50 - 100
Very stiff	VSt	100 - 200
Hard	H	>200
Friable	Fr	-

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	Density Index (%)
Very loose	VL	<15
Loose	L	15-35
Medium dense	MD	35-65
Dense	D	65-85
Very dense	VD	>85

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Extremely weathered material – formed from in-situ weathering of geological formations. Has soil strength but retains the structure or fabric of the parent rock;
- Alluvial soil – deposited by streams and rivers;
- Estuarine soil – deposited in coastal estuaries;
- Marine soil – deposited in a marine environment;
- Lacustrine soil – deposited in freshwater lakes;
- Aeolian soil – carried and deposited by wind;
- Colluvial soil – soil and rock debris transported down slopes by gravity;
- Topsoil – mantle of surface soil, often with high levels of organic material.
- Fill – any material which has been moved by man.

Moisture Condition – Coarse Grained Soils

For coarse grained soils the moisture condition should be described by appearance and feel using the following terms:

- Dry (D) Non-cohesive and free-running.
- Moist (M) Soil feels cool, darkened in colour.
  Soil tends to stick together.
  Sand forms weak ball but breaks easily.
- Wet (W) Soil feels cool, darkened in colour.
  Soil tends to stick together, free water forms when handling.

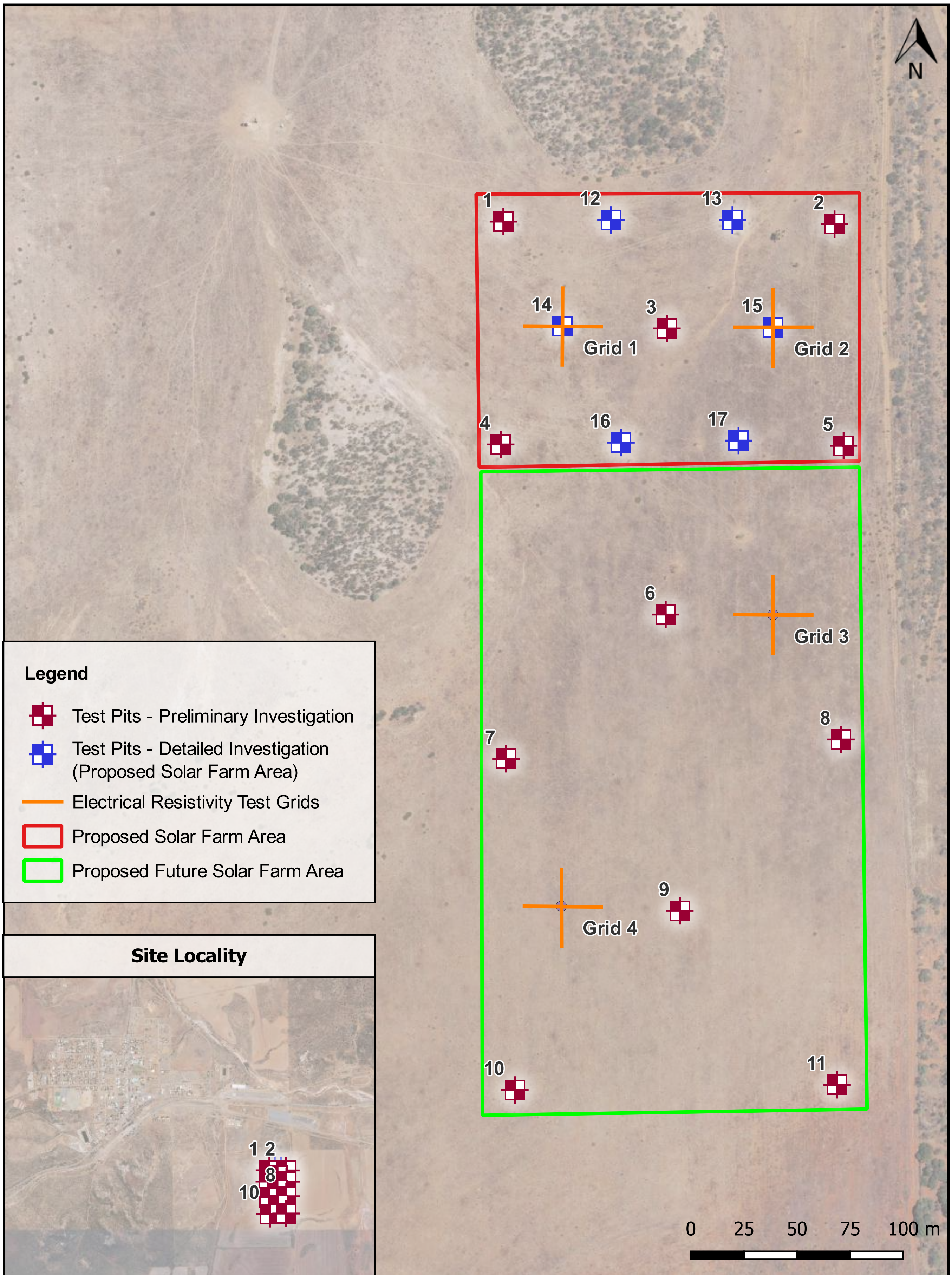
Moisture Condition – Fine Grained Soils

For fine grained soils the assessment of moisture content is relative to their plastic limit or liquid limit, as follows:

- 'Moist, dry of plastic limit' or 'w <PL' (i.e. hard and friable or powdery).
- 'Moist, near plastic limit' or 'w ≈ PL (i.e. soil can be moulded at moisture content approximately equal to the plastic limit).
- 'Moist, wet of plastic limit' or 'w >PL' (i.e. soils usually weakened and free water forms on the hands when handling).
- 'Wet' or 'w ≈LL' (i.e. near the liquid limit).
- 'Wet' or 'w >LL' (i.e. wet of the liquid limit).

Appendix B

Test Location Plan



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Geotechnics / Environment / Groundwater

Site and Test Locations

Project: Proposed Microgrid Solar Farm

Location: Darlot Road, Mullewa, WA

CLIENT: Sunrise Energy Pty Ltd

PROJECT:	222100.00
Drawing No:	1
REV:	0
DATE:	6/6/2023

Appendix C

Results of Field Work

TEST PIT LOG

CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 279 m AHD*
EASTING: 355748
NORTHING: 6841408

PIT No: 1
PROJECT No: 222100.00
DATE: 23/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
		Gravelly SAND SP-SM: fine to medium grained, brown to orange-brown, fine to medium sub-rounded to sub-angular laterite gravel, with silt, dry to moist, very dense, colluvial.		D	0.3				>>
	0.55	GRANITE: fine grained, pale grey-brown, moderately weathered, high strength.		D	0.6		rock sample		
	0.65	Pit discontinued at 0.65m ; hard refusal							
	1								
	2								

RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket **LOGGED:** VH **SURVEY DATUM:** MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

TEST PIT LOG

CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 280m AHD*
EASTING: 355904
NORTHING: 6841406

PIT No: 2
PROJECT No: 222100.00
DATE: 23/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		Silty SAND SM: fine to medium grained, brown, low plasticity silt, with gravel, dry to moist, very dense, topsoil.							
	0.2	Silty Sandy GRAVEL GM: fine to coarse sub-angular to angular laterite, orange-brown, fine to coarse grained sand, low plasticity silt, dry to moist, very dense, colluvial.			0.6		Thermal Resistivity Test		>>
	1.2	GRANITE: fine-grained, pale grey-brown mottled off-white and red-brown, moderately to highly weathered, high to very high strength with ferruginous deposits.		D	1.25		rock sample		
	1.3	Pit discontinued at 1.3m ; hard refusal							

RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket **LOGGED:** VH **SURVEY DATUM:** MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 281 m AHD*
EASTING: 355825
NORTHING: 6841357

PIT No: 3
PROJECT No: 222100.00
DATE: 23/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
		Silty Sandy GRAVEL GM: fine to coarse sub-angular to angular siltstone, orange-brown, fine to coarse grained sand, low plasticity silt, dry to moist, very dense, colluvial.			0.6		Thermal Resistivity Test		
	1								1
	1.4	GRANITE: fine-grained, pale grey-brown mottled off-white and red-brown, moderately to highly weathered, medium to high strength with ferruginous deposits.		D	1.5		rock sample		
	1.7	Pit discontinued at 1.7m ; effective refusal							
	2								

RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket
LOGGED: VH
SURVEY DATUM: MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

TEST PIT LOG

CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 282 m AHD*
EASTING: 355746
NORTHING: 6841303

PIT No: 4
PROJECT No: 222100.00
DATE: 23/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		Clayey Gravelly SAND SC: fine to medium grained, brown, medium plasticity clay, fine to medium sub-angular to sub-rounded laterite gravel, dry to moist, very dense, topsoil.		D	0.2				>>
	0.3	Clayey Sandy GRAVEL GC: fine to coarse sub-angular to angular laterite gravel, orange-brown, fine to coarse grained sand, low plasticity clay, dry to moist, colluvial.			0.6		Thermal Resistivity Test		
				D	0.8				
1	1.0	GRANITE: fine-grained, off-white, red-brown and yellow-brown mottled, highly weathered to extremely weathered, very low to low strength, with quartz veins.		D	1.2		rock sample		
	1.35	Pit discontinued at 1.35m ; effective refusal							
2									

RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket
LOGGED: VH
SURVEY DATUM: MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 281 m AHD*
EASTING: 355908
NORTHING: 6841303

PIT No: 5
PROJECT No: 222100.00
DATE: 23/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	Silty SAND SM: fine to medium grained, brown, low plasticity silt, with gravel, dry to moist, very dense, topsoil.							>>
		Sandy GRAVEL GP-GM: fine to coarse sub-angular to angular laterite, orange-brown, fine to medium grained sand, with low plasticity silt, dry to moist, very dense, colluvial.		B	0.5				
	1								
	2								
	2.15	GRANITE: fine-grained, off-white, red-brown and yellow-brown mottled, highly to extremely weathered, very low to medium strength.		D	2.2		rock sample		
	2.4	Pit discontinued at 2.4m ; effective refusal							

RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket **LOGGED:** VH **SURVEY DATUM:** MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

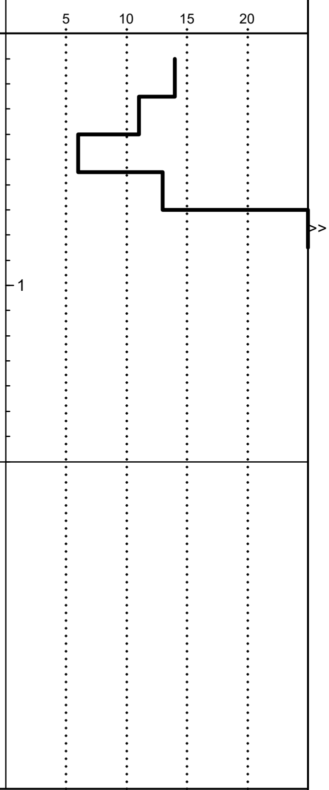
CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 283 m AHD*
EASTING: 355824
NORTHING: 6841223

PIT No: 6
PROJECT No: 222100.00
DATE: 23/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
	0.2	Silty SAND SM: fine to medium grained, brown, low plasticity silt, with fine sub-rounded gravel, dry to moist, topsoil.						
		Silty Sandy GRAVEL GM: fine to coarse sub-angular to angular laterite gravel with coarse quartz gravel, orange-brown, fine to medium grained sand, low plasticity silt, dry to moist, colluvial.			0.6		Thermal Resistivity Test	
	1.6							
	1.7	GRANITE: fine-grained, off-white, red-brown and yellow-brown mottled, highly weathered to extremely weathered, medium to high strength.		D	1.65		rock sample	
		Pit discontinued at 1.7m ; effective refusal						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket **LOGGED:** VH **SURVEY DATUM:** MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 285 m AHD*
EASTING: 355748
NORTHING: 6841155

PIT No: 7
PROJECT No: 222100.00
DATE: 23/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	Silty SAND SM: fine to medium grained, brown, low plasticity silt, with fine sub-rounded gravel, dry to moist, very dense, topsoil.							
		Sandy GRAVEL GP-GM: fine to medium sub-angular to sub-rounded laterite, orange-brown, fine to medium grained sand, trace silt and clay, dry to moist, very dense, colluvial.		D	0.5 0.6		Thermal Resistivity Test		
1									
	1.35	GRANITE: fine-grained, off-white, red-brown and yellow-brown mottled, highly weathered to extremely weathered, high to very high strength.		D	1.4		rock sample		
	1.5	Pit discontinued at 1.5m ; hard refusal							
2									

RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket **LOGGED:** VH **SURVEY DATUM:** MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

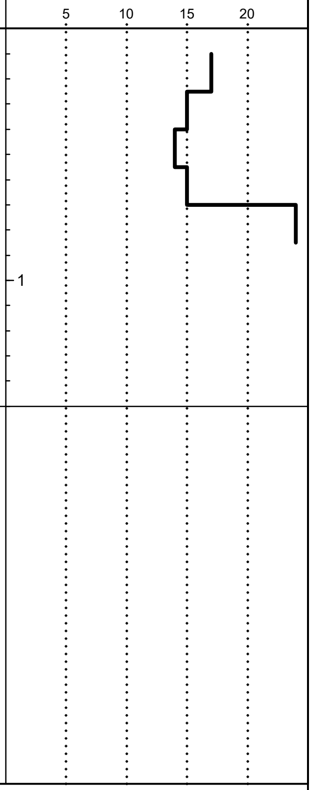
TEST PIT LOG

CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 283 m AHD*
EASTING: 355907
NORTHING: 6841164

PIT No: 8
PROJECT No: 222100.00
DATE: 23/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	Silty SAND SM: fine to medium grained, brown, low plasticity silt, with fine sub-rounded gravel, dry to moist, topsoil.							
		GRAVELGP-GM: fine to medium sub-angular to sub-rounded laterite, orange-brown, with fine to coarse grained sand, trace silt and clay, dry to moist, colluvial.		B	0.5 0.6		Thermal Resistivity Test		
	1								
	1.4 1.5	GRANITE: off-white mottled red-brown and yellow-brown, highly to extremely weathered, high to very high strength.		D	1.45		rock sample		
		Pit discontinued at 1.5m ; hard refusal							
	2								



RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket **LOGGED:** VH **SURVEY DATUM:** MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

TEST PIT LOG

CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 285 m AHD*
EASTING: 355831
NORTHING: 6841083

PIT No: 9
PROJECT No: 222100.00
DATE: 23/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
	0.1	Gravelly Silty SAND SM: fine to medium grained, brown, low plasticity silt, fine to medium sub-angular to sub-rounded laterite gravel, dry to moist, very dense, topsoil.							
		Silty GRAVEL GM: fine to medium sub-angular to sub-rounded laterite gravel with trace coarse angular quartz gravel, orange-brown, low plasticity sit, with fine to medium grained sand, dry to moist, very dense, colluvial.		B	0.5 0.6		Thermal Resisitivity Test		>>
	1								1
	1.45 1.5	GRANITE: off-white mottled red-brown and yellow-brown, highly to extremely weathered, high strength.							
		Pit discontinued at 1.5m ; hard refusal							
	2								

RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket **LOGGED:** VH **SURVEY DATUM:** MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 287 m AHD*
EASTING: 355753
NORTHING: 6840999

PIT No: 10
PROJECT No: 222100.00
DATE: 23/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	Gravelly Silty SAND SM: fine to medium grained, brown, low plasticity silt, fine to medium sub-angular to sub-rounded laterite gravel, dry to moist, very dense, topsoil.							>>
	1.35	Sandy GRAVEL GP-GM: fine to medium aub-angular to sub-rounded laterite, orange-brown, fine to coarse grained sand, trace silt and clay, dry to moist, colluvial.							
	1.45	GRANITE: fine-grained, pale grey-brown mottled off-white, moderately to highly weathered, high to very high strength with ferruginous deposits.		D	1.4		rock sample		
		Pit discontinued at 1.45m ; hard refusal							

RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket **LOGGED:** VH **SURVEY DATUM:** MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics | Environment | Groundwater

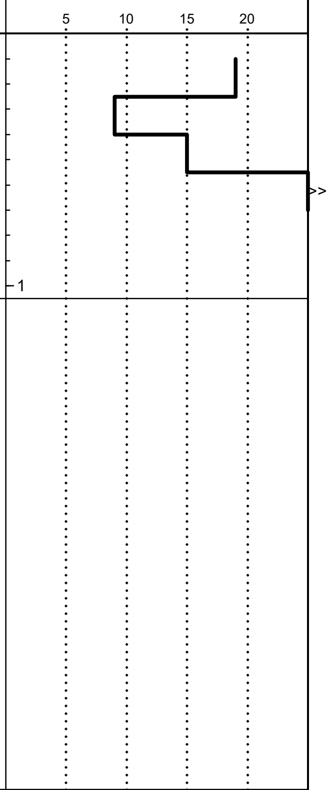
TEST PIT LOG

CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 284 m AHD*
EASTING: 355905
NORTHING: 6841001

PIT No: 11
PROJECT No: 222100.00
DATE: 23/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	Silty SAND SM: fine to medium grained, red-brown, low plasticity silt, with gravel, dry to moist, very dense, topsoil.							
		Silty SAND SM: fine to medium grained, red-brown, low plasticity silt, with gravel, dry to moist, very dense, colluvial.		B	0.5				
	0.6	Silty Gravelly SAND SM: fine to coarse grained sand, orange-brown, fine to medium sub-angular to sub-rounded laterite, low plasticity silt, trace clay, dry to moist, colluvial.			0.6		Thermal Resistivity Test		
1	0.95	GRANITE: off-white mottled red-brown and yellow-brown, highly to extremely weathered, medium strength with extremely high strength quartz veins more than 50mm thick.		D	1.0		rock sample		
	1.05	Pit discontinued at 1.05m ; hard refusal							
2									



RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket
LOGGED: VH
SURVEY DATUM: MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 279 m AHD*
EASTING: 355798
NORTHING: 6841408

PIT No: 12
PROJECT No: 222100.00
DATE: 24/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	SAND SP: fine to medium grained, brown, trace clay, dry to moist, very dense, topsoil.							>>
	1.25	Sandy GRAVEL GP-GM: fine to medium sub-angular to sub-rounded laterite gravel, orange-brown, fine to medium grained sand, trace silt and clay, dry to moist, very dense, colluvial. - granite at 0.6m depth in north end of test pit							
	1.4	GRANITE: fine grained, off-white mottled red-brown and yellow-brown, highly to extremely weathered, very low to low strength with ferruginous deposits.		D	1.3		rock sample		
		Pit discontinued at 1.4m ; effective refusal							

RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket **LOGGED:** VH **SURVEY DATUM:** MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

TEST PIT LOG

CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 280 m AHD*
EASTING: 355855
NORTHING: 6841408

PIT No: 13
PROJECT No: 222100.00
DATE: 24/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	Silty SAND SM: fine to medium grained, brown, low plasticity silt, with gravel, dry to moist, very dense, topsoil.							>>
	1	Silty Sandy GRAVEL GP-GM: fine to coarse sub-angular to sub-rounded laterite gravel, orange-brown, with low plasticity silt and fine to medium grained sand, dry to moist, very dense, colluvial.		B	0.5				
	1.15			D	1.2		rock sample		
	1.25	GRANITE: fine grained, pale grey-brown to off-white, moderately to highly weathered, high to very high strength.							
		Pit discontinued at 1.25m ; hard refusal							
	2								

RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket **LOGGED:** VH **SURVEY DATUM:** MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

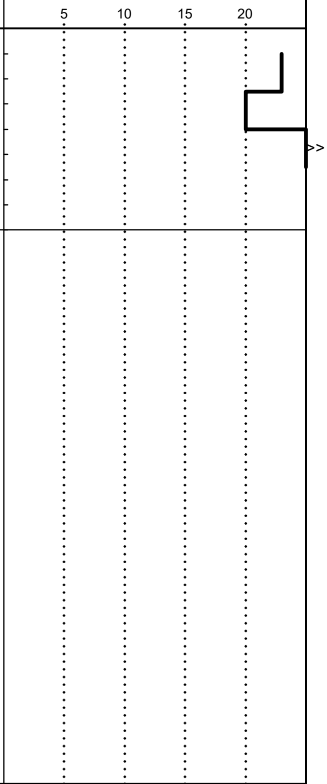
TEST PIT LOG

CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 280 m AHD*
EASTING: 355775
NORTHING: 6841359

PIT No: 14
PROJECT No: 222100.00
DATE: 24/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	Silty SAND SM: fine to medium grained, brown, low plasticity silt, with gravel, dry to moist, very dense, topsoil.							
	0.6	Clayey Sandy GRAVEL GC: fine to medium sub-angular to sub-rounded laterite gravel, orange-brown, fine to medium grained sand, low plasticity clay, dry to moist, very dense, colluvial.		B	0.5				
	0.8	GRANITE: fine grained, pale grey-brown to off-white, moderately to highly weathered, high to very high strength.		D	0.7		rock sample		
		Pit discontinued at 0.8m ; hard refusal							



RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket **LOGGED:** VH **SURVEY DATUM:** MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

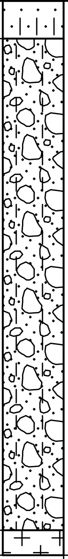
TEST PIT LOG

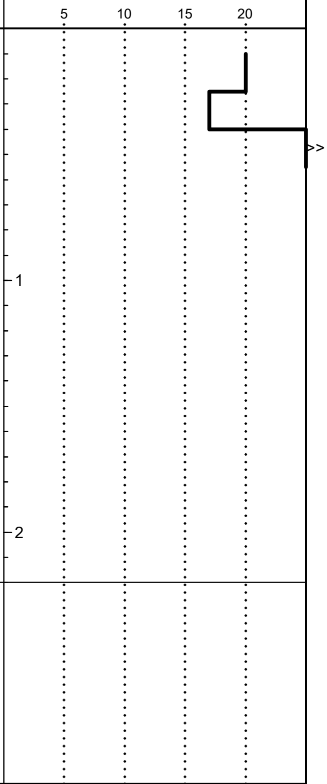
CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 281 m AHD*
EASTING: 355875
NORTHING: 6841358

PIT No: 15
PROJECT No: 222100.00
DATE: 24/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.15	Silty SAND SM: fine to medium grained, brown, low plasticity silt, with gravel, dry to moist, very dense, topsoil.							
1		Silty Sandy GRAVEL GM: fine to medium angular to sub-angular laterite gravel, orange-brown, low plasticity silt, fine to medium grained sand, dry to moist, colluvial.							
2	2.1			D	2.15		rock sample		
	2.2	GRANITE: fine-grained, off-white, red-brown and yellow-brown mottled, highly weathered to extremely weathered, medium strength, with quartz veins to more than 50mm thick.							
		Pit discontinued at 2.2m ; hard refusal							





RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket **LOGGED:** VH **SURVEY DATUM:** MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 282 m AHD*
EASTING: 355803
NORTHING: 6841304

PIT No: 16
PROJECT No: 222100.00
DATE: 24/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
	0.1	Gravelly Silty SAND SM: fine to medium grained, brown, low plasticity silt, fine to medium sub-angular to sub-rounded laterite gravel, dry to moist, very dense, topsoil.							>>
		Silty Sandy GRAVEL GM: fine to medium sub-angular to sub-rounded laterite gravel, orange-brown, fine to medium grained sand, low plasticity silt, dry to moist, very dense, colluvial.							
	0.9	GRANITE: off-white mottled red-brown and yellow-brown, highly to extremely weathered, high strength, with quartz veins more than 100mm thick.		D	0.95		rock sample		
1	1.0	Pit discontinued at 1.0m ; effective refusal							1
2									

RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket **LOGGED:** VH **SURVEY DATUM:** MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

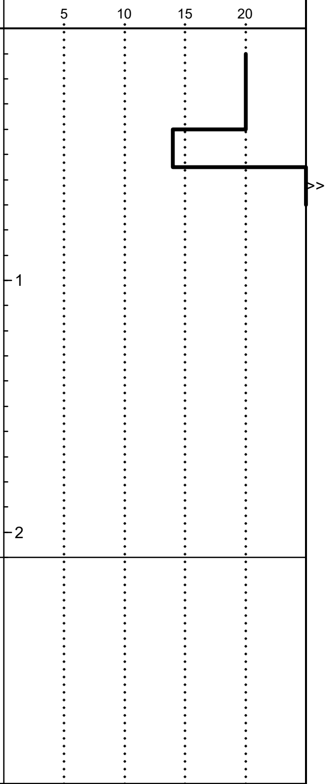
CLIENT: Sunrise Energy Pty Ltd
PROJECT: Proposed Mullewa Microgrid Solar Farm
LOCATION: Mullewa, WA

SURFACE LEVEL: 282 m AHD*
EASTING: 355858
NORTHING: 6841305

PIT No: 17
PROJECT No: 222100.00
DATE: 24/5/2023
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
	0.15	Silty SAND SM: fine to medium grained, brown, low plasticity silt, dry to moist, very dense, topsoil.						
1		Silty Sandy GRAVEL GM: fine to medium sub-angular to sub-rounded laterite gravel trace coarse angular quartz gravel, orange-brown, low plasticity silt, fine to medium grained sand, dry to moist, very dense, colluvial.						
2	1.95	GRANITE: off-white mottled red-brown and yellow-brown, highly to extremely weathered, high strength, with quartz veins more than 100mm thick.		D	2.0		rock sample	
	2.1	Pit discontinued at 2.1m ; effective refusal						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 20 tonne excavator fitted with a 750mm wide toothed bucket **LOGGED:** VH **SURVEY DATUM:** MGA94 Zone 50 J

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface levels derived from DPIRD 2 m contour intervals.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

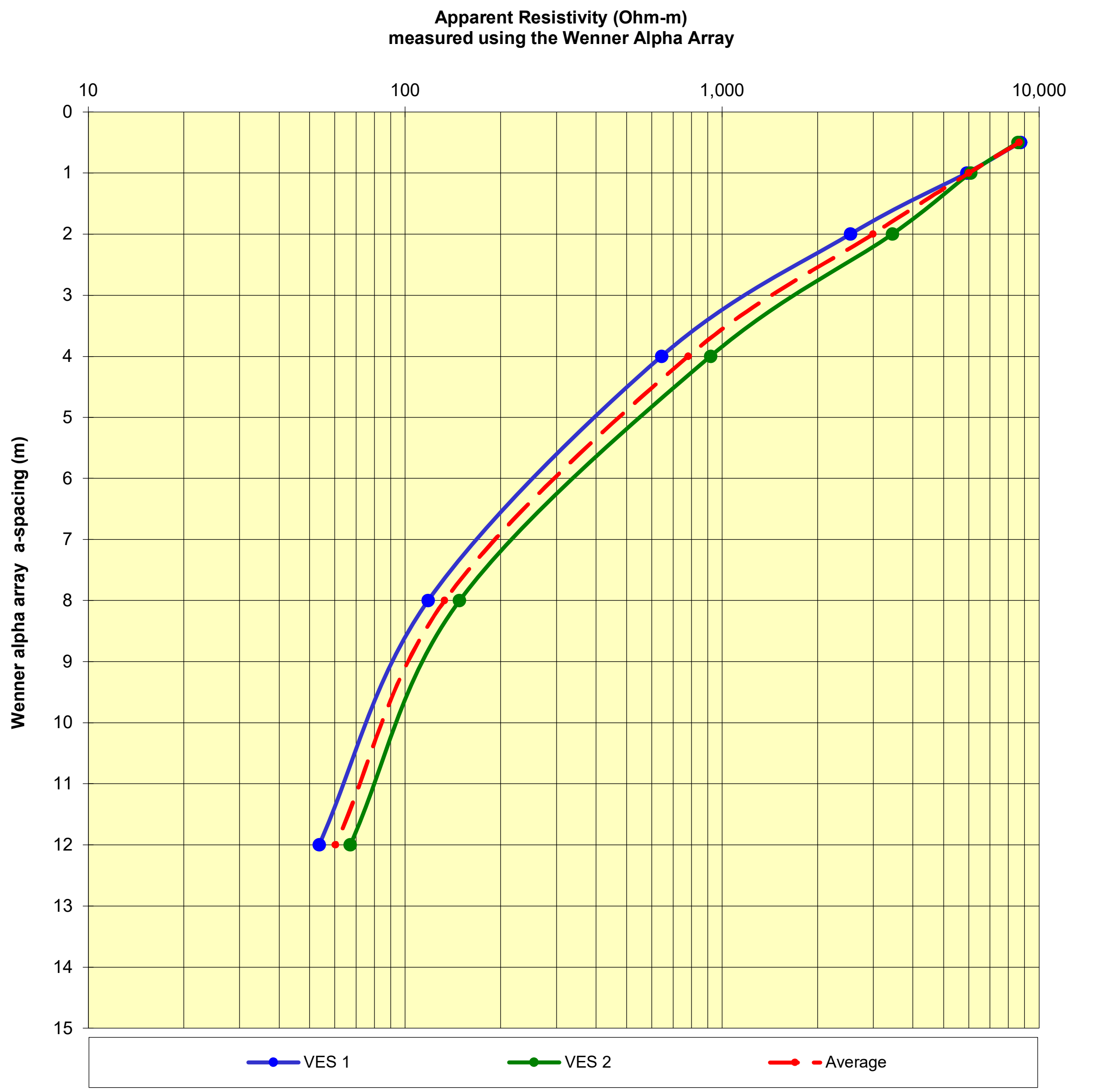
SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

Electrode a-spacing (m)	Resistance (R)			Apparent Resistivity (ρ_a = 2πaR)		
	VES 1 (Ω)	VES 2 (Ω)	Average (Ω)	VES 1 (Ω-m)	VES 2 (Ω-m)	Average (Ω-m)
0.5	2780.0	2730.0	2755.00	8733.6	8576.5	8655.1
1	942.0	968.0	955.00	5918.8	6082.1	6000.4
2	202.0	274.0	238.00	2538.4	3443.2	2990.8
4	25.6	36.6	31.10	643.4	919.9	781.6
8	2.4	3.0	2.65	118.1	148.3	133.2
12	0.7	0.9	0.80	53.5	67.1	60.3

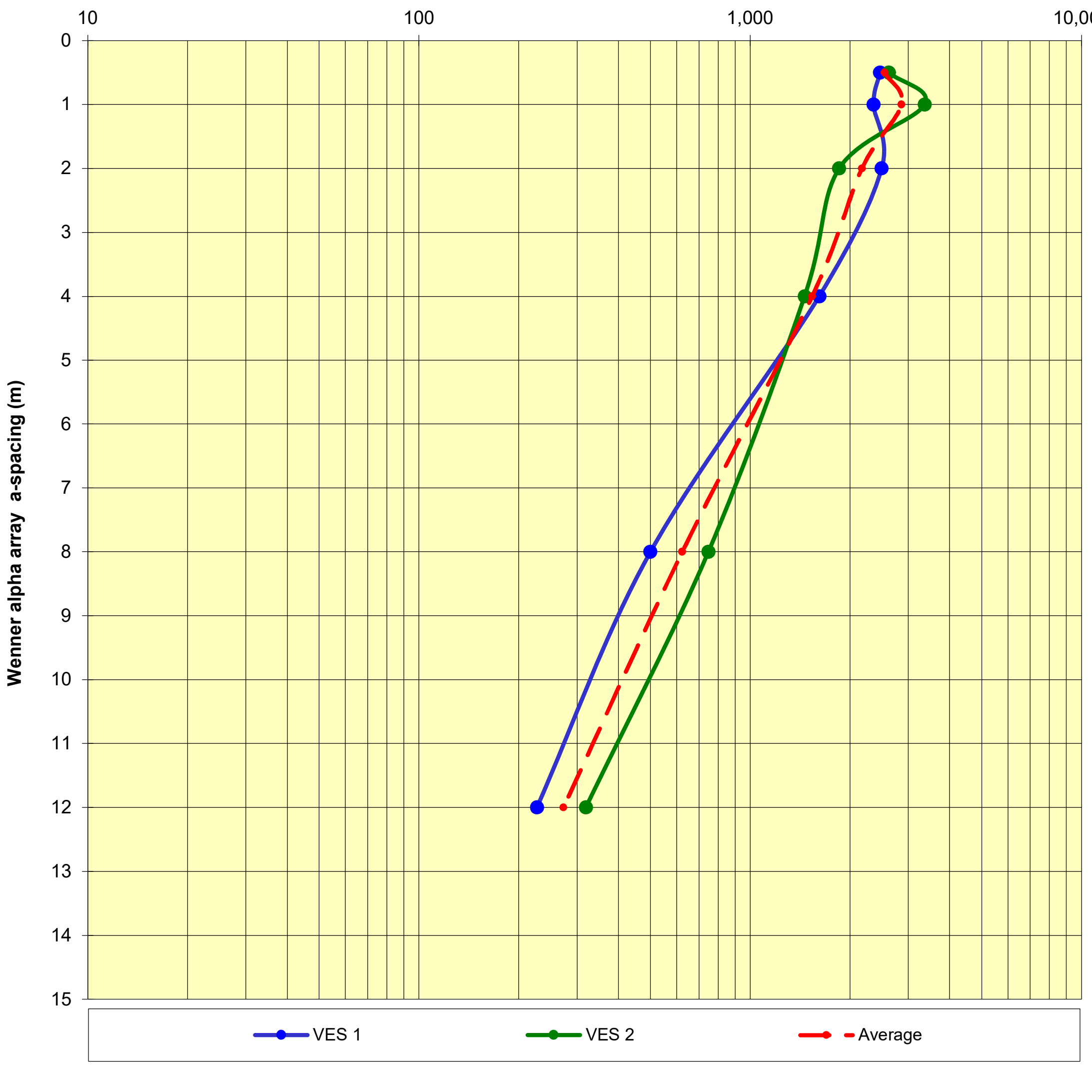
Location ID:	Grid 1	**Centre E, N:**	355 775 mE 6 841 359 mN GDA94 Zone 50
Orientations:	concentric orthogonal pair of arrays	**Instrument:**	ABEM LS2
Surface Description:	colluvium to 0.6 m depth over granite		



Douglas Partners Geotechnics / Environment / Groundwater	**Vertical Electrical Sounding (VES)**	PROJECT:	222100.00
	Proposed Mullewa Microgrid Solar Farm	DWG No:	ER1
		REV:	0
	CLIENT: Sunrise Energy Group Pty Ltd	DATE:	23 May 2023

Electrode a-spacing (m)	Resistance (R)			Apparent Resistivity (ρ_a = 2πaR)		
	VES 1 (Ω)	VES 2 (Ω)	Average (Ω)	VES 1 (Ω-m)	VES 2 (Ω-m)	Average (Ω-m)
0.5	785.0	833.0	809.00	2466.2	2616.9	2541.5
1	375.0	535.0	455.00	2356.2	3361.5	2858.8
2	198.3	147.7	173.00	2491.9	1856.1	2174.0
4	64.3	58.1	61.20	1616.0	1460.2	1538.1
8	9.9	14.9	12.41	499.1	748.0	623.5
12	3.0	4.2	3.62	226.9	318.9	272.9
Location ID:	Grid 2		**Centre E, N:**	355 875 mE 6 841 358 mN GDA94 Zone 50		
Orientations:	concentric orthogonal pair of arrays		**Instrument:**	ABEM LS2		
Surface Description:	colluvium to 2.1 m depth over granite					

Apparent Resistivity (Ohm-m)
measured using the Wenner Alpha Array

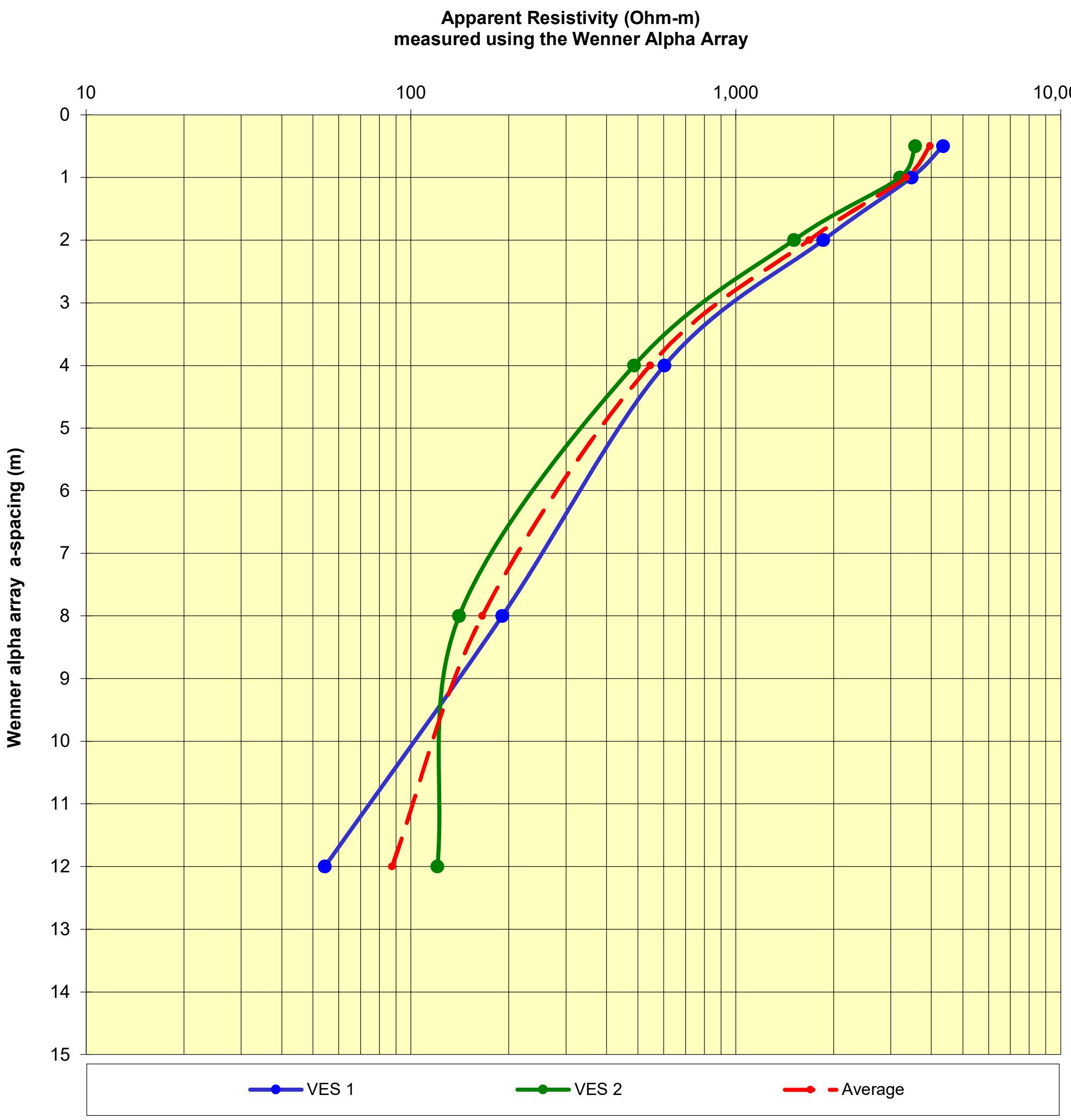


Douglas Partners
Geotechnics / Environment / Groundwater

Vertical Electrical Sounding (VES)		PROJECT:	222100.00
Proposed Mullewa Microgrid Solar Farm		DWG No:	ER2
		REV:	0
CLIENT:	Sunrise Energy Group Pty Ltd	DATE:	23 May 2023

Electrode a-spacing (m)	Resistance (R) VES 1 (Ω)	Resistance (R) VES 2 (Ω)	Resistance (R) Average (Ω)	Apparent Resistivity (ρ_a = 2πaR) VES 1 (Ω-m)	Apparent Resistivity VES 2 (Ω-m)	Apparent Resistivity Average (Ω-m)
0.5	1383.0	1135.0	1259.00	4344.8	3565.7	3955.3
1	553.0	510.0	531.50	3474.6	3204.4	3339.5
2	147.8	120.0	133.90	1857.3	1508.0	1682.6
4	24.0	19.4	21.68	603.2	486.3	544.8
8	3.8	2.8	3.30	191.0	140.7	165.9
12	0.7	1.6	1.16	54.3	120.6	87.5

Location ID:	Grid 3	**Centre E, N:**	355 873 mE 6 841 225 mN GDA94 Zone 50
Orientations:	concentric orthogonal pair of arrays	**Instrument:**	ABEM LS2
Surface Description:	colluvium to approximately 1.4 m to 1.6 m depth over granite		

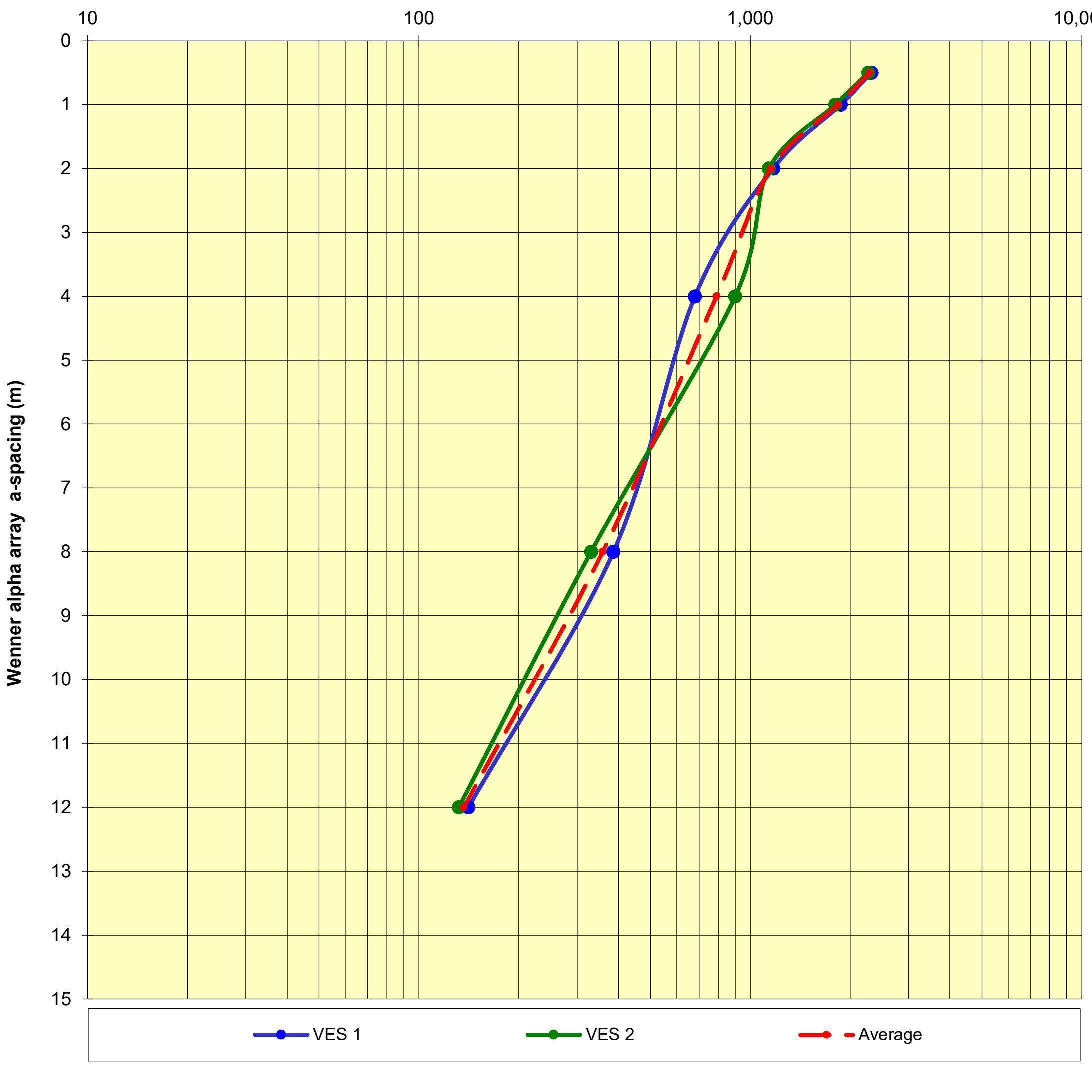


Douglas Partners Geotechnics / Environment / Groundwater	**Vertical Electrical Sounding (VES)**	PROJECT:	222100.00
	Proposed Mullewa Microgrid Solar Farm	DWG No:	ER3
		REV:	0
	CLIENT: Sunrise Energy Group Pty Ltd	DATE:	23 May 2023

Electrode a-spacing (m)	Resistance (R) VES 1 (Ω)	VES 2 (Ω)	Average (Ω)	Apparent Resistivity (ρ_a = 2πaR) VES 1 (Ω-m)	VES 2 (Ω-m)	Average (Ω-m)
0.5	738.0	722.0	730.00	2318.5	2268.2	2293.4
1	298.0	287.0	292.50	1872.4	1803.3	1837.8
2	93.2	90.5	91.85	1171.2	1137.3	1154.2
4	27.1	35.8	31.45	681.1	899.8	790.4
8	7.7	6.6	7.13	386.0	330.7	358.4
12	1.9	1.8	1.81	141.0	131.9	136.5

Location ID:	Grid 4	**Centre E, N:**	355 783 mE 6 841 084 mN GDA94 Zone 50
Orientations:	concentric orthogonal pair of arrays	**Instrument:**	ABEM LS2
Surface Description:	colluvium to approximately 1.3 m to 1.5 m depth over granite		

Apparent Resistivity (Ohm-m)
measured using the Wenner Alpha Array



Douglas Partners Geotechnics / Environment / Groundwater	**Vertical Electrical Sounding (VES)**	PROJECT:	222100.00
	Proposed Mullewa Microgrid Solar Farm	DWG No:	ER4
		REV:	0
	CLIENT: Sunrise Energy Group Pty Ltd	DATE:	23 May 2023

Appendix D

Laboratory Test Results

WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9167_1_PI
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9167
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	4 - 0.2m	*Date Tested:*	12/06/2023

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**23**
AS 1289.3.2.1	**Plastic Limit (%)**	**13**
AS 1289.3.3.1	**Plasticity Index (%)**	**10**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**3.5**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Cracked**

Comments:

Approved Signatory:

Name: Matthew Lichon

Date: 13/June/2023

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SOIL | AGGREGATE | CONCRETE | CRUSHING

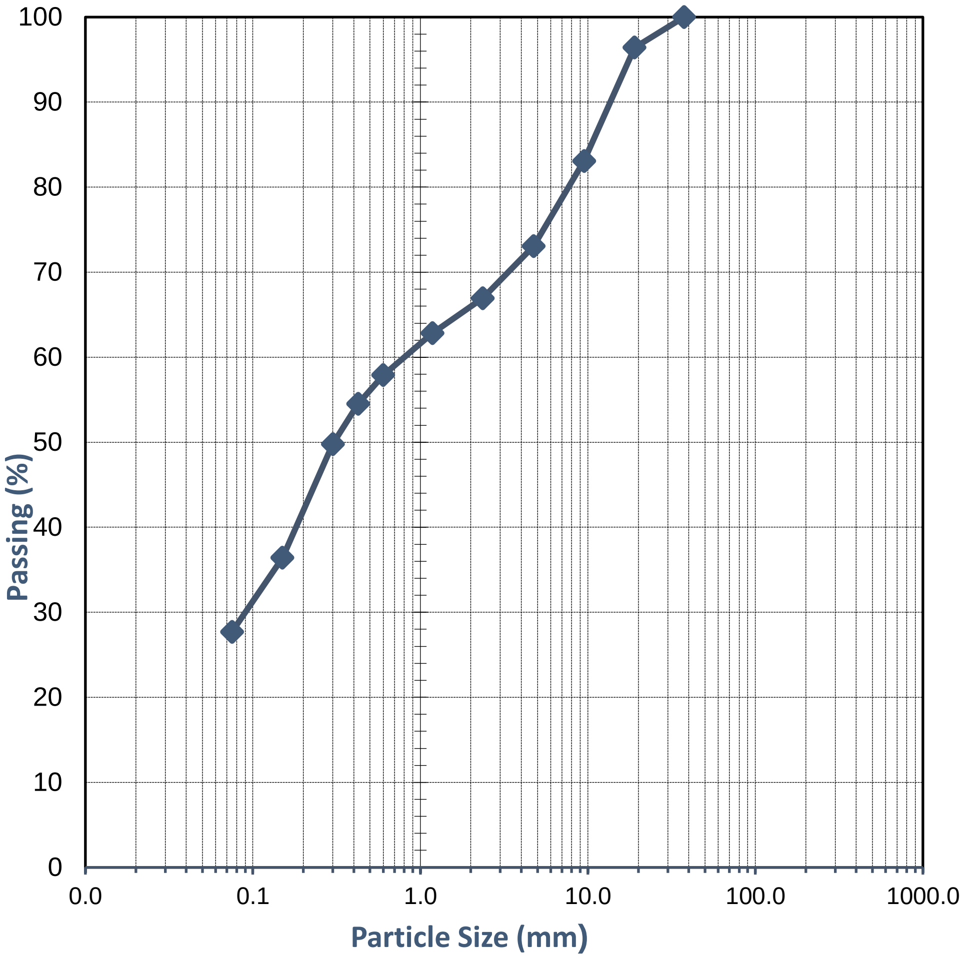
TEST REPORT - AS 1289.3.6.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9167_1_PSD
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9167
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	4 - 0.2m	*Date Tested:*	09/6 - 12/6/23

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	100
19.0	96
9.5	83
4.75	73
2.36	67
1.18	63
0.600	58
0.425	55
0.300	50
0.150	36
0.075	28



Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 12-June-2023

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

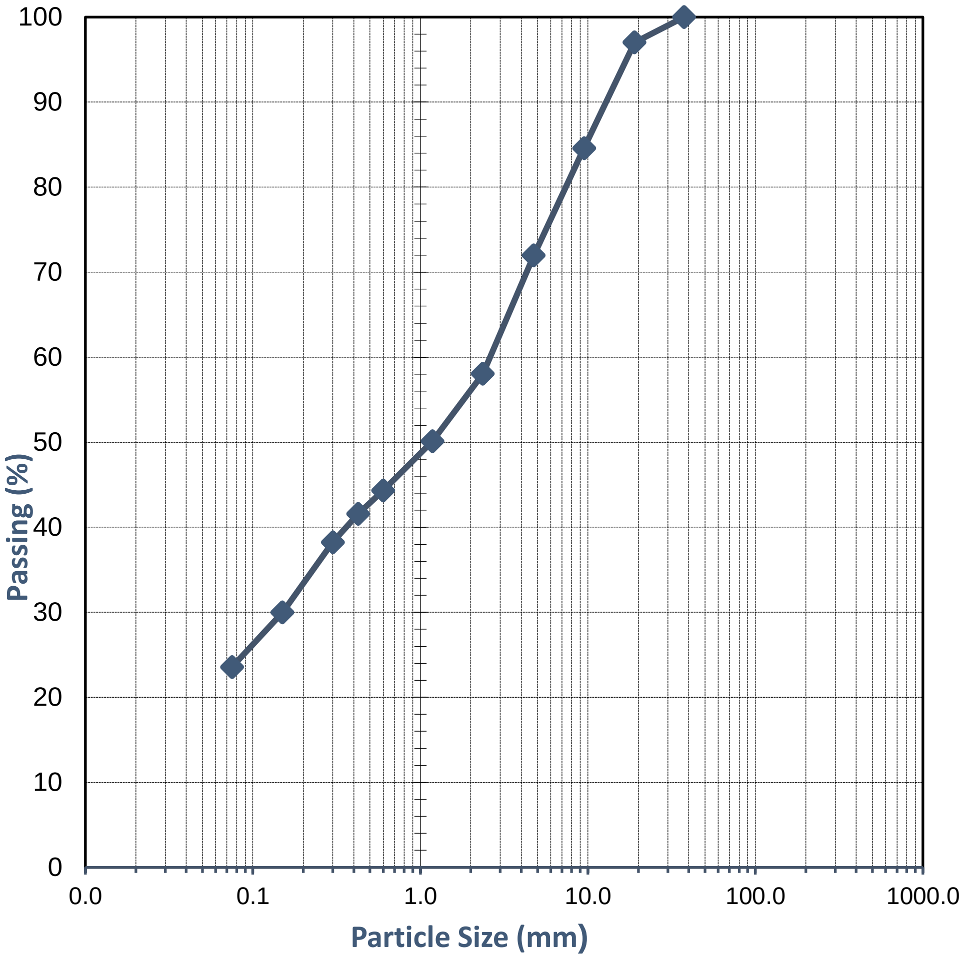
TEST REPORT - AS 1289.3.6.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9168_1_PSD
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9168
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	4 - 0.8m	*Date Tested:*	09/6 - 12/6/23

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	100
19.0	97
9.5	85
4.75	72
2.36	58
1.18	50
0.600	44
0.425	42
0.300	38
0.150	30
0.075	24



Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 12-June-2023

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - *AS 1289.5.2.1, AS 1289.2.1.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9170_1_MMDD
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9170
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	5 - 0.5m	*Date Tested:*	13-06-2023

TEST RESULTS - Modified Maximum Dry Density

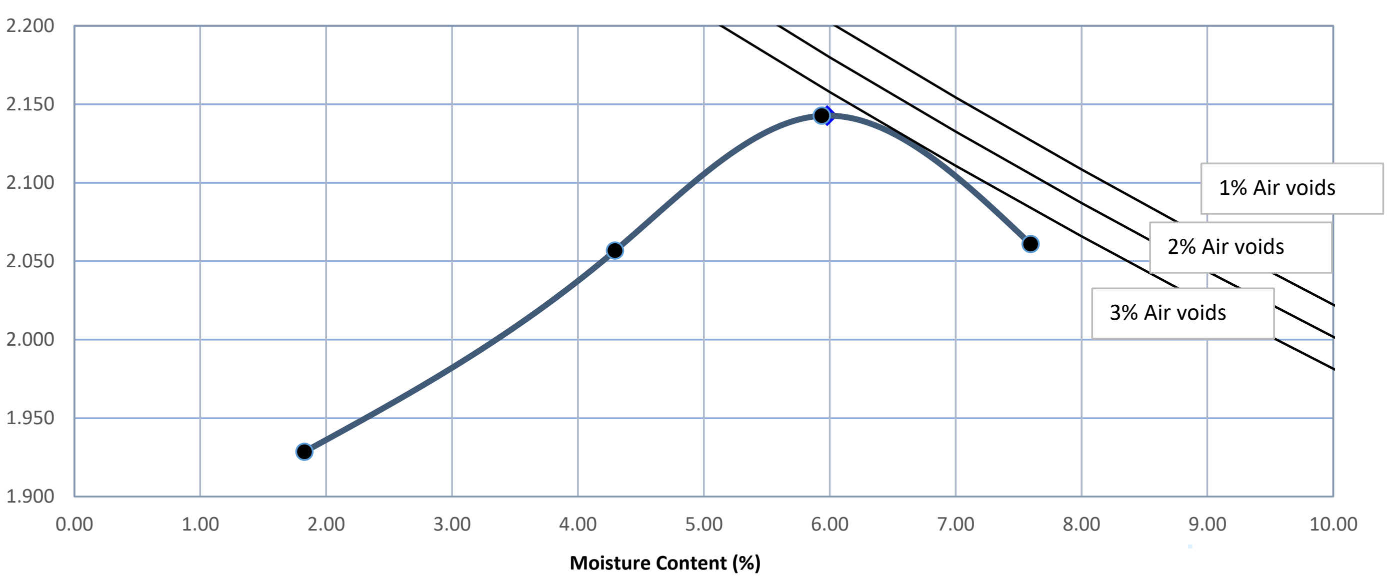
Sampling Method: Sampled by Client, Tested as Received

Sample Curing Time (Hours): 24

Method used to Determine Liquid Limit: Visual / Tactile Assessment by Competent Technician

Material + 19.0mm (%): 21 **Material + 37.5mm (%)** -

Moisture Content (%)	**1.8**	**4.3**	**5.9**	**7.6**	
Dry Density (t/m³)	**1.929**	**2.057**	**2.143**	**2.061**	



Modified Maximum Dry Density (t/m³) **2.14**

Optimum Moisture Content (%) **6.0**

Comments: The above air void lines are derived from a calculated apparent particle density of 2.567 t/m³

Deviation from test method, greater than 20% retained on the 19.00mm sieve. Tested as per clients request. NATA accreditation does not cover the performance of this service.

Approved Signatory:

Name: Brooke Elliott

Date: 20-June-2023

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9170_1_PI
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9170
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	5 - 0.5m	*Date Tested:*	12/06/2023

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50^{o}C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**Not Obtainable**
AS 1289.3.2.1	**Plastic Limit (%)**	**Non-Plastic**
AS 1289.3.3.1	**Plasticity Index (%)**	**Non-Plastic**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**0.5**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**-**

Comments:

Approved Signatory:

Name: Matthew Lichon

Date: 13/June/2023

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

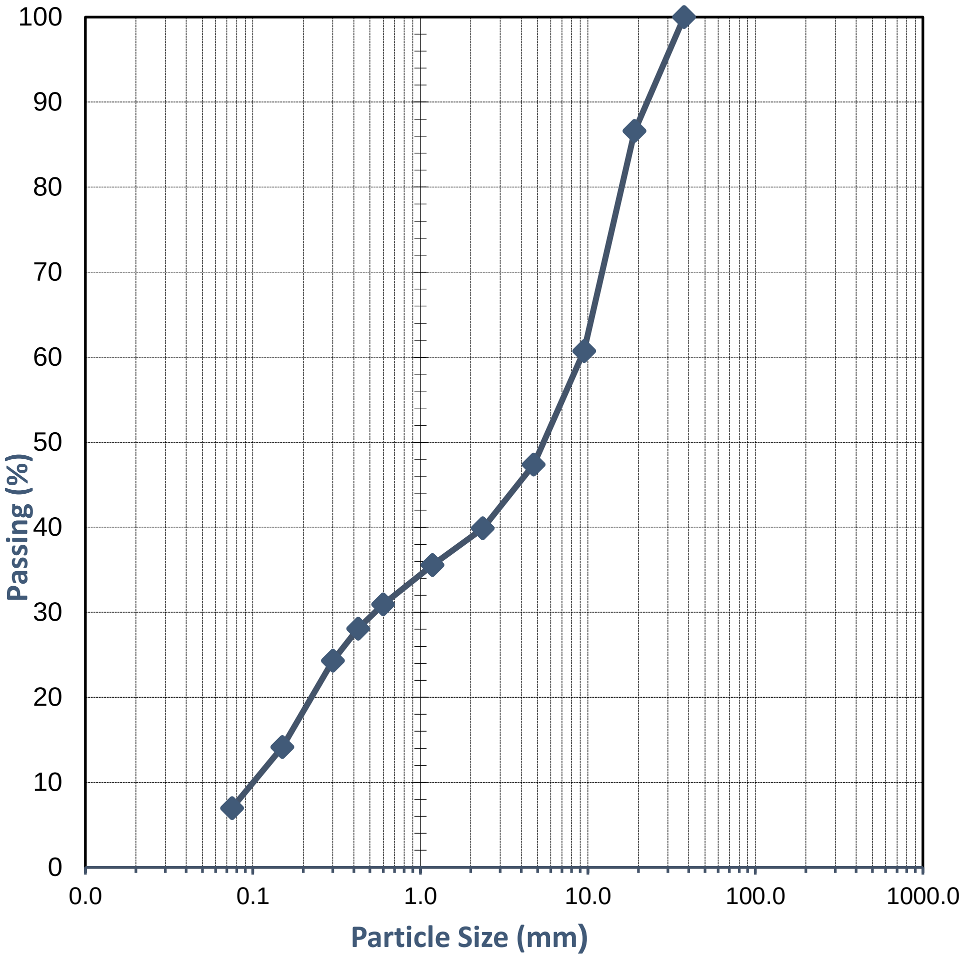
TEST REPORT - AS 1289.3.6.1, *AS 1289.1.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9170_1_PSD
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9170
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	5 - 0.5m	*Date Tested:*	09/06 - 12/06/2023

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	100
19.0	87
9.5	61
4.75	47
2.36	40
1.18	36
0.600	31
0.425	28
0.300	24
0.150	14
0.075	7



*Comments: *AS 1289.1.1- Deviation from standard: Insufficient sample according to test method requirements. NATA accreditation does not cover the performance of this service.*

Approved Signatory:

Name: Brooke Elliott

Date: 12/June/2023

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.1.1

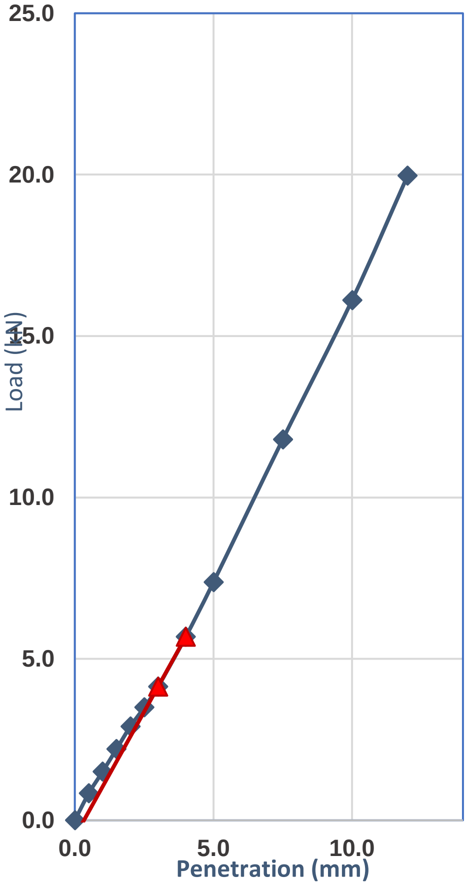
Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9170_1_SCBR
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9170
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	5 - 0.5m	*Date Tested:*	13/06 - 19/06/2023

TEST RESULTS - CALIFORNIA BEARING RATIO

Sample Description: Silty Gravel

Sampling Method: Sampled by Client, Tested as Received

Load Penetration Curve



Compaction Details			
Compaction Method	AS 1289.5.2.1	Hammer Type	Modified
Plasticity Determined by	Estimated	Curing Time (Hours)	24.0
% Retained 19.0mm	21	Excluded/Replaced	Excluded
Maximum Dry Density (t/m^3)	2.14	Optimum Moisture (%)	6.0
Target Dry Density Ratio (%)	95	Target Moisture Ratio (%)	100

Specimen Conditions At Compaction			
Dry Density (t/m3)	2.04	Moisture Content (%)	5.8
Density Ratio (%)	95.0	Moisture Ratio (%)	96.5

Specimen Conditions After Soak			
Soaked or Unsoaked	Soaked	Soaking Period (days)	4
Surcharges Applied (kg)	4.50	Measured Swell (%)	0.0
Dry Density (t/m³)	2.04	Dry Density Ratio (%)	95.0
Moisture Content (%)	11.0	Moisture Ratio (%)	182.5

Specimen Conditions After Test			
Top 30mm Moisture (%)	9.9	Remaining Depth (%)	10.4

Correction applied to Penetration: 0.3mm

Determined at a Penetration of: 5.0mm

California Bearing Ratio (CBR): 40%

Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 20-June-2023

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - ǂIEEE Standard 442, ǂ ASTM D5334, AS 1289.2.1.1 & AS 1289.5.2.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9170_1_TR
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9170
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	5 - 0.5m	*Date Tested:*	15-06-2023

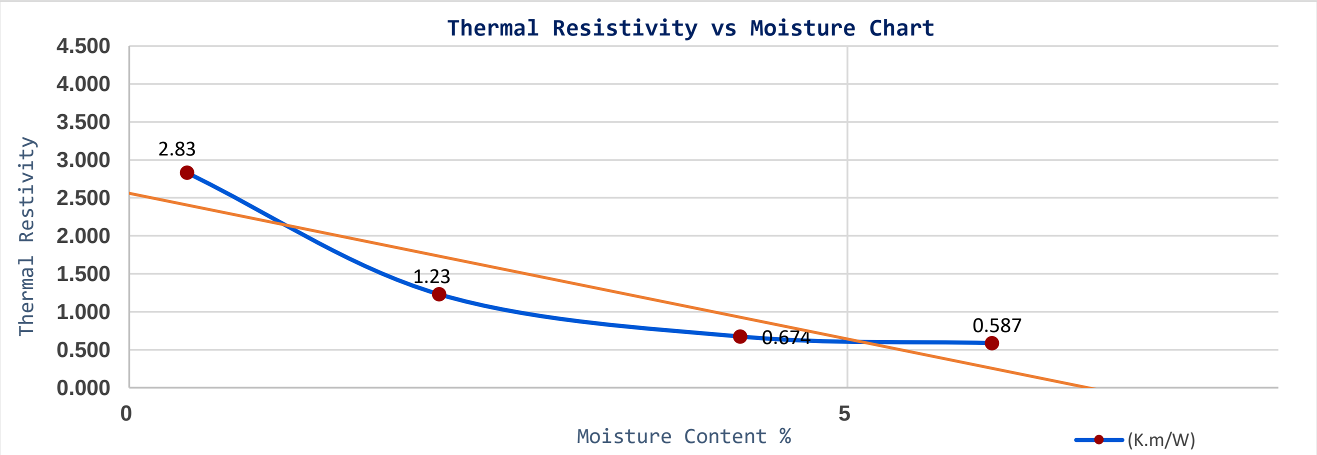
TEST RESULTS - THERMAL RESISTIVITY & CONDUCTIVITY

Sampling Method: **Sampled by Client, Tested as Received**

Compaction Details		Reference MDD Details	
Maximum Dry Density (t/m^3)	2.143	Compaction Type	Modified
Optimum Moisture Content (%)	6.0	Compactive Effort (kJ/m^3)	2703
Target Dry Density Ratio (%)	95	Mass of Rammer (kg)	4.5
Target Moisture Ratio (%)	See Below	Number of Layers	5
% Retained on the 19.0mm Sieve	2	Blows per Layer	25

Specimen Conditions At Test and After Compaction

Specimen No.	1	2	3	4
Dry Density Ratio (%)	94.6	94.7	94.7	94.9
Target Moisture Ratio (%)	0.0	2.0	4.0	6.0
Moisture Content (%)	0.4	2.2	4.3	6.0
ǂ - Thermal Resistivity (K.m/W	2.830	1.230	0.674	0.587



Comments:
ǂ - NATA Accreditation does not cover the performance of this service .

Approved Signatory:

Name: Matt van Herk

Date: 19-June-2023

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - ‡IEEE Standard 442, ‡ ASTM D5334, & AS 1289.2.1.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9170-9184-1_1_TR
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9170-9184-1
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	Various - See Below	*Date Tested:*	12 - 15/6/23

TEST RESULTS - THERMAL RESISTIVITY & CONDUCTIVITY

Sampling Method: **Sampled by Client, Tested as Received**

Sample Number	Sample Idenfitication	Moisture Content (%)	‡ - Thermal Resistivity (K.m/W)
WG23.9170-1	5 - 0.5m	4.7	0.602
WG23.9174-1	8 - 0.5m	6.3	0.429
WG23.9176-1	9 - 0.5m	4.0	0.769
WG23.9179-1	11 - 0.5m	5.3	0.624
WG23.9182-1	13 - 0.5m	5.6	0.674
WG23.9184-1	14 - 0.5m	10.2	0.182

Comments: Material dried back to 0%
‡ - NATA Accreditation does not cover the performance of this service .

Approved Signatory:

Name: Matt van Herk

Date: 19-June-2023

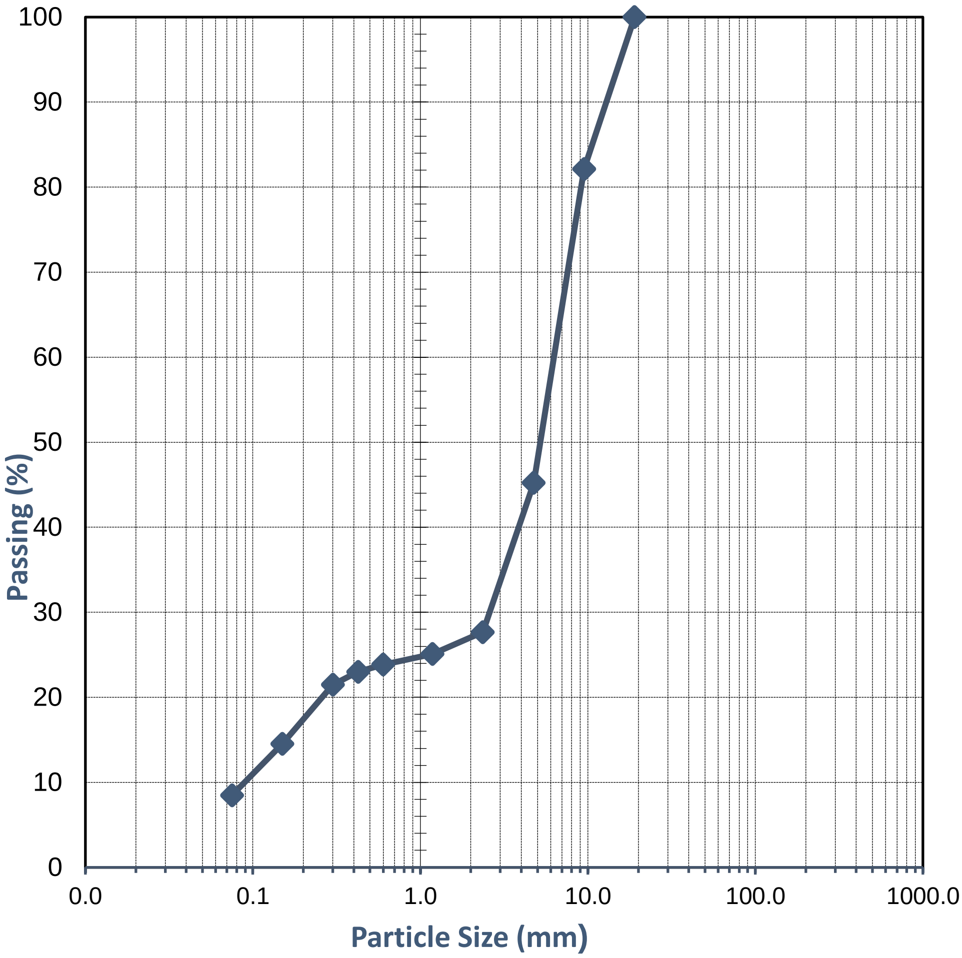
TEST REPORT - AS 1289.3.6.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9174_1_PSD
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9174
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	8 - 0.5m	*Date Tested:*	09/06 - 12/06/2023

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	82
4.75	45
2.36	28
1.18	25
0.600	24
0.425	23
0.300	21
0.150	15
0.075	8



Comments:

Approved Signatory:

Name: Brooke Elliott
Date: 12/June/2023

Accreditation No. 20599
Accredited for compliance
with ISO/IEC 17025 - Testing

WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - ‡IEEE Standard 442, ‡ ASTM D5334, AS 1289.2.1.1 & AS 1289.5.2.1*

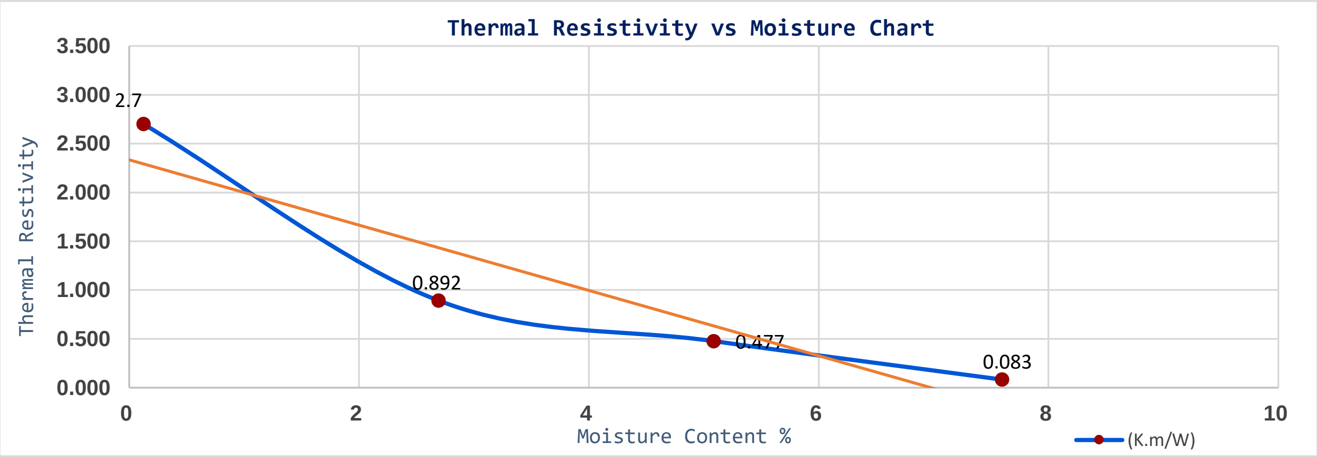
Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9174_1_TR
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9174
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	8 - 0.5m	*Date Tested:*	12-06-2023

TEST RESULTS - THERMAL RESISTIVITY & CONDUCTIVITY

Sampling Method: Sampled by Client, Tested as Received

Compaction Details		Reference MDD Details	
Maximum Dry Density (t/m^3)	2.200 *	Compaction Type	Assumed
Optimum Moisture Content (%)	7.5 *	Compactive Effort (kJ/m^3)	NA
Target Dry Density Ratio (%)	95	Mass of Rammer (kg)	NA
Target Moisture Ratio (%)	See Below	Number of Layers	NA
% Retained on the 19.0mm Sieve	NA	Blows per Layer	NA

Specimen Conditions At Test and After Compaction				
Specimen No.	1	2	3	4
Dry Density Ratio (%)	94.4	94.2	94.8	94.7
Target Moisture Ratio (%)	0.0	2.5	5.0	7.5
Moisture Content (%)	0.1	2.7	5.1	7.6
‡ - Thermal Resistivity (K.m/V	2.700	0.892	0.477	0.083



Comments:
**Remoulded to assumed MMDD/OMC values.*
‡ - NATA Accreditation does not cover the performance of this service .

Approved Signatory:

Name: Matt van Herk

Date: 19-June-2023

NATA

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TEST REPORT - AS 1289.5.2.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9176_1_MMDD
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9176
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	9 - 0.5m	*Date Tested:*	9-06-2023

TEST RESULTS - Modified Maximum Dry Density

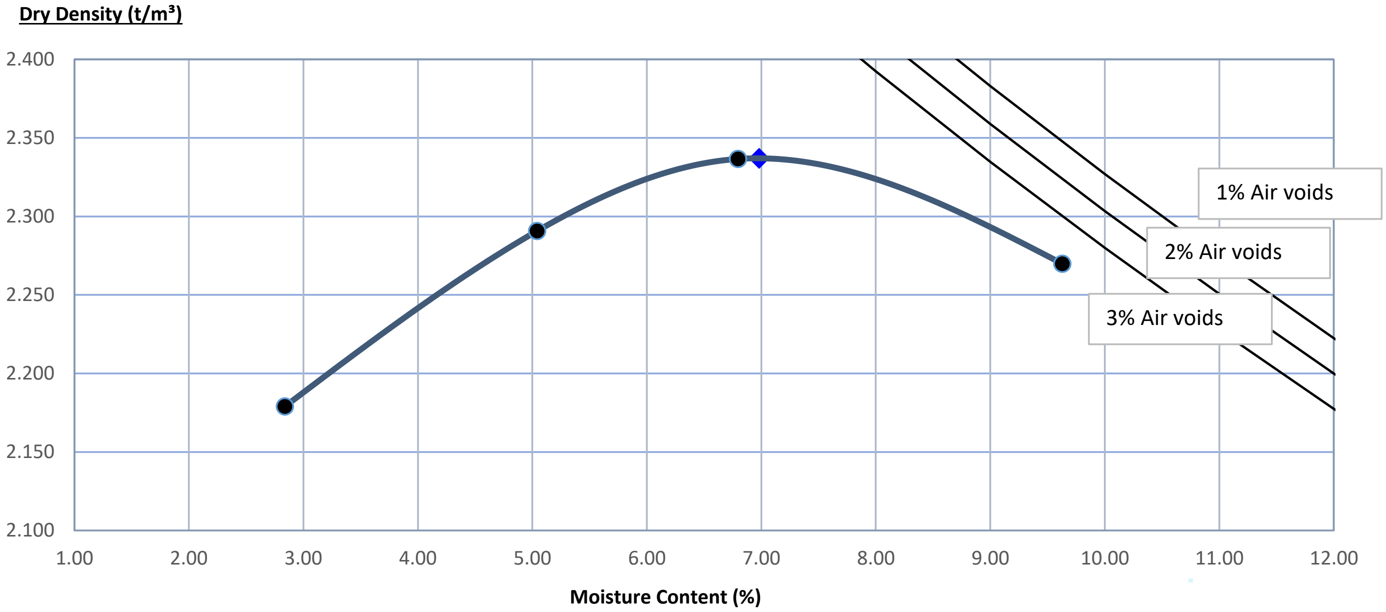
Sampling Method: Sampled by Client, Tested as Received

Sample Curing Time (Hours): 24 hrs

Method used to Determine Liquid Limit: Visual / Tactile Assessment by Competent Technician

Material + 19.0mm (%): 2 **Material + 37.5mm (%)** -

Moisture Content (%)	**2.8**	**5.0**	**6.8**	**9.6**	
Dry Density (t/m³)	**2.179**	**2.291**	**2.337**	**2.270**	



Modified Maximum Dry Density (t/m³) **2.34**

Optimum Moisture Content (%) **7.0**

Comments: *The above air void lines are derived from a calculated apparent particle density of 3.073 t/m³*

Approved Signatory:

Name: Brooke Elliott

Date: 12-June-2023

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9176_1_PI
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9176
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	9 - 0.5m	*Date Tested:*	12/06/2023

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50^{o}C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**Not Obtainable**
AS 1289.3.2.1	**Plastic Limit (%)**	**Non-Plastic**
AS 1289.3.3.1	**Plasticity Index (%)**	**Non-Plastic**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**1.5**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**-**

Comments:

Approved Signatory:

Name: Matthew Lichon

Date: 13/June/2023

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

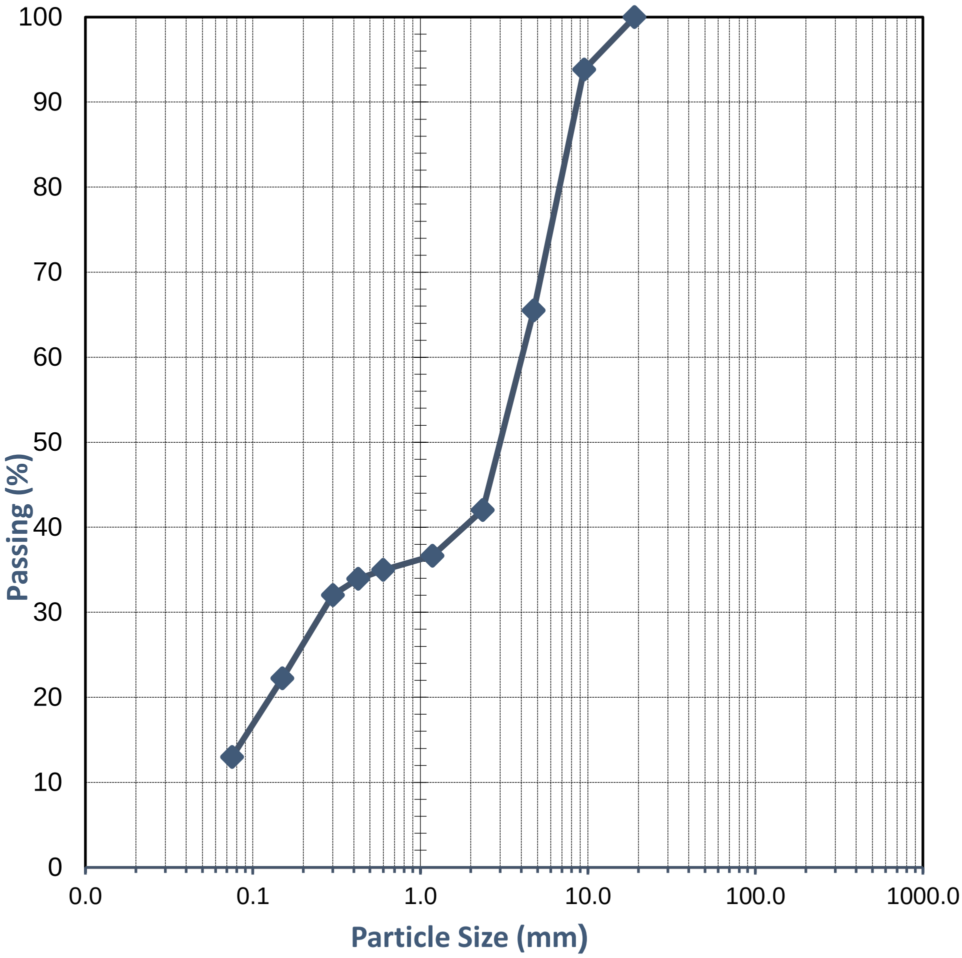
TEST REPORT - AS 1289.3.6.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9176_1_PSD
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9176
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	9 - 0.5m	*Date Tested:*	09/06 - 12/06/2023

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	94
4.75	65
2.36	42
1.18	37
0.600	35
0.425	34
0.300	32
0.150	22
0.075	13



Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 12/June/2023

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.1.1

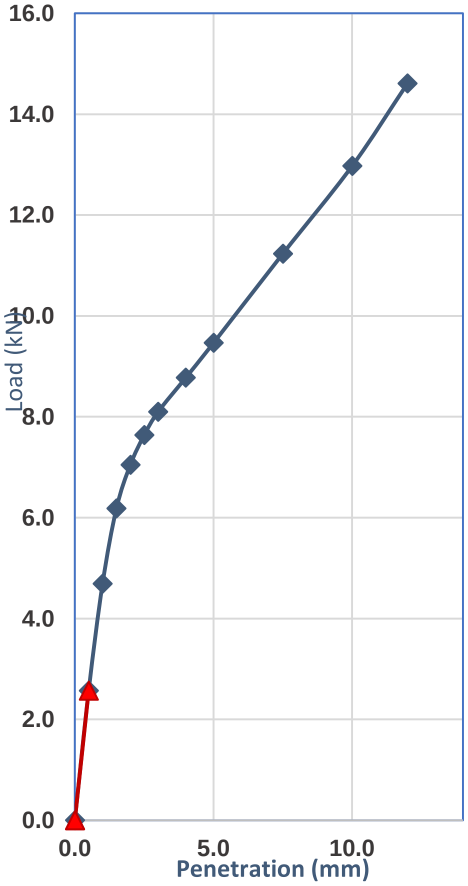
Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9176_1_SCBR
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9176
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	9 - 0.5m	*Date Tested:*	09/06 - 17/06/2023

TEST RESULTS - CALIFORNIA BEARING RATIO

Sample Description: Silty Gravel

Sampling Method: Sampled by Client, Tested as Received

Load Penetration Curve



Compaction Details			
Compaction Method	AS 1289.5.2.1	Hammer Type	Modified
Plasticity Determined by	Estimated	Curing Time (Hours)	24.0
% Retained 19.0mm	2	Excluded/Replaced	Excluded
Maximum Dry Density (t/m^3)	2.34	Optimum Moisture (%)	7.0
Target Dry Density Ratio (%)	95	Target Moisture Ratio (%)	100

Specimen Conditions At Compaction			
Dry Density (t/m3)	2.23	Moisture Content (%)	6.5
Density Ratio (%)	95.5	Moisture Ratio (%)	93.5

Specimen Conditions After Soak			
Soaked or Unsoaked	Soaked	Soaking Period (days)	4
Surcharges Applied (kg)	4.50	Measured Swell (%)	0.0
Dry Density (t/m^3)	2.23	Dry Density Ratio (%)	95.5
Moisture Content (%)	8.8	Moisture Ratio (%)	126.0

Specimen Conditions After Test			
Top 30mm Moisture (%)	7.4	Remaining Depth (%)	8.0

Correction applied to Penetration: 0mm

Determined at a Penetration of: 2.5mm

California Bearing Ratio (CBR): 60%

Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 20-June-2023

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - ‡IEEE Standard 442, ‡ ASTM D5334, AS 1289.2.1.1 & AS 1289.5.2.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9176_1_TR
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9176
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	9 - 0.5m	*Date Tested:*	12-06-2023

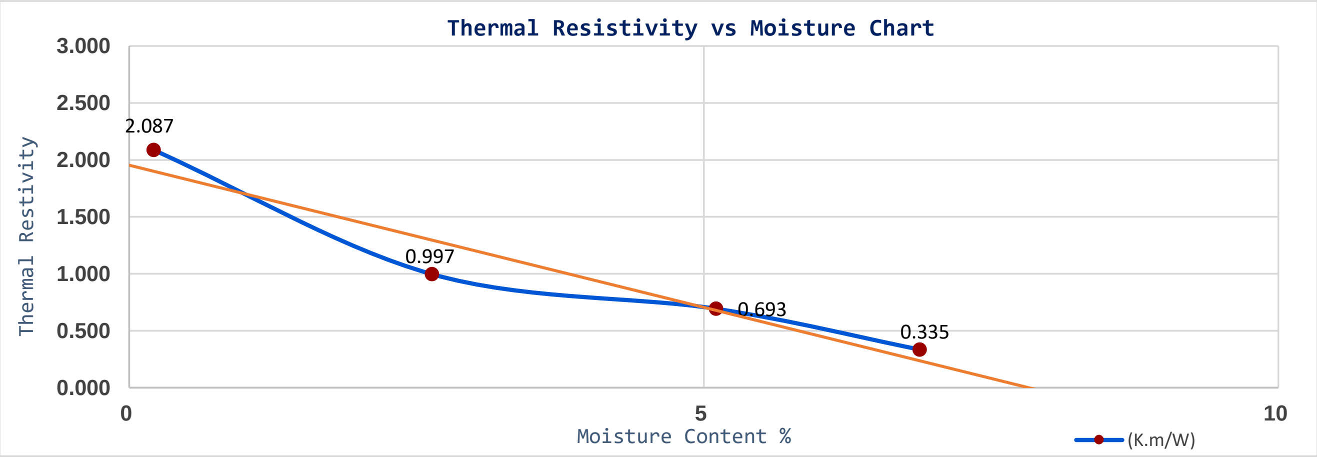
TEST RESULTS - THERMAL RESISTIVITY & CONDUCTIVITY

Sampling Method: **Sampled by Client, Tested as Received**

Compaction Details		Reference MDD Details	
Maximum Dry Density (t/m^3)	2.337	Compaction Type	Modified
Optimum Moisture Content (%)	7.0	Compactive Effort (kJ/m³)	2703
Target Dry Density Ratio (%)	95	Mass of Rammer (kg)	4.5
Target Moisture Ratio (%)	See Below	Number of Layers	5
% Retained on the 19.0mm Sieve	2	Blows per Layer	25

Specimen Conditions At Test and After Compaction

Specimen No.	1	2	3	4
Dry Density Ratio (%)	94.4	94.7	94.8	94.8
Target Moisture Ratio (%)	0.0	2.5	5.0	7.0
Moisture Content (%)	0.2	2.6	5.1	6.9
‡ - Thermal Resistivity (K.m/V	2.087	0.997	0.693	0.335



Comments: ‡ - NATA Accreditation does not cover the performance of this service .

Approved Signatory:

Name: Matt van Herk

Date: 19-June-2023

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.5.2.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9179_1_MMDD
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9179
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	11 - 0.5m	*Date Tested:*	12-06-2023

TEST RESULTS - Modified Maximum Dry Density

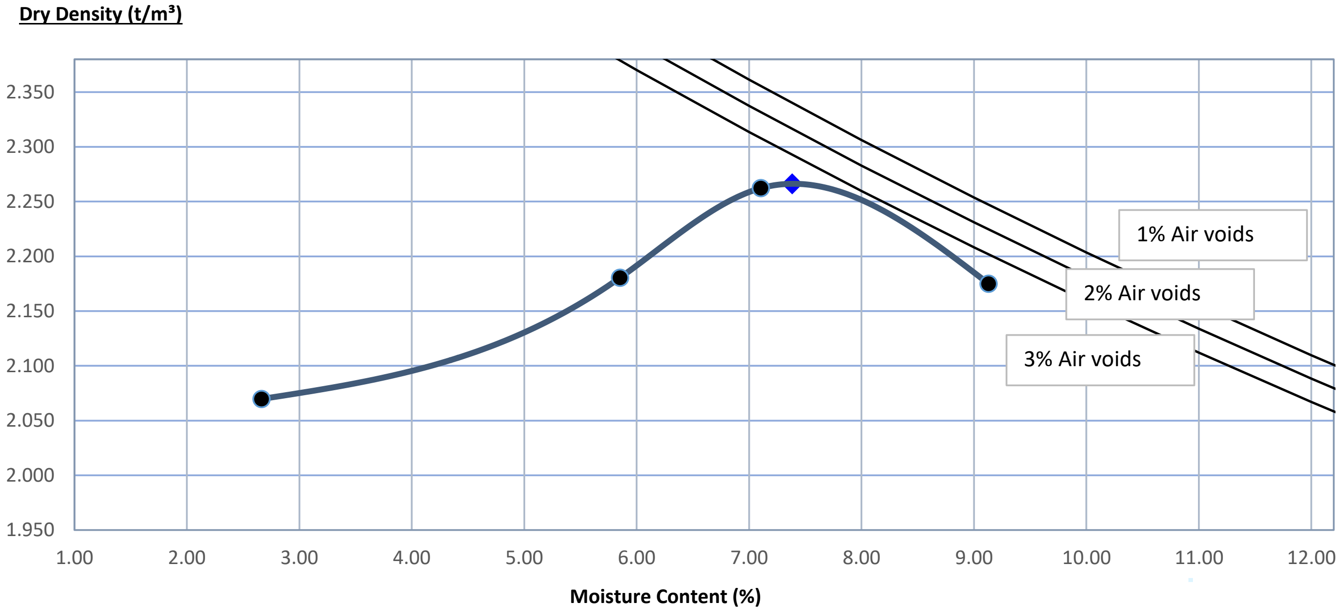
Sampling Method: Sampled by Client, Tested as Received

Sample Curing Time (Hours): 96

Method used to Determine Liquid Limit: Visual / Tactile Assessment by Competent Technician

Material + 19.0mm (%): 2 **Material + 37.5mm (%)** -

Moisture Content (%)	**2.7**	**5.9**	**7.1**	**9.1**	
Dry Density (t/m^3)	**2.070**	**2.181**	**2.262**	**2.175**	



Modified Maximum Dry Density (t/m^3) **2.27**

Optimum Moisture Content (%) **7.5**

Comments: *The above air void lines are derived from a calculated apparent particle density of 2.863 t/m³*

Approved Signatory:

Name: Madhav Basnet

Date: 19-June-2023

NATA

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9179_1_PI
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9179
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	11 - 0.5m	*Date Tested:*	12/06/2023

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50^{o}C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**Not Obtainable**
AS 1289.3.2.1	**Plastic Limit (%)**	**Non-Plastic**
AS 1289.3.3.1	**Plasticity Index (%)**	**Non-Plastic**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**2.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**-**

Comments:

Approved Signatory:

Name: Matthew Lichon

Date: 13/June/2023

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SOIL | AGGREGATE | CONCRETE | CRUSHING

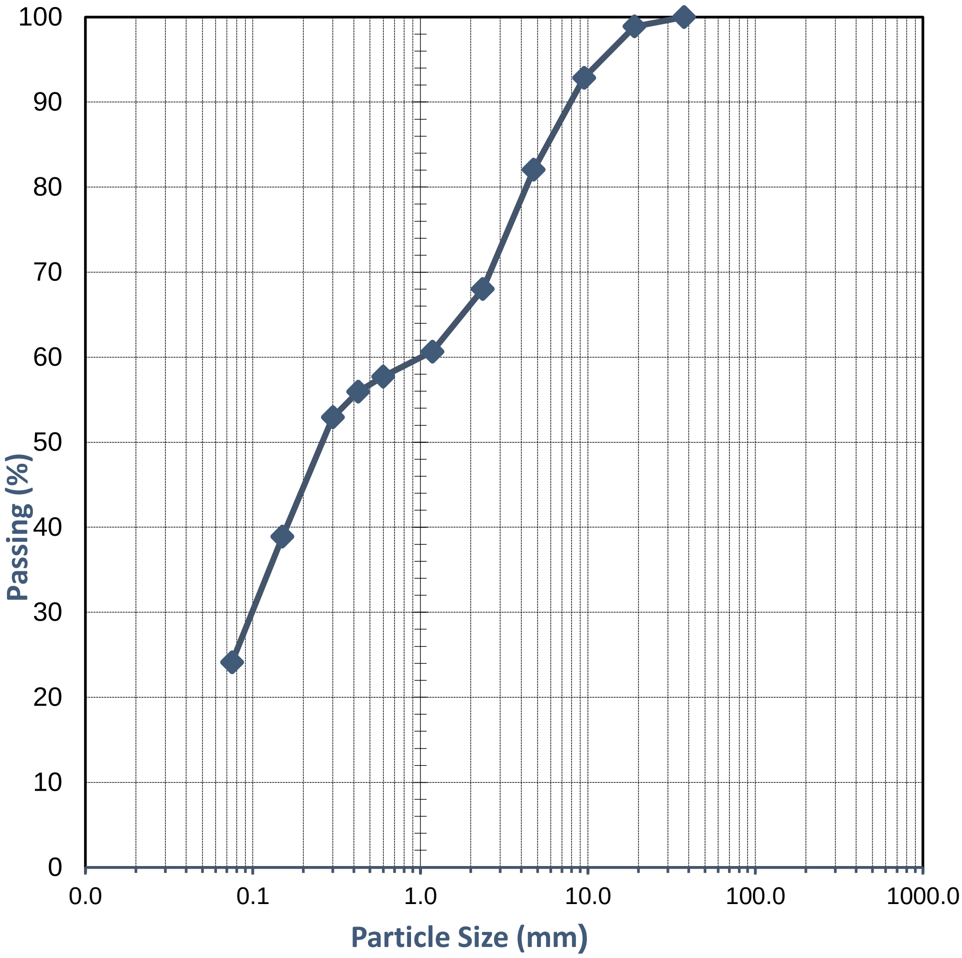
TEST REPORT - AS 1289.3.6.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9179_1_PSD
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9179
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	11 - 0.5m	*Date Tested:*	09/06 - 12/06/2023

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	100
19.0	99
9.5	93
4.75	82
2.36	68
1.18	61
0.600	58
0.425	56
0.300	53
0.150	39
0.075	24



Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 12/June/2023

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.1.1

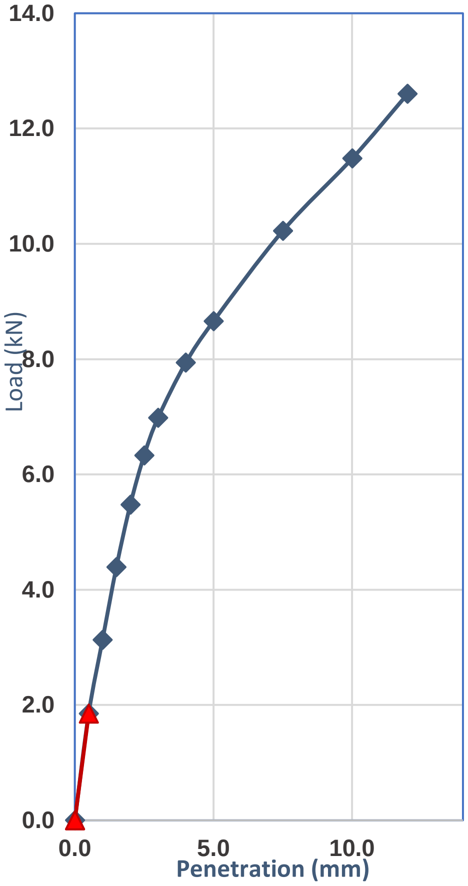
Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9179_1_SCBR
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9179
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	11 - 0.5m	*Date Tested:*	12/06 - 19/06/2023

TEST RESULTS - CALIFORNIA BEARING RATIO

Sample Description: Silty Gravel

Sampling Method: Sampled by Client, Tested as Received

Load Penetration Curve



Compaction Details			
Compaction Method	AS 1289.5.2.1	Hammer Type	Modified
Plasticity Determined by	Estimated	Curing Time (Hours)	48.0
% Retained 19.0mm	2	Excluded/Replaced	Excluded
Maximum Dry Density (t/m^3)	2.27	Optimum Moisture (%)	7.5
Target Dry Density Ratio (%)	95	Target Moisture Ratio (%)	100

Specimen Conditions At Compaction			
Dry Density (t/m3)	2.15	Moisture Content (%)	7.4
Density Ratio (%)	95.0	Moisture Ratio (%)	100.0

Specimen Conditions After Soak			
Soaked or Unsoaked	Soaked	Soaking Period (days)	4
Surcharges Applied (kg)	4.50	Measured Swell (%)	0.0
Dry Density (t/m³)	2.15	Dry Density Ratio (%)	95.0
Moisture Content (%)	9.7	Moisture Ratio (%)	131.5

Specimen Conditions After Test			
Top 30mm Moisture (%)	9.1	Remaining Depth (%)	8.7

Correction applied to Penetration: 0mm

Determined at a Penetration of: 2.5mm

California Bearing Ratio (CBR): 50%

Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 20-June-2023

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - ‡IEEE Standard 442, ‡ ASTM D5334, AS 1289.2.1.1 & AS 1289.5.2.1

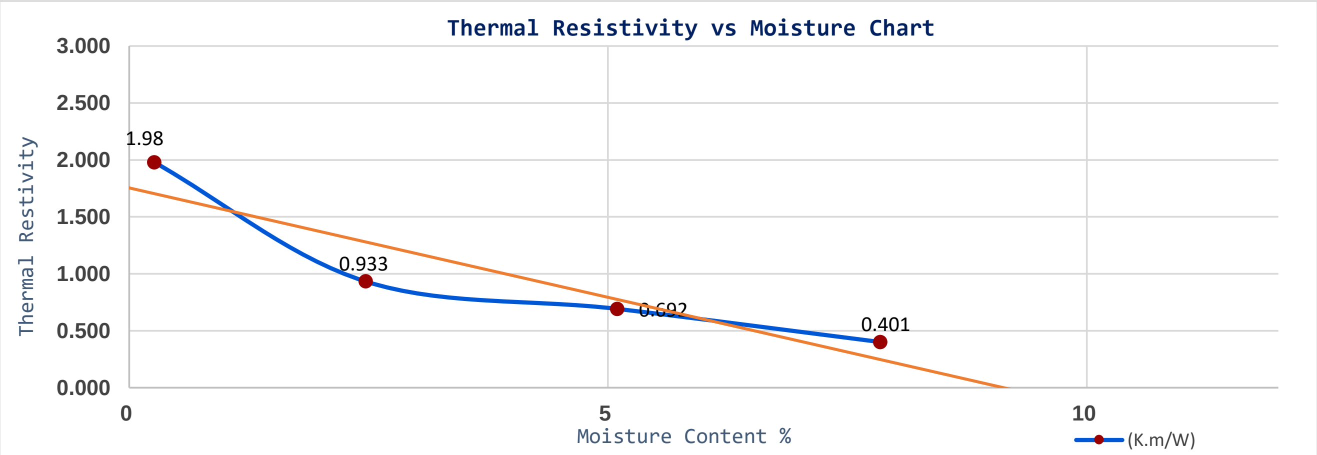
Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9179_1_TR
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9179
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	11 - 0.5m	*Date Tested:*	13-06-2023

TEST RESULTS - THERMAL RESISTIVITY & CONDUCTIVITY

Sampling Method: Sampled by Client, Tested as Received

Compaction Details		Reference MDD Details	
Maximum Dry Density (t/m^3)	2.266	Compaction Type	Modified
Optimum Moisture Content (%)	7.4	Compactive Effort (kJ/m^3)	2703
Target Dry Density Ratio (%)	95	Mass of Rammer (kg)	4.5
Target Moisture Ratio (%)	See Below	Number of Layers	5
% Retained on the 19.0mm Sieve	15	Blows per Layer	25

Specimen Conditions At Test and After Compaction				
Specimen No.	1	2	3	4
Dry Density Ratio (%)	94.6	95.0	94.8	94.6
Target Moisture Ratio (%)	0.0	2.5	5.0	7.4
Moisture Content (%)	0.3	2.5	5.1	7.8
‡ - Thermal Resistivity (K.m/W	1.980	0.933	0.692	0.401



Comments: ‡ - NATA Accreditation does not cover the performance of this service .

Approved Signatory:

Name: Matt van Herk

Date: 19-June-2023

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

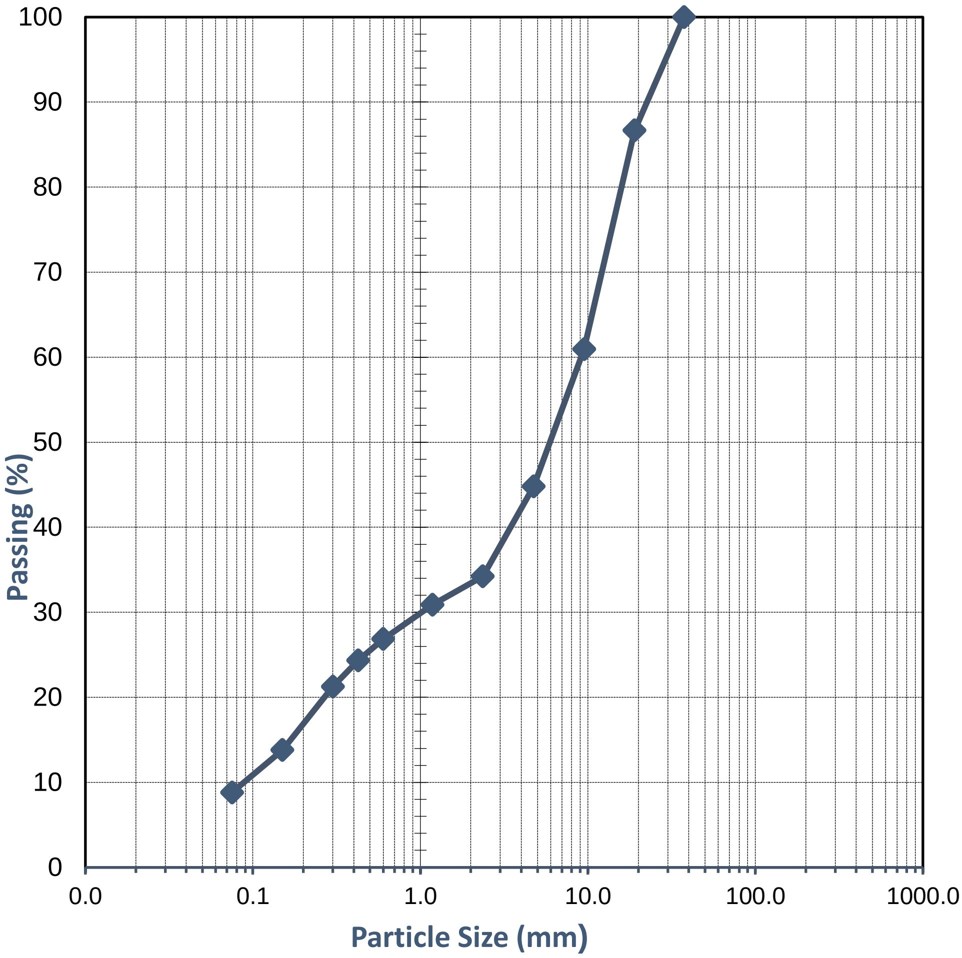
TEST REPORT - AS 1289.3.6.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9182_1_PSD
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9182
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	13 - 0.5m	*Date Tested:*	09/06 - 12/06/2023

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	100
19.0	87
9.5	61
4.75	45
2.36	34
1.18	31
0.600	27
0.425	24
0.300	21
0.150	14
0.075	9



Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 12/June/2023

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - ǂIEEE Standard 442, ǂ ASTM D5334, AS 1289.2.1.1 & AS 1289.5.2.1

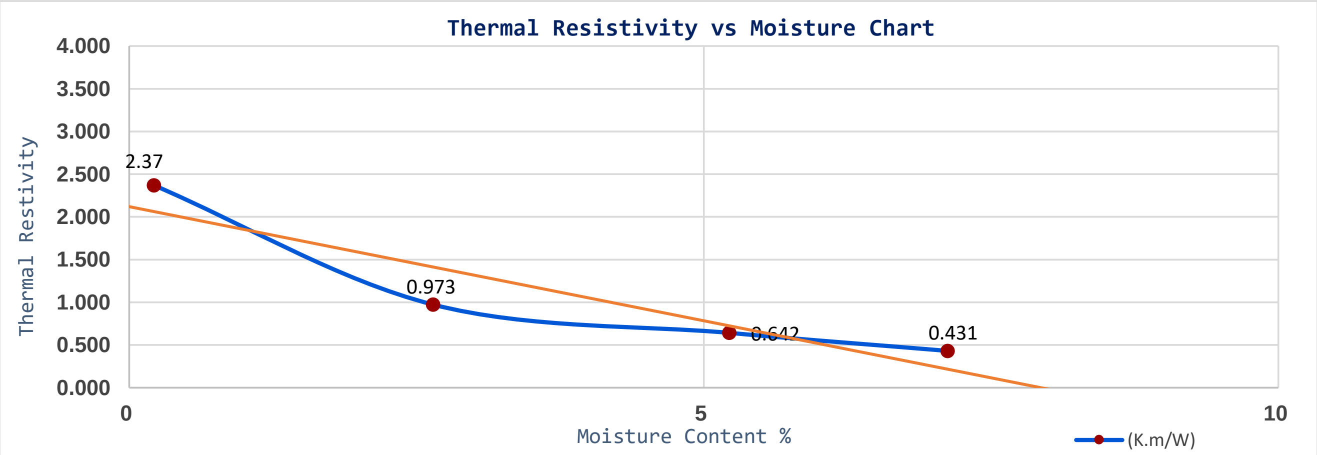
Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9182_1_TR
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9182
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	13 - 0.5m	*Date Tested:*	12-06-2023

TEST RESULTS - THERMAL RESISTIVITY & CONDUCTIVITY

Sampling Method: **Sampled by Client, Tested as Received**

Compaction Details		Reference MDD Details	
Maximum Dry Density (t/m^3)	2.200 *	Compaction Type	Assumed
Optimum Moisture Content (%)	7.5 *	Compactive Effort (kJ/m³)	NA
Target Dry Density Ratio (%)	95	Mass of Rammer (kg)	NA
Target Moisture Ratio (%)	See Below	Number of Layers	NA
% Retained on the 19.0mm Sieve	NA	Blows per Layer	NA

Specimen Conditions At Test and After Compaction				
Specimen No.	1	2	3	4
Dry Density Ratio (%)	94.5	94.9	94.7	95.0
Target Moisture Ratio (%)	0.0	2.5	5.0	7.5
Moisture Content (%)	0.2	2.6	5.2	7.1
ǂ - Thermal Resistivity (K.m/W	2.370	0.973	0.642	0.431



Comments: ǂ - NATA Accreditation does not cover the performance of this service .
**Remoulded to assumed MMDD/OMC values.*

Approved Signatory:

Name: Matt van Herk

Date: 19-June-2023

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.5.2.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9184_1_MMDD
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9184
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	14 - 0.5m	*Date Tested:*	9-06-2023

TEST RESULTS - Modified Maximum Dry Density

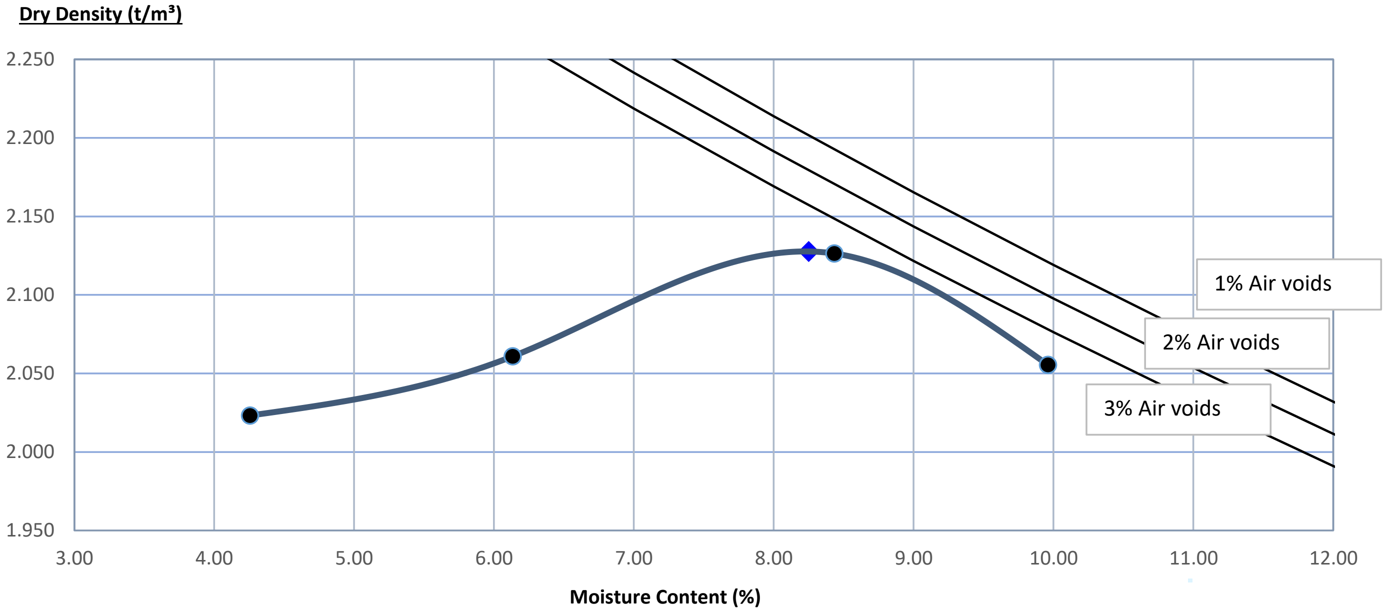
Sampling Method: Sampled by Client, Tested as Received

Sample Curing Time (Hours): 24

Method used to Determine Liquid Limit: Visual / Tactile Assessment by Competent Technician

Material + 19.0mm (%): 2 **Material + 37.5mm (%)** -

Moisture Content (%)	**4.3**	**6.1**	**8.4**	**10.0**	
Dry Density (t/m³)	**2.023**	**2.061**	**2.126**	**2.055**	



Modified Maximum Dry Density (t/m³) **2.13**

Optimum Moisture Content (%) **8.0**

Comments: *The above air void lines are derived from a calculated apparent particle density of 2.723 t/m³*

Approved Signatory:

Name: Brooke Elliott

Date: 12-June-2023

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9184_1_PI
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9184
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	14 - 0.5m	*Date Tested:*	12/06/2023

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50^{o}C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**25**
AS 1289.3.2.1	**Plastic Limit (%)**	**13**
AS 1289.3.3.1	**Plasticity Index (%)**	**12**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**5.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Cracked**

Comments:

Approved Signatory:

Name: Matthew Lichon

Date: 13/June/2023

Accreditation No. 20599
Accredited for compliance
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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

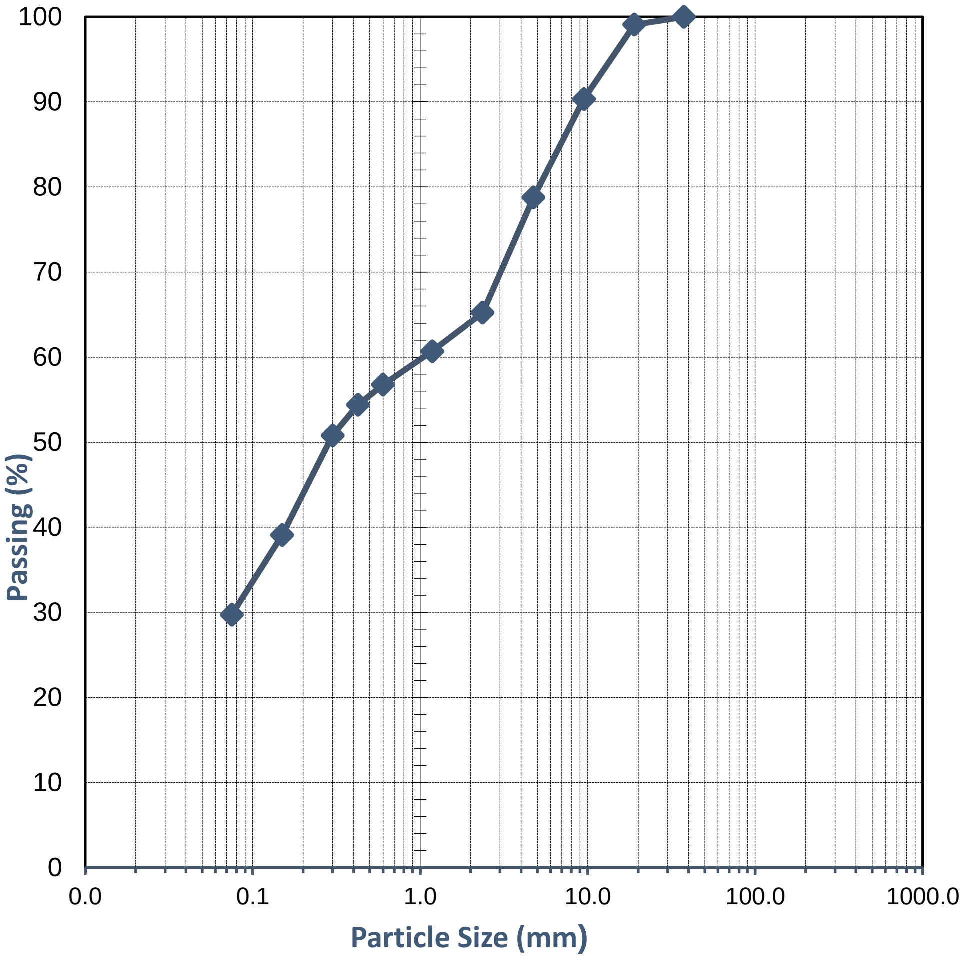
TEST REPORT - AS 1289.3.6.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9184_1_PSD
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9184
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	14 - 0.5m	*Date Tested:*	09/06 - 12/06/2023

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	100
19.0	99
9.5	90
4.75	79
2.36	65
1.18	61
0.600	57
0.425	54
0.300	51
0.150	39
0.075	30



Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 12/June/2023

NATA Accreditation No. 20599
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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.1.1

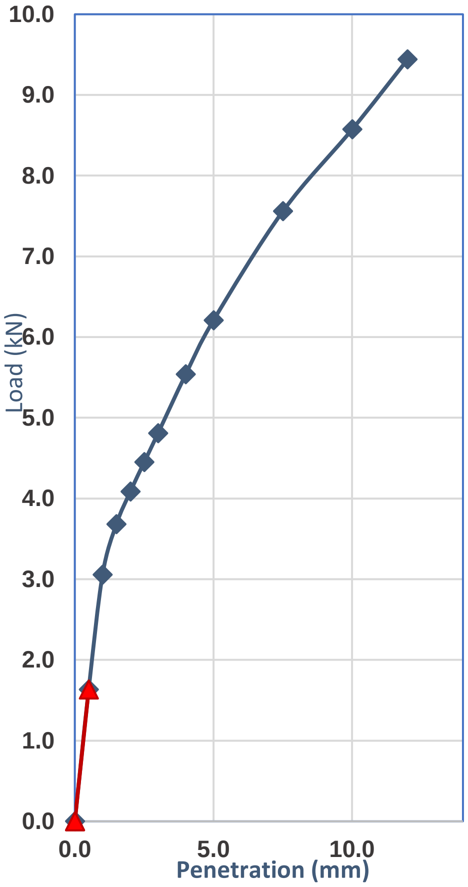
Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9184_1_SCBR
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9184
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	14 - 0.5m	*Date Tested:*	09/06 - 17/06/2023

TEST RESULTS - CALIFORNIA BEARING RATIO

Sample Description: Silty Gravel

Sampling Method: Sampled by Client, Tested as Received

Load Penetration Curve



Compaction Details			
Compaction Method	AS 1289.5.2.1	Hammer Type	Modified
Plasticity Determined by	Estimated	Curing Time (Hours)	24.0
% Retained 19.0mm	2	Excluded/Replaced	Excluded
Maximum Dry Density (t/m^3)	2.13	Optimum Moisture (%)	8.0
Target Dry Density Ratio (%)	95	Target Moisture Ratio (%)	100

Specimen Conditions At Compaction			
Dry Density (t/m3)	2.02	Moisture Content (%)	8.5
Density Ratio (%)	95.0	Moisture Ratio (%)	103.5

Specimen Conditions After Soak			
Soaked or Unsoaked	Soaked	Soaking Period (days)	4
Surcharges Applied (kg)	4.50	Measured Swell (%)	0.0
Dry Density (t/m^3)	2.02	Dry Density Ratio (%)	94.5
Moisture Content (%)	11.3	Moisture Ratio (%)	138.0

Specimen Conditions After Test			
Top 30mm Moisture (%)	10.5	Remaining Depth (%)	11.0

Correction applied to Penetration: 0mm

Determined at a Penetration of: 2.5mm

California Bearing Ratio (CBR): 35%

Comments:

Approved Signatory:

Name: Brooke Elliott

Date: 19-June-2023

NATA WORLD RECOGNISED ACCREDITATION

Accreditation No. 20599
Accredited for compliance with ISO/IEC 17025 - Testing

WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - ǂIEEE Standard 442, ǂ ASTM D5334, AS 1289.2.1.1 & AS 1289.5.2.1

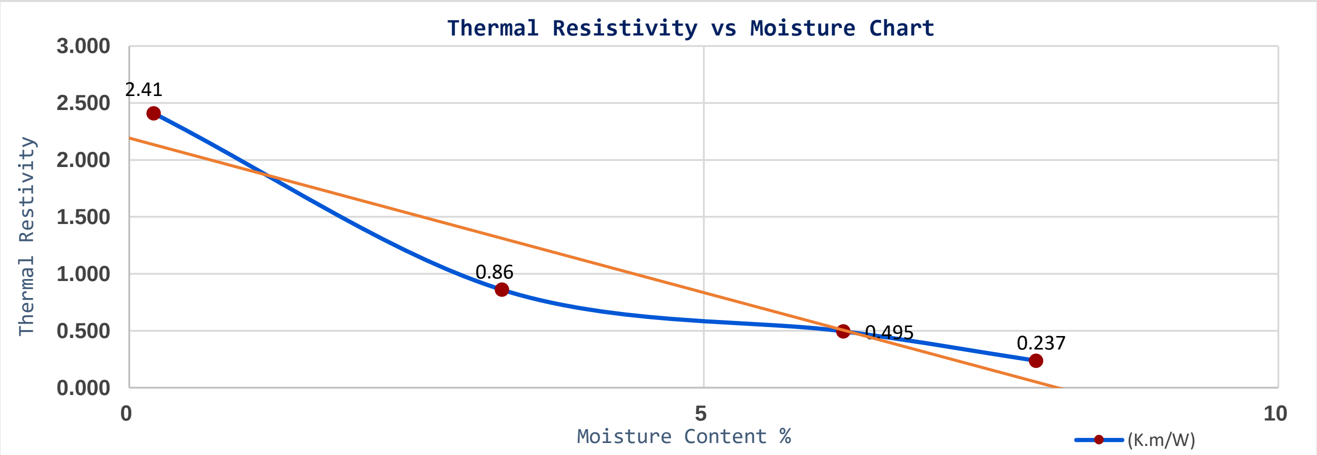
Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S10002
Client Address:	-	*Report No.*	WG23.9184_1_TR
Project:	Microgrid Solar Farm	*Sample No.*	WG23.9184
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	23-25/5/23
Sample Identification:	14 - 0.5m	*Date Tested:*	12-06-2023

TEST RESULTS - THERMAL RESISTIVITY & CONDUCTIVITY

Sampling Method: **Sampled by Client, Tested as Received**

Compaction Details		Reference MDD Details	
Maximum Dry Density (t/m^3)	2.128	Compaction Type	Modified
Optimum Moisture Content (%)	8.2	Compactive Effort (kJ/m^3)	2703
Target Dry Density Ratio (%)	95	Mass of Rammer (kg)	4.5
Target Moisture Ratio (%)	See Below	Number of Layers	5
% Retained on the 19.0mm Sieve	2	Blows per Layer	25

Specimen Conditions At Test and After Compaction				
Specimen No.	1	2	3	4
Dry Density Ratio (%)	94.3	94.6	94.5	94.7
Target Moisture Ratio (%)	0.0	3.0	6.0	8.2
Moisture Content (%)	0.2	3.2	6.2	7.9
ǂ - Thermal Resistivity (K.m/W	2.410	0.860	0.495	0.237



Comments: ǂ - NATA Accreditation does not cover the performance of this service .

Approved Signatory:

Name: Matt van Herk

Date: 19-June-2023

NATA
Accreditation No. 20599
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with ISO/IEC 17025 - Testing

LABORATORY SERVICES

AGGREGATE | ROCK | CONCRETE

TEST REPORT - AS 4133.4.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S0033
Client Address:	65 Hay Street, Subiaco WA 6008	*Report No.*	ARC-R23.372 - 387_1_PL
Project:	Microgrid Solar Farm	*Sample No.*	ARC-R23.372 - 387
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	*23-05-2023*
Sample Identification:	Various Locations & Depths - See below	*Date Tested:*	*13-06-2023*

TEST RESULTS - Rock Strength Tests - Determination of Point Load Strength Index

Sampling Method: *Sampled by Client, Tested as Received*

Sample Number:	ARC-R23.372	ARC-R23.373	ARC-R23.374	ARC-R23.375	ARC-R23.376
Sample Identification:	1	2	4	5	6
Depth:	0.6m	1.25m	1.2m	2.2m	1.65m
Test Type:	Lump	Lump	Lump	Lump	Lump
Lithology/Description:	Sedimentary	Sedimentary	Sedimentary	Sedimentary	Sedimentary
Moisture Condition:	As Submitted	As Submitted	As Submitted	As Submitted	As Submitted
Diameter (mm):	46.00	36.00	43.49	53.04	43.32
Width (mm):	87.81	92.51	97.24	82.82	95.42
Length/Diameter Ratio:	1.91	2.57	2.24	1.56	2.20
Mode of Failure:	Axial Split	Axial Split	Axial Split	Axial Split	Axial Split
Load at Failure (kN):	2.420	9.367	0.128	1.833	1.730
Is (MPa):	1.44	10.41	0.09	0.76	1.20
Is (50)(MPa):	1.32	8.27	0.08	0.76	1.06

Comments

Specimen Dimensions, Load at Failure and Specific Failure Mode Not covered by scope of Accreditation, reported as per clients request.

Approved Signatory:

Name: Beau Griffiths

Function: Laboratory Manager

Date: 20-June-2023

Accreditation No. 21169
Accredited for compliance with ISO/IEC 17025 - Testing

AGGREGATE | ROCK | CONCRETE

TEST REPORT - AS 4133.4.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S0033
Client Address:	65 Hay Street, Subiaco WA 6008	*Report No.*	ARC-R23.372 - 386_1_PL
Project:	Microgrid Solar Farm	*Sample No.*	ARC-R23.372 - 386
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	*23-05-2023*
Sample Identification:	Various Locations & Depths - See below	*Date Tested:*	*13-06-2023*

TEST RESULTS - Rock Strength Tests - Determination of Point Load Strength Index

Sampling Method: ***Sampled by Client, Tested as Received***

Sample Number:	ARC-R23.377	ARC-R23.378	ARC-R23.379	ARC-R23.380	ARC-R23.381
Sample Identification:	7	8	9	10	11
Depth:	1.4m	1.45m	1.45m	1.4m	1.0m
Test Type:	Lump	Lump	Lump	Lump	Lump
Lithology/Description:	Sedimentary	Sedimentary	Sedimentary	Sedimentary	Sedimentary
Moisture Condition:	As Submitted	As Submitted	As Submitted	As Submitted	As Submitted
Diameter (mm):	48.76	49.00	36.70	63.60	46.77
Width (mm):	97.32	74.32	110.29	106.37	78.44
Length/Diameter Ratio:	2.00	1.52	3.01	1.67	1.68
Mode of Failure:	Axial Split	Axial Split	Axial Split	Axial Split	Axial Split
Load at Failure (kN):	8.822	5.748	2.611	10.090	18.645
Is (MPa):	5.51	4.20	2.90	3.88	12.91
Is (50)(MPa):	4.99	3.67	2.31	3.91	11.41

Comments

Specimen Dimensions, Load at Failure and Specific Failure Mode Not covered by scope of Accreditation, reported as per clients request.

Approved Signatory:

Name: Beau Griffiths

Function: Laboratory Manager

Date: 20-June-2023

Accreditation No. 21169

Accredited for compliance

with ISO/IEC 17025 - Testing

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AGGREGATE | ROCK | CONCRETE

TEST REPORT - AS 4133.4.1

Client:	Sunrise Energy Pty Ltd	*Ticket No.*	S0033
Client Address:	65 Hay Street, Subiaco WA 6008	*Report No.*	ARC-R23.372 - 387_1_PL
Project:	Microgrid Solar Farm	*Sample No.*	ARC-R23.372 - 387
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	*23-05-2023*
Sample Identification:	Various Locations & Depths - See below	*Date Tested:*	*13-06-2023*

TEST RESULTS - Rock Strength Tests - Determination of Point Load Strength Index

Sampling Method: ***Sampled by Client, Tested as Received***

Sample Number:	ARC-R23.382	ARC-R23.383	ARC-R23.384	ARC-R23.385	ARC-R23.386
Sample Identification:	12	13	14	15	16
Depth:	1.3m	1.2m	0.7m	2.15m	0.95m
Test Type:	Lump	Lump	Lump	Lump	Lump
Lithology/Description:	Sedimentary	Sedimentary	Sedimentary	Sedimentary	Sedimentary
Moisture Condition:	As Submitted	As Submitted	As Submitted	As Submitted	As Submitted
Diameter (mm):	74.29	62.00	49.00	48.00	37.00
Width (mm):	122.21	90.01	75.07	91.66	58.76
Length/Diameter Ratio:	1.65	1.45	1.53	1.91	1.59
Mode of Failure:	Axial Split	Axial Split	Axial Split	Axial Split	Axial Split
Load at Failure (kN):	0.966	8.161	7.252	1.005	1.856
Is (MPa):	0.23	3.54	5.02	0.54	2.55
Is (50)(MPa):	0.26	3.48	4.44	0.51	1.93

Comments

Specimen Dimensions, Load at Failure and Specific Failure Mode Not covered by scope of Accreditation, reported as per clients request.

Approved Signatory: [signature]

Name: Beau Griffiths

Function: Laboratory Manager

Date: 20-June-2023

Accreditation No. 21169
Accredited for compliance with ISO/IEC 17025 - Testing

WORLD RECOGNISED ACCREDITATION

LABORATORY SERVICES

AGGREGATE | ROCK | CONCRETE

TEST REPORT - AS 4133.4.1

Client:	Microgrid Solar Farm	*Ticket No.*	S0033
Client Address:	65 Hay Street, Subiaco WA 6008	*Report No.*	ARC-R23.372 - 387_1_PL
Project:	Microgrid Solar Farm	*Sample No.*	ARC-R23.372 - 387
Location:	Darlot Road, Mullewa WA	*Date Sampled:*	*23-05-2023*
Sample Identification:	Various Locations & Depths - See Below	*Date Tested:*	*13-06-2023*

TEST RESULTS - Rock Strength Tests - Determination of Point Load Strength Index

Sampling Method: ***Sampled by Client, Tested as Received***

Sample Number:	ARC-R23.387				
Sample Identification:	17				
Depth:	2.0m				
Test Type:	Lump				
Lithology/Description:	Sedimentary				
Moisture Condition:	As Submitted				
Diameter (mm):	50.01				
Width (mm):	71.08				
Length/Diameter Ratio:	1.42				
Mode of Failure:	Axial Split				
Load at Failure (kN):	2.393				
Is (MPa):	2.77				
Is (50)(MPa):	2.66				

Comments

Specimen Dimensions, Load at Failure and Specific Failure Mode Not covered by scope of Accreditation, reported as per clients request.

Approved Signatory:

Name: Beau Griffiths

Function: Laboratory Manager

Date: 20-June-2023

Accreditation No. 21169
Accredited for compliance with ISO/IEC 17025 - Testing

WORLD RECOGNISED ACCREDITATION

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16-18 Hayden Court Myaree WA 6154
ph +61 8 9317 2505 fax +61 8 9317 4163
lab@mpl.com.au
www.mpl.com.au

Certificate of Analysis PEF0615

Client Details

Client	Western Geotechnical & Laboratory Services
Contact	Brooke Elliot
Address	235 Bank Street, WELSHPOOL, WA, 6101

Sample Details

Your Reference	S10002 - Microgrid Solar Farm
Number of Samples	4 Soil
Date Samples Received	09/06/2023
Date Samples Registered	09/06/2023

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date Results Requested by	16/06/2023
Date of Issue	16/06/2023

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Accredited for compliance with ISO/IEC 17025. Tests not covered by NATA are denoted with *.

Authorisation Details

Results Approved By	Michael Hall, Inorganics & Metals Supervisor
Laboratory Manager	Michael Kubiak

Certificate of Analysis PEF0615

Samples in this Report

Envirolab ID	Sample ID	Depth	Matrix	Date Sampled	Date Received
PEF0615-01	WG23.9168 - 4 - 0.8m	0.80	Soil	25/05/2023	09/06/2023
PEF0615-02	WG23.9174 - 8 - 0.5m	0.50	Soil	25/05/2023	09/06/2023
PEF0615-03	WG23.9179 -11 - 0.5m	0.50	Soil	25/05/2023	09/06/2023
PEF0615-04	WG23.9182 - 13 - 0.5m	0.50	Soil	25/05/2023	09/06/2023

Certificate of Analysis PEF0615

Inorganics - General Physical Parameters (Soil)

Envirolab ID	Units	PQL	PEF0615-01	PEF0615-02	PEF0615-03	PEF0615-04
Your Reference			WG23.9168 - 4 - 0.8m	WG23.9174 - 8 - 0.5m	WG23.9179 -11 - 0.5m	WG23.9182 - 13 - 0.5m
Date Sampled			25/05/2023	25/05/2023	25/05/2023	25/05/2023
Depth			0.80	0.50	0.50	0.50
pH	pH units		4.6	5.1	5.3	4.7

Certificate of Analysis PEF0615

Inorganics - General Chemical Parameters (Soil)

Envirolab ID	Units	PQL	PEF0615-01	PEF0615-02	PEF0615-03	PEF0615-04
Your Reference			WG23.9168 - 4 - 0.8m	WG23.9174 - 8 - 0.5m	WG23.9179 -11 - 0.5m	WG23.9182 - 13 - 0.5m
Date Sampled			25/05/2023	25/05/2023	25/05/2023	25/05/2023
Depth			0.80	0.50	0.50	0.50
Chloride	mg/kg	10	<10	<10	17	20
Sulfate	mg/kg	10	28	22	28	20

Method Summary

Method ID	Methodology Summary
INORG-001	pH - Measured using pH meter and electrode based on APHA latest edition, Method 4500-H+. Please note that the results for water analyses are indicative only, as analysis can be completed outside of the APHA recommended holding times. Solids are reported from a 1:5 water extract unless otherwise specified. Alternatively, pH is determined in a 1:5 extract using 0.01M calcium chloride or a solid is extracted at a ratio of 1:2.5 (AS1289.4.3.1), pH is measured in the extract.
INORG-081	Anions determined by Ion Chromatography. Waters samples are filtered on receipt prior to analysis. Solids are analysed from a water extract. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

Result Definitions

Identifier	Description
NR	Not reported
NEPM	National Environment Protection Measure
NS	Not specified
LCS	Laboratory Control Sample
RPD	Relative Percent Difference
>	Greater than
<	Less than
PQL	Practical Quantitation Limit
INS	Insufficient sample for this test
NA	Test not required
NT	Not tested
DOL	Samples rejected due to particulate overload (air filters only)
RFD	Samples rejected due to filter damage (air filters only)
RUD	Samples rejected due to uneven deposition (air filters only)
##	Indicates a laboratory acceptance criteria outlier, for further details, see Result Comments and/or QC Comments

Quality Control Definitions

Blank

This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, and is determined by processing solvents and reagents in exactly the same manner as for samples.

Surrogate Spike

Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

LCS (Laboratory Control Sample)

This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Matrix Spike

A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

Duplicate

This is the complete duplicate analysis of a sample from the process batch. The sample selected should be one where the analyte concentration is easily measurable.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria. Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction. Spikes for Physical and Aggregate Tests are not applicable. For VOCs in water samples, three vials are required for duplicate or spike analysis.

General Acceptance Criteria (GAC) - Analyte specific criteria applies for some analytes and is reflected in QC recovery tables.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% - see ELN-P05 QAQC tables for details (available on request); <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase. Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was typically insufficient in order to satisfy laboratory QA/QC protocols.

Miscellaneous Information

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached. We have taken the sampling date as being the date received at the laboratory.

Two significant figures are reported for the majority of tests and with a high degree of confidence, for results <10*PQL, the second significant figure may be in doubt i.e. has a relatively high degree of uncertainty and is provided for information only.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS where sediment/solids are included by default.

Urine Analysis - The BEI values listed are taken from the 2022 edition of *TLVs and BEIs Threshold Limits by ACGIH*.

Air volume measurements are not covered by Envirolab's NATA accreditation.

Data Quality Assessment Summary PEF0615

Client Details

Client	Western Geotechnical & Laboratory Services
Your Reference	S10002 - Microgrid Solar Farm
Date Issued	16/06/2023

Recommended Holding Time Compliance

Recommended holding time exceedances exist - See detailed list below

Quality Control and QC Frequency

QC Type	Compliant	Details
Blank	Yes	No Outliers
LCS	Yes	No Outliers
Duplicates	Yes	No Outliers
Matrix Spike	Yes	No Outliers
Surrogates / Extracted Internal Standards	Yes	No Outliers
QC Frequency	Yes	No Outliers

Surrogates/Extracted Internal Standards, Duplicates and/or Matrix Spikes are not always relevant/applicable to certain analyses and matrices. Therefore, said QC measures are deemed compliant in these situations by default. See Laboratory Acceptance Criteria for more information

Data Quality Assessment Summary PEF0615

Recommended Holding Time Compliance

Analysis	Sample Number(s)	Date Sampled	Date Extracted	Date Analysed	Compliant
pH | Soil	1-4	25/05/2023	14/06/2023	15/06/2023	No
Chloride | Soil	1-4	25/05/2023	14/06/2023	15/06/2023	Yes
Sulfate | Soil	1-4	25/05/2023	14/06/2023	15/06/2023	Yes

Quality Control PEF0615

INORG-001 | Inorganics - General Physical Parameters (Soil) | Batch BEF1519

Analyte	Units	PQL	Blank	DUP1 PEF0615-01 Samp | QC | RPD %	DUP2 BEF1519-DUP2# Samp | QC | RPD %	LCS %
pH	pH units		5.2	4.6 | 4.6 | 1.30	8.6 | 8.6 | 0.00	102

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

INORG-081 | Inorganics - General Chemical Parameters (Soil) | Batch BEF1190

Analyte	Units	PQL	Blank	DUP1 BEF1190-DUP1# Samp | QC | RPD %	LCS %	Spike % BEF1190-MS1#
Chloride	mg/kg	10	<10	<10 | <10 | [NA]	99.4	106
Sulfate	mg/kg	10	<10	<10 | <10 | [NA]	97.3	111

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Appendix E

Lateral Capacity and Deflection of Piles Using Broms

Lateral Capacity and Deflection of Piles Using Broms

A. Background

The methods of Broms (Ref 1 and 2) can be used to calculate the resistance of soil to lateral loads on piles. Solutions are provided for both 'short' and 'long' piles, for 'free head' and 'fixed head' restraint, and for both cohesive soils (Ref 1) and cohesionless soils (Ref 2). If it is not clear whether a pile is 'short' or 'long', then the pile should be checked for both, and the lesser value adopted.

The Broms methods are relatively simplistic, compared to more complex finite element solutions, but can be applied without using complex software packages.

The methods are limited to homogeneous soils, adopting either undrained shear strength (c_u) for short term loading in cohesive soils (eg silts and clays), or friction angle (ø) for either short term or long term loading in cohesionless soils (eg sands and gravels). For long term sustained loading in cohesive soils, the cohesionless approach can be adopted using effective stress parameters (c', ø'), but with c' equal to zero.

For the cohesive soils model, ultimate lateral resistance is assumed as zero down to a depth of 1.5B (where B is the pile diameter) and $9c_uB$ below this depth. For the cohesionless soils model, the ultimate lateral resistance is estimated as three times the passive Rankine earth pressure, ie $3K_p\gamma BL$ (where K_p is the coefficient of passive earth pressure, γ is soil density, and L is pile depth below ground level).

Calculation of deflection is usually considered as indicative only (it may not be as accurate as other methods), and corresponds to application of working stress (ie where the ultimate lateral load is factored down by 2 or 3).

B. Calculation of Ultimate Lateral Load

To calculate the ultimate lateral load ,P_u, for a 'short' pile, use Figure 1 for the cohesive soil model and Figure 2 for the cohesionless soil model. Enter the x-axis by calculating the length to diameter, L/B, ratio. Select the appropriate line to use, based on ground restraint conditions, and, where 'free head', the load eccentricity to pile diameter, e/B, ratio. After obtaining the appropriate values on the y-axis, multiply this by c_uB^2 for cohesive soil or $K_pB^3\gamma$ for cohesionless soil to obtain the ultimate lateral load, P_u.

To calculate the ultimate lateral load ,P_u, for a 'long' pile, corresponding to the yield moment, M_{yield}, use Figure 3 for the cohesive soil model and Figure 4 for the cohesionless soil model. Enter the x-axis by calculating M_{yield}/c_uB^3. Select the appropriate line to use, based on ground restraint conditions, and, where 'free head', the load eccentricity to pile diameter, e/B, ratio. After obtaining the appropriate values on the y-axis, multiply this by $c_u B^2$ for cohesive soil or $K_p B^3 \gamma$ for cohesionless soil to obtain the ultimate lateral load, P_u.

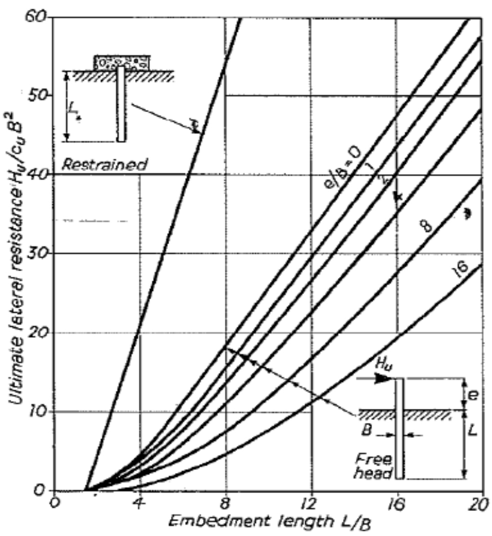


Fig 1: Ultimate lateral resistance for cohesive soil, short pile (Ref 1)

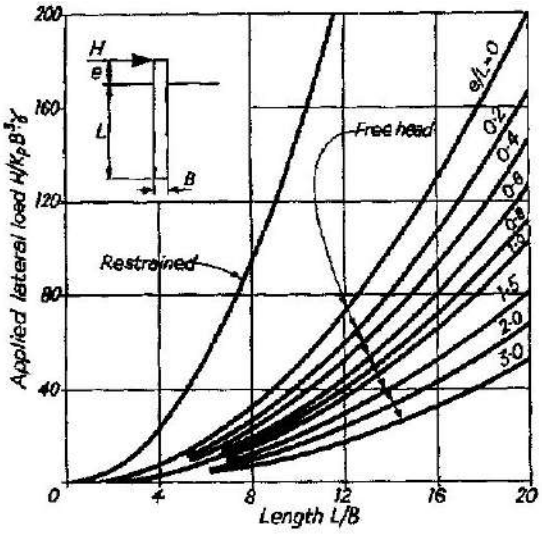


Fig 2: Ultimate lateral resistance for cohesionless soil, short pile (Ref 2)

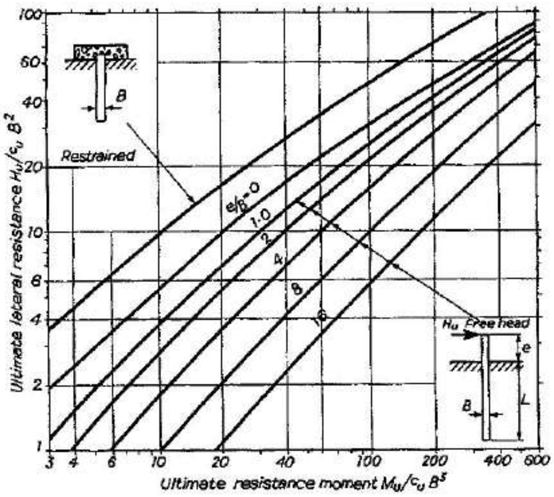


Fig 3: Ultimate lateral resistance for cohesive soil, long pile (Ref 1)

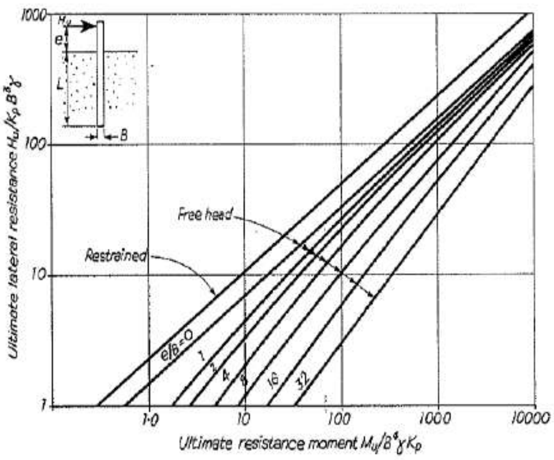


Fig 4: Ultimate lateral resistance for cohesionless soil, long pile (Ref 2)

C. Estimating Lateral Deflection

At working lateral load H (ie P_u divided by 2 to 3) the lateral deflection can be estimated by assuming that, at any particular pile depth, the unit soil reaction, p, increases linearly with increasing lateral deflection, as follows:

$p = k_h y$

where k_h = the modulus of horizontal subgrade reaction (kN/m^3);
p = unit soil reaction (kN/m^2);
y = lateral deflection (m)

Cohesive Soil ('stiff' or better): For 'stiff' and overconsolidated clay soils, k_h is assumed to be constant with depth, resulting in the dimensionless lateral deflections being plotted in Figure 5 as a function of dimensionless length βL in which:

$\beta = (k_h B/4EI)^{1/4}$

where E = the elastic modulus of the pile material;
I = the moment of inertia of the pile;
B = pile diameter

After entering the x-axis on Figure 5 with the βL value, select the line appropriate to the restraint condition, and, in the case of a 'free-head' pile, the load eccentricity to pile depth, e/D, ratio. The lateral deflection at ground surface due to the applied working load, H, is then calculated by dividing the y-axis value by $k_h BL/H$.

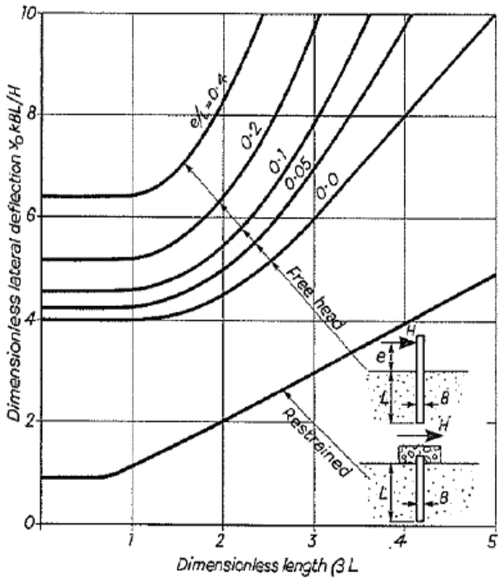


Fig 5: Lateral deflection at ground surface for cohesive soil

Cohesionless Soil (and 'soft' clays): For sands and gravels and 'soft' clays, k_h is assumed to increase linearly with depth as follows:

$k_h = \eta_h z/B$

where k_h = the modulus of horizontal subgrade reaction (kN/m^3);
z = depth below ground level (m);
η_h = coefficient of modulus variation with depth;
B = pile diameter

This results in the dimensionless lateral deflections being plotted in Figure 6 as a function of dimensionless length ηL in which:

$\eta = (\eta_h/EI)^{1/5}$

After entering the x-axis on Figure 6 with the ηL value, select the line appropriate to the restraint condition, and, in the case of a 'free-head' pile, the load eccentricity to pile depth, e/D, ratio. The lateral deflection at ground surface due to the applied working load, H, is then calculated by dividing the y-axis value by $(EI)^{3/5}.(\eta_h)^{2/5}/(HL)$.

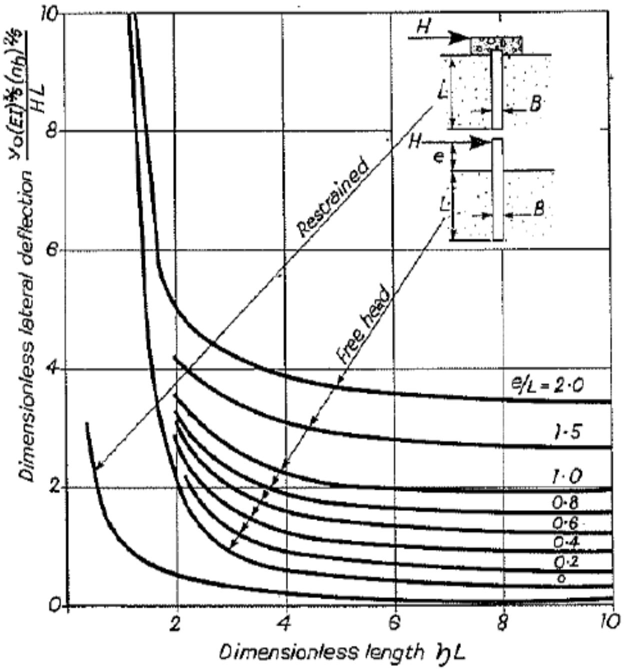


Fig 6: Lateral deflection at ground surface for cohesionless soil

D. References

1. Broms, Bengt B, "Lateral Resistance of Piles in Cohesive Soils", Proceedings of the American Society of Civil Engineers, Journal of the Soil Mechanics and Foundations Division, Vol 90, SM2, 1964.

2. Broms, Bengt B, "Lateral Resistance of Piles in Cohesionless Soils", Proceedings of the American Society of Civil Engineers, Journal of the Soil Mechanics and Foundations Division, Vol 90, SM3, 1964.

APPENDIX D

Wind Turbine Documentation

BlairFox
Building the connections

Thursday, 18 May 2023

Matthew Stewart
Sunrise Energy Group
Level 2
65 Hay Street
SUBIACO WA 6008

Dear Matthew,

I am writing to provide you with the outcome of the energy prediction study I conducted for two used Enercon E40 600kW wind turbines on 76m towers located at Lot 5 in Mullewa.

As per our discussion, the study aimed to locate the two E40 turbines on the site, estimate annual energy yield, provide an estimation of the expected monthly performance, and create a representative average daily generation curve for summer and winter.

After conducting a high-level desktop analysis, I have estimated the combined annual energy yield of the turbines to be 2.982GWh. The estimation is based on various factors, including the predicted wind speed and direction, the height of the turbines, and the turbine specifications.

Regarding the seasonal performance, I have predicted that the turbines will produce the highest energy output during the summer months, while the lowest output is expected during winter.

Finally, I have created a representative daily generation curve based on a summer and winter profile, which illustrates the expected energy output from the turbines throughout a typical day in each season.

Please let me know if you have any questions or concerns regarding the study. I look forward to hearing from you soon.

Best regards,

Matthew Rosser

Unit 2, 33 McDonald Crescent Bassendean, WA 6054 Email: mrosser@blairfox.com.au

Note On Methodology

The methodology employed involved utilizing a wind flow model to assess the suitability of the area surrounding Mullewa for wind farm development.

The wind flow model employed in this process is OpenWind, which enables horizontal and vertical extrapolation of wind data. This means that once the background wind resource is calculated, it can be applied to other locations within the landscape or adjusted to different heights at the same location. OpenWind encompasses a comprehensive set of models that account for the impact of sheltering obstacles, changes in surface roughness, and variations in terrain height on wind behaviour.

A vital component of traditional wind farm modeling is having a site-specific wind speed dataset collected at the same height as the proposed wind turbine hubs. Typically, this dataset is gathered over a two-year period to establish the initial parameters for the model. However, due to the unavailability of wind speed data at this particular site, a theoretical dataset was constructed. A probabilistic wind speed model was developed based on the industry-standard Weibull distribution functions. The initial Weibull parameters were determined using my experience with wind speed monitoring in the Geraldton region and publicly available Weibull parameters derived from high-quality 30m wind monitoring data. It is important to note that this constructed dataset represents an estimation at best and a guess at worst. Constructing a suitable initiating wind speed dataset will require site-specific wind monitoring at the Mullewa site.

Accurate topographical information is also crucial for initiating the wind flow model. In this case, digital topographical data was provided by Landgate.
The third set of initializing data pertained to the wind turbine model and its performance characteristics. The flow model was initiated with the Enercon E40/E2 – 600kW wind turbine, which is a class II turbine suitable for inland medium to low wind speed sites. This wind turbine model is frequently available as a second-hand option, commonly sourced from repowering projects in low wind speed inland wind farms located in Germany.

Another factor influencing turbine performance is air density, which constitutes the fourth element in the modeling. Based on my prior experience in the Mid West region, I utilized a mean air density ranging from 1.029 to 1.043 kg/m^3 across the site.

Constructed Wind Speed Distribution For Mullewa

I have generated a probabilistic wind speed distribution using the industry standard Weibull distribution functions. The initial Weibull parameters were determined based on my experience with wind speed monitoring in the Geraldton region and available published Weibull parameters. However, it is important to highlight that the constructed data is at best an estimation and at worst a rough approximation. For an accurate assessment of the constructed initiating wind speed distribution, it is essential to conduct site-specific wind monitoring. Ideally, two years of on-site data recorded at a height of 78m would be available.

Initiating Mumbida Data
The constructed wind speed distribution was derived from published distributions from high-quality wind speed data collected at the Mumbida wind farm site, located approximately 70km directly east of the Mullewa site. The instruments used for data collection at Mumbida were of high quality and calibrated, and the data was collected at heights of 30m and 10m.

It is important to note that the Mumbida site is situated at an elevation of around 250m, while the Mullewa site is at approximately 280m, making it a more elevated location.

Figure 1 Mumbida wind monitoring and Mullewa proposed turbine locations

Results

The predicted annual wind speed distribution colour scale is shown in Figure 2.

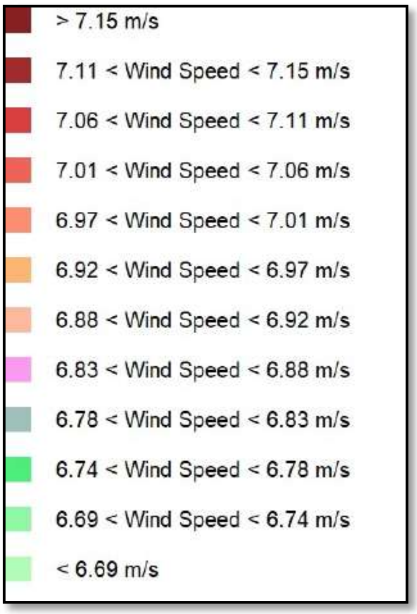


Figure 2 Predicted annual wind speed distribution colour scale

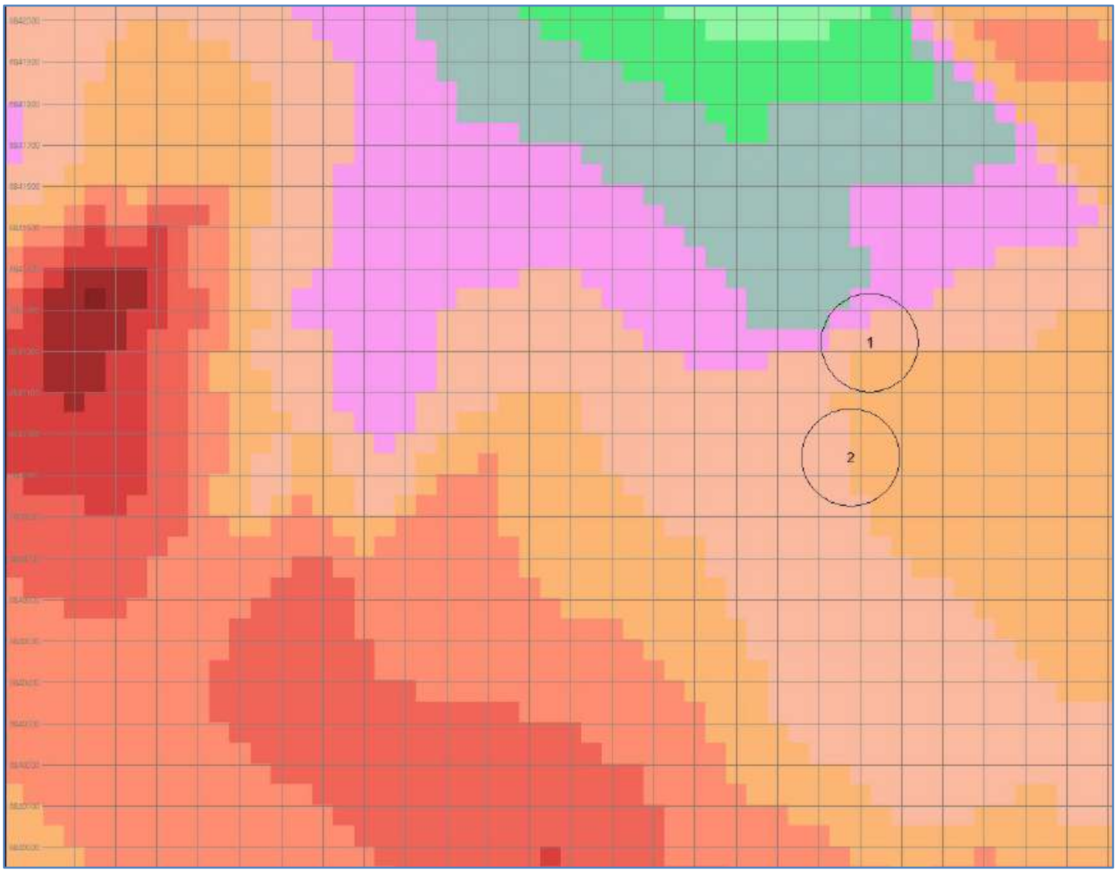


Figure 3 Predicted annual Wind Speed Distribution at Mullewa showing turbine locations. Grid spacing is 100m. Colours represent higher wind speeds – see figure 2.

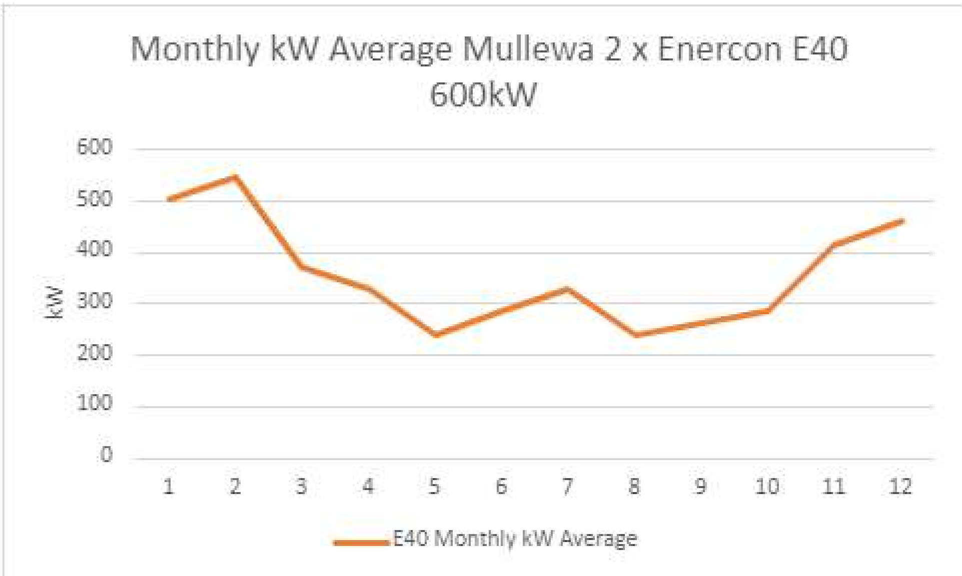
Predicted Mullewa Wind Speed and Annual Energy Output – Enercon E40 / E2 – 600kW 78m hub height

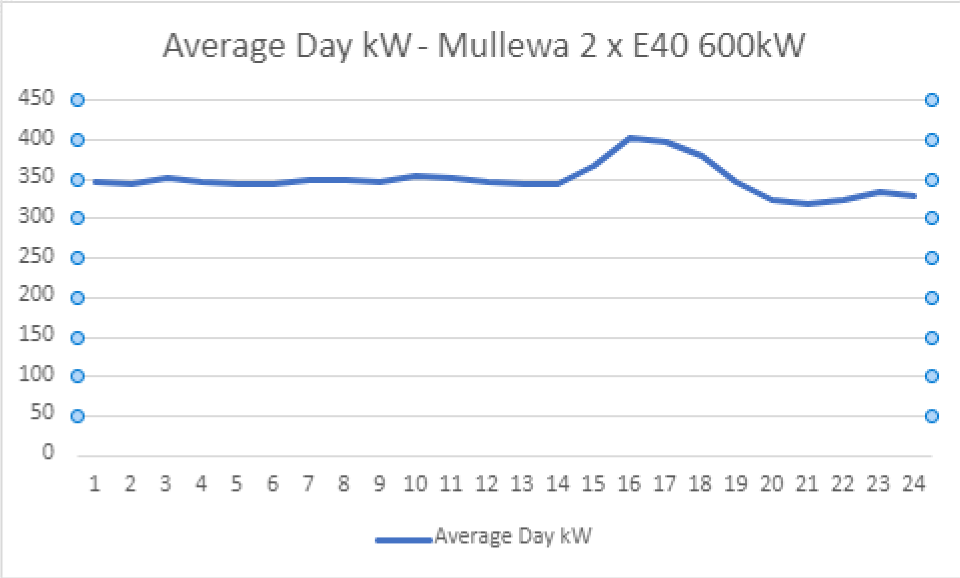
	Terrain Elevation m	Mean Free m/s	Mean Wake Affected m/s	Net Yield [MWh]	Capacity Factor %
T1	**278**	**6.91**	**6.87**	**1475.3**	**28.0**
T2	**280**	**6.92**	**6.91**	**1506.7**	**28.6**
				2982	**28.3**

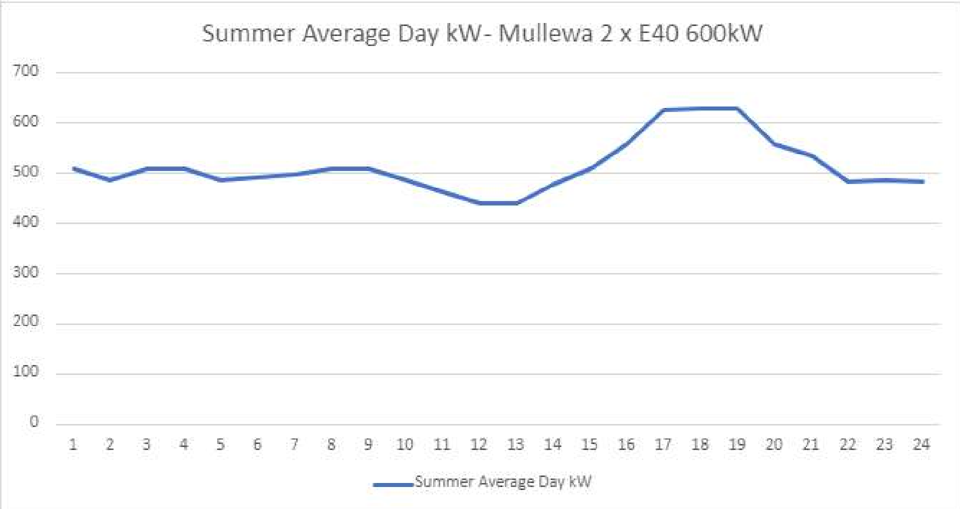
Anticipated Average Monthly Daily Profile – Summer and Winter

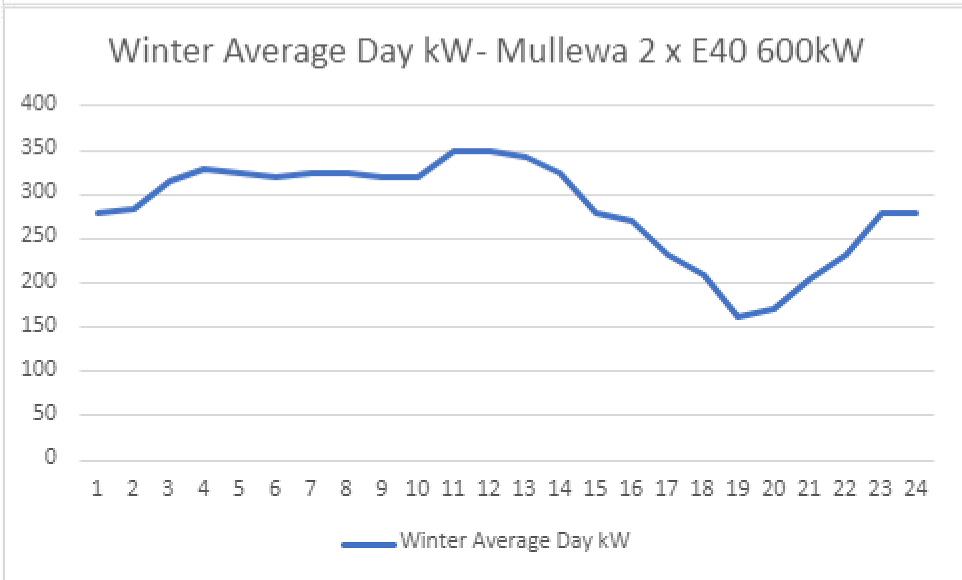
The windiest period is anticipated to be during the summer months, indicating a significant presence of a strong sea breeze effect that is projected to impact the site. However, given its inland location, there is a certain level of risk associated with this assumption. Therefore, it is crucial to emphasize the significance of implementing localized onsite monitoring to validate the availability of adequate wind resources. This aspect is further explored in the following section, which underscores the necessity of on-site monitoring to confirm the presence of viable wind conditions.

Predicted Average Monthly Profile




Average Day kW - Mullewa 2 x E40 600kW
450
400
350
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Average Day kW


Summer Average Day kW- Mullewa 2 x E40 600kW
700
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Summer Average Day kW


Winter Average Day kW- Mullewa 2 x E40 600kW
400
350
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Winter Average Day kW

Note on Wind Monitoring

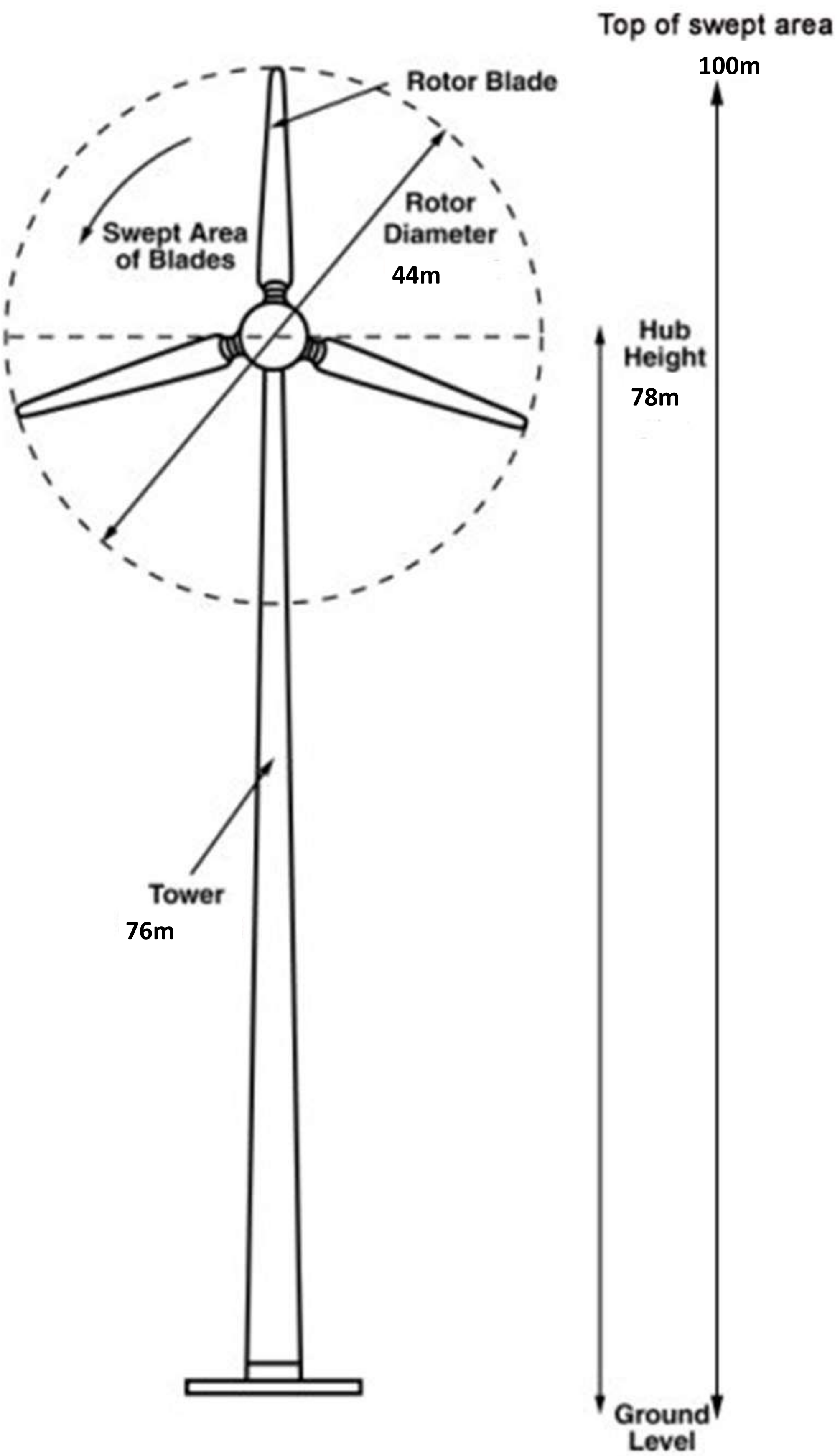
Wind farms rely on the presence of wind for their operation. Essentially, sites with low wind speeds are less financially viable compared to those with high wind speeds. Since wind farms do not incur fuel costs and capital costs remain unaffected by wind speed, the economic feasibility of the project is significantly influenced by the wind resource. This relationship is further strengthened by the fact that the energy available in the wind is directly proportional to the cube of the wind speed, resulting in substantial variations in energy generation due to even minor changes in average wind speed.

Figure 4 Typical 60m Monitoring Mast

Therefore, it is customary, although not always followed, to assess the wind resource at a specific site before initiating wind farm development. This involves deploying wind monitoring techniques like a monitoring mast or a SODAR unit at the site under consideration. Following best practices, it is recommended to gather a minimum of two years of wind speed data at the proposed wind turbine hub height.

To establish meaningful correlations, it is advisable to install on-site hub height wind monitoring equipment and compare this data with nearby long-term data sets. By extending the analysis to long-term data sets, the duration of the on-site wind monitoring program can be reduced, minimizing the impact of seasonal and year-to-year fluctuations in average wind speed.

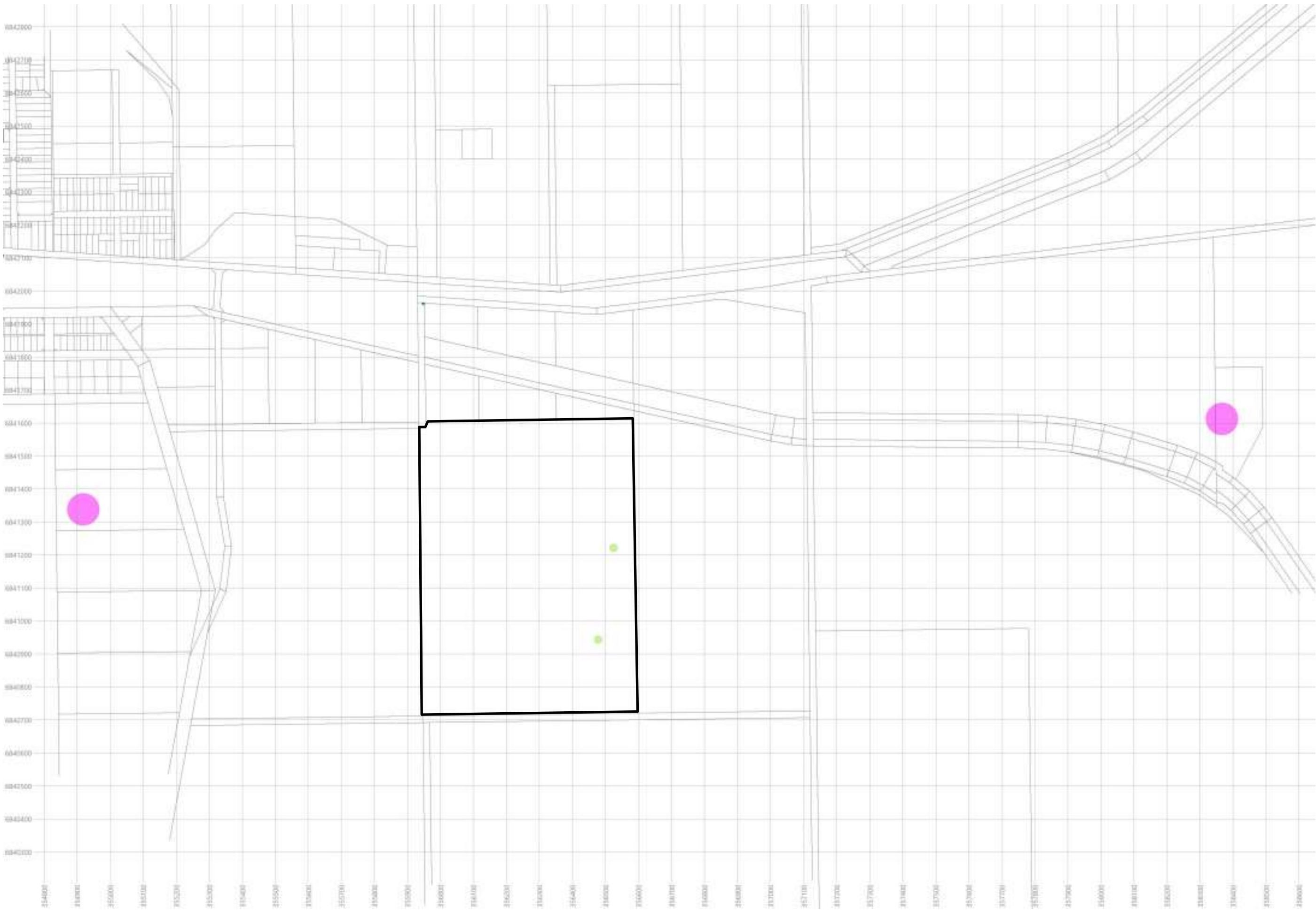
Figure 5 SODAR Monitoring Device



Turbine dimensions are shown.

- Tower — 76m
- Hub height - 78m
- Rotor Diameter — 44m
- Top of swept area — 100m

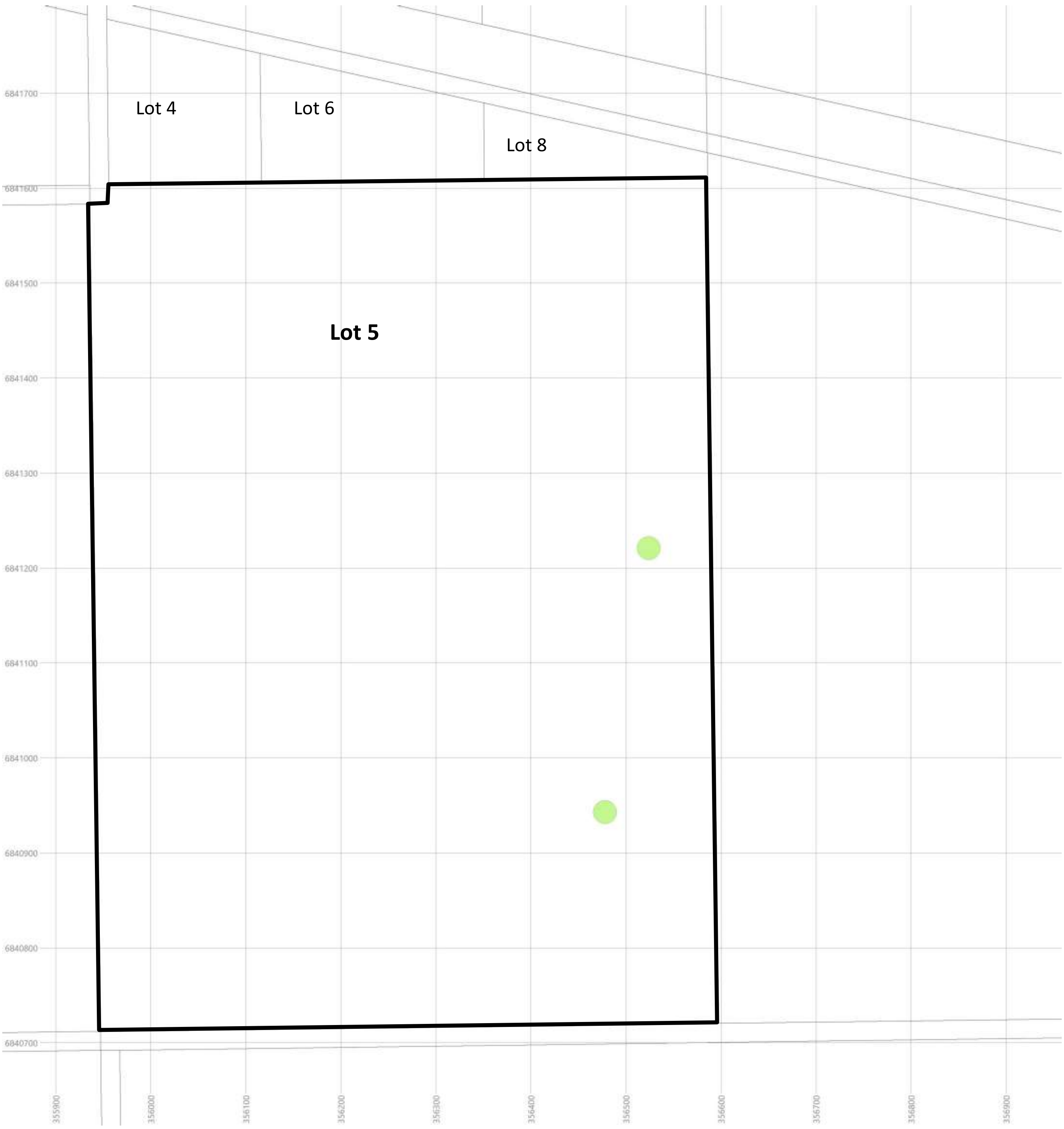
PROJECT	Mullewa Wind Farm WA		
TITLE	Enercon E-40 / E2 – 600 KW-78m Dimensions		
CREATED BY: MR	DATUM	DATE 28/04/2023	
CLEARANCE BY MR	SCALE	DRAWING NO. MUL 001	REV 001
APPROVED M. Rosser	BlairFox Building the connections	Unit 2, 33 McDonald Crescent Bassendean WA 6054 mrosser@blairfox.com.au	



100m

Nearest Dwelling	
Turbine Location	
Lot 5—Property Boundary	

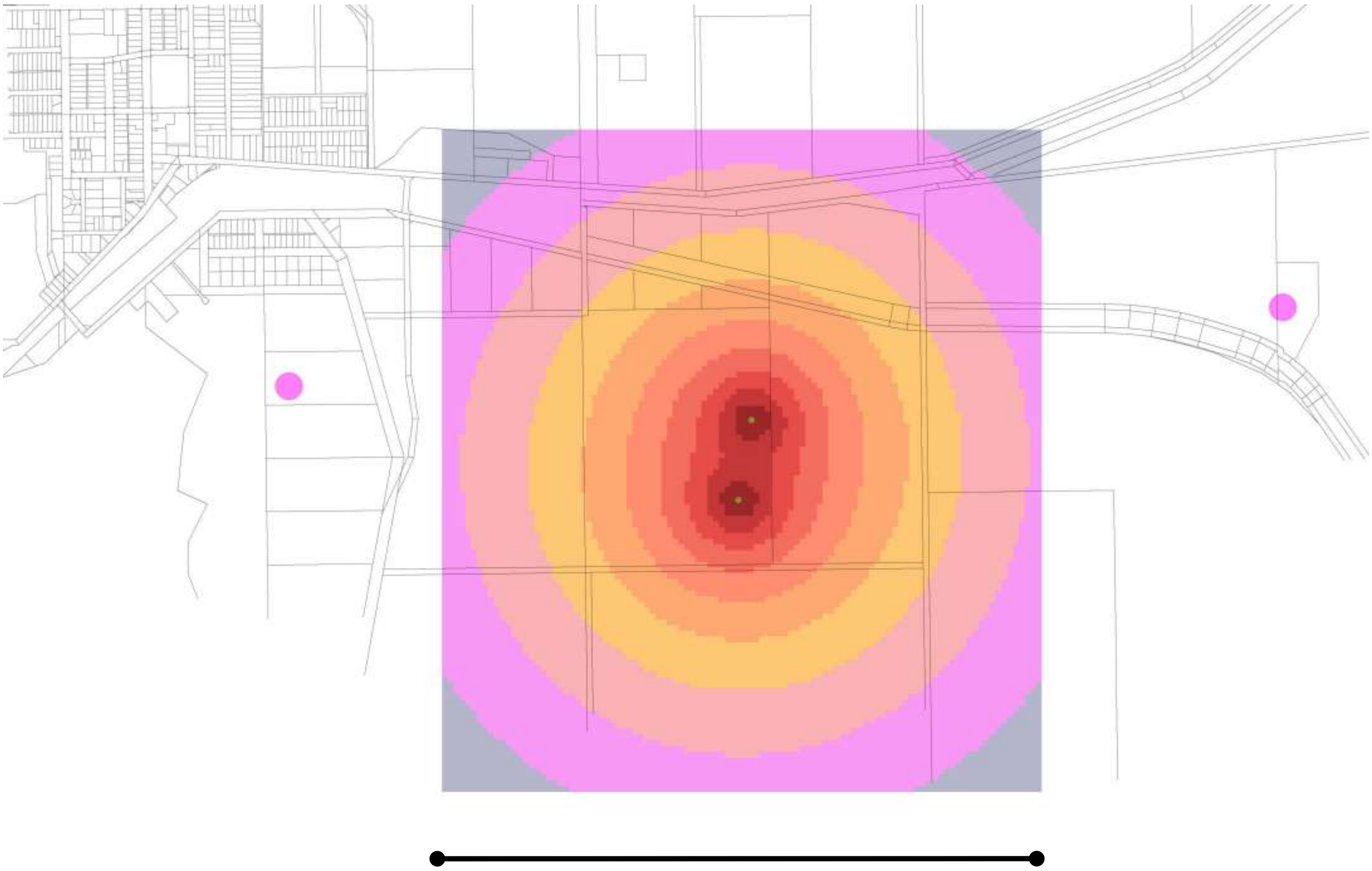
PROJECT Mullewa Wind Farm			
TITLE Nearest Dwelling			
CREATED BY: MR	DATUM GDA94, MGA 50	DATE 29/04/2023	
CLEARANCE BY MR	SCALE	DRAWING NO. MUL 002	REV 001
APPROVED M. Rosser	BlairFox Building the connections	Unit 2 McDonald Crescent, Bassendean WA 6054 mrosser@blairfox.com.au	



Coordinates	X(m)	Y(m)
Turbine 1	356524	6841221
Turbine 2	356478	6840943

100m

Legend				
● Proposed Turbines	PROJECT Mullewa Wind Farm			
— Property Boundary	TITLE Turbine Layout and Coordinates			
	CREATED BY: MR	DATUM GDA94, MGA 50	DATE 29/04/2023	
	CLEARANCE BY MR	SCALE	DRAWING NO. MUL 003	REV 001
	APPROVED M. Rosser	BlairFox Building the connections	Unit 2 McDonald Crescent, Bassendean WA 6054 mrosser@blairfox.com.au	

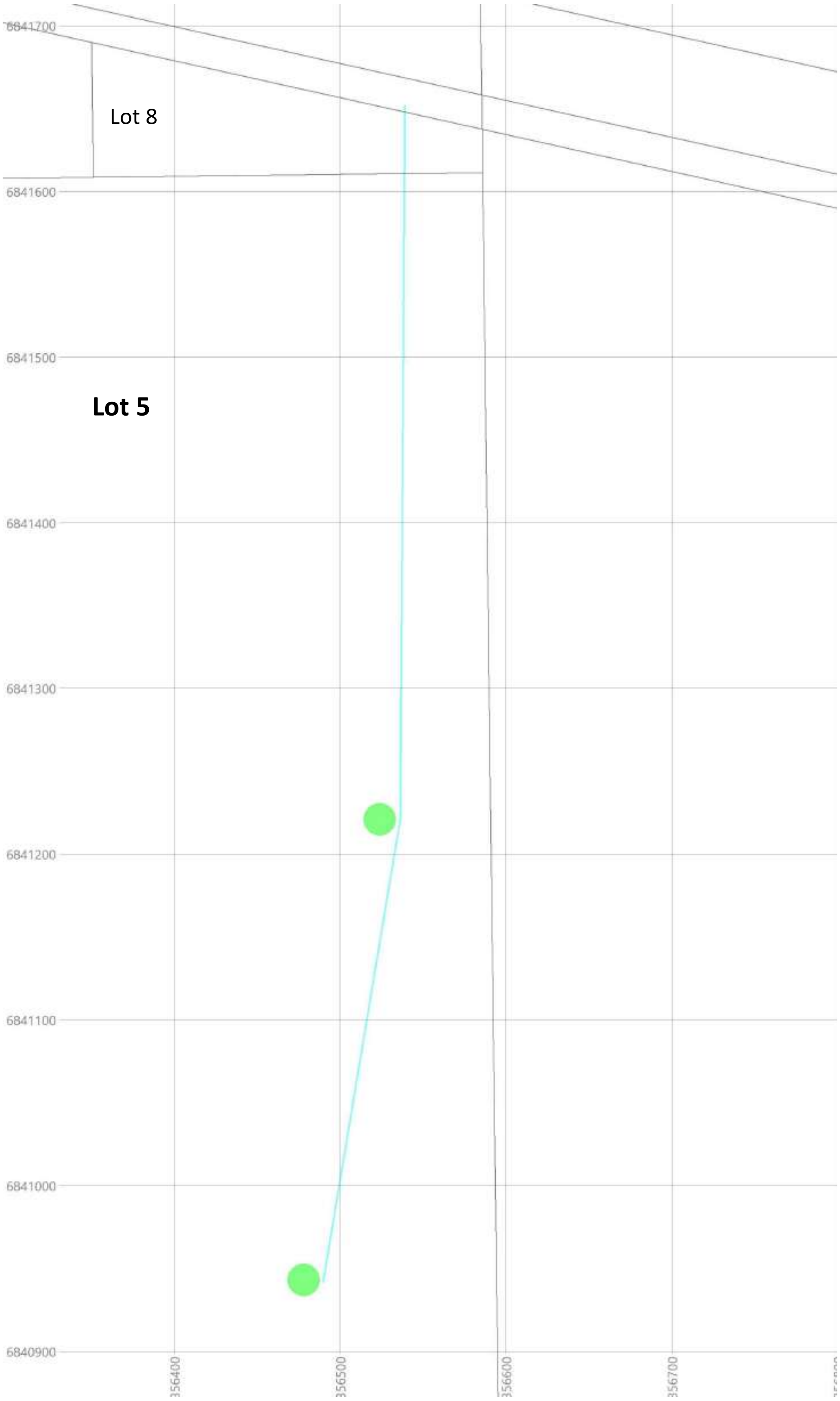


2 km

- > 55.00
- 52.23 < Noise [dB] < 55.00
- 49.46 < Noise [dB] < 52.23
- 46.69 < Noise [dB] < 49.46
- 43.92 < Noise [dB] < 46.69
- 41.15 < Noise [dB] < 43.92
- 38.38 < Noise [dB] < 41.15
- 35.62 < Noise [dB] < 38.38
- 32.85 < Noise [dB] < 35.62
- 30.08 < Noise [dB] < 32.85
- 27.31 < Noise [dB] < 30.08

● Nearest Dwelling

PROJECT Mullewa Wind Farm			
TITLE Noise Contours			
CREATED BY: MR	DATUM GDA94, MGA 50	DATE 29/04/2023	
CLEARANCE BY MR	SCALE	DRAWING NO. MUL 004	REV 004
APPROVED M. Rosser	BlairFox Building the connections	Unit 2 McDonald Crescent, Bassendean WA 6054 mrosser@blairfox.com.au	



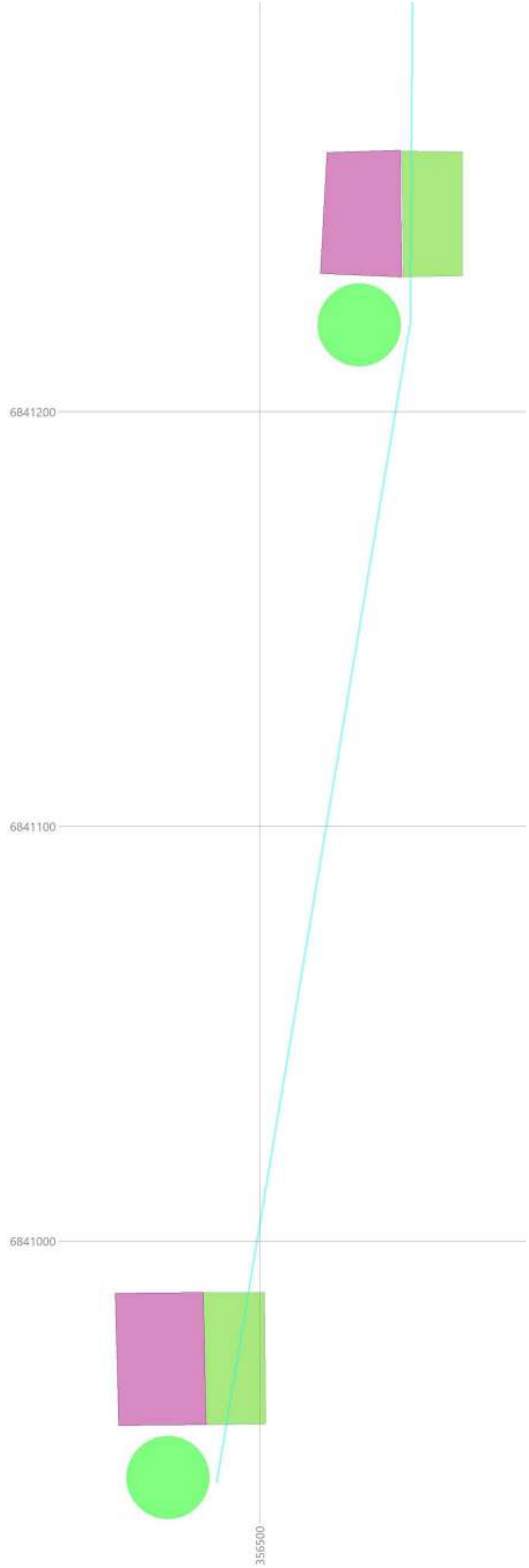
100m

Road Details	
Length	725m
Road width	4m
Clearance width	5m
Clearance height	4.6m
Radius of external curve	28m
Able to withstand axel load	12t
Able to withstand overall vehicle weight	120t

Proposed Turbines

Access Road

PROJECT Mullewa Wind Farm			
TITLE Access Road			
CREATED BY: MR	DATUM GDA94, MGA 50	DATE 07/05/2023	
CLEARANCE BY MR	SCALE	DRAWING NO. MUL 003	REV 001
APPROVED M. Rosser	BlairFox Building the connections	Unit 2 McDonald Crescent, Bassendean WA 6054 mrosser@blairfox.com.au	



Details	
Crane pad dimensions	20m x 30m
Lay down dimensions	15m x 30m
Distance crane pad from turbine centre point	9.5m
Crane pad withstand pressure	185kN/m2
Laydown Area able to withstand axel load	12t
Material	gravel

100m

Legend	
(green dot)	Proposed Turbines
(blue line)	Access Road
(pink)	Crane pad
(green)	Laydown area

PROJECT Mullewa Wind Farm				
TITLE Crane Pad and Laydown Area				
CREATED BY: MR	DATUM GDA94, MGA 50	DATE 07/05/2023		
CLEARANCE BY MR	SCALE	DRAWING NO. MUL 0037	REV 001	
APPROVED M. Rosser	BlairFox Building the connections	Unit 2 McDonald Crescent, Bassendean WA 6054 mrosser@blairfox.com.au		

APPENDIX E

Avora FEED Report

2023

Mullewa Solar FEED Report

Jeff Brill
Avora Pty Ltd
28/07/2023

Document Control

Revision	Description	By	Checked	Date
0	Issued to Client	JB	BD	28/07/2023
C	Issue for Client review	JB	CY	18/07/2023
B	Issued for external review	JB	CY	29/06/2023
A	Issued for internal review	JB		02/06/2023

Contents

1.0) Introduction

This FEED report has been developed for the proposed solar installation to be located at the town of Mullewa, Western Australia.

The FEED report was commissioned by Sunrise Energy Group. The FEED report covers a proposed solar array at a site currently called “Solar Site” and construction/integration works at the Connection Point compound where a proposed backup generator and Jarrah protection container / transformer would be located, plus HV connecting power infrastructure to link both sites into the exiting Western Power grid. There is also a wind turbine site which is not part of this FEED.

The Solar Installation consist of:

- 1.1MWDC single axis tracking solar array
- 25 row, 81 module NEXTracker tracking system
- 2,025 panels, 550W Longi bi-facial
- One FIMER PVS980-CS 3.5MVA skid
- Skid to be fitted with a 1045kVA-L+IN PVS980-58 solar inverter, 2091kVA-I type bi-directional BESS inverter and 3.5MW 33kV 2-winding transformer
- One SAFT 3MWh BESS container
- Connection to the existing 33kVA high voltage Western Power network
- Pre-commissioning

The Connection Point is located immediately to the North of the Solar Site and is the point at which the solar/wind and diesel all connect along with the Jarrah protection container and the installation works include:

Overhead:

- 3 x 33kV reclosers
- 2 x fused switches
- 3 x air-break switches
- 1 x metering unit
- 1 x 63 kVA power transformer

Ground:

- 1 x protection and automation container
- 1 x zig-zag neutral earthing transformer
- 1 x 1.0 MVA power transformer
- 1 x diesel generator
- 1 x diesel generator fuel tank
- Fence with access gates
- Security camera
- Access Road

Underground:

- Earthing mat
- Earthing rods
- Earth Grid

2.0) Array Layout

A solar array layout has been developed which achieves a 1.1MWDC at the Solar Site location. Geotechnical testing has also been conducted at this site which indicates the presence of rock. NEXTracker review of the geotechnical testing has indicated that pre-drilling is required for all piles.

The layout shows the proposed single block of NEXTracker array, 25 rows of 81 modules per row, the inverter skid and the BESS container.

The solar array is fenced for safety and security and will have a double gate for access.

Refer to Appendix 1 for the array layout.

3.0) Major Equipment - Modules

Module pricing is stabilising as we move through 2023. Based on the delivery port of Fremantle, Western Australia, pricing was sought on a FOB and CIF basis.

We have selected Longi bi-facial 550W modules for this FEED study. Current and historical module pricing is shown in the table below and the power modelling was completed using Longi 550W bi-facial modules:

- Longi LR5-72HPH;
- Bi-facial modules;
- 550W power class:

Pricing based on Q1 2024 delivery was obtained at USD $0.2245/W CIF (USD $0.22/W FOB) and an exchange rate of 0.65 was utilised resulting in AUD$0.345/W CIF.

Refer to Appendix 2 for Data Sheets.

4.0) Major Equipment – NEXTracker Single Axis Tracking System

We have selected the NEXTracker NX Horizon tracking system, which is a single axis, self-powered tracking system with an integrated UPS designed for long term installations. One of the advantages of this system is the independent construction of the rows compared to other tracking systems which are physically linked together. This improves the access along the rows for future maintenance and operability.

The self-powered rows are individually powered by a small solar panel and UPS battery and each row wirelessly communicate to the NEXTracker Control Unit via a ZigBee mesh network. This setup allows for easier maintenance and eliminates the need for additional wiring or mechanical drives between rows.

The NEXTracker system is an 81-module row configuration, consisting of 11 supporting piles that are driven into natural cleared ground to a typical depth of 2m. The final pile depth is based on actual geotechnical conditions (confirmed by physical pile testing with results fed back to NEXTracker). The system consists of a supported torque tube that rotates the 81 modules plus or minus 60 degrees using a solar powered UPS motor based on the suns position to maximise solar collection. The key component materials are pre-galvanized structural steel. The system also has 2 in situ weather stations that monitor wind speed and direction which will put the system into stow mode for safety during excessive wind conditions. NEXTracker design and operational standards will cause all rows will rotate into stow mode at

40mph wind speed, the design limit is 3sec gust of 93mph @ 10m height (ASCE 7-10, Category I), this design limit requires pile tests for NEXTracker warranty and design confirmation.

Refer to Appendix 2 for Data Sheets.

5.0) Major Equipment - Inverters

The proposed solution consists of one 40ft FIMER PVS980-CS 3.5MVA skid using one 1500V PVS980-58-1045kVA-L solar inverter and one PVS980-58BC-2091kVA-I type bi-directional BESS inverter for the battery storage system and a 3.5MW 33kV 2-winding transformer.

This solution allows for a peak solar output of 1150kVA at 35degC which derates down to 1045kVA at 50degC. The BESS inverter has a rated output of 2300kVA at 35degC which derates to 2091kVA at 50degC, this gives a large degree of reactive power control for the grid.

The FIMER inverter station is the preferred inverter solution due to the lower cost, open control system and ease of maintenance. This is supported by Jarrah Solution's experience in controlling (and interrogating information from) each brand whereby the FIMER product is more open and provides better access to information for the SCADA control system, particularly important when investigating a fault.

Refer to Appendix 2 for Data Sheets.

6.0) Major Equipment – Battery Storage System

Coupled to the inverter skid are the battery container supplied by SAFT, a company owned by the Total Group. The advantage is that the SAFT battery solution is fully integrated solution that is compatible with the current PVS980-58BC battery inverter and is able to be shipped fully assembled which means the site-based installation and connection works and therefore technical risk are significantly reduced.

The SAFT standard offering is a 20-foot container configured with 3MWh of battery storage. The battery container is delivered plug and play, fully assembled, and tested ex-factory. Importantly these battery container solutions have been integrated with FIMER inverters previously and are a known and proven solution.

Commissioning of the SAFT system on site would be conducted by SAFT commissioning team and the commissioning of the FIMER system by a FIMER team.

SAFT Intensium Shift 3.0MWh high energy lithium-ion battery storage container specs:

Main Characteristics	Intensium® Shift high energy
Cell type	Lithium Iron Phosphate (LFP)
Minimum Voltage (0% SOC, OCV)	1166 Vdc
Maximum Voltage (100% SOC, OCV)	1500 Vdc
Rated BoL Energy (DC) based on cell energy at C/5	3.0 MWh
Max DC Power charge or discharge	1.5 MW
Dimensions (L x W x H) **Note 1**	(6.1 x 2.4 x 2.9) m
Weight	30.5T
Operating Temperature Range	-25°C to +55°C

Ingress Protection (IP) Rating	IP54
Design Lifetime	≤ 20 years
Altitude above sea level	≤ 2000 meters
Ambient relative humidity	Up to 100%
Painting	C3 (option C5)
Ambient temperature during storage	–25°C to +55°C (under conditions)
Storage time	Up to 12 months (under conditions)
Safety	IEC 61619, IEC 62477, UL1973, UL9540, UL9540A
Marking	CE, UL
Directives	REACH
Manufacturing hubs	ISO 9001, QS 9000, ISO 14000
Cybersecurity	IEC 62443-4-2
Transport (fully populated)	UN3536

Refer to Appendix 2 for Data Sheets.

7.0) Warranty Information

7.1) Longi Bi-Facial PV Modules

The Supplier warrants that for a period of 12 years since the Warranty Start Date that the Solar Modules (including the DC connectors and cables) will be free of defects in material or workmanship which affects the normal installation or utilization of the modules, provided that the Solar Modules are installed, utilized and maintained according to the stipulations of the Installation Manual provided by the Supplier.

The Supplier warrants for a period of 30-year performance warranty (“Performance Warranty Period”) in details as below: during the first year of the Performance Warranty Period, the actual power output (performance) of the modules will reach at least 98% of the nominal power output; and from the second year, the actual power output will decline annually by no more than 0.45% for a period of 29 years; by the end of the 30th year, an actual output of at least 85% of the nominal power output is guaranteed.

7.2) NEXTracker Single-axis Tracker Warranty

(a) for a period of ten (10) years from date of shipment, Products' structural components will be free from defects in material and workmanship, when used under normal conditions and used in accordance with NEXTracker documentation, and when constructed and installed in compliance with all applicable construction codes and regulatory requirements that have been approved by a licensed professional engineer; and,
(b) for a period of five (5) years from date of shipment, Products' motor, gear, and controller will be free from defects in material and workmanship, when used under normal conditions and used in accordance with its documentation, and when constructed in compliance with all applicable construction codes and regulatory requirements that have been approved by a licensed professional engineer; and,
(c) such warranty shall cover latent defects, understood as the damage produced as a result of manufacturing faults, errors in calculation solely performed by NEXTracker, material faults, smelting, welding or adjustment errors (not occurring during installation) and, in general, similar inherent causes in the Products' design and manufacturing process; and,
(d) If during the applicable warranty period, a defect is confirmed in accordance with Section 5 below, NEXTracker, as its sole obligation and Customer's exclusive remedy, will assume the direct material damages arising from NEXTracker's repair or replacement of the warranted Product or parts thereof. Such decision to repair or replace shall be at NEXTracker's sole discretion. Any such defective Products or parts thereof may be replaced with either new or factory refurbished or remanufactured Products or parts thereof. This Limited Product Warranty covers all the commercial components that comprise the Products, however, none of the peripheral or additional equipment that should be connected to the original Product that NEXTracker delivers for the production of energy (e.g. photovoltaic panels, inverters, devices, foundation pier if foundation pier is not a component of the purchased tracker system, etc.) is covered by this Limited Product Warranty. This Limited Product Warranty does not include labor and traveling expenses; and,
(e) In the event of incidents or damage to the Products, the Customer expressly undertakes not to carry out any operation on them, without prior express and written consent from NEXTracker, provided that Customer may carry out repairs if use of the damaged Product would create an imminent safety risk or threat to human life.

7.3) FIMER Inverter Warranty

Inverter Station Skid: Warranty period in relation to defects in materials, manufacture or assembly for the entire station (except inverters) shall be 24 months from commissioning date, or 30 months from manufacturing, whichever happens first, provided that the required maintenance activities are followed by the Customer as per FIMER’s equipment requirements.

PVS980 Inverters: Material warranty for inverters shall be 60 months from commissioning date, or 66 months from manufacture, whichever happens first, provided that the required maintenance activities are followed by the Customer as per FIMER's equipment requirements. The Warranty may be extended to a total of 10 years at additional cost, provided that the purchase of the Warranty Extension occurs within 12 months of purchasing the inverter.

7.4) SAFT BESS

Saft warrants that the Product will be free from Defects in materials and workmanship for the relevant Factory Warranty Period applicable to the said Product.

Saft warrants that the Product supplied pursuant to the Supply Agreement shall, during the Factory Warranty Period applicable to that Product:

a.) conform, in all respects, with the Supply Agreement;
b.) be new, of merchantable quality and free from defects in materials and workmanship;
c.) be capable of providing the functions and features described in the contractual specifications; and
d.) any replacement parts of the Product will be new or serviceably used, comparable in function and characteristics to the original part of the Product so replaced.

Standard Factory Warranty Periods are defined below. The CUSTOMER shall have the option to extend the Factory Warranty Period for the Product for an additional period by giving written notice to SAFT at least 90 days before the warranty expiration.

Battery Cells and module: 5 years (optional up to year 20)
Battery container bill of system: 2 years (optional up to year 20)
Spare Parts: 1 year after replacement or repair

The Standard Factory Warranty includes repair or replacement of the defective part at Saft's expenses (parts, shipment of spare parts, travel expenses (train, plane, other transport, hotel, hospitality costs, etc.) and man-hours of Saft employees and / or third parties under Saft's responsibility).

7.5) Combiner Boxes and Cables

Suppliers offer 1 year of "defect warranty" or "satisfactory operation" where they would replace defective parts or materials if it can be proven.

8.0) Scope Battery Limits

The following scope battery limits apply to link this FEED to allow the FEED being prepared by Blair Fox and Jarrah Solutions to provide a complete technical solution.

Scope Battery Limits –Array

- Natural ground level and condition;
- Connection Point;

Scope Battery Limits – Connection Point

- Natural ground level and condition;
- 40' Jarrah switchroom gland interfaces;
- New 33kV Western Power HV network;

9.0) Assumptions and Exclusions

The following assumptions and exclusions apply to this report:

- Civil works including trenching/directional drilling/earth rod drilling exclude rock. Refusal and hard digging. Our subcontractors will move onto rates if they encounter rock when completing construction scopes;
- We have not allowed for Main Roads approval or the development of traffic management plans as we have assumed roads used for construction of the solar array and isolation point will be sufficient;
- The construction areas will be managed under the Avora HSE management systems;
- We have allowed for accommodation and food costs for the construction team;
- The management of logistics in and out of the project area will be completed by Avora construction personnel, we have assumed this responsibility will be delegated to the construction team;
- Landscaping has been excluded as it is assumed not to be a council requirement;
- Battery shelters have been excluded but should be considered;
- A stand alone weather station has been excluded;

10.0) Design Brief and Construction Implications

10.1) Civils

The civil scope is to prepare the site for access and solar farm construction and includes the following:

- Solar site, Clearing, grubbing, grading of site and stockpile vegetation and topsoil on site (178m x 127m);
- Solar site, Grade fence line;
- Solar site, Development of site access and internal tracks to solar farm area, 450m long x 4m wide 200mm thick;
- Solar site, Construction of laydown area, 180m x 20m, gravel base 250mm thick
- Connection Compound, access track 50m long x 4m wide, 200mm thick
- Connection Compound, laydown 32m x 30m x 250mm thick
- Gravel will be locally sourced by civil contractor and free of contamination;

It is important to note that there is no allowance to remove vegetation nor excess topsoil from the site. Any usable materials stockpiled on site will be used in the construction, however the estimate is based on construction materials (gravel, blue metal, road base) being supplied by the civil contractor from a local quarry.

10.2) Fencing

The proposed Solar Site fencing is 1.8m high chain link fencing with 3 strand barbed wire above, allowance has been made for 650 lineal meters with 1 double gate for access/egress.

The proposed Connection Point fencing is 1.8m high chain link fencing with 3 strand barbed wire above, allowance has been made for 120 lineal meters with 1 double gate for access/egress.

We have assumed that there will be no council requirements on the fence as it is essentially an internal development. However given this site location in town, security fencing will be required to manage access both during construction and under operation.

10.3) Earthing

The MAVs, inverter stations and BESS all require earthing. A dedicated earth grid consisting of copper rod earth stakes is to be distributed throughout the array. Each combiner box location is to have a dedicated earth stake that is bonded to the main buried earth grid. The inverter stations and battery containers are to have multiple redundant connections to the main earth grid plus multiple earth rods.

In situ earth testing is recommended to determine the final earthing design to be used for the project.

10.4) DC Cabling

The array consists of 75 PV strings connected to 5 combiner boxes which are connected to the inverter through fused inputs. Sub-array cabling is to be 300mm^2 aluminium cable mounted in cable tray and terminated via bi-metal lugs. All cable, fuses and DC switchgear are to be rated for 1500V DC.

10.5) AC Cabling

The inverter station consists of an integrated solar inverter, transformer, battery inverter and RMU. The inverter station is to be connected on a single line using the integrated RMU's through to the HV Connection Point via underground 35mm2 copper XLPE cables.

10.6) PV Array Wiring

The solar array has a total of 75 PV strings all of which are to be 27 panels long. PV strings are to be combined and wired individually into the combiner boxes fused inputs using 6mm^2 solar cable. Combiner box configurations are to be identical with 15 pairs of fused inputs each, a main DC disconnector and a type 1+2 SPD. All cable, fuses and DC switchgear are to be rated for 1500V DC.

10.7) Inverter Foundations and Roof Structure

The inverter stations require foundations for mounting in the field, managing cable entries, and containing an oil bund that is required for the oil filled transformers. The foundations will consist of concrete foundations cast in-situ. A prefabricated oil-bund will be mounted beneath the inverter station transformer. Additionally, a roof structure will be built over the inverter stations to protect the equipment from direct sunlight, maximise equipment longevity and to minimize water ingress into the oil bunds. This structure will be secured to additional Surefoot footings.

11.0) Execution Plan

The project would be executed using PIMBOK project philosophy by utilising the following stages of initiation / planning / execution / monitoring / closing:

Initiation

A kick off meeting would be held including all relevant parties to complete planning and align efforts. Site specific mobilisation requirements (including inductions) and site access protocols would be established as would project responsibilities. Considering the duration of the construction and the logistics of managing deliveries and personnel to the site we have assumed that the construction team would be handed over the delegated responsibility to manage these aspects independent of the site operations management.

Planning

This stage includes project planning, which is the alignment of the detailed design effort, the timing of procurement, (allowing for long lead items including the Inverters, batteries, tracker, panels, diesel gensets, combiner boxes and cable) noting that the balance of the materials are expected to be readily available in WA or wider Australia. Site access and availability to begin site setup would be an important date to agree which allows early establishment.

Detailed design would be completed for the project which allows final equipment selection to be made and the procurement processes to begin. This is especially important given the current manufacturing landscape, until an order is placed actual delivery dates cannot be confirmed. Equipment would be delivered directly to site or to Avora's warehouse facility (in the case of smaller components) for marshalling and delivery to site when it is required.

Execution
The execution stage will begin with a mobilisation to site and setup of construction facilities. This would include setting up site admin office, crib hut and infrastructure, establishing communications and safety systems and marking out the site boundaries.

This will be followed by the removal of vegetation, leveling of the site, development of site access tracks (internal and external as required) and laydown areas. The surveyor will peg out the required locations (fence lines, tracker piles, inverters, batteries, combiner boxes, main cable runs and protection equipment) which set the arrangement of the site up. The fencing will be installed to secure the site.

The build then commences with tracker receival and deployment and earthing installation. The foundations for the inverter and BESS will be constructed and the items landed into position ready for electrical connection.

The electrical team can then be mobilised to site for DC string cabling runs to combiner boxes, bonded earthing grid connections across the site and sub array cables connections into combiner boxes. Testing of installed cables will be completed progressively across the array to achieve complete DC array blocks.

The construction of the required foundations (inverters, BESS) will be completed followed by placement of the associated equipment as it is delivered to site. This then will allow final installation of AC cables and connection (including communications) as required followed by pre-commissioning testing. Following successful pre-commissioning the site is handed over to Jarrah commissioning team and trade support is provided as required. During this period the construction equipment will be progressively demobilised.

Monitoring and Closing
Standard HSEQ monitoring and reporting will be agreed with Client at the start of the project and reported on regularly during the project execution. Project cost will be monitored throughout using Avora cost control system and internal project controls resource. The schedule will also be monitored and reported regularly. From a quality perspective a MDS file will be progressively created for handover to the Client.

12.0) Schedule

The schedule is driven by the timing of the project kick off and then by the long lead item procurement process.

Major Procurement Item	Procurement Timeframe (sea freight including customs clearance)
Inverter	28 weeks
Battery	26 weeks
Tracker	28 weeks
Panels	14 weeks

Combiner boxes	18 weeks
Cable	18 weeks

13.0) Risk Mitigation

The following risks have been identified and mitigation outlined below:

Event	**Risk**	**Mitigation**	**Residual Risk Level**
Project			
Site access delays	Schedule delays, cost overruns, unable to meet the target date	Coordinate site access with Client	M
Loss of key personnel	Schedule delays, cost overruns, unable to meet the target date, market conditions currently resource constrained	Keep personnel happy to remain engaged with project, replace key personnel with alternative personnel as required	L
Security	Construction in town will require additional security provisions for materials and equipment	Cameras, security guards	L
Design			
Delays in detailed design of system	Schedule delays due to delays in placing procurement orders	Start detailed design well in advance of required date so procurement is not impacted	L
Procurement			
Volatility of currency exchange rates	Australian Dollar continues to fall below $0.60 to USD, cost escalation	Hedge USD or EUR	H
Volatility of panel pricing	Currently volatile due to world conditions	Place order when possible and manage closely	M
Volatility of cable pricing	Currently volatile due to world conditions	Place order when possible and manage closely	M
Logistics pricing and delays	Currently volatile due to world conditions and overseas items subject to delays	Place order when possible and manage closely	H
Construction			
Rock	Piling and Trenching delays	Piling will require pre-drilling, trenching to be trialled	L
Contamination	Risk of dieback or fungal contamination when bringing vehicles and imported fill into the site	Contract requirements will dictate vehicle and material entry requirements	L
Manual	Personal injury	Experienced installers and	L

Handling		purpose built installation aids will be used to handle racking, panels and cable	
Electrical	Personnel injury & plant/equipment damage	Experienced electricians will be used to install electrical system	L
Lifting	Crane overload/collapse, Personal Injury, & damage to plant, equipment, environment	Experienced crane operator and riggers will be used, minimal number of lifts	L
Rubbish	Control of rubbish from site, in particular panel packing	Control unpacking panels to control and contain rubbish, daily clean up around fence line	L
Dust	Airborne dust interferes with construction operations	Appropriate PPE, depends on time of year	L
Labour Market	Labour difficult to find and retain given current market	Use known personnel and sub-contractors to maintain experienced personnel	L
COVID	Interruptions to project due to Covid directly or indirectly	Abide by government, client and Avora protocols	L

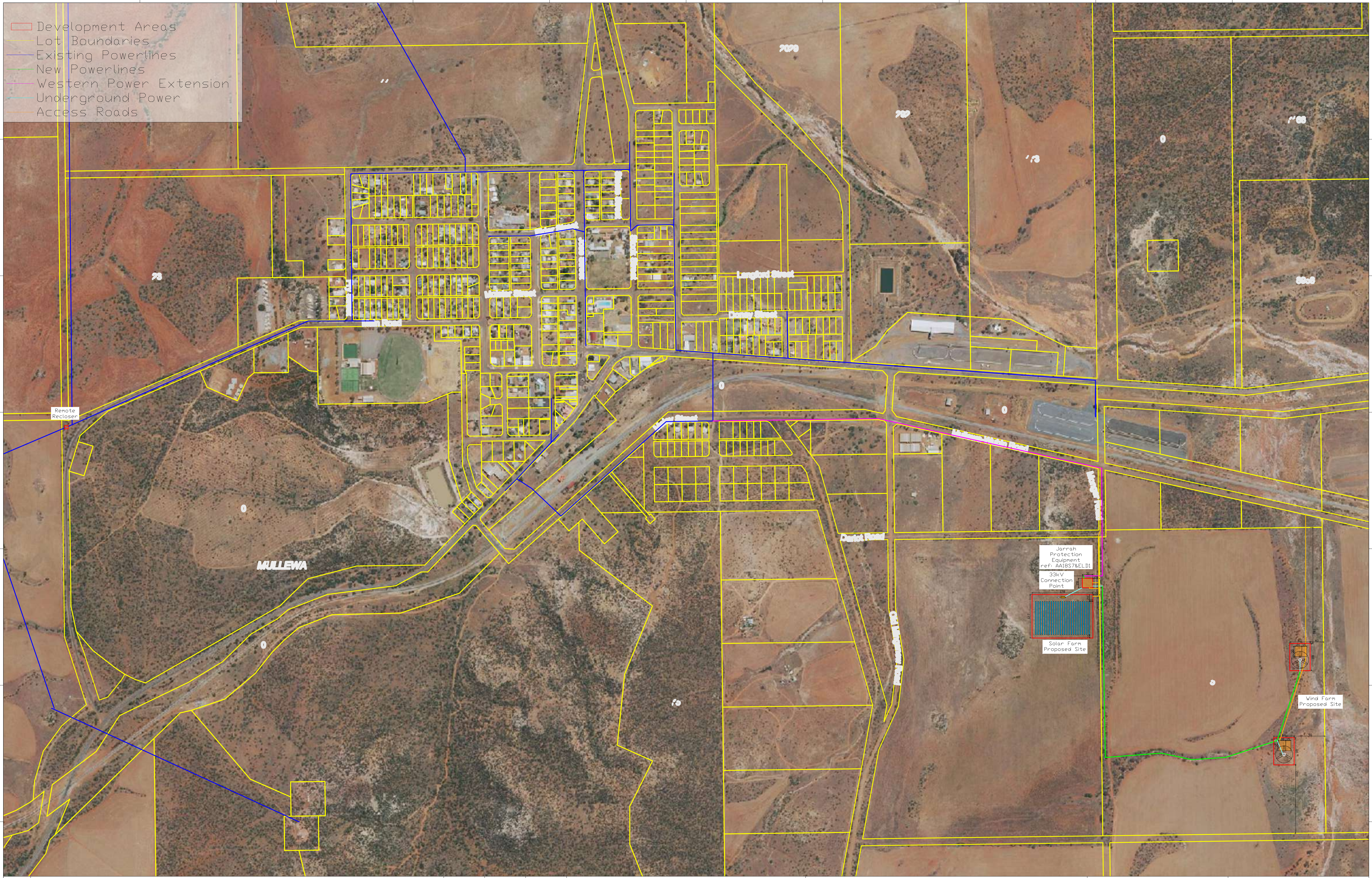
APPENDIX 1

Site Overview

Connection Point Layout

Array Layout

Turbine Layout



RevNo	Revision note	Date	Signature	Checked
I	Changed Locations, Rerouted Powerline to New Connection Point	26/07/2023	CY	
J	Additional Labelling, Highlighted Western Power Extension	27/07/2023	CY	

Avora ENERGY

FILE NAME MullewaLayoutDrawing RevJ.dwg

SIZE A3

DRAWN 27/07/2023

ISSUED

SCALE 1:10000

SHEET

DWG NAME Site Overview

RevNo	Revision note	Date	Signature	Checked
I	Changed Locations, Rerouted Powerline to New Connection Point	26/07/2023	CY	
J	Additional Labelling, Highlighted Western Power Extension	27/07/2023	CY	

Avora ENERGY

FILE NAME	MullewaLayoutDrawing RevJ.dwg	SCALE 1:100	SHEET
SIZE	A3	DWG NAME	Array Layout
DRAWN	27/07/2023		
ISSUED			

RevNo	Revision note	Date	Signature	Checked
I	Changed Locations, Rerouted Powerline to New Connection Point	26/07/2023	CY	
J	Additional Labelling, Highlighted Western Power Extension	27/07/2023	CY	

Avora ENERGY

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DRAWN	27/07/2023	Turbine Layout	
ISSUED			

APPENDIX 2

Modules Data Sheet

Tracker Data Sheet

Inverters Data Sheet

Batteries Data Sheet

Hi-MO 5

(G2)

LR5-72HBD
535~555M

- Based on M10 wafer, best choice for ultra-large power plants
- Advanced module technology delivers superior module efficiency
  - M10 Gallium-doped Wafer • Integrated Segmented Ribbons • 9-busbar Half-cut Cell
- Globally validated bifacial energy yield
- High module quality ensures long-term reliability

12 12-year Warranty for Materials and Processing

30 30-year Warranty for Extra Linear Power Output

Complete System and Product Certifications

IEC 61215, IEC 61730, UL 61730

ISO9001:2015: ISO Quality Management System

ISO14001: 2015: ISO Environment Management System

ISO45001: 2018: Occupational Health and Safety

IEC62941: Guideline for module design qualification and type approval

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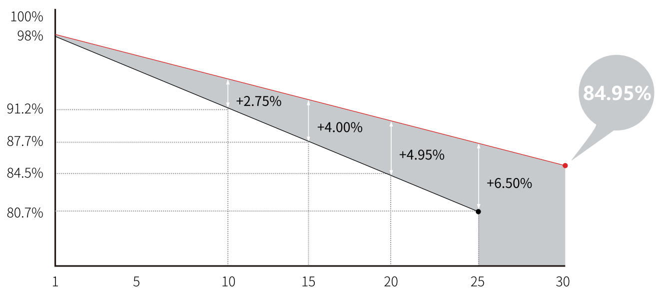
Hi-MO 5

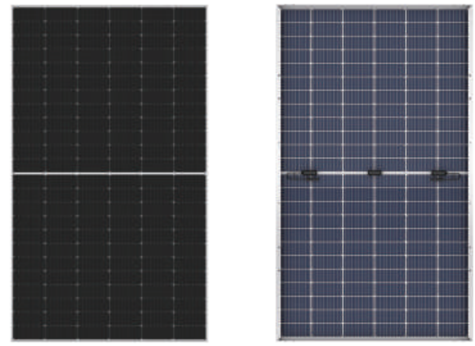
LR5-72HBD 535~555M

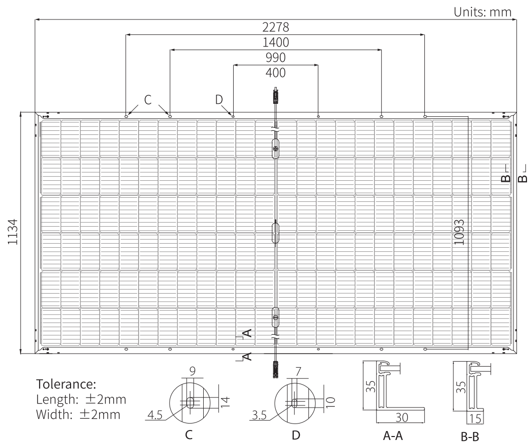
21.5%	0~3%	<2%	0.45%	HALF-CELL
MAX MODULE EFFICIENCY	POWER TOLERANCE	FIRST YEAR POWER DEGRADATION	YEAR 2-30 POWER DEGRADATION	Lower operating temperature

Additional Value

30-Year Power Warranty







Mechanical Parameters

Cell Orientation	144 (6×24)
Junction Box	IP68, three diodes
Output Cable	4mm², +400, -200mm/±1400mm length can be customized
Glass	Dual glass, 2.0+2.0mm heat strengthened glass
Frame	Anodized aluminum alloy frame
Weight	32.6kg
Dimension	2278×1134×35mm
Packaging	31pcs per pallet / 155pcs per 20' GP / 620pcs per 40' HC

Electrical Characteristics

STC : AM1.5 1000W/m² 25°C NOCT : AM1.5 800W/m² 20°C 1m/s Test uncertainty for Pmax: ±3%

Module Type	LR5-72HBD-535M		LR5-72HBD-540M		LR5-72HBD-545M		LR5-72HBD-550M		LR5-72HBD-555M	
Testing Condition	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Maximum Power (Pmax/W)	535	399.9	540	403.6	545	407.4	550	411.1	555	414.8
Open Circuit Voltage (Voc/V)	49.35	46.40	49.50	46.54	49.65	46.68	49.80	46.82	49.95	46.97
Short Circuit Current (Isc/A)	13.78	11.12	13.85	11.17	13.92	11.23	13.99	11.29	14.05	11.34
Voltage at Maximum Power (Vmp/V)	41.50	38.72	41.65	38.86	41.80	39.00	41.95	39.14	42.10	39.28
Current at Maximum Power (Imp/A)	12.90	10.33	12.97	10.39	13.04	10.45	13.12	10.51	13.19	10.56
Module Efficiency(%)	20.7		20.9		21.1		21.3		21.5	

Electrical characteristics with different rear side power gain (reference to 545W front)

Pmax /W	Voc/V	Isc /A	Vmp/V	Imp /A	Pmax gain
572	49.65	14.61	41.80	13.69	5%
600	49.65	15.31	41.80	14.34	10%
627	49.75	16.00	41.90	14.99	15%
654	49.75	16.70	41.90	15.65	20%
681	49.75	17.39	41.90	16.30	25%

Operating Parameters

Operational Temperature	-40°C ~ +85°C
Power Output Tolerance	0 ~ 3%
Voc and Isc Tolerance	±3%
Maximum System Voltage	DC1500V (IEC/UL)
Maximum Series Fuse Rating	30A
Nominal Operating Cell Temperature	45±2°C
Protection Class	Class II
Bifaciality	70±5%
Fire Rating	UL type 29 IEC Class C

Mechanical Loading

Front Side Maximum Static Loading	5400Pa
Rear Side Maximum Static Loading	2400Pa
Hailstone Test	25mm Hailstone at the speed of 23m/s

Temperature Ratings (STC)

Temperature Coefficient of Isc	+0.050%/°C
Temperature Coefficient of Voc	-0.265%/°C
Temperature Coefficient of Pmax	-0.340%/°C

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Web: www.longi.com

NX Horizon

Smart Solar Tracking System

Serving as the backbone on over 35 gigawatts of solar power plants around the world, the NX Horizon™ smart solar tracker system combines best-in-class hardware and software to help EPCs and asset owners maximize performance and minimize operational costs.

Flexible and Resilient by Design

With its self-aligning module rails and vibration-proof fasteners, NX Horizon can be easily and rapidly installed. The self-powered, decentralized architecture allows each row to be commissioned in advance of site power, and is designed to withstand high winds and other adverse weather conditions. On a recent 838 megawatt project in Villanueva, Mexico, these design features allowed for the project to go online nine months ahead of schedule.

TrueCapture and Bifacial Enabled

Incorporating the most promising innovations in utility scale solar, NX Horizon with TrueCapture™ smart control system can add additional energy production by up to six percent. Further unlocking the advantages of independent-row architecture and the data collected from thousands of sensors across its built-in wireless network, the software continuously optimizes the tracking algorithm of each row in response to site terrain and changing weather conditions. NX Horizon can also be paired with bifacial PV module technology, which can provide even more energy harvest and performance. With bifacial technology, NX Horizon outperforms conventional tracking systems with over 1% more annual energy.

Quality and Reliability from Day One

Quality and reliability are designed and tested into every NX Horizon component and system across our supply chain and manufacturing operations. Nextracker is the leader in dynamic wind analysis and safety stowing, delivering major benefits in uptime and long-term durability NX Horizon is certified to UL 2703 and UL 3703 standards, underscoring Nextracker's commitment to safety, reliability and quality.

Features and Benefits

5 years in a row

Global Market Share Leader (2015-18)

35 GW

Delivered on 5 Continents

Best-in Class

Software Ecosystem and Global Services

Up to 6%

Using TrueCapture Smart Control System

GENERAL AND MECHANICAL

Tracking type	Horizontal single-axis, independent row.
String voltage	1,500 V_{DC} or 1,000 V_{DC}
Typical row size	78-90 modules, depending on module string length.
Drive type	Non-backdriving, high accuracy slew gear.
Motor type	24 V brushless DC motor
Array height	Rotation axis elevation 1.3 to 1.8 m / 4'3" to 5'10"
Ground coverage ratio (GCR)	Configurable. Typical range 28-50%.
Modules supported	Mounting options available for virtually all utility-scale crystalline modules, First Solar Series 6 and First Solar Series 4.
Bifacial features	High-rise mounting rails, bearing + driveline gaps and round torque tube.
Tracking range of motion	Options for ±60° or ±50°
Operating temperature range	SELF POWERED: -30°C to 55°C (-22°F to 131°F) AC POWERED: -40°C to 55°C (-40°F to 131°F)
Module configuration	1 in portrait. 3 x 1,500 V or 4 x 1,000 V strings per standard tracker. Partial length trackers available.
Module attachment	Self-grounding, electric tool-actuated fasteners.
Materials	Galvanized steel
Allowable wind speed	Configurable up to 225 kph (140 mph) 3-second gust
Wind protection	Intelligent wind stowing with symmetric dampers for maximum array stability in all wind conditions
Foundations	Standard W6 section foundation posts

ELECTRONICS AND CONTROLS

Solar tracking method	Astronomical algorithm with backtracking. TrueCapture™ upgrades available for terrain adaptive backtracking and diffuse tracking mode
Control electronics	NX tracker controller with inbuilt inclinometer and backup battery
Communications	Zigbee wireless communications to all tracker rows and weather stations via network control units (NCUs)
Nighttime stow	Yes
Power supply	SELF POWERED: NX provided 30 or 60W Smart Panel AC POWERED: Customer-provided 120-240 V_{AC} circut

INSTALLATION, OPERATIONS AND SERVICE

PE stamped structural calculations and drawings	Included
Onsite training and system commissioning	Included
Installation requirements	Simple assembly using swaged fasteners and bolted connections. No field cutting, drilling or welding.
Monitoring	NX Data Hub™ centralized data aggregation and monitoring
Module cleaning compatibility	Compatible with NX qualified cleaning systems
Warranty	10-year structural, 5-year drive and control components.
Codes and standards	UL 3703 / UL 2703 / IEC 62817

Bidirectional converter PVS980-58BC

FIMER bidirectional converter, PVS980-58BC, is aimed at large-scale grid connected energy storage applications. The converters are available from 1454 kVA up to 2091 kVA. PVS980-58BC bidirectional converter is based on the world's leading converter platform used also in FIMER solar inverters ensuring high performance, reliability and availability of global service support.

From 1454 to 2091 kVA

World's leading converter platform
Like FIMER central inverters, the PVS980-58BC bidirectional converter has been developed on the basis of decades of experience in the industry and proven technology platform. Unrivalled expertise from the world's market and technology leader in frequency converters is the hallmark of the PVS980-58 series.

PVS980-58BC bidirectional converter from FIMER
FIMER PVS980-58BC bidirectional converters are ideal for multi-megawatt energy storage systems, providing maximum grid stability for power plants with intermittent energy sources. For power plants combining photovoltaics and energy storage, the common platform shared with PVS980-58BC bidirectional converter and PVS980-58 central inverter brings synergies in both the availability of service and support personnel and the spare part logistics.

The high DC input voltage, high efficiency, proven components, compact and modular design and a host of life cycle services available ensure FIMER PVS980-58BC bidirectional converters provide a rapid return on investment.

Highlights
- High total performance
- Outstanding endurance for outdoor use
- Full four quadrant active power and reactive power support
- High DC input voltage up to 1500 V_{DC} for minimizing system cost
- Self-contained cooling system suitable for harsh environments
- Compact, modular product design
- Life cycle service and support through FIMER's extensive global service network

Technical data and type

Product Type designation	PVS980-58BC -1454kVA-E	PVS980-58BC -1575kVA-F	PVS980-58BC -1696kVA-G	PVS980-58BC -1818kVA-I	PVS980-58BC -1909kVA-J	PVS980-58BC -2000kVA-K	PVS980-58BC -2091kVA-L
Input (DC)							
Full power DC voltage range, (U_{DC}) a 50 °C 1)	680 to 880 V	737 to 950 V	794 to 1020 V	850 to 1100 V	893 to 1100 V	935 to 1100 V	978 to 1100 V
DC voltage operating range, (U_{DC}) 1)	680 to 1500 V	737 to 1500 V	794 to 1500 V	850 to 1500 V	893 to 1500 V	935 to 1500 V	978 to 1500 V
Maximum DC voltage ($U_{max (DC)}$)	1500 V	1500 V	1500 V	1500 V	1500 V	1500 V	1500 V
Maximum DC current ($I_{max (DC)}$) at 35 °C	2400 A	2400 A	2400 A	2400 A	2400 A	2400 A	2400 A
Maximum DC current ($I_{max (DC)}$) at 50 °C	2182 A	2182 A	2182 A	2182 A	2182 A	2182 A	2182 A
Number of DC inputs	8 inputs, as option 12 inputs or 16 inputs (+/-) and DC input current measurement						
Max DC short circuit withstand	73 kApeak, 17 MA²s, external aR fuses required between converter and BES						
DC grounding	Floating only						
DC surge arrestor	Type 2 as standard. High Energy Type 1 as option						
DC disconnector	as option						
Output (AC)							
Output power ($S_{max(AC)}$) at 50 °C	1454 kVA	1575 kVA	1696 kVA	1818 kVA	1909 kVA	2000 kVA	2091 kVA
Nominal power ($S_{N(AC)}$) at 35 °C	1600 kVA	1733 kVA	1866 kVA	2000 kVA	2100 kVA	2200 kVA	2300 kVA
Maximum AC current ($I_{max (AC)}$) at 50 °C	1750 A	1750 A	1750 A	1750 A	1750 A	1750 A	1750 A
Maximum AC current ($I_{max (AC)}$) at 35 °C	1925 A	1925 A	1925 A	1925 A	1925 A	1925 A	1925 A
Nominal output voltage ($U_{N(AC)}$) 2)	480 V	520 V	560 V	600 V	630 V	660 V	690 V
Output frequency	50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz
Harmonic distortion, current 3)	< 3%	< 3%	< 3%	< 3%	< 3%	< 3%	< 3%
Distribution network type	IT	IT	IT	IT	IT	IT	IT
Power factor	Four quadrant						
AC disconnector / AC breaker	as option						
AC surge arrestor	Type 2 as standard. High Energy Type 1 as option						
Efficiency							
Maximum 4)	98.6%	98.7%	98.7%	98.8%	98.8%	98.8%	98.8%
Auxiliary power consumption							
Max. own consumption in operation	2500 W	2500 W	2500 W	2500 W	2500 W	2500 W	2500 W
Standby operation consumption	235 W	235 W	235 W	235 W	235 W	235 W	235 W
Auxiliary voltage source	External, 1 phase auxiliary power input 5)						

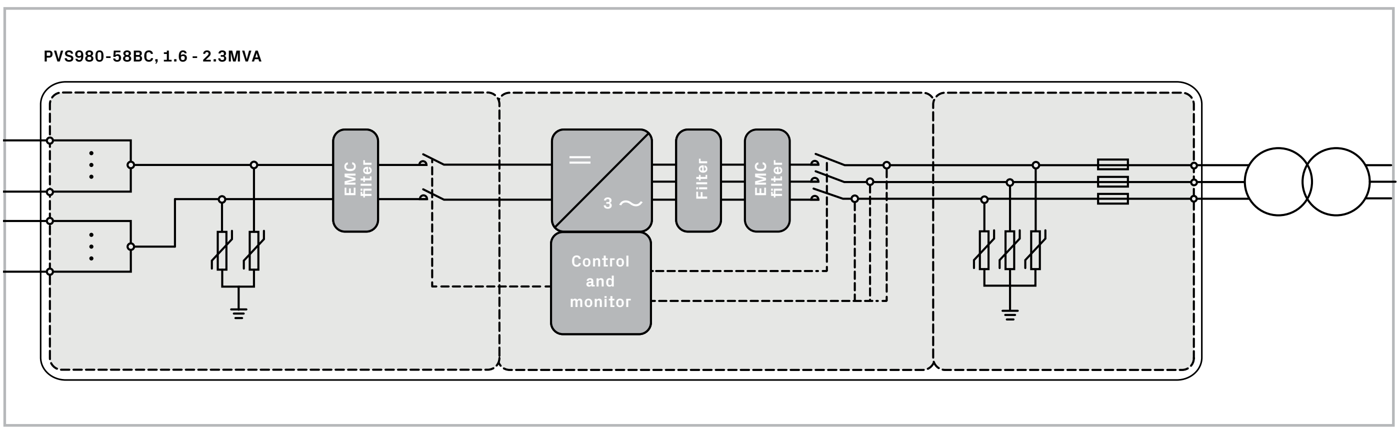
1) Minimum DC ($U_{DC,min}$) for $U_{N(AC)}$ and power factor=1. The minimum DC voltage depends on AC voltage and power factor. The AC dependency follows formula $U_{DC,min} = U_{AC} * \sqrt{2} * 1.002$ with PF=1. Contact FIMER for more information.
2) ±10%
3) At nominal active power
4) Without auxiliary power consumption at min U_{DC}
5) As option internal auxiliary power (internal transformer from inverter output)

Technical data and type

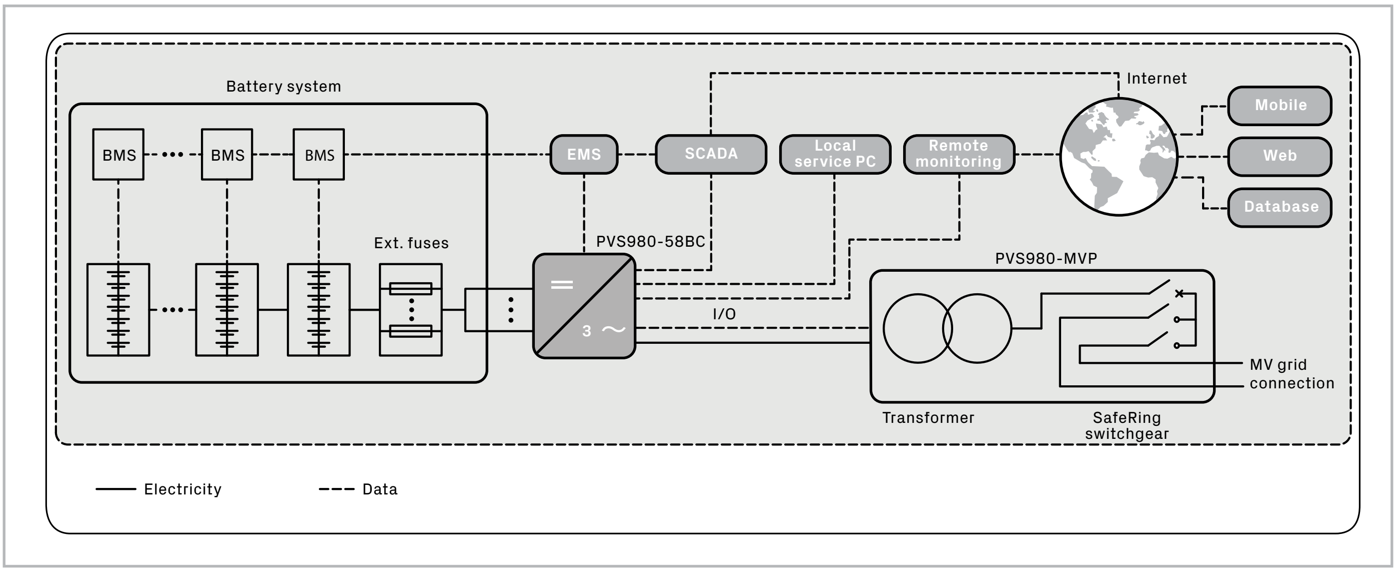
Product Type designation	PVS980-58BC -1454kVA-E	PVS980-58BC -1575kVA-F	PVS980-58BC -1696kVA-G	PVS980-58BC -1818kVA-I	PVS980-58BC -1909kVA-J	PVS980-58BC -2000kVA-K	PVS980-58BC -2091kVA-L
Dimensions and weight							
Width/Height/Depth, mm (W/H/D)	3180/2443/1522						
Weight appr.	3500 kg						
Environmental limits							
Degree of protection [6]	IP66/UL Type 3R						
Ambient temp. range (nom. ratings) [7]	-20 °C to +50 °C						
Maximum ambient temperature [8]	+60 °C						
Relative humidity	5% to 100%						
Maximum altitude (above sea level) [9]	4000 m						
Maximum sound pressure level [10]	88 dBA						
Protection							
Ground fault monitoring	Yes						
Grid monitoring	Yes						
Anti-islanding	Yes						
DC reverse polarity	Yes						
AC/DC short circuit and overcurrent [11]	Yes						
AC/DC overvoltage and temperature	Yes						
Energy Storage firmware							
PQ setpoints	Yes						
Start and stop sequence for battery energy storage system	Yes						
User interface and communications							
Local user interface	Local control panel						
Analog inputs	2 as standard						
Digital inputs/relay outputs	7/1 as standard						
Fieldbus connectivity [12]	Modbus, Profinet, Ethernet						
Product compliance [13]							
Safety and EMC	CE according to LV and EMC directives						
Certifications and approvals	IEC, UL, CSA, RCM, IEEE, BDEW, CEI, SAGC, FCC						
Grid support and grid functions	Reactive power compensation, Power reduction, LVRT, HVRT, FqRT, Anti-islanding						

6) IP66 excluding under pressure testing, IP56 with under pressure
7) -40 °C as option
8) Power derating after 50 °C
9) Derating above 1000 m, as option above 2000 m
10) A-weighted Sound pressure level at 1m
At partial power typically < 75 dB
11) DC short circuit protection with external aR fuses
12) More communication options as engineered option
13) Approvals pending, contact FIMER for more information

PVS980-58BC bidirectional converter block diagram



Battery energy storage system example with FIMER PVS980-58BC bidirectional converter



Options
- AC breaker
- AC disconnector switch
- DC disconnector switch
- Heavy duty (Type 1) surge protection
- AC busbar interface
- Internal auxiliary power supply
- Fieldbus and Ethernet connections
- High altitude version
- Low temperature version
- Warranty extensions
- Converter care contracts

Related products
- Medium voltage station (transformer and switchgear) as outdoor or containerised solution
- Remote monitoring solutions

Support and service
FIMER supports its customers with a dedicated global service network and provides a complete range of life cycle services from installation and commissioning to preventative maintenance, spare parts, repairs and recycling.

For more information please contact your local FIMER representative or visit:

fimer.com

PVS980-58BC bidirectional converter_EN REV. C 31-03.2021

FIMER

Central inverter PVS980-58

FIMER central inverters raise reliability, efficiency and ease of installation to new levels. The central inverters are aimed at system integrators and end users who require high-performance solar inverters for large photovoltaic (PV) power plants and are optimized for cost-effective, multi-megawatt power plants.

From 909 to 1045 kVA

World's leading inverter platform
Like other FIMER central inverters, the PVS980-58 has been developed on the basis of decades of experience in the industry and a proven technology platform. Unrivalled expertise from the world's market and technology leader in frequency converters is the hallmark of this solar inverter series.

The PVS980-58 inverter is one of the most efficient and cost-effective ways of converting the direct current (DC) generated by solar modules into high quality and CO_2-free alternating current (AC) that can be fed into the power distribution network.

PVS980-58 central inverters from FIMER
PVS980-58 central inverters are ideal for large PV power plants. The high DC input voltage, high efficiency, proven components, compact and modular design and a host of life cycle services ensure FIMER PVS980-58 central inverters provide a rapid return on investment.

Highlights
- High total performance
- Outstanding endurance for outdoor use
- Compact, modular product design
- High DC input voltage up to 1500 V_{DC}
- Extensive DC and AC side protection
- Self-contained cooling system with high efficiency
- Versatile design for large-scale PV plants to minimize system costs
- Complete range of industrial data communication options, including remote monitoring
- Life cycle service and support through FIMER's extensive global service network solar inverters

Maximum energy revenues

FIMER central inverters have a high total efficiency. Precise, optimized system control and maximum power point tracking (MPPT) combined with the unit's highly efficient power converter design deliver the maximum energy from the PV modules to the power distribution network. For end users, this generates the highest possible revenues from the energy sales.

Self-contained, low-maintenance cooling system
PVS980-58 inverters feature a proven closed loop cooling system used in other industrial applications.
This innovative, low-maintenance cooling solution is designed for demanding applications and harsh environments, cutting maintenance costs and ensuring outstanding endurance.

Compact and modular design
PVS980-58 inverters are designed for fast and easy installation. The industrial design and modular platform provide a wide range of options, such as remote monitoring, fieldbus connection and modular and flexible DC input connections.
The integrated DC cabinet saves space and costs as the solar array junction boxes can be connected directly to the fused busbars in the DC cabinet. PVS980-58 inverters are customized for the needs of end users and will be available with short delivery times.

Versatile design for large-scale PV plants to minimize system costs
FIMER's PVS980-58 central inverters enable system integrators to design PV power plants that use the optimum combination of inverters with different power ratings. Equipped with extensive electrical and mechanical protection, the inverters are engineered to provide a long and reliable service life of at least 25 years.

Advanced grid support features
The PVS980-58 software includes all the latest grid support and monitoring features, including active power limitation, fault ride through (FRT) with current feed-in and reactive power control.
Active and reactive power output can be controlled by an external control system or automatically by the inverter.
All grid support functions are parameterized, allowing easy adjusting for local utility requirements. FIMER central inverters are also able to support grid stability at night by providing reactive power with the DC input disconnected.

Technical data and types

Product Type designation	PVS980-58 1.0 MVA -909kVA-I+IN	PVS980-58 1.05 MVA -954kVA-J+IN	PVS980-58 1.1 MVA -1000kVA-K+IN	PVS980-58 1.15 MVA - 1045kVA-L+IN
Input (DC)				
Maximum recommended PV power ($P_{PV, max}$) [1]	1454 kWp	1527 kWp	1600 kWp	1672 kWp
Maximum DC current ($I_{max (DC)}$)	1200 A	1200 A	1200 A	1200 A
DC voltage range, mpp ($U_{DC, mpp}$) at 35 °C	850 to 1500 V	893 to 1500 V	935 to 1500 V	978 to 1500 V
DC voltage range, mpp ($U_{DC, mpp}$) at 50 °C	850 to 1100 V	893 to 1100 V	935 to 1100 V	978 to 1100 V
Maximum DC voltage ($U_{max (DC)}$)	1500 V	1500 V	1500 V	1500 V
Number of MPPT trackers	1	1	1	1
Number of protected DC inputs	8 [2]	8 [2]	8 [2]	8 [2]
Output (AC)				
Maximum power ($S_{max (AC)}$) [3]	1000 kVA	1050 kVA	1100 kVA	1150 kVA
Nominal power ($S_{N(AC)}$) [4]	909 kVA	954 kVA	1000 kVA	1045 kVA
Maximum AC current ($I_{max (AC)}$)	962 A	962 A	962 A	962 A
Nominal AC current ($I_{N(AC)}$)	875 A	875 A	875 A	875 A
Nominal output voltage ($U_{N(AC)}$) [5]	600 V	630 V	660 V	690 V
Output frequency [5]	50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz
Harmonic distortion, current [6]	< 3%	< 3%	< 3%	< 3%
Distribution network type [7]	TN and IT	TN and IT	TN and IT	TN and IT
Efficiency				
Maximum [8]	98.8%	98.8%	98.8%	98.8%
Euro-eta [8]	98.6%	98.6%	98.6%	98.6%
CEC efficiency [9]	98.0%	98.5%	98.5%	98.5%
Power consumption				
Self consumption in normal operation	≤ 1500 W	≤ 1500 W	≤ 1500 W	≤ 1500 W
Standby operation consumption	200 W	200 W	200 W	200 W
Auxiliary voltage source [10]	Internal, 1-phase	Internal, 1-phase	Internal, 1-phase	Internal, 1-phase

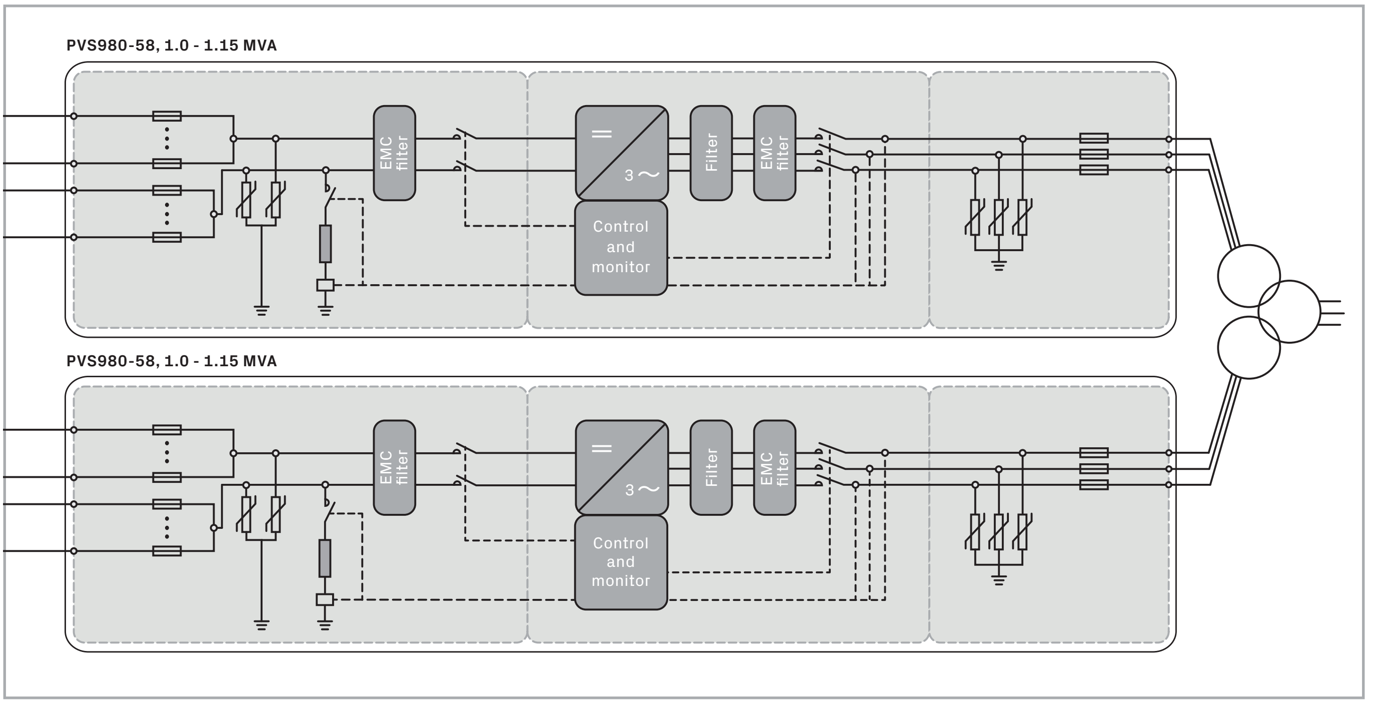
[1] DC/AC ratio over 1.6 might decrease maintenance intervals
[2] As standard
[3] At 35 °C
[4] At 50 °C
[5] ±10%
[6] At nominal power
[7] Inverter side must be IT type
[8] Without auxiliary power consumption at min U_{DC}
[9] With auxiliary power included
[10] Internal as option

Technical data and types

Product Type designation	PVS980-58 1.0 MVA -909kVA-I+IN	PVS980-58 1.05 MVA -954kVA-J+IN	PVS980-58 1.1 MVA -1000kVA-K+IN	PVS980-58 1.15 MVA - 1045kVA-L+IN
Environmental limits				
Degree of protection	IP66 [11]			
Ambient temp. range (nom. ratings) [12]	-20 °C to +50 °C			
Maximum ambient temperature [13]	+60 °C			
Relative humidity	5% to 100%			
Maximum altitude (above sea level)	4000 m [14]			
Maximum noise level	<88 dBA [15]			
Protection				
Ground fault monitoring	Yes			
Grid monitoring	Yes			
Anti-islanding	Yes			
DC reverse polarity	Yes			
AC and DC short circuit and overcurrent	Yes			
AC and DC overvoltage and surge	Yes			
User interface and communications				
Local user interface	Control panel			
Analog inputs	2 as standard			
Digital inputs/relay outputs	7/1 as standard			
Fieldbus connectivity	Modbus, Profinet, Ethernet [16]			
Product compliance				
Safety and EMC [16]	CE conformity according to LV and EMC directives			
Certifications and approvals	IEC, CEA			
Grid support and grid functions	Reactive power compensation [17], Power reduction, LVRT, HVRT, FqRT			
Dimensions and weight				
Width/Height/Depth, mm (W/H/D)	2181/2443/1522	2181/2443/1522	2181/2443/1522	2181/2443/1522
Weight appr.	2500 kg	2500 kg	2500 kg	2500 kg

11) Excluding underpressure testing, IP56 with underpressure
12) -40 °C as option
13) Power derating after 50 °C
14) Power derating above 1000 m
15) At partial power typically < 75 dBA
16) More communication options as engineered option
17) Also at night

PVS980-58 central inverter block diagram



Central inverter
PVS980-58 from 909 to 1045 kVA

High total performance
- High efficiency
- Low auxiliary power consumption
- Innovative controlled cooling
- Efficient maximum power point tracking
- Long and reliable service life of at least 25 years

Outstanding endurance for outdoor use
- Water- and dustproof outdoor enclosure
- Designed to withstand the toughest environments
- Long and reliable service life following the FIMER life cycle model

Modular industrial design
- Compact and easy-to-maintain product design
- Fast and easy installation
- Integrated and flexible DC input section

Life cycle service and support
- FIMER's extensive global service network
- Extended warranties
- Service contracts
- Technical support throughout the service life

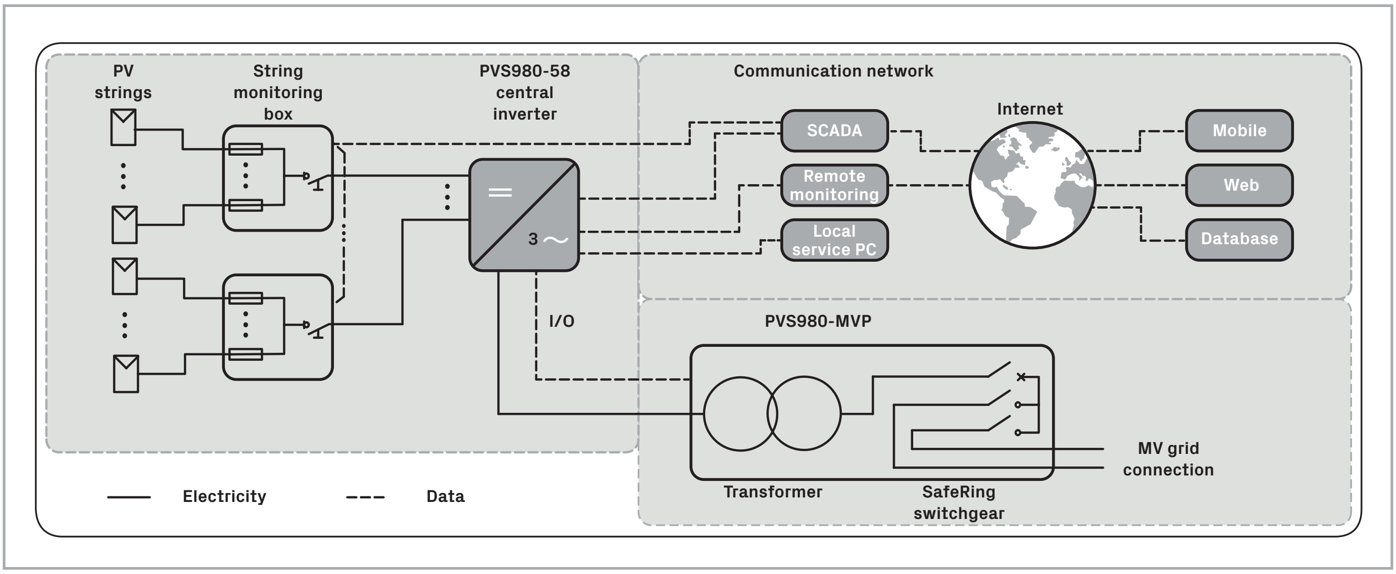
Self-contained cooling system
- Closed loop cooling system based on phase transition and thermosiphon technology
- Liquid-cooled inverter power ratings with the simplicity of air cooling
- No fillable liquids, pumps, valves, inhibitors or leaks
- Low maintenance

Versatile design for largescale PV plants
- Integrated DC connection with variable number of inputs
- A wide range and highly efficient MPPT algorithm
- Versatile AC connection methods

Minimizes system costs
- 1500 V_{DC} system voltage
- Wide ranged and highly efficient MPPT algorithm
- Integrated protection to minimize external components
- Fast and easy installation and commissioning

Wide communication options
- Complete range of industrial data communication options for SCADA connections
- Ethernet/Internet Protocol
- Remote monitoring

Data communication principle for PVS980-58 central inverter



Options

- Integrated and flexible DC input extension
- AC breaker
- Type 2/Type 1 surge protection
- AC busbar interface
- Internal auxiliary power supply
- DC grounding, positive
- Floating DC
- Fieldbus and Ethernet connections
- Current measurement to each DC input
- High altitude version
- Low temperature version
- Warranty extensions
- Solar inverter care contracts
- DC/AC ratio higher than 1.6

Related products

- Medium voltage station (transformer and switchgear) as outdoor or containerized solution
- String monitoring junction boxes
- Remote monitoring solutions

Support and service

FIMER supports its customers with a global service network and provides a complete range of life cycle services from installation and commissioning to preventative maintenance, spare parts, repairs and recycling.

For more information please contact your local FIMER representative or visit:

fimer.com

PVS980-58 from 909 to 1045 central inverter_IN REV. A 10.06.2020

FIMER

Solar inverter
PVS980-CS

The FIMER compact skid is a plug-and-play solution designed for large-scale solar power generation using PVS980-58 high-power central inverters.
It houses all the electrical equipment that is needed to rapidly connect a photovoltaic (PV) power plant to a medium voltage (MV) electricity grid.

Up to 4600 kVA

Turnkey-solution for PV power plants
The FIMER compact skid design capitalizes on FIMER's long experience in developing and manufacturing solutions for utilities and major end users worldwide in conventional power transmission installations.

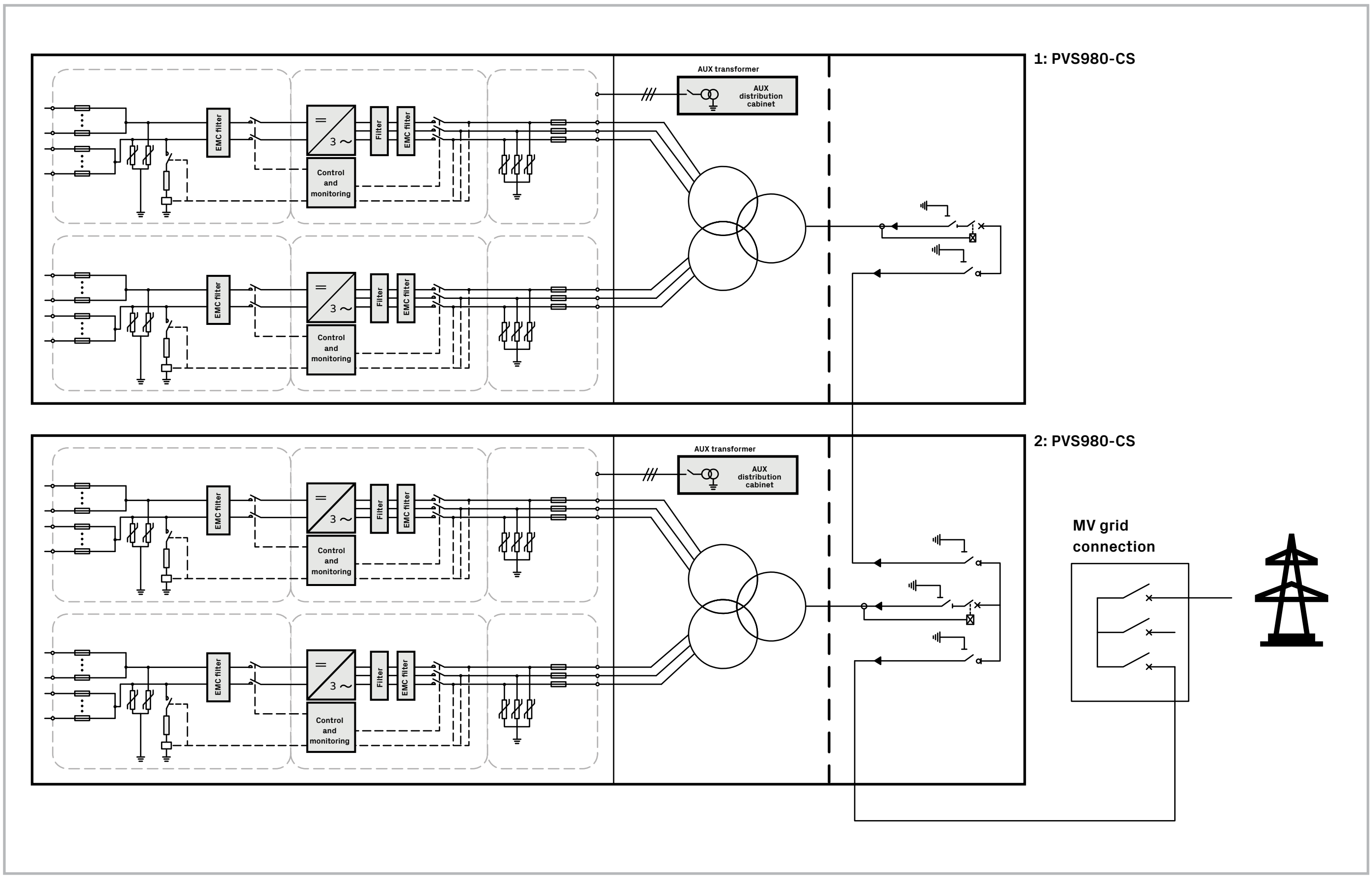
A skid houses one or two outdoor 1818 to 2091 kVA FIMER PVS980-58 central inverters, an optimized MV oil immersed transformer, MV switchgear and all needed auxiliary services. The FIMER compact skid is used to connect a PV power plant to a MV electricity grid easily and rapidly. To meet the PV power plant's demanded capacity, several FIMER compact skids can be used.

Compact design eases transportation
The compact skid solution has dimensions suitable for transportation inside closed 40 feet High Cube shipping container. The total package weighs less than 24 tons.
The standardized shipping dimensions ensures cost-effective and safe transportability to the site, even overseas.

Inverter's optimized air circulation and filtering system, together with hermetically sealed oil immersed transformer enable installations in various ambient conditions, from harsh desert temperatures to cold and humid environments.
The FIMER compact skid is designed for at least 25 years of operation.

Highlights
- Proven technology and reliable components
- Compact and robust design
- Outstanding endurance for outdoor use
- High DC input voltage up to 1500 V_{DC}
- High total efficiency
- Extensive DC and AC side protection
- Self-contained cooling system for inverters
- Modular and serviceable system
- Embedded auxiliary power distribution system
- Extendable manufacturing footprint with fast deliveries
- Global life cycle services and support
- Transportable inside closed 40 feet HC shipping container
- Arc-proof design

Compact skid design and grid connection



PVS980-CS

Solar inverters
Like other FIMER central inverters, the PVS980-58 has been developed on the basis of decades of experience in the industry and proven technology platform. Unrivalled expertise from the world's market and technology leader in frequency converters is the hallmark of this solar inverter series.
The PVS980-58 inverter is one of the most efficient and cost-effective ways of converting the direct current (DC) generated by solar modules into high quality and CO_2-free alternating current (AC) that can be fed into the power distribution network. One or two FIMER central inverters are used in the FIMER compact skid. The inverters provide high conversion efficiency with low auxiliary power consumption, as well as very low maintenance need.

Transformer
The FIMER compact skid includes an oil immersed transformer. The transformer is designed to meet the reliability, durability and efficiency required in PV applications. It is specifically designed and optimized for FIMER solar inverters to provide the best performance throughout the lifetime of the plant.
Different power transformers are available to meet customer requirements. All transformers are manufactured in accordance with the most demanding industry and international standards.

Switchgear
The FIMER compact skid is equipped, as standard, with the widely proven SF_6-insulated switchgear.

A sealed steel tank with constant atmospheric conditions ensures a high level of reliability as well as personnel safety. The virtually maintenance-free system comes in a compact and flexible design that allows for a versatile switchgear configuration with arc-proof capability.

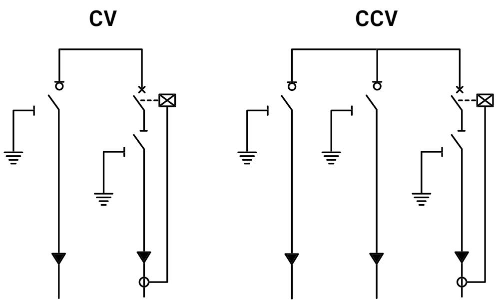
Technical data and type

Type code	2.0MVA	2.1MVA	2.2MVA	2.3MVA	4.0MVA	4.2MVA	4.4MVA	4.6MVA
Maximum rating in kVA	2000	2100	2200	2300	4000	4200	4400	4600
Inverter								
Inverter	PVS980-58, 2.0 - 2.3MVA							
Maximum operating DC input voltage	1500 V							
Number of inverters	1	1	1	1	2	2	2	2
Number of independent MPPT	1	1	1	1	2	2	2	2
MPPT range @ 35° C in V	850-1500	893-1500	935-1500	978-1500	850-1500	893-1500	935-1500	978-1500
MPPT range @ 50° C in V	850-1100	893-1100	935-1100	978-1100	850-1100	893-1100	935-1100	978-1100
AC output voltage	600 V	630 V	660 V	690 V	600 V	630 V	660 V	690 V
MV transformer								
Transformer type	Oil immersed (ONAN)							
AC Power @ 35° C in kVA	2000	2100	2200	2300	4000	4200	4400	4600
AC Power @ 50° C in kVA	1818	1909	2000	2091	3636	3818	4000	4182
Number of secondary windings	1	1	1	1	2	2	2	2
Low voltage level	600 V	630 V	660 V	690 V	600 V	630 V	660 V	690 V
Medium voltage level range	≤ 36 kV							
Rated frequency	50Hz or 60 Hz							
Oil type	Mineral (vegetable optional)							
Tap changer	± 2 x 2.5%							
Winding material (primary / secondary)	Al / Al							
Eco efficiency optional	Yes							
MV switchgear								
Switchgear type	SF6-insulated							
Rated current	630 A							
Configuration	Single (CV) or double feeder (CCV)							
Protection (up to 24 kV / up to 36 kV)	Circuit breaker (16 kA or 20 kA / 20 kA or 25 kA)							
Protection relay type	REJ603 (others on request)							
Motorized optional	Yes							

Technical data and type

Type code	2.0MVA	2.1MVA	2.2MVA	2.3MVA	4.0MVA	4.2MVA	4.4MVA	4.6MVA
Auxiliary supply								
Auxiliary transformer power	10 kVA (20kVA, 30kVA optional)							
Auxiliary transformer primary voltage level	600 V	630 V	660 V	690 V	600 V	630 V	660 V	690 V
Auxiliary transformer secondary voltage level	400-230 V							
Low voltage distribution panel for auxiliary functions	Yes							
Mechanical characteristics								
Dimensions (lenght x width x height) in mm	11850 x 2150 x 2570 (40ft HC container dimensions)							
Weight approx. in ton	17	17	17	17	24	24	24	24
Environmental								
Operating temperature range	-20° C ... +50° C							
Operating altitude range	≤ 2000 m							
Relative humidity (non-condensing)	≤ 95%							
Environmental protection rating	IP 54 (IP 66 for inverter)							
Painting corrosion protection	C4 (C5M optional)							
Product compliance								
Conformity	IEC 60364, IEC 61936-1, IEC 60502-1							
Grid support	Reactive power compensation (also at night), power reduction, LVRT, HVRT, FqRT							

MV switchgear standard configurations for FIMER compact skid



Accessories
- Solar array junction boxes with string monitoring
- Remote monitoring solutions
- Warranty extensions

Options
- MV AC output voltages up to 36 kV
- Different MV switchgear configurations
- I/O extensions
- DC grounding, positive
- Floating DC
- Fieldbus and Ethernet connections
- Auxiliary power supply up to 40kVA
- C5M enclosure corrosion protection

Support and service
FIMER supports its customers with a dedicated global service network and provides a complete range of life cycle services from installation and commissioning to preventative maintenance, spare parts, repairs and recycling.

For more information please contact your local FIMER representative or visit:

fimer.com

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Intensium® Shift

3.0 MWh high energy lithium-ion battery storage container

The Intensium® Shift is Saft's modular and ready to install containerized Energy Storage System (ESS), enabling space-optimized utility-scale storage solutions for renewables and power grids.

Benefits at a glance

1 Compact modularity

- 3 MWh high energy building block suitable for storage projects up to Gigawatt-hours scale
- Able to address 2 to 8 hours applications through multiple container paralleling
- Reduced floorspace per MWh for full system installation compatible with most Power Conversion Systems available in the market

2 De-risked projects

- Full system including controls designed by Saft
- Fully assembled, tested and certified in Saft factories
- Easy transport by road and sea
- Quick and cost-effective installation, 'plug and play' delivered

3 Maximized economics

- Optimized energy and power availability over state of charge
- Multiple charge-discharge cycles per day with minimum auxiliary consumption
- Long lifetime cells and optimum thermal management
- High availability and service ability

4 Low maintenance

Real-time battery control, supervision and big-data publishing platform for enhanced analytics and services with Saft I-Sight

5 Safety driven design

Guaranteed safe behavior during operations and in case of an abusive event, protecting assets, operators and first responders

Built with Lithium Iron Phosphate (LFP) cells, the Intensium® Shift is a fully integrated storage system with high levels of safety and operational reliability designed for 2 to 8 hours energy shifting applications. Thanks to its line-up architecture with modular, 'plug and play' building blocks, large utility systems can be realized quickly and with minimum space occupancy

Applications

- Renewable integration: smoothing, shifting, minimizing curtailment
- Peaking capacity
- Transmission & Distribution grid support

Features

Advanced industrial design offering highest safety and robustness

- 20-foot outdoor container with reduced installation distance requirements
- Integrated thermal management system, safety barriers and control interfaces with easily accessible control and distribution room
- Fully assembled and tested within Saft manufacturing hubs with minimized, fast, and replicable site-works installation

Proven architecture for high availability

- Individually connectible strings with one Battery Management Module per string
- Master Battery Management for global charge and discharge management, auxiliary equipment monitoring and diagnostic functions
- Multi-container paralleling into virtual battery banks. Augmentation enabled

TotalEnergies

Sophisticated battery management for enhanced operability

- Monitoring and control of voltage, current and temperature
- Balancing of State of Charge (SoC) between cells and strings
- Indication of State of Health (SoH) integrating cycling and calendar aging
- I-Sight digital platform for external communication, remote monitoring and supervision, data management with a high cybersecurity level

Advanced thermal management system based on air conditioning unit and controllable fans

- Optimum operating temperature for long lifetime of battery cells
- Homogeneous temperature across all modules
- High cooling efficiency with individual module control with low energy consumption
- Robust system with low maintenance

Safety design to guarantee safe behavior

- UL9540A compliant
- Short-circuit, over-current, over-temperature and over-voltage management
- Stop push button, disconnect switch
- Fire detection and two levels of suppression systems (gas, water) to fight fires in their initial stages and prevent collateral damages
- Blast panels on the container roof and overpressure valve with integrated flame detector
- Rockwool thermal insulation

Specifications

Electrical	2 hours [1]	4 hours [1]
Rated energy (C/5) [2]	3.0 MWh	
Discharge duration	2 – 4 hours	4 - 8 hours
Voltage range	1060 V – 1500 V	
Maximum DC power charge/discharge	1.5 MW	0.75 MW
Rated current charge/discharge	1100 A	550 A
Maximum current charge/discharge	1370 A	690 A

Mechanical	
Dimensions (L, W, H)	6.1m, 2.4m, 2.9m / 20ft, 8ft, 9ft 6in
Weight	< 30.5 T
Container protection class	IP 54

Operating & storage conditions	
Ambient temperature	-20°C to +45°C (option +55°C)
Design lifetime	≤ 20 years
Altitude above sea level	≤ 2000 meters
Ambient relative humidity	Up to 100%
Painting	C5H
Ambient temperature during storage	−25°C to +55°C (under conditions)
Storage time	Up to 12 months (under conditions)

Standards	
Safety	IEC 62619, IEC 62477-1, UL 1973:2022, UL9540A
Marking	CE, UL
Directives	REACH
Manufacturing hubs	ISO 9001, QS 9000, ISO 14000
Cybersecurity	IEC 62443-4-2
Transport (fully populated)	UN3536

[1] Depending of protection scheme selected
[2] According to IEC 60620

Saft

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www.saftbatteries.com
Saft, a subsidiary of TotalEnergies
Saft Groupe SAS au capital de 26 724 876 €
RCS Nanterre 481.480.465

TotalEnergies

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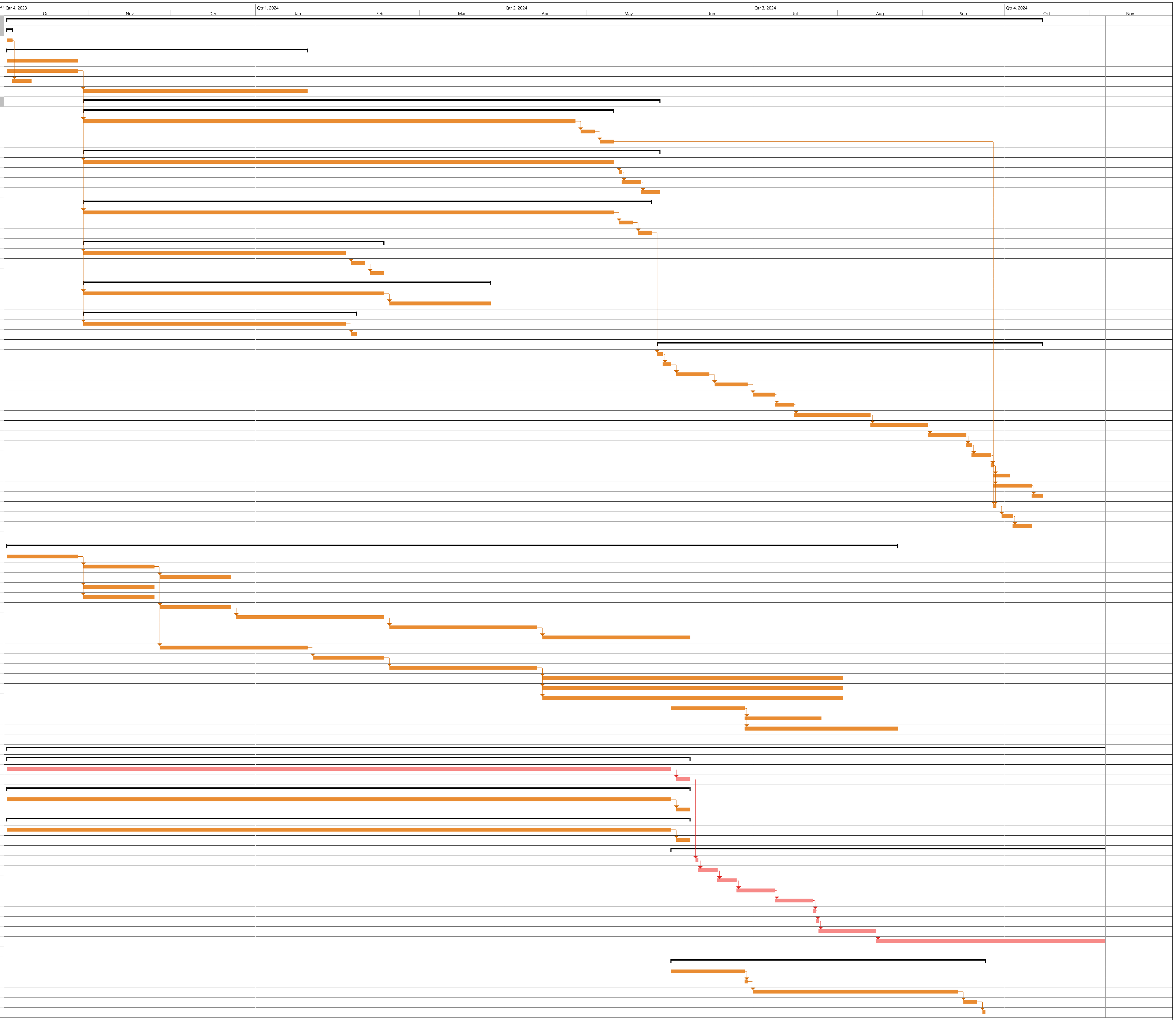
APPENDIX 4

Schedule

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		**Schedule - Solar**	**271 days**	**Mon 2/10/23**	**Mon 14/10/2**	
2		**Site Investigation Works**	**2 days**	**Mon 2/10/23**	**Tue 3/10/23**	
3		Pile Testing	2 days	Mon 2/10/23	Tue 3/10/23	
4		**Detailed Design**	**80 days**	**Mon 2/10/23**	**Fri 19/01/24**	
5		Solar DC Design	20 days	Mon 2/10/23	Fri 27/10/23	
6		BESS Design & Functional Specification	20 days	Mon 2/10/23	Fri 27/10/23	
7		NEXTracker Piling Design Verification	5 days	Wed 4/10/23	Tue 10/10/23	3
8		Detailed design	60 days	Mon 30/10/23	Fri 19/01/24	6
9		**Procurement**	**151 days**	**Mon 30/10/23**	**Mon 27/05/2**	
10		**Battery Energy Storage System Manufacture and Delivery**	**140 days**	**Mon 30/10/23**	**Fri 10/05/24**	
11		Manufacture and Transport	26 wks	Mon 30/10/23	Fri 26/04/24	6
12		Customs Clearance	5 days	Mon 29/04/24	Fri 3/05/24	11
13		Transport to site	5 days	Mon 6/05/24	Fri 10/05/24	12
14		**Inverter Skid Manufacture and Delivery**	**151 days**	**Mon 30/10/23**	**Mon 27/05/2**	
15		Manufacture and Transport	28 wks	Mon 30/10/23	Fri 10/05/24	6
16		Unpack	1 day	Mon 13/05/24	Mon 13/05/24	15
17		Customs Clearance	5 days	Tue 14/05/24	Mon 20/05/24	16
18		Transport to site	5 days	Tue 21/05/24	Mon 27/05/24	17
19		**Solar Tracker System**	**150 days**	**Mon 30/10/23**	**Fri 24/05/24**	
20		Manufacure and transport	28 wks	Mon 30/10/23	Fri 10/05/24	6
21		Customs Clearance	5 days	Mon 13/05/24	Fri 17/05/24	20
22		Transport to site	5 days	Mon 20/05/24	Fri 24/05/24	21
23		**Solar Panels**	**80 days**	**Mon 30/10/23**	**Fri 16/02/24**	
24		Manufacture	14 wks	Mon 30/10/23	Fri 2/02/24	6
25		Freight and Customs Clearance	5 days	Mon 5/02/24	Fri 9/02/24	24
26		Transport to site	5 days	Mon 12/02/24	Fri 16/02/24	25
27		**Combiner Boxes**	**107 days**	**Mon 30/10/23**	**Tue 26/03/24**	
28		Manufacture	16 wks	Mon 30/10/23	Fri 16/02/24	6
29		Freight and Delivery to Avora	27 days	Mon 19/02/24	Tue 26/03/24	28
30		**Cable**	**72 days**	**Mon 30/10/23**	**Tue 6/02/24**	
31		Manufacture and Delivery to Cable Grid	14 wks	Mon 30/10/23	Fri 2/02/24	6
32		Freight and Delivery to Avora	2 days	Mon 5/02/24	Tue 6/02/24	31
33		**Site Works, Installation and Commissioning**	**101 days**	**Mon 27/05/24**	**Mon 14/10/2**	
34		Mobilisation and Site Establishment	2 days	Mon 27/05/24	Tue 28/05/24	22
35		Survey	3 days	Wed 29/05/24	Fri 31/05/24	34
36		Civils	10 days	Mon 3/06/24	Fri 14/06/24	35
37		Fencing	10 days	Mon 17/06/24	Fri 28/06/24	36
38		Piling and CB piles / shrouds	6 days	Mon 1/07/24	Mon 8/07/24	37
39		Earthing, trenching, sub array and DC conduit installation	5 days	Tue 9/07/24	Mon 15/07/24	38
40		NEXTracker Assembly	20 days	Tue 16/07/24	Mon 12/08/24	39
41		Module Placement	15 days	Tue 13/08/24	Mon 2/09/24	40
42		Panel String wiring and DC cabling	10 days	Tue 3/09/24	Mon 16/09/24	41
43		Mount Combiner Boxes	2 days	Tue 17/09/24	Wed 18/09/24	42
44		Construct skid & BC foundations	5 days	Thu 19/09/24	Wed 25/09/24	43
45		Place Inverter Skid onto Pad	1 day	Thu 26/09/24	Thu 26/09/24	44
46		Connect Sub-Array Cabling	4 days	Fri 27/09/24	Wed 2/10/24	45
47		HV Cable	10 days	Fri 27/09/24	Thu 10/10/24	45
48		Commissioning PV	2 days	Fri 11/10/24	Mon 14/10/24	47
49		Place Battery Container onto Pad	1 day	Fri 27/09/24	Fri 27/09/24	13,45
50		DC Cable - interconnecting between skid and BC	4 days	Mon 30/09/24	Thu 3/10/24	49
51		Commissioning BC	5 days	Fri 4/10/24	Thu 10/10/24	50
52						
53		**Schedule - Wind**	**234 days**	**Mon 2/10/23**	**Thu 22/08/24**	
54		Project planning	4 wks	Mon 2/10/23	Fri 27/10/23	
55		Turbine purchase and dismantle	4 wks	Mon 30/10/23	Fri 24/11/23	54
56		Transport from port to site	4 wks	Mon 27/11/23	Fri 22/12/23	55
57		Containers and packing material	4 wks	Mon 30/10/23	Fri 24/11/23	54
58		Order spare parts	4 wks	Mon 30/10/23	Fri 24/11/23	54
59		Cleaning at port survey report	4 wks	Mon 27/11/23	Fri 22/12/23	55
60		Ocean freight	8 wks	Mon 25/12/23	Fri 16/02/24	59
61		Port handling and transport in Australia	8 wks	Mon 19/02/24	Fri 12/04/24	60
62		refubish blades and test nacelles	8 wks	Mon 15/04/24	Fri 7/06/24	61
63		Geotech and foundation design	8 wks	Mon 27/11/23	Fri 19/01/24	55
64		Roads and hardstand	4 wks	Mon 22/01/24	Fri 16/02/24	63
65		Footings and earthing	8 wks	Mon 19/02/24	Fri 12/04/24	64
66		Electrical services work	16 wks	Mon 15/04/24	Fri 2/08/24	65
67		SCADA	16 wks	Mon 15/04/24	Fri 2/08/24	65
68		LGC and protection meter	16 wks	Mon 15/04/24	Fri 2/08/24	65
69		Construction - base tower sections	4 wks	Sat 1/06/24	Thu 27/06/24	
70		Construction - top tower sections, generators and blades	4 wks	Fri 28/06/24	Thu 25/07/24	69
71		Commissioning and grease maintenance	8 wks	Fri 28/06/24	Thu 22/08/24	69
72						
73		**Schedule - Generators / Protection Container**	**288 days**	**Mon 2/10/23**	**Wed 6/11/24**	
74		**Generator**	**180 days**	**Mon 2/10/23**	**Fri 7/06/24**	
75		Generator manufacture and delivery	35 wks	Mon 2/10/23	Fri 31/05/24	
76		Transport to site	5 days	Mon 3/06/24	Fri 7/06/24	75
77		**Protection Container**	**180 days**	**Mon 2/10/23**	**Fri 7/06/24**	
78		Manufacture and delivery	35 wks	Mon 2/10/23	Fri 31/05/24	
79		Transport to site	5 days	Mon 3/06/24	Fri 7/06/24	78
80		**Transformer**	**180 days**	**Mon 2/10/23**	**Fri 7/06/24**	
81		Manufacture and delivery	35 wks	Mon 2/10/23	Fri 31/05/24	
82		Transport to site	5 days	Mon 3/06/24	Fri 7/06/24	81
83		**Site works, Installation and Commissioning**	**113 days**	**Sat 1/06/24**	**Wed 6/11/24**	
84		Survey	1 day	Mon 10/06/24	Mon 10/06/24	76
85		Civils	5 days	Tue 11/06/24	Mon 17/06/24	84
86		Fencing	5 days	Tue 18/06/24	Mon 24/06/24	85
87		Foundations	10 days	Tue 25/06/24	Mon 8/07/24	86
88		Trenching / Earthing / Conduit Installation	10 days	Tue 9/07/24	Mon 22/07/24	87
89		Transformer placement	1 day	Tue 23/07/24	Tue 23/07/24	88
90		Protection container placement	1 day	Wed 24/07/24	Wed 24/07/24	89
91		Electrical Installation	15 days	Thu 25/07/24	Wed 14/08/24	90
92		Commissioning	60 days	Thu 15/08/24	Wed 6/11/24	91
93						
94		**Schedule - HV Power Construction**	**81 days**	**Sat 1/06/24**	**Mon 23/09/2**	
95		Procurement	4 wks	Sat 1/06/24	Thu 27/06/24	
96		Mobilisation	1 day	Fri 28/06/24	Fri 28/06/24	95
97		Construction	11 wks	Mon 1/07/24	Fri 13/09/24	96
98		Testing	1 wk	Mon 16/09/24	Fri 20/09/24	97
99		Demobilisation	1 day	Mon 23/09/24	Mon 23/09/24	98



Project: Schedule 4 Procuremen
Date: Mon 7/08/23

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Critical | Critical Split | Progress | Manual Progress

APPENDIX F

Jarrah Solutions FEED Report

SOLUTIONS PTY LTD

Technical Report

Reference Designation: AA18S7&EDD1 Rev B

Sunrise – Mullewa Microgrid – Front End Engineering Design (FEED) Report – Jarrah Solutions Contributions

28/08/2023

Providing People with the Power to do Amazing Things

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Table of Contents

Document Control

Approvals List

Rev Number	Name	Title	Signature
Created By	James Stokes	Principal Engineer	
Checked By	James Stokes	Principal Engineer	
Approved By	James Stokes	Principal Engineer	

Revisions List

Rev Number	Description	Date	Revised By
A	Issued for Review (HOLD on Fault Studies)	04-Aug-2023	Not Applicable
B	Issued for FEED study	28 Aug 2023	James Stokes

Approval Period

Date for next review: Not applicable

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2. Introduction

Sunrise Energy are leading a leading a consortium to develop plans for new supply options for the town of Mullewa in Western Australia. The town is located at the end of a 100km radial 33kV feeder from Geraldton.

Jarrah Solutions have been engaged to help develop a power system, protection system and control system architecture to enable the following:

- A functioning Microgrid located electrically close to the town of Mullewa. This Microgrid is to include wind, solar, battery and diesel powered generation sources.
- The creation of an automated system to detect the failure of the power supply to the town of Mullewa, switch over to supply Mullewa from the Microgrid, and then switch back once supply to the town of Mullewa is restored.

This document will describe the architecture and functionality of the Mullewa Microgrid.

3. Glossary of Terms

Term	Description
BESS	Battery Energy Storage System
CB	Circuit Breaker
CMD	Customer Maximum Demand
CT	Current Transformer
EMS	Energy Management System
ERA	Economic Regulator Authority of Western Australia
DSOC	Declared Sent Out Capacity (the export limit of generation that is being applied for).
HMI	Human Machine Interface
OHL	33kV Overhead Line
PPC	Power Park Controller
PV	Photo-voltaic (solar) generation source
REC	Renewable Energy Certificate
RMU	Ring Main Unit (High Voltage ground mount switchgear)
RTU	Remote Terminal Unit (SCADA hardware)
SCADA	Supervisory Control and Data Acquisition
SLD	Electrical Single Line Diagram
SWIN	South West Interconnected Network
VT	Voltage Transformer
WP	Western Power
WTG	Wind Turbine Generator

4. Microgrid High Level Design Philosophy

The single line diagram is contained within Attachment 1.

The Mullewa Microgrid will be designed and created to provide the following two services:

4.1 GRID UP

For this project, the word ‘grid’ is more specifically the SWIN who’s Network Service Provider is Western Power. When grid supply is available at Mullewa, the Mullewa Microgrid will operate in an arrangement that is typical of a renewable grid-connected generation site. A connection point will be required and the ERA technical rules requirements will apply at this grid connection.

The DSOC (export limit) will be selected to allow all renewables at the Mullewa Microgrid to export power into the grid. This will be the sum of wind and solar generation. Hence if there is an excess of power, over and above the town of Mullewa’s needs, then this Microgrid will supply power to other customers between Mullewa and Geraldton. Neither the battery or diesel generator will be supplying (generating) power at the time of full solar + wind generation.

The CMD (import limit) will be selected as a negligible amount to supply auxiliary loads at the Microgrid. The CMD will not need to be selected to charge the battery as the charging of the battery will be performed by a combination of wind and solar generation.

In grid-up mode, the sources will supply power to the grid through a retail supply agreement.

4.2 GRID DOWN

Mullewa is supplied from an overhead 33kV radially fed line from Geraldton. This length of line will fail at unexpected and unplanned times. The cause of failure will be unknown at the time of event and could include such factors as high wind, lightning, equipment damage, equipment failure, etc. If the root cause is persistent, eg equipment damage, then Western Power will need to identify the location of failure and either repair or work around the failure to restore power to Mullewa.

Western Power have diesel generators currently installed near Mullewa which are manually started and then manually switched ON to restore power to Mullewa at times when the grid supply is down. This is a rented service. During the time it takes to manually switch over to Diesel, Mullewa town is without a power supply.

The Mullewa Microgrid will replace the need for these generators and implement and automated detection and switching system with the following automated features:

- Detection of an unplanned outage of the grid supply.
- Starting of the Microgrid and automated establishment of a 33kV earth reference.
- Disconnection of Mullewa from the grid (a new Western Power recloser will be required).
- Restoration of power to Mullewa from the Microgrid.
- Watch and wait for the restoration of supply from the grid. Following restoration, and after waiting a period of time to check for stability, the Mullewa Microgrid will automatically synchronise back onto grid supply in a seamless manner, and then isolate the 33kV local earth reference.

With this new system, restoration of supply to Mullewa will be achievable in less than one minute.

Whilst Mullewa is islanded from the grid and supplied from the Microgrid, a combination of all sources (diesel, wind and solar) will supply power and the BESS will be utilised for frequency control and system stability services.
The following figure shows the location of a new Western Power recloser that the Micgrorid will interface with.

Figure 1: New recloser (crossed red circle) to be installed by Western Power.

The recloser can be of a standard type currently used by Western Power, however utilised and configured in a unique way to facilitate this service. An interface will be required which will be descried in more detail throughout this report.

The protection and automation systems will be of Jarrah type that has been proven to work in several power system arrangements. The integration, configuration and commissioning will all be performed with local Western Australian based resources. This will allow the potential to observe and learn from operations of the Mullewa Microgrid. If modifications and improvements are required, then the system will be flexible enough to allow this to be done locally in Western Australia.

Power Plant Sizing

4.3 Active Power Sizing

Two years of historical active power measurement data of an existing Western Power recloser located upstream of Mullewa was analysed as part of this study. The results, stratified based on the month of the year, are shown in the following figure.

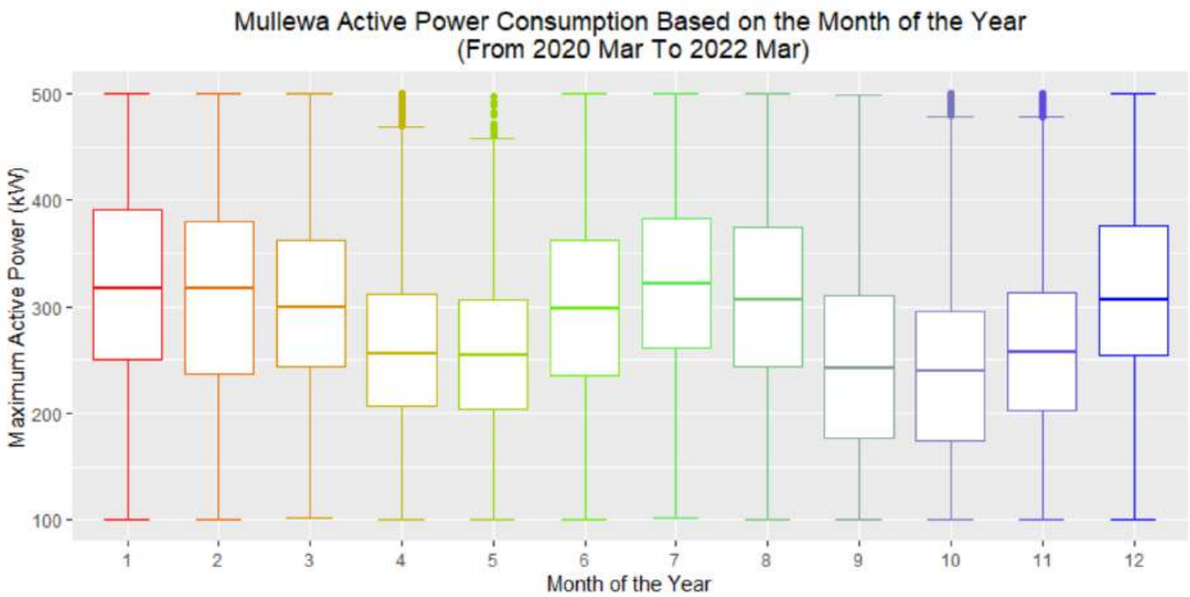


Figure 2 : Active Power Measurements - Based on the Month of the Year

Note that data outliers above 500kW were removed from the data set.

Interpreting this active power measurement data:

- The Mullewa town load is seasonal with the highest load in the Summer months, most likely caused by air conditioning load increase.
- The shoulder seasons (spring and autumn) are lower in consumption.
- There is a winter increase in load over the shoulder seasons, most likely caused by increased heating.
- The average load throughout the year is approximately 300 kW and the third quartile of data (ie 75% of data measurements) are less than 400 kW of load.

The Mullewa Microgrid, refer Single Line Diagram AA18S7&EFA1/1 Revision E which includes the following generation active power sources:

Source	Maximum kW Capacity	Notes / constraints
1 x Diesel Generator	600 kW	Available any time. Duration dependent on fuel supply.
1 x Solar Farm	1000 kW	Available in the day.
1 x Wind Turbines	1200 kW	Available with wind.
1 x BESS	1500 kW	3000 kWh so can supply an average of 10 hours from a fully charged battery.
TOTAL	**4300 kW**	

Table 1: Total Active Power Capacity of Mullewa Microgrid

From this active power sizing information, there should be sufficient capacity to provide a reliable and continuous power supply to Mullewa when the grid supply is unavailable. Excess wind and solar generation will charge the BESS and the diesel will be used as a backup for long periods of unavailability of renewable generation sources.

4.4 Diesel Fuel Storage Sizing

Assuming a long period of poor weather and/or an unplanned outage of the solar farm, diesel fuel storage will be required to facilitate continued mine operations.

This has been calculated at a low level of detail (checking basis only):

- 350 kW of average load
- 100 L of diesel consumption per hour
- 4000 L of fuel storage
- 40 hours of continuous operation with no other sources

It is expected that along with wind, solar and the ability to monitor and re-fuel as required, that a continuous power supply will be possible for Mullewa when operating in island (grid disconnected) mode.

4.5 Reactive Power Sizing

Two years of historical reactive power measurement data of an existing Western Power recloser located upstream of Mullewa was analysed as part of this study. The results, stratified based on the month of the year, are shown in the following figure.

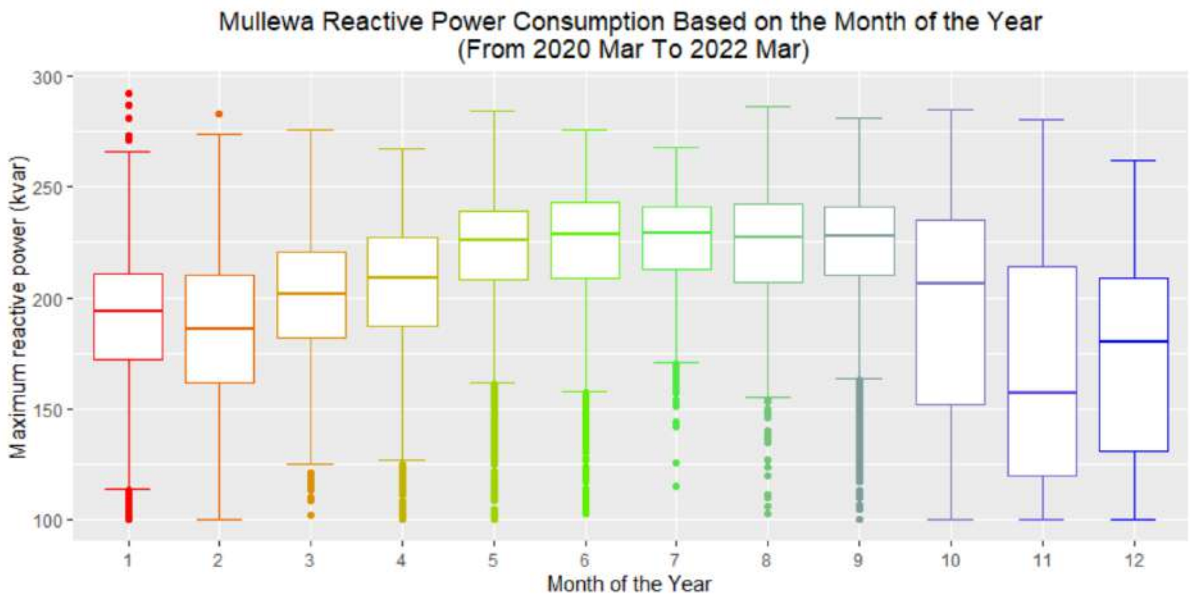


Figure 3: Mullewa Reactive Power Measurements - Based on the Month of the Year

With outliers removed (eg high reactive power inrush on energisation of lines), the reactive power demand of Mullewa is averaging less than 225kVA. This value is significantly less than the reactive power capacity of the Mullewa Microgrid. The Microgrid reactive power capacity includes the solar inverter, BESS, inverter, wind turbines and diesel generator which are all controllable.

5. Power System Studies

5.1 Load Flow

The existing power supply to Mullewa is stable and operational. This is with limited localised grid control capability when grid connected.

When the Mullewa town is supplied from the Microgrid, there will be more advanced reactive power control capability available. Reactive power control is available from all generation sources (generator, BESS inverter, solar inverter and wind turbines). The ‘Q at night’ feature of the solar and BESS inverters is a requirement.

With these two factors, it is expected that voltage stability during steady-state load flow conditions will be achievable for the Mullewa Microgrid when running in island mode.

Detailed load flow studies have been allowed for during detailed design.

5.2 Fault Studies

The Mullewa Microgrid has been steady-state power system modelled using DIgSILENT PowerFactory 2019 SP4 (Build 19.0.6 (9043) / Rev 66182).

Fault studies are typically performed for various reasons including short-circuit withstand, protection grading and protection sensitivity studies.

When the Mullewa Microgrid is islanded, fault levels will be significantly lower than when grid connected and hence the short-circuit withstand capability of existing equipment is unlikely to be an issue. This was not studied further.

Protection grading studies will be performed during detailed design for minimum and maximum calculated fault levels. This was not studied in detail during FEED. It is noted that when the Mullewa Microgrid is supplying Mullewa township in “GRID DOWN” (island) mode then a lack of protection grading or discrimination is considered acceptable. If more customers lose power than necessary during GRID DOWN mode following a short circuit fault, then this is still a far better position to be in than having no supply to Mullewa during GRID DOWN conditions.

What was studied and is considered relevant is minimum fault levels and protection sensitivity during GRID DOWN (island) mode. The fault locations studied are shown in the following figure.

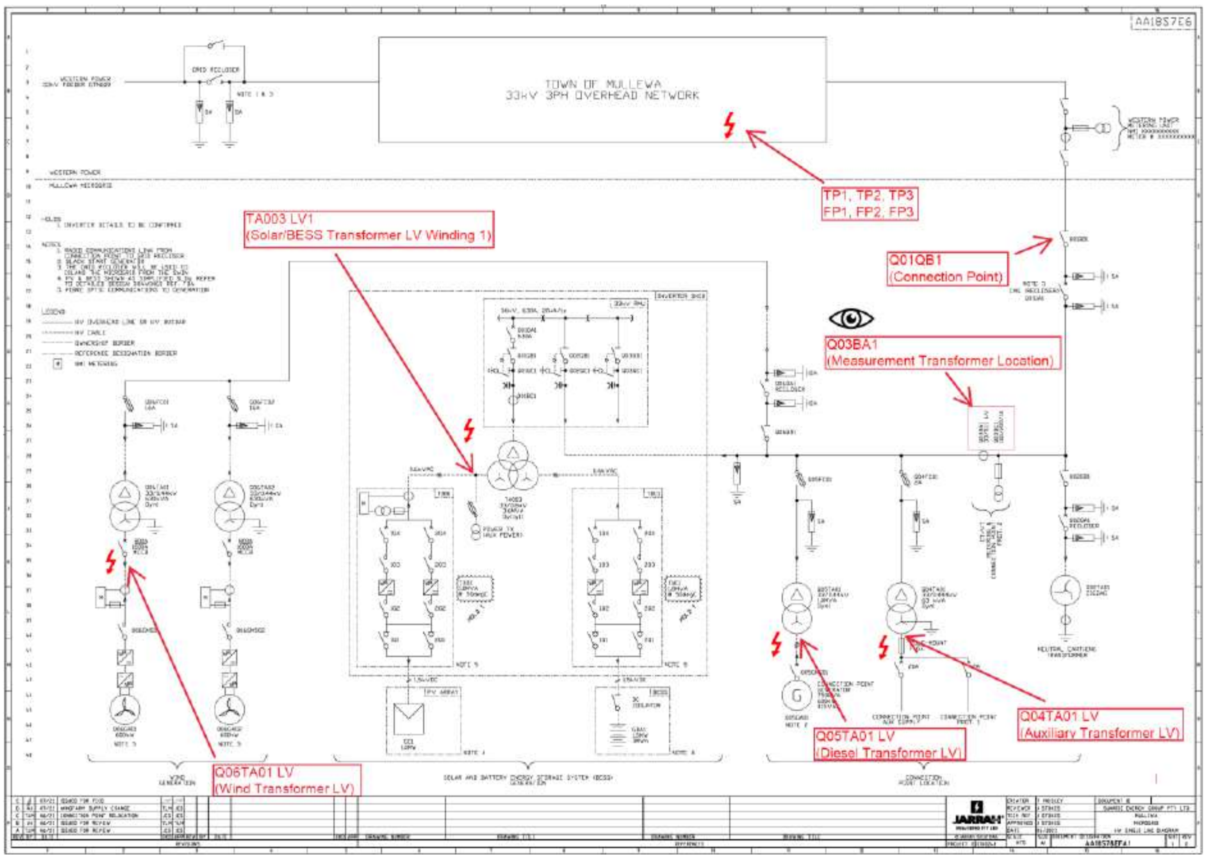


Table 2: Fault locations studied and their identifiers

Within the existing network labelled “TOWN OF MULLEWA 33kV”, the fault locations studied are further detailed in the following three figures.

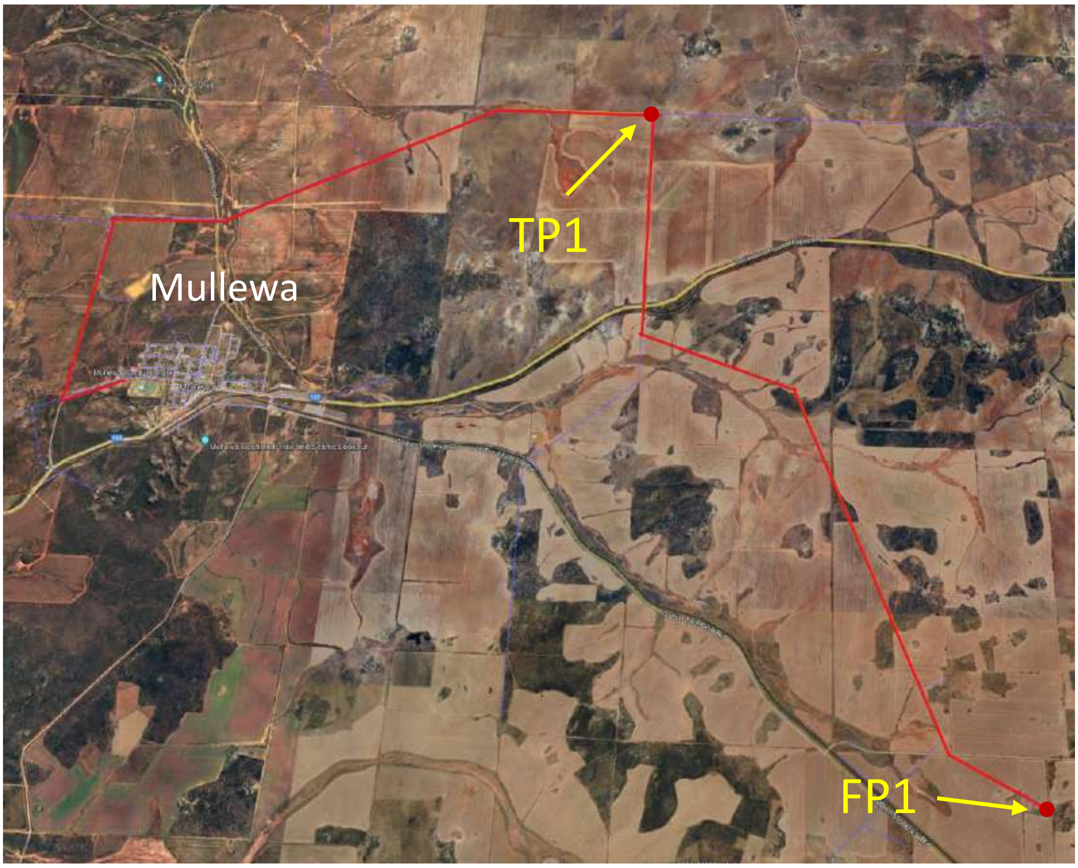


Figure 4: Fault Study – Transition Point 1 (TP1) and Furthest Point 1 (FP1)

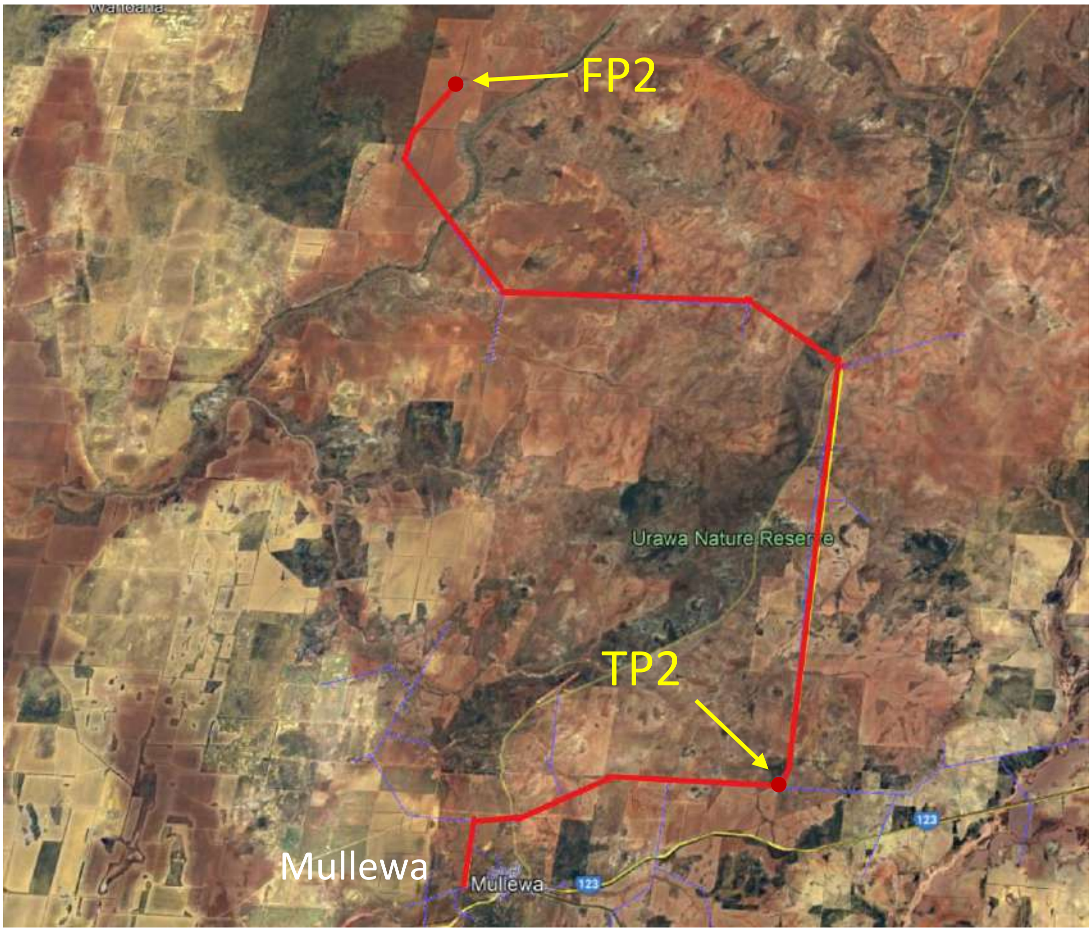


Figure 5: Fault Study – Transition Point 2 (TP2) and Furthest Point 2 (FP2)

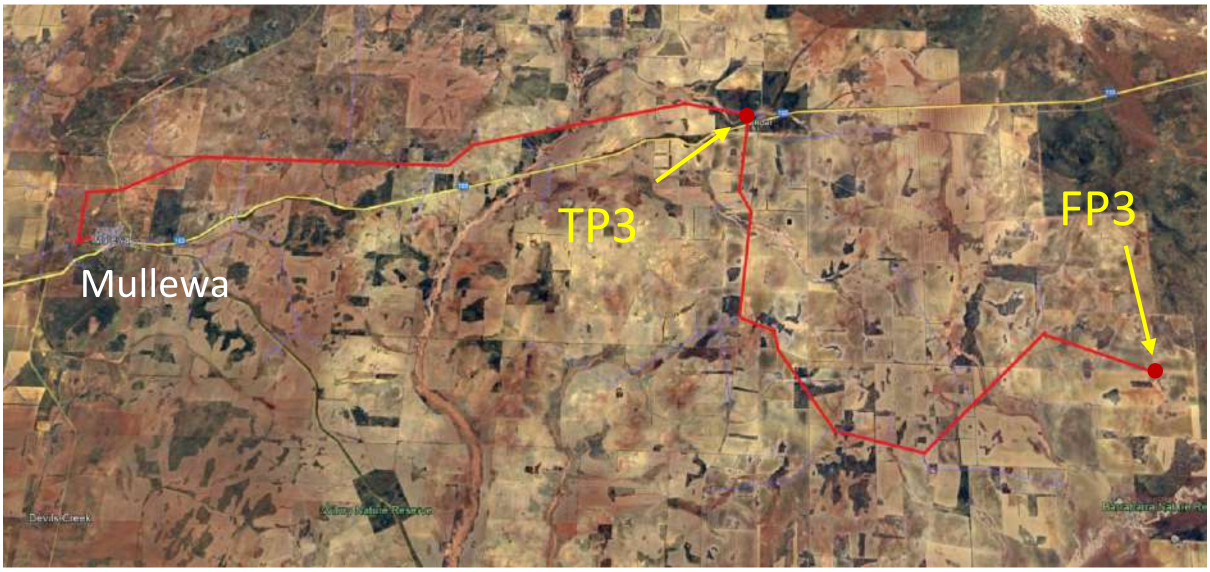


Figure 6: Fault Study – Transition Point 3 (TP3) and Furthest Point 3 (FP3)

The transition points (TP1, 2, 3) are where the 33kV overhead line transitions from 3-phase to single-phase line. The "furthest" points (FP1, 2, 3) are at the ends of the longest 33kV single-phase lines. These are the locations of highest impedance to the source and hence the lowest fault current levels.

The following table describes all fault locations studied.

Location	Nominal Voltage	Description	Applied Fault Types
TP1	33kV phase-to-phase	Transition Point 1. Refer Figure 4	3PH, PH-E
FP1	19.1 kV phase-to-earth	Furthest Point 1. Refer Figure 4	PH-E
TP2	33kV phase-to-phase	Transition Point 2. Refer Figure 5	3PH, PH-E
FP2	19.1 kV phase-to-earth	Furthest Point 2. Refer Figure 5	PH-E
TP3	33kV phase-to-phase	Transition Point 3. Refer Figure 6	3PH, PH-E
TP3	33kV phase-to-phase	Furthest Point 3. Refer Figure 6	PH-E
Q01QB1 (Connection Point)	33kV phase-to-phase	Connection Point. Refer Figure 7	3PH, PH-E
Q06TA01 LV	33kV phase-to-phase	Wind Transformer LV	3PH, PH-E
TA003 LV1	33kV phase-to-phase	Solar/BESS Transformer LV Winding 1	3PH, PH-E
Q05TA01 LV	33kV phase-to-phase	Diesel Transformer LV	3PH, PH-E
Q04TA01 LV	33kV phase-to-phase	Auxiliary Transformer LV	3PH, PH-E

Table 3: Fault Study Location Details

When in islanded (GRID DOWN) mode and the Mullewa Microgrid is supplying power to both the township and the outgoing feeders (FP1, 2 & 3), there will be different operating scenarios depending on source availability. These scenarios are described in the following table.

Scenario	Description
Diesel Only	Turn On Diesel Generator Only Turn Off All Renewable Generations and BESS
BESS Only	Turn On BESS Only Turn Off All Renewable Generations and Diesel Generator
BESS + Solar	Turn On BESS and Solar Farm
BESS + Wind	Turn On BESS and Two Wind Turbines
Diesel + BESS + Wind + Solar	Turn On All Embedded Generation

Table 4: Operation Scenarios

The fault study results for these combinations of locations and operating scenarios are provided in the in the following table.

Scenario	Fault Occurred Location	Results measurement Location	Minimum PH-E Current (kA)	Minimum 3PH Current (kA)	U Fault Voltage (pu) 3PH fault
Diesel Only	TP1	Q03BA1 (Measurement Transformer)	0.113	0.091	0.016
	TP2	Q03BA1 (Measurement Transformer)	0.110	0.090	0.030
	TP3	Q03BA1 (Measurement Transformer)	0.101	0.087	0.070
	FP1	Q03BA1 (Measurement Transformer)	0.096	N/A	N/A
	FP2	Q03BA1 (Measurement Transformer)	0.058	N/A	N/A
	FP3	Q03BA1 (Measurement Transformer)	0.066	N/A	N/A
	Q01QB1 (Connection Point)	Q03BA1 (Measurement Transformer)	0.118	0.092	N/A
	Q05TA01 LV (Diesel Transformer LV)	Q05GA01 (Generator)	11.824	9.314	0

Scenario	Fault Occurred Location	Results measurement Location	Minimum PH-E Current (kA)	Minimum 3PH Current (kA)	U Fault Voltage (pu) 3PH fault
	Q04TA01 LV (Auxiliary Transformer LV)	Q04FC01 (Transformer HV Fuse)	0.011	0.018	0.803 (Note, 0.882 for PH-E fault)
BESS Only	TP1	Q03BA1 (Measurement Transformer)	0.027	0.030	0.005
	TP2	Q03BA1 (Measurement Transformer)	0.027	0.030	0.010
	TP3	Q03BA1 (Measurement Transformer)	0.026	0.030	0.024
	FP1	Q03BA1 (Measurement Transformer)	0.025	N/A	N/A
	FP2	Q03BA1 (Measurement Transformer)	0.020	N/A	N/A
	FP3	Q03BA1 (Measurement Transformer)	0.021	N/A	N/A
	Q01QB1 (Connection Point)	Q03BA1 (Measurement Transformer)	0.028	0.030	N/A
	TA003 LV1 (Solar/BESS Transformer LV Winding 1)	TBB1 AC Output (BESS)	N/A	1.576	0.054
	Q04TA01 LV (Auxiliary Transformer LV)	Q04FC01 (Transformer HV Fuse)	0.006	0.013	0.578 (Note, 0.600 for PH-E fault)
BESS + Solar	TP1	Q03BA1 (Measurement Transformer)	0.041	0.059	0.011
	TP2	Q03BA1 (Measurement Transformer)	0.040	0.059	0.020
	TP3	Q03BA1 (Measurement Transformer)	0.038	0.058	0.047
	FP1	Q03BA1 (Measurement Transformer)	0.035	N/A	N/A

Scenario	Fault Occurred Location	Results measurement Location	Minimum PH-E Current (kA)	Minimum 3PH Current (kA)	U Fault Voltage (pu) 3PH fault
	FP2	Q03BA1 (Measurement Transformer)	0.025	N/A	N/A
	FP3	Q03BA1 (Measurement Transformer)	0.028	N/A	N/A
	Q01QB1 (Connection Point)	Q03BA1 (Measurement Transformer)	0.042	0.060	N/A
	TA003 LV1 (Solar/BESS Transformer LV Winding 1)	TBB1 AC Output (Solar)	N/A	1.749	0.054
	TA003 LV1 (Solar/BESS Transformer LV Winding 1)	TBC1 AC Output (BESS)	N/A	1.566	0.053
	Q04TA01 LV (Auxiliary Transformer LV)	Q04FC01 (Transformer HV Fuse)	0.007	0.016	0.732 (Note, 0.592 for PH-E fault)
BESS + Wind	TP1	Q03BA1 (Measurement Transformer)	0.040	0.051	0.009
	TP2	Q03BA1 (Measurement Transformer)	0.040	0.050	0.017
	TP3	Q03BA1 (Measurement Transformer)	0.037	0.049	0.040
	FP1	Q03BA1 (Measurement Transformer)	0.035	N/A	N/A
	FP2	Q03BA1 (Measurement Transformer)	0.025	N/A	N/A
	FP3	Q03BA1 (Measurement Transformer)	0.027	N/A	N/A
	Q01QB1 (Connection Point)	Q03BA1 (Measurement Transformer)	0.041	0.051	N/A
	Q06TA01 LV (Wind Transformer LV)	Q06GMS01 (Wind Turbine)	2.788	0.803	0.128

Scenario	Fault Occurred Location	Results measurement Location	Minimum PH-E Current (kA)	Minimum 3PH Current (kA)	U Fault Voltage (pu) 3PH fault
	TA003 LV1 (Solar/BESS Transformer LV Winding 1)	TBC1 AC Output (BESS)	N/A	1.514	0.039
	Q04TA01 LV (Auxiliary Transformer LV)	Q04FC01 (Transformer HV Fuse)	0.007	0.015	0.700 (Note, 0.581 for PH-E fault)
Diesel + BESS +Wind +Solar	TP1	Q03BA1 (Measurement Transformer)	0.182	0.176	0.032
	TP2	Q03BA1 (Measurement Transformer)	0.174	0.172	0.058
	TP3	Q03BA1 (Measurement Transformer)	0.153	0.161	0.131
	FP1	Q03BA1 (Measurement Transformer)	0.132	N/A	N/A
	FP2	Q03BA1 (Measurement Transformer)	0.065	N/A	N/A
	FP3	Q03BA1 (Measurement Transformer)	0.078	N/A	N/A
	Q01QB1 (Connection Point)	Q03BA1 (Measurement Transformer)	0.193	0.181	N/A
	TA003 LV1 (Solar/BESS Transformer LV Winding 1)	TBB1 AC Output (Solar)	N/A	1.749	0.231
	Q06TA01 LV (Wind Transformer LV)	Q06GMS01 (Wind Turbine)	9.815	0.803	0.389
	TA003 LV1 (Solar/BESS Transformer LV Winding 1)	TBC1 AC Output (BESS)	N/A	1.354	0.230
	Q05TA01 LV (Diesel Transformer LV)	Q05GA01 (Generator)	17.297	10.244	0.183

Scenario	Fault Occurred Location	Results measurement Location	Minimum PH-E Current (kA)	Minimum 3PH Current (kA)	U Fault Voltage (pu) 3PH fault
	Q04TA01 LV (Auxiliary Transformer LV)	Q04FC01 (Transformer HV Fuse)	0.012	0.020	0.905 (Note, 0.956 for PH-E fault)

Table 5: Fault Study Summary Results – Fault Currents as Measured from the defined measurement location

5.2.1 Town of Mullewa 33kV Faults

When the town of Mullewa is supplied from the Microgrid, 33kV faults will be very low and detection of such low fault currents will be challenging.

Detection of 33kV earth faults from the Mullewa Microgrid should be achievable with earth fault overcurrent protection.

Detection of 3-phase faults will be more challenging. From the fault summary table, the minimum 3-phase fault currents at the transition points (TP1, 2 & 3) have been calculated to be less than load current for certain scenarios. For example, the minimum calculated 3-phase fault current at TP1 in the BESS only scenario is only 5 Amps primary. This will be very challenging to detect using conventional overcurrent protection.

To suitably locate and clear such faults is achievable however would require a significant investment in new technologies such as reclosers and fault locators. This is considered unfeasible for the Mullewa Microgrid as the high cost is unlikely to be justified by the marginal improvement in reliability. Mullewa's reliability is improved by having the Microgrid available and the likelihood of 33kV faults whilst Mullewa is islanded is unlikely.

It is recommended that voltage-based protection is used as a backup to detect and clear 33kV faults. This would result in the loss of the whole Microgrid and hence the township of Mullewa. It would, however, be a low cost and achievable solution.

5.2.2 Microgrid System Faults

From the fault studies performed, faults within the Microgrid itself appear to be of high enough magnitude to be detectable and provide discrimination.

5.2.3 System Fault and Protection Sensitivity Caveat

The studies performed are of a level of detail sufficient for a FEED study. It is noted that, should the project go ahead, a more detailed power system model will need to be developed and a more detailed protection study performed for a larger set of fault locations and operating scenarios. These studies have been allowed for in the estimate. New information and recommendations may evolve from these studies however fundamentally it is believed that the concept of an island mode backup protection system that trips the Microgrid, and isolates the township, will be the feasible outcome.

5.3 Dynamic Studies

Dynamic (RMS) studies have not been performed during FEED.

6. Mullewa Microgrid Connection Point HV Substation

The Mullewa Microgrid will electrically connect to Western Power at a single location (connection point). The location of the connection is shown in the following figure:

Figure 7: Location (blue rectangle) of the Mullewa Microgrid connection point

A connection point 33kV substation will be required to meet Western Australian technical rules requirements. This will also be used to provide the required protection and control systems.

The single line diagram and general arrangements are attached to this study in Appendix 1. The isometric drawing is shown in the following figure:

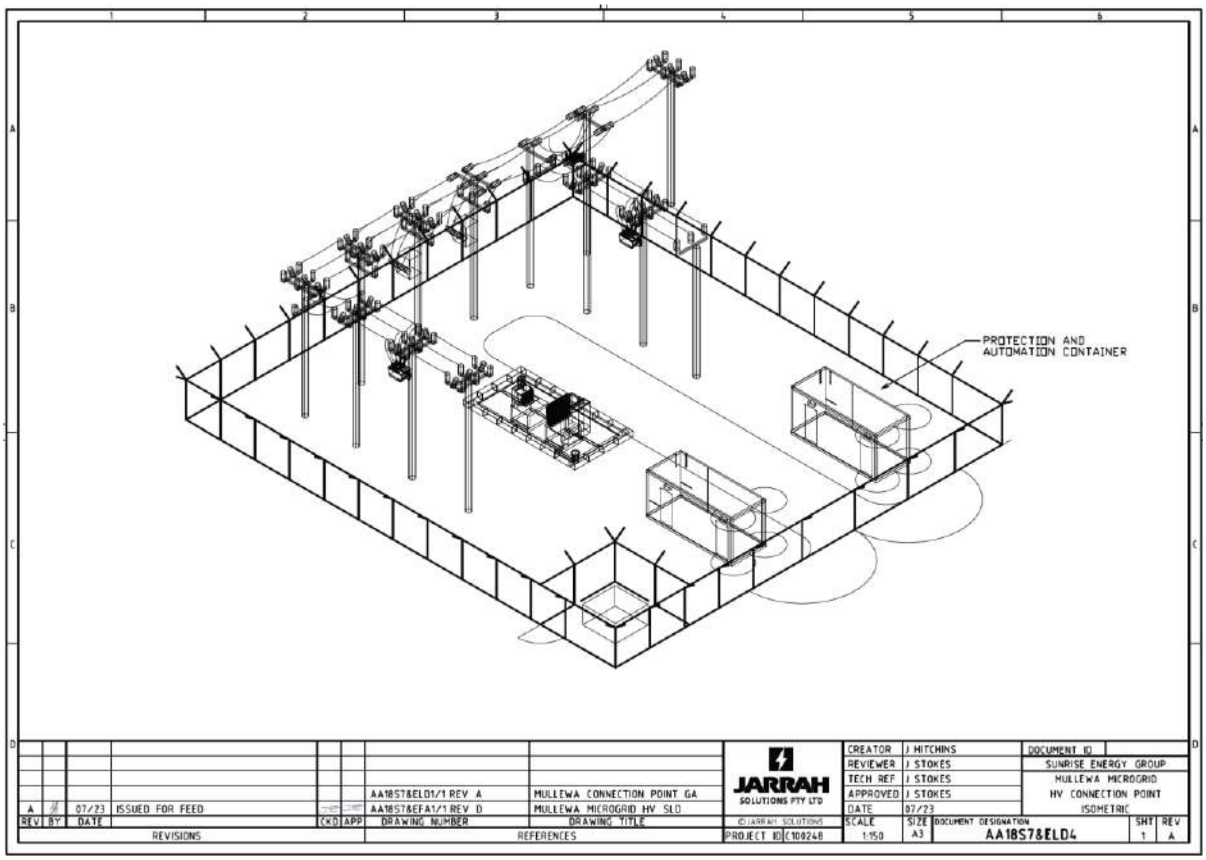


Figure 8: Isometric view of the Connection Point HV Substation

The 33kV primary overhead conductor and HV switchgear will be mounted above ground and on wooden poles. Due to the quantity of ground-mount equipment and cables/conductors, it is recommended to fence in this substation area. This will provide security for this remote location.

This HV substation will include the following equipment and features:

- A Customer Main Switch (CMS) as an interface between the Microgrid and Western Power, as required by the ERA Technical Rules.
- HV connection point metering for renewable energy credits and controls.
- A switchable Neutral Earthing Tranfsormer to create an earth reference when the Microgrid is supplying power to Mullewa in island mode (grid disconnected).
- A 600kW diesel generator, step-up transformer, fuel tank and associated protections and controls.
- HV Switchgear for switching and isolations of the wind turbine supply.
- Protection, automation and communications systems.

The protection and automation equipment will be mounted within a ground-mount 20’ container.

A containerised protection and automation solution will be provided that can be re-deployed or re-purposed elsewhere.

7. Microgrid Protection

Connection point protections will be required to meet ERA technical rules requirements. These protections will be located at the 33kV connection point and within the substation.

When in grid-disconnected mode and the Microgrid is supplying power to Mullewa independently from Western Power, the protection system will adapt to a different mode of operation. The mode of operation (Grid Connected or Grid Disconnected) status will be provided automatically to the protection system. In Grid Disconnected mode, the fault levels will reduce, and fault detection and sensitivity requirements will become relevant and important. The protection systems will need to be designed for sensitive to short-circuit faults on the HV and LV networks. Detecting and selectively clearing for low level minimum fault currents will likely be the challenge to this project as discussed in the “Fault Studies” section.

Directional overcurrent protections along with undervoltage backup protections will likely be required. The HV protection systems and input measurements (CTs and VTs) have been designed to allow for this flexibility. Protection studies have been allowed for in the FEED estimate, to be carried out during detailed design.

Lightning protection at the substation has not been allowed for as the overhead components (eg reclosers, air breaks, fuses, etc) are designed and commonly used for outdoor overhead operation.

HV protection relays will be renowned international branded devices, and types SEL (USA origin) and Siemens (European origin) will be utilised.

8. Microgrid Automation & Control

A Jarrah proprietary Energy Management System (EMS) with Power Park Controller (PPC) will be implemented for the Mullewa Microgrid Automation and Control system. This has proven interfaces in grid applications with the following equipment:

- FIMER solar inverters intended for this Microgrid, and
- FIMER BESS inverters intended for this Microgrid, and
- HV switchgear protection and automation systems, and
- EasyGen generator controllers which have been specified for the Diesel generators, and
- Noja type overhead line reclosers including types used by Western Power, and
- New revenue metering and Power Quality Monitoring devices, and
- Saft Battery Energy Management System (BESS), and
- Western Power upstream substation RTU communications for grid control and status.

8.1 Control Philosophy – Grid Up Mode

In ‘Grid Up Mode, the Western Power supply will be available, and the Mullewa Microgrid will run in synchronisation.

During the grid connected mode, it is expected that there will typically be no export limits during normal operation. All excess generation from the Mullewa Microgrid will be exported to grid connection from Geraldton (GTN609 feeder). If Western Power communicate a grid export limit, then the Microgrid will automatically receive this command and scale back generation to meet the new export limit setpoint.

The diesel generator is not expected to operate in Grid Up mode.

The neutral earthing transformer will not be connected in Grid Up mode.

The BESS will be charged and discharged according to the economic dispatch model provided by Sunrise.

8.2 Control Philosophy – Grid Down Mode

In 'Grid Down Mode', the Western Power supply will be unavailable. This is typically an unplanned event however it could also be an unplanned event.

For an unplanned event, the high-level control philosophy is described within the following logic diagram:

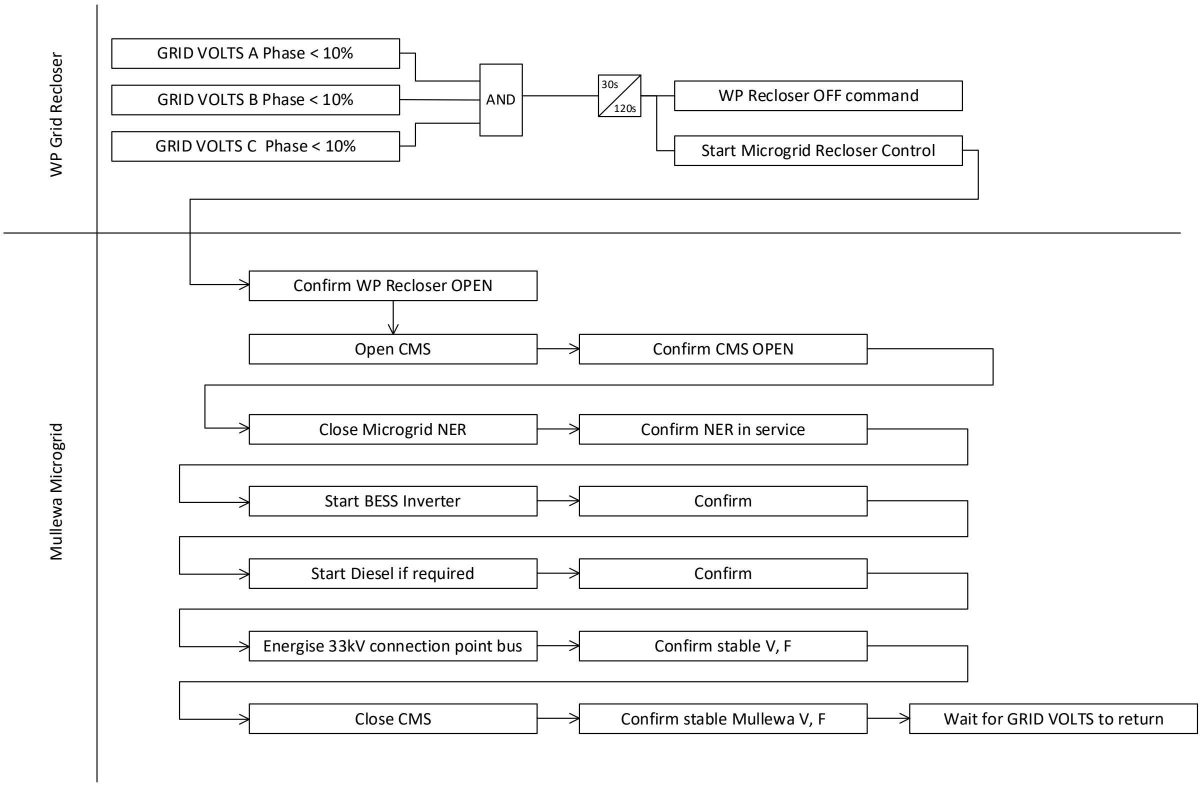


Figure 9: Mullewa Microgrid High Level Control Philosophy - Grid Down Mode

The diesel generator will only be utilised if the BESS state of charge (SOC) is low enough such that it requires recharging when there is insufficient renewable generation available.

The neutral earthing transformer will be connected during Grid Down mode. This is to provide an Earth Reference at the 33kV voltage level as the existing earth reference (at Geraldton) will be disconnected at the Western Power upstream recloser.

The BESS will be charged and discharged for the following purposes:

- To provide frequency stability when running in island mode, and
- To reduce the reliance upon diesel (non-renewable) generation during island mode as excess renewable generation can be used to charge the battery when available.

To facilitate this control mode, a new 33kV recloser will be required to be installed on the Western Power network and interface with the Mullewa Microgrid. The Recloser type can be a standard NOJA type recloser. This recloser will be located upstream of the Mullewa township in approximately the location depicted in Figure 1. It is expected that this device will be owned and operated by Western Power and it would be a standard stock item. Jarrah Solutions can provide the protection settings and interface equipment, design and configurations.

The grid-down mode would be a network service provided to Western Power to improve reliability to the town of Mullewa.

8.3 Remote Monitoring Capability

Remote monitoring and remote operational support capabilities will be provided.

Jarrah will also have the ability to deliver remote changes improvements to the system as it is expected that the system will require improvement as lessons become evident.

9. Communications

Communications will centralise at the new connection point protection and automation container. Communications will be required to the solar farm (fibre optics), wind turbines (fibre optics), to the Western Power control centre and also to the new Western Power grid recloser upstream of Mullewa Town.

The Western Power communications will be explained in further detail below.

9.1 Western Power Network Control Communications

Given the capacity of the new generation connected, it is expected that an interface will be required to communicate with the Western Power Network control centre. This will provide visibility to Western Power and also facilitate controls (ON, OFF and export limit setpoints). This type of communications is known as Remote Monitoring and Control (RMC). The most efficient means will be a combination of mobile radio (3G/4G) and satellite communications. A serial interface will be provided through hardware installed within the Geraldton substation.

9.2 Western Power Grid Recloser Communications

This communication link will need to be reliable as the townships power system reliability will depend on its functioning at times of need.

The Western Power Grid Recloser location has been selected on high ground and to provide (close to) line-of-sight communications. A radio path analysis has been performed to check the expected reliability of this radio path.

Figure 10: Radio Path analysed for communications reliability

The analysis of this radio path (shown as a red line in the above figure) are shown in the following two figures.

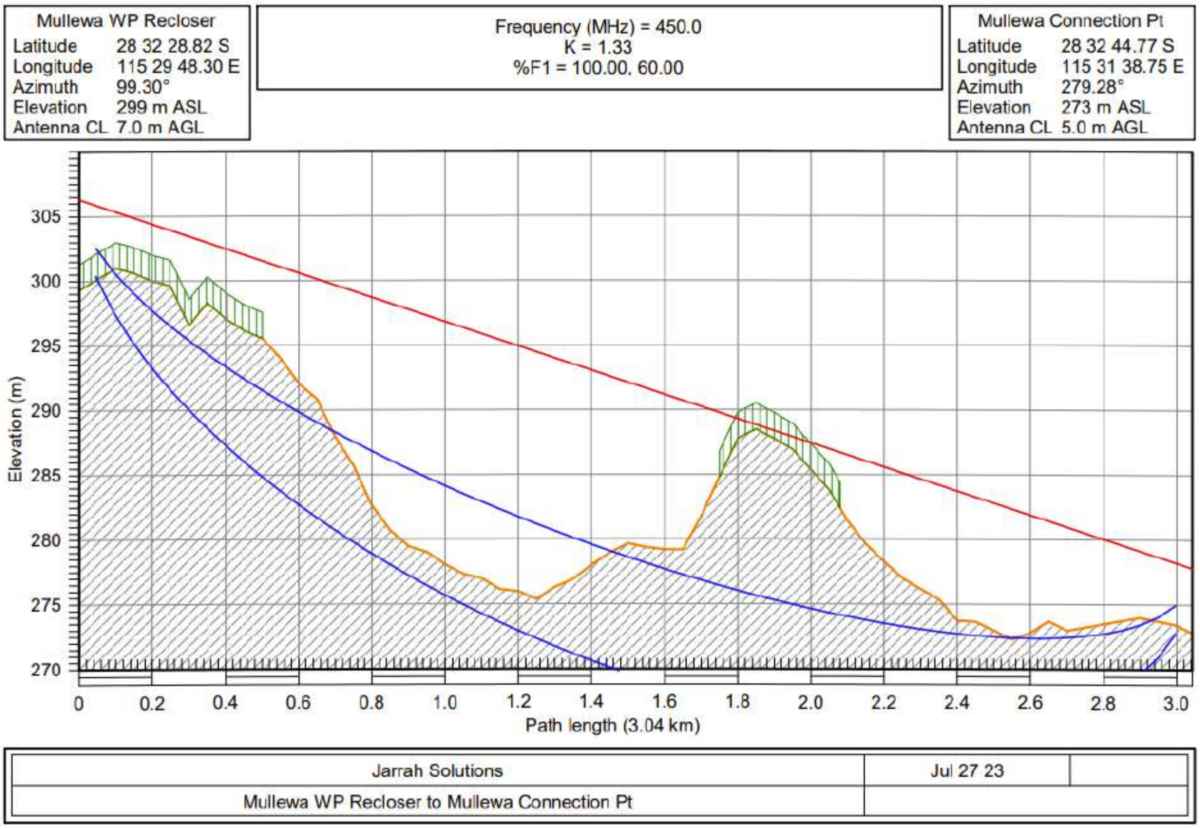


Figure 11: Radio path analysis

	Mullewa WP Recloser	Mullewa Connection Pt
Elevation (m)	299.30	272.83
Latitude	28 32 28.82 S	28 32 44.77 S
Longitude	115 29 48.30 E	115 31 38.75 E
True azimuth (°)	99.30	279.28
Vertical angle (°)	-0.55	0.53
Antenna height (m)	7.00	5.00
Antenna gain (dBi)	11.15	11.15
(dBd)	9.00	9.00
TX line length (m)	10.00	6.00
TX line unit loss (dB /100 m)	8.86	8.86
TX line loss (dB)	0.89	0.53
Connector loss (dB)	0.50	0.50
Frequency (MHz)	450.00	
Polarization	Horizontal	
Path length (km)	3.04	
Free space loss (dB)	95.20	
Diffraction loss (dB)	12.18	
Net path loss (dB)	87.49	87.49
TX power (watts)	1.00	1.00
(dBm)	30.00	30.00
Effective Radiated Power (Watts)	5.77	6.26
(dBm)	37.61	37.97
RX Sensitivity (µv)	3.98	3.98
(dBm)	-95.00	-95.00
RX Signal (µv)	298.41	298.41
(dBm)	-57.49	-57.49
RX Field Strength (µv/m)	1419.92	1363.15
Fade Margin (dB)	37.51	37.51
Rayleigh Fade Probability (%)	0.02	0.02
Log Normal Fade Probability (%)	2.04E-08	2.04E-08

Thu, Jul 27 2023
Mullewa WP Recloser - Mullewa Microgrid Connection Point.pl4
Location - Woodland (sigma = 6 dB)

Figure 12: Radio path analysis results

This analysis was based on a recloser end antenna height of 7m (ie mounted on the same pole as the grid recloser) and 5m at the connection point substation (ie mounted on an antenna pole off the protection and automation container). The following input data was used:

- 450MHz 12.5kHz channel, which should be easy to obtain
- GE MCR Orbit licensed radio
- 64QAM modulation, giving 60Kbps
- Modest 6 element Yagi antennas at each end, 1m long

Given this, the Rayleigh Fade calculation yields a radio path availability of 99.98% which equates to 1hr 33m a year of unavailability in the radio link. This is considered an acceptable level of reliability for the purpose of managing Mullewa being supplied by the new Microgrid and interfacing successfully with the Western Power disconnection location (grid recloser).

10. Metering and Power Quality Monitoring

10.1 Solar, Wind and BESS Metering

Renewable Energy Certificates (RECs) are a measure that one MWh of energy has been produced from renewable sources. These RECs can be sold, so are a revenue stream for the project. To certify them, an NMI accredited revenue and power quality meter will be required at the 33kV connection point.

This meter will require measuring signals which will be obtained from a pole mounted metering unit located within the connection point substation.

11. Earthing

11.1 33 kV System Earthing

To achieve an earth reference on the 33kV network when operating in island mode, a Neutral Earthing Transformer (Zig Zag ZN0) will be provided. The intent at FEED stage is to design the Neutral Earthing Transformer to provide similar earth fault magnitude levels to what is currently experienced at Mullewa under normal grid-connected operation.

The Neutral Earthing Transformer will be provided with a neutral Current Transformer (CT) to provide backup protection for system earth faults.

The Neutral Earthing transformer will only be connected when the Mullewa Microgrid is supplying power to the town and islanded from the grid.

11.2 33 kV Substation Earthing

Within the substation, grading rings and earth electrodes will be required. This is to manage step-and-touch potentials.

A detailed study of the earthing system will be required and has been allowed for. This will require soil resistivity testing at the site. This will be required during detailed design.

Risks

The following risks apply to the FEED study for the Mullewa Microgrid:

1) This is a complex network with integration of diesel, batteries and renewables in an islanded (off-grid) remotely located context. There is a risk of unplanned outages caused by Microgrid instability. This risk will need to be mitigated with Engineering effort and the ability to adapt the system over time. Furthermore:
    a. Electrical system protections will be in place to ensure that Mullewa customers are disconnected and isolated if the Microgrid does not meet the required power quality requirements, and
    b. Monitoring over time will be provided and compliance monitoring can be performed.
2) Cost and delivery risks associated with a buoyant WA energy market meaning access to skilled and specialised Engineering resources is challenging.

This project should lead to an improvement in power system reliability to the town of Mullewa. Hence it is expected that the risks of this project are more associated with managing costs.

It is considered that the risks of integration of these types of inverters (Fimer), Generator controllers (EasyGen) and HV Switchgear (Reclosers) have been mitigated through experience with past Jarrah projects.

12. Appendixes

Appendix 1 – Connection point substation design drawings

REV	BY	DATE	REVISIONS	CKD	APP
E		07/23	ISSUED FOR FEED		
D	AJ	07/23	WINDFARM SUPPLY CHANGE	TLM	JCS
C	TLM	06/23	CONNECTION POINT RELOCATION	JCS	JCS
B	JH	06/23	ISSUED FOR REVIEW	TLM	TLM
A	TLM	06/23	ISSUED FOR REVIEW	JCS	JCS

REV	BY	DATE	CKD	APP	DRAWING NUMBER	DRAWING TITLE

REFERENCES

DRAWING NUMBER	DRAWING TITLE

JARRAH® SOLUTIONS PTY LTD

PROJECT ID C100248

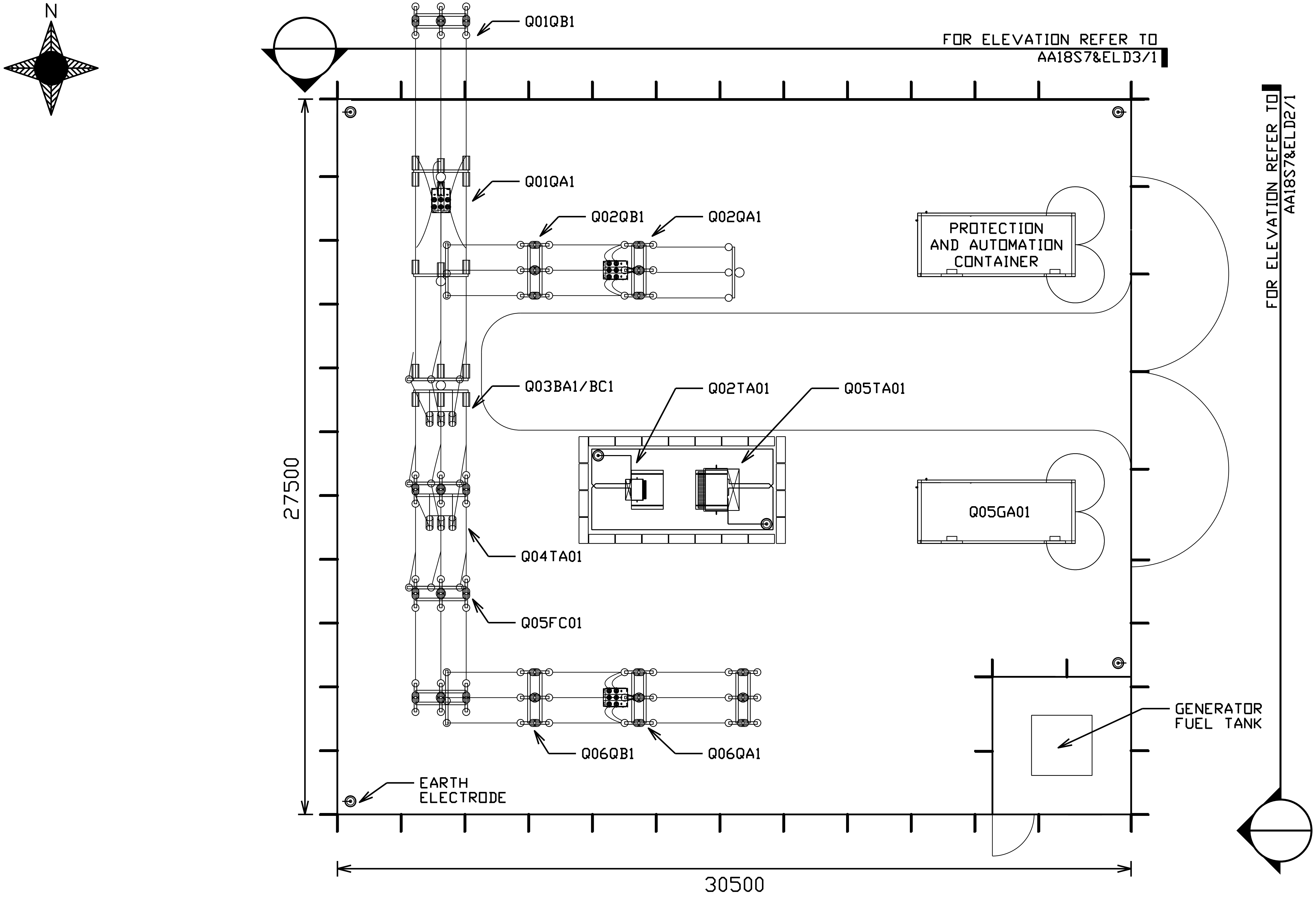
CREATOR	T MOISLEY
REVIEWER	J STOKES
TECH REF	J STOKES
APPROVED	J STOKES
DATE	06/2023

DOCUMENT ID

SUNRISE ENERGY GROUP PTY LTD

MULLEWA
MICROGRID
HV SINGLE LINE DIAGRAM

SCALE	SIZE	DOCUMENT DESIGNATION	SHT	REV
NTS	A1	AA18S7&EFA1	1	D



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REV	BY	DATE		CKD	APP	DRAWING NUMBER	DRAWING TITLE
REVISIONS						REFERENCES	

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PROJECT ID C100248

CREATOR	J HITCHINS
REVIEWER	J STOKES
TECH REF	J STOKES
APPROVED	J STOKES
DATE	07/23

DOCUMENT ID

SUNRISE ENERGY GROUP

MULLEWA MICROGRID
HV CONNECTION POINT
GENERAL ARRANGEMENT

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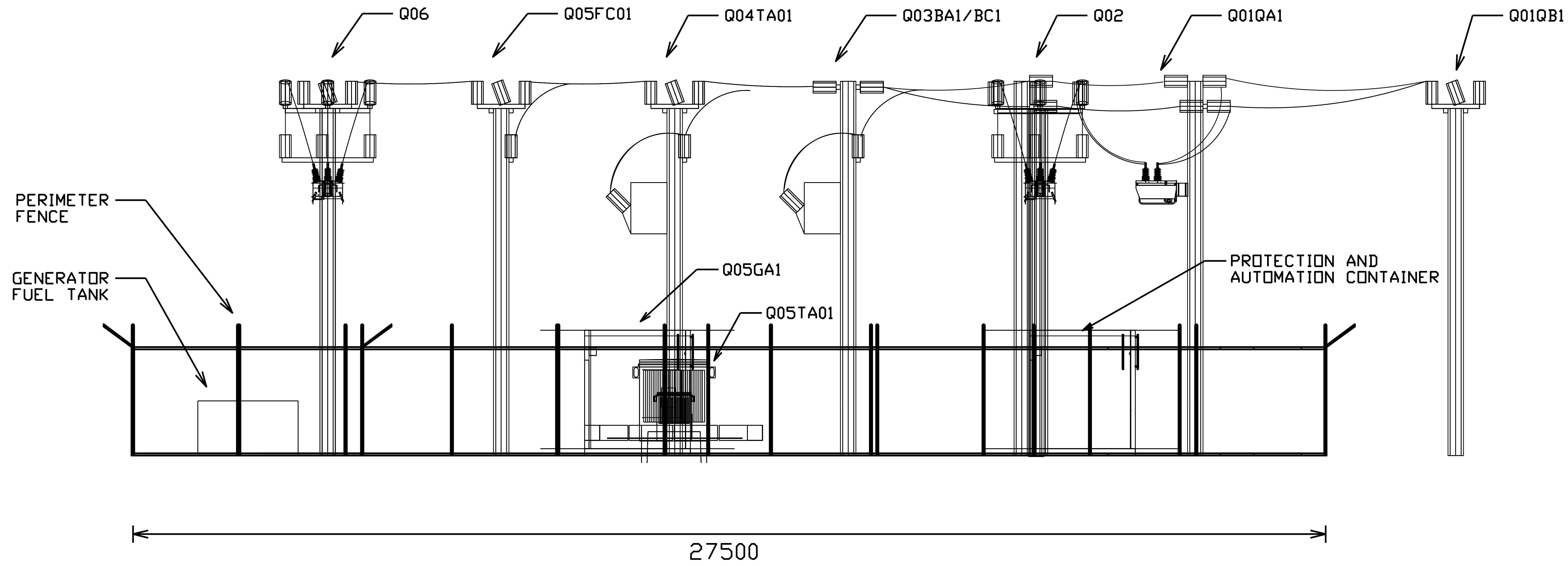

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REFERENCES

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PROJECT ID C100248

CREATOR	J HITCHINS
REVIEWER	J STOKES
TECH REF	J STOKES
APPROVED	J STOKES
DATE	07/23

DOCUMENT ID

SUNRISE ENERGY GROUP

MULLEWA MICROGRID
HV CONNECTION POINT
ELEVATION 1

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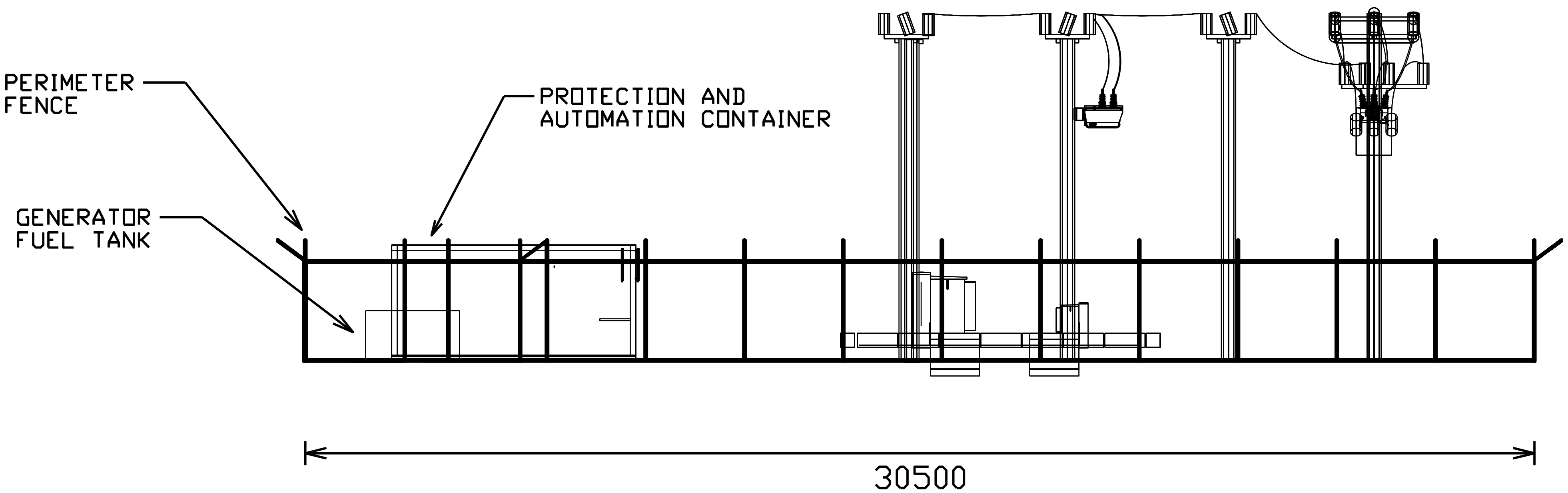

REV	BY	DATE		CKD	APP
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REVISIONS

DRAWING NUMBER	DRAWING TITLE
AA18S7&ELD1/1 REV A	MULLEWA CONNECTION POINT GA
AA18S7&EFA1/1 REV D	MULLEWA MICROGRID HV SLD

REFERENCES

JARRAH SOLUTIONS PTY LTD

PROJECT ID C100248

CREATOR	J HITCHINS
REVIEWER	J STOKES
TECH REF	J STOKES
APPROVED	J STOKES
DATE	07/23
SCALE	10:1
SIZE	A3

DOCUMENT ID

SUNRISE ENERGY GROUP

MULLEWA MICROGRID
HV CONNECTION POINT
ELEVATION 2

DOCUMENT DESIGNATION	SHT	REV
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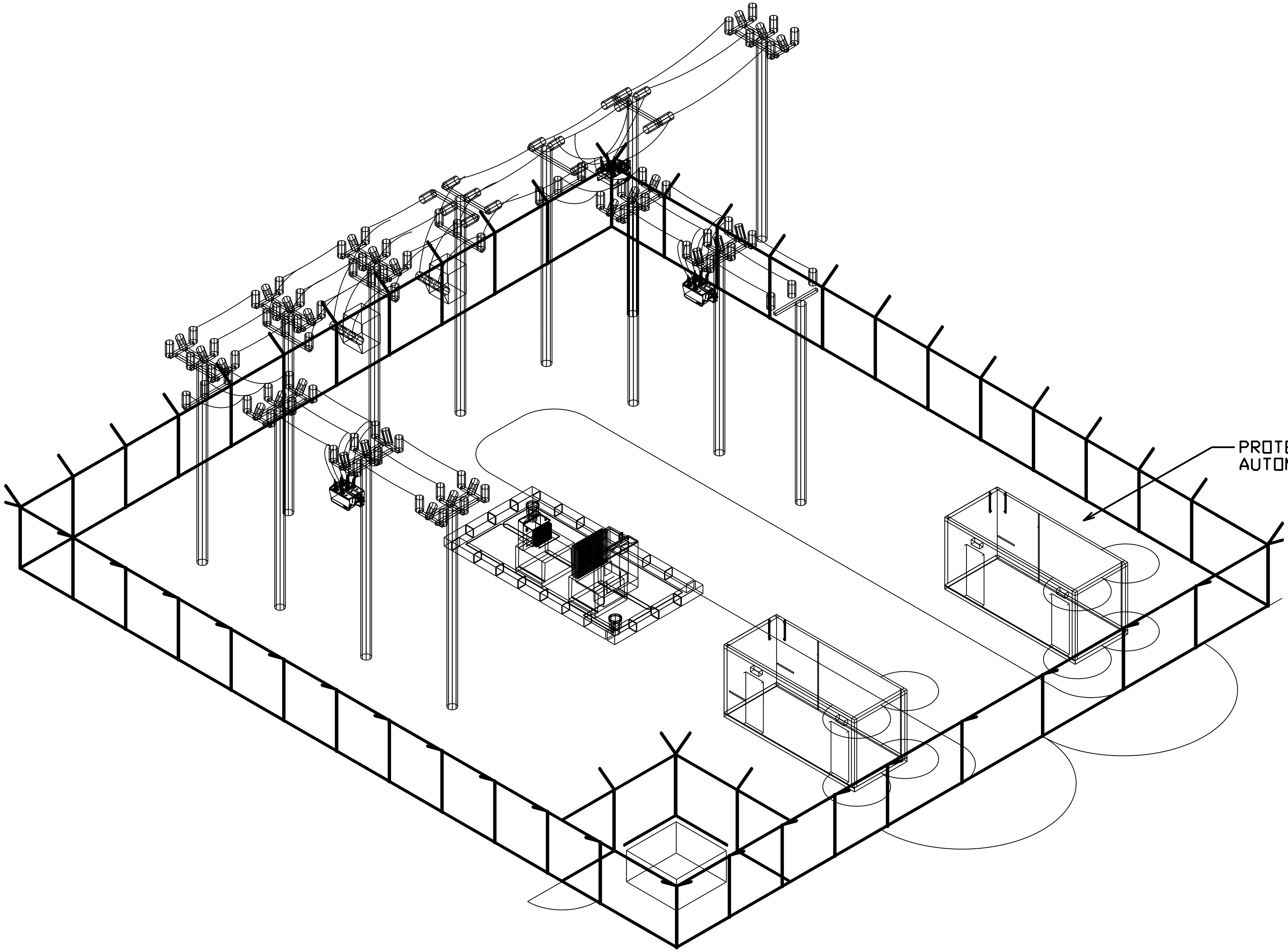

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REVISIONS					

DRAWING NUMBER	DRAWING TITLE
AA18S7&ELD1/1 REV A	MULLEWA CONNECTION POINT GA
AA18S7&EFA1/1 REV D	MULLEWA MICROGRID HV SLD

REFERENCES

JARRAH SOLUTIONS PTY LTD

PROJECT ID C100248

CREATOR	J HITCHINS
REVIEWER	J STOKES
TECH REF	J STOKES
APPROVED	J STOKES
DATE	07/23

DOCUMENT ID

SUNRISE ENERGY GROUP

MULLEWA MICROGRID
HV CONNECTION POINT
ISOMETRIC

SCALE	SIZE	DOCUMENT DESIGNATION	SHT	REV
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APPENDIX G

Jarrah Solutions Line Loss Calculation

Technical Report

Reference Designation: AA18S7&EDD2 Rev A

Sunrise – Mullewa Microgrid – System Line Loss Calculations

4/08/2023

Providing People with the Power to do Amazing Things

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Table of Contents

1. DOCUMENT CONTROL

1.1 Approvals List

Rev Number	Name	Title	Signature
Created By	Ryan Ran	Graduate Engineer	
Checked By	James Stokes	Principal Engineer	
Approved By	James Stokes	Principal Engineer	

1.2 Revisions List

Rev Number	Description	Date	Revised By
A	Issued for FEED	04 Aug 2023	Not Applicable

1.3 Approval Period

Date for next review: Not applicable

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3. Executive Summary

This study demonstrates the following:

- That the Mullewa Microgrid will reduce the distribution (33kV) system line losses.
- The amount of energy saved will be impacted primarily by the other non-Mullewa loads along the existing 100km line from Geraldton.

By simulating a lumped load of 4 MW halfway between Geraldton and Mullewa, 162 kW of line losses were calculated when the Mullewa Microgrid was exporting its full renewable generation capacity. This reduced to 58 kW with 20% of renewable generation capacity.

For a more accurate study of the impact to distribution system line losses, the upstream Western Power distribution line impedances and loadings will be required. At the time of publishing this report, this information was not available.

4. Data Analysis

4.1 Mullewa Recloser Load Data

Western Power provided recloser power flow data for a 33kV recloser located upstream of the town of Mullewa. The identifier of this recloser is “PID_009141719”.

This data was analysed for active and reactive power flows. The data set used covers March 2021 to March 2023, with the specific location of the recloser shown in the figure below.

	Latitude	Longitude
Degrees, Minutes, Seconds	28° 32' 40.41" S	115° 29' 17.27" E
Decimal Degrees	-28.544557604081408	115.48813019823815

Table 1: Existing Upstream Mullewa Recloser (PID_009141719) Location

The location covers the rural and township power flows associated with Mullewa, as shown in the following figure:

Figure 1: Existing Mullewa Recloser Location

4.2 Data Processing

Box Plots are used to conduct this analysis. The figure shown below explains what each of the components within a box plot signifies.

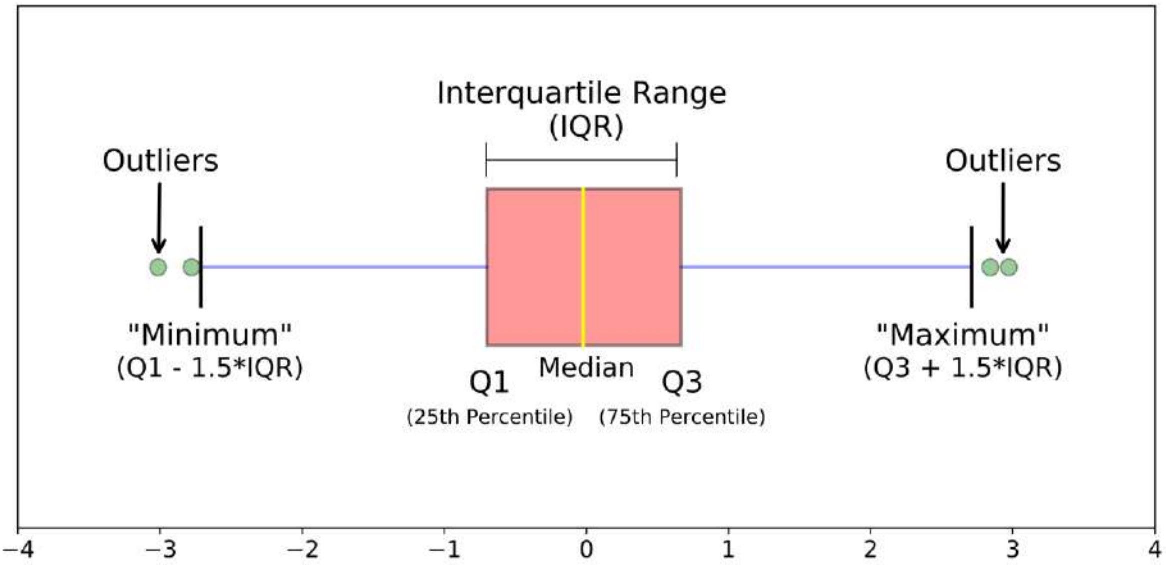

Figure 2: Box Plot Explanation

The data provided by the recloser includes the active power and reactive power of Mullewa, based on which the corresponding figures can be plotted. The raw data from the recloser contains outliers which are believed to be from non-normal operating conditions such as short-circuit faults or inrush from line energisation and switching activities. These outliers were removed from the dataset for clarity.

The data values outside of the limits shown in the table below were removed:

Power Type	Lower Limit	Upper Limit
Active Power (kW)	100	500
Reactive Power (kvar)	100	300

Table 2: Box Plot Selected Range

The below box plot is the Mullewa active power and reactive power consumption processed based on the month of the year, from which indicates the higher power consumption mainly occur during summer (Jun to Aug) and winter (Dec to Feb).

Note that 'maximum' power values are provided in the recloser data sets. However, the sampling period is within the order of minutes so these can be assumed to be a slightly conservative reflection of the actual load.

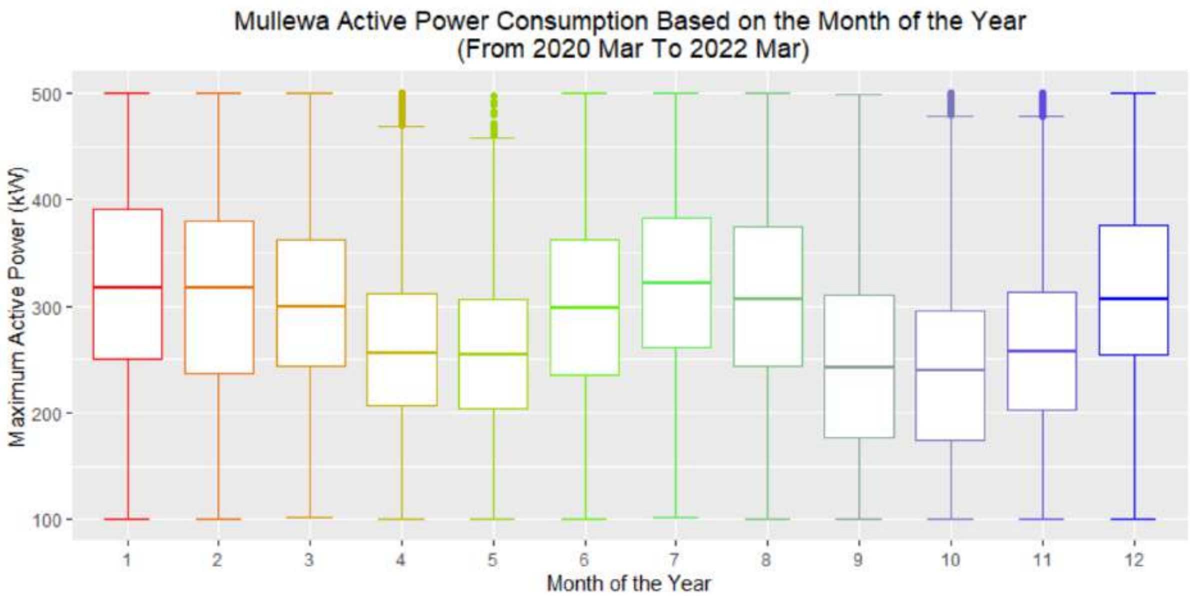

Figure 3 : Active Power Measurements - Based on the Month of the Year

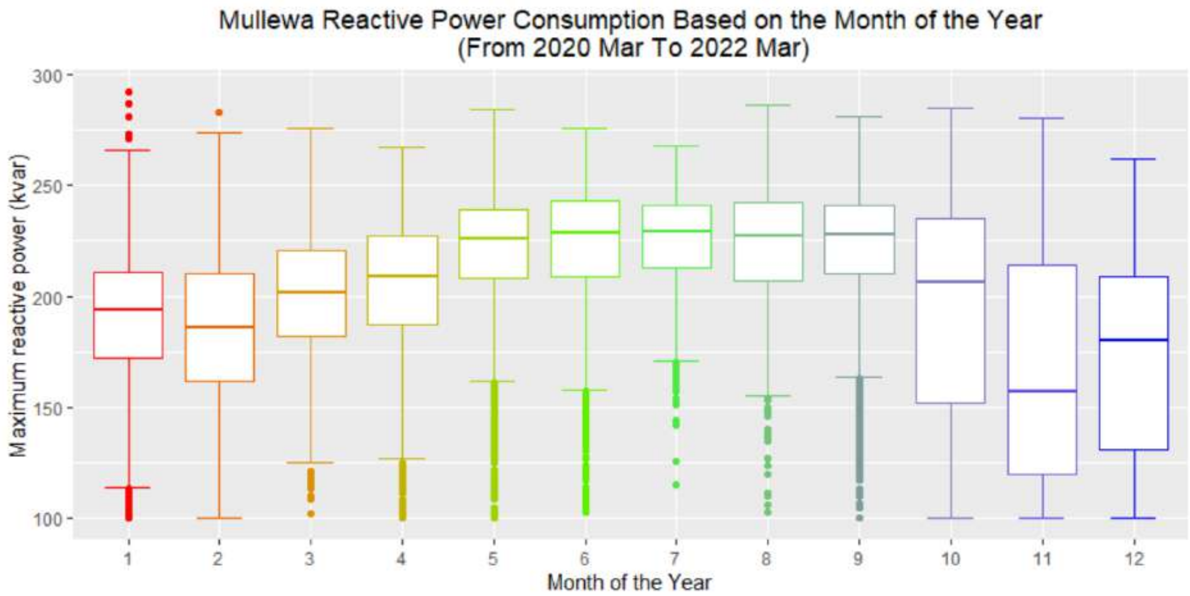

Figure 4: Reactive Power Measurements - Based on the Month of the Year

The following plots show the active power consumption based on the day of the week and the hour of the day. From the plot of the day of the week there is no meaningful difference of power over the week, which has a slightly increase from Wednesday to Saturday. From the plot of the hour of the day, there are two peak period over the day, which is during the night time (18:00 to 21:00) and morning time (6:00 to 8:00), while the time during noon (10:00 to 14:00) consumes the least power.

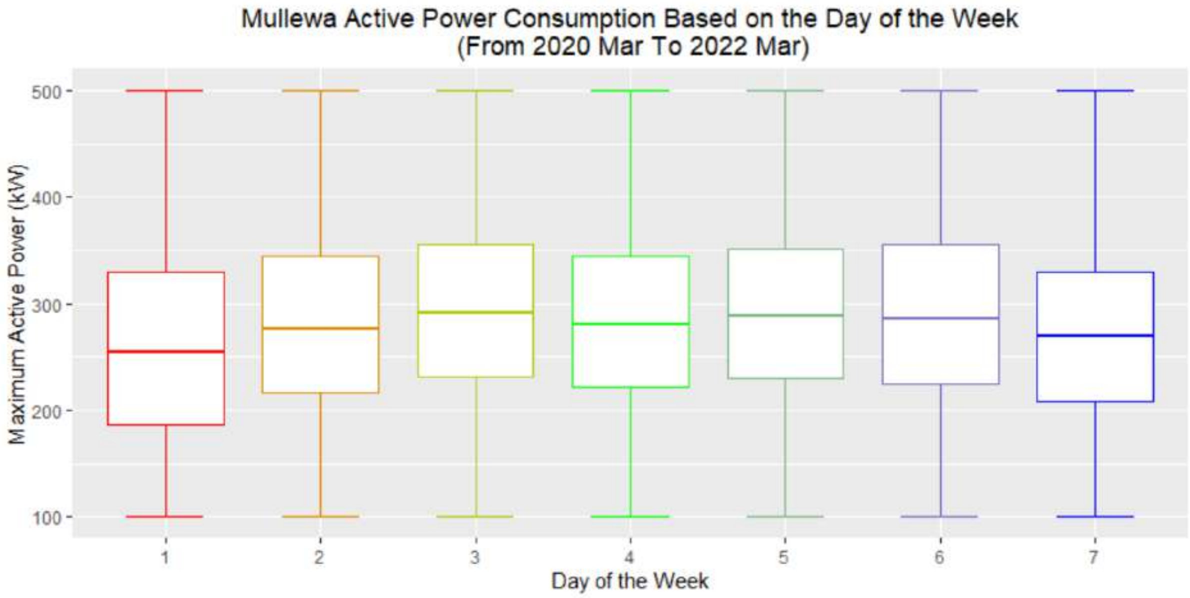

Figure 5: Active Power Measurements - Based on the Day of the Week

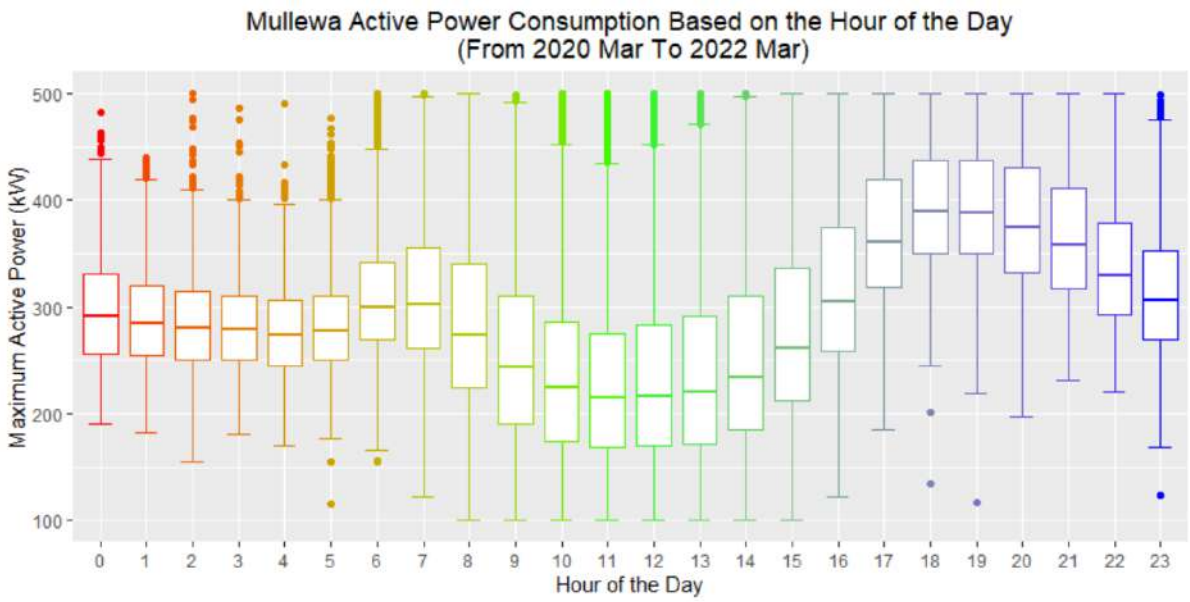

Figure 6: Active Power Measurements - Based on the Hour of the Day

4.3 Summary Information

The data used to create the above figures is summarised in the following table:

Power Type	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Active Power (kW)	100.0	217.0	279.0	283.9	346.0	500.0
Reactive Power (kvar)	100.0	176.0	210.0	200.4	232.0	292.0

Table 3: Summary Statistics - Mullewa Active & Reactive Power Measurements

The mean values from the above table were used as the Mullewa load input data.

6. Loss Calculations

For calculating the active power losses associated with Mullewa, only the 33kV network was modelled. Impacts on the upstream 132kV and higher system voltages was assumed to be negligible and were not modelled or calculated.

6.1 33kV Overhead Line - Input Information

For 33kV overhead line modelling, the length of line between the upstream Geraldton substation and load (Mullewa) was measured as 99.1km. Whilst some information was available, Western Power did not provide the actual 33kV line impedances and hence assumptions were made. It was assumed that there are two conductors similar to the real case, both were used for comparison in this calculation. The selected conductor materials are the "Cherry" type and the "Grape" type, and their electrical properties are shown in the figure below.

Product code	Equivalent area		Resistance		Current ratings (Rural weathered)				Current ratings (Industrial)				Geo-metric mean radius mm	Inductive reactance (X_a) to 0.3048m Ω/km
					Winter night		Summer noon		Winter night		Summer noon			
	Copper mm²	Alum mm²	D.C. at 20°C /km	A.C. at 75°C /km	Still air Amps	1 m/s wind Amps	Still air Amps	1 m/s wind Amps	Still air Amps	1 m/s wind Amps	Still air Amps	1 m/s wind Amps		
QUINCE	5.50	8.70	3.250	4.050	54	94	43	85	58	87	40	84	0.70	0.382
RAISIN	11.20	17.80	1.590	2.020	87	147	67	132	95	152	62	130	1.00	0.360
SUPER SULTANA	16.10	25.70	1.100	1.430	112	185	84	166	122	192	78	163	1.20	0.348
SULTANA	19.80	31.50	0.897	1.170	122	203	91	180	133	209	85	177	1.50	0.334
WALNUT	30.90	49.20	0.573	0.773	165	269	120	237	180	279	111	232	1.87	0.320
ALMOND	18.20	29.00	0.975	1.270	111	188	85	168	121	194	79	165	2.43	0.303
APRICOT	22.00	35.10	0.805	1.060	125	209	96	189	137	219	89	186	2.68	0.297
APPLE	26.20	41.80	0.677	0.900	140	233	105	207	153	241	98	204	2.92	0.292
BANANA	41.00	65.20	0.433	0.601	189	309	139	272	207	321	127	267	3.65	0.278
CHERRY	65.80	104.70	0.271	0.403	257	411	183	358	283	428	166	350	4.61	0.263
GRAPE	90.40	144.00	0.196	0.240	349	543	242	468	386	568	217	456	7.22	0.235
LEMON	130.20	207.00	0.136	0.167	452	685	309	585	501	719	276	567	8.66	0.224
LYCHEE	153.20	244.00	0.116	0.142	492	758	344	644	562	797	306	624	9.38	0.219
LIME	177.30	282.30	0.100	0.123	563	833	380	704	625	877	336	682	10.11	0.214
MANGO	234.40	373.40	0.0758	0.0967	654	955	438	802	727	1007	386	775	10.93	0.209
ORANGE	275.00	438.00	0.0646	0.0827	732	1058	487	884	816	1117	428	853	11.84	0.204
OLIVE	319.00	508.10	0.0557	0.0716	813	1163	538	967	907	1230	471	931	12.76	0.199
PAW PAW	366.20	583.20	0.0485	0.0628	893	1265	587	1046	997	1341	512	1006	13.67	0.195
PEACH	586.50	934.00	0.0303	0.0408	1248	1714	803	1389	1399	1827	691	1327	17.31	0.180

Figure 7: Electrical Characteristics of ACSR/GZ

For modelling of the impedance, the height and conductor spacings of the suspension pole were based on a standard H01-1 Western Power pole with insulator height form the ground of 10 meters.

6.2 Lines Loss Calculations

The calculated results with simulated overhead line and load are listed in the following table. The line loss used was the difference of active power between Geraldton substation (into the line) and Mullewa (out of the line). For both conductors the calculation results are listed below, from which it shows the total line loss for both is similar.

Conductor Type	Total Line Loss (kW)
Cherry	2.0
Grape	1.5

Table 4: Summary of Overhead Line Loss – Mullewa Load Only

These results table the difference in losses between no load on this feeder and 100% of Mullewa load on this feeder. In reality, there are other loads along the feeder. This is explored further in the following section.

6.3 Impact of Distributed Load Along the 33kV Line

To further study the impact of load along the line, a dummy (simulated) 4MW lumped load with 0.9 power factor lagging was placed halfway between Geraldton and Mullewa.

The Mullewa Microgrid contains one diesel generator, two wind generators, one PV array and one BESS (battery energy storage system), and the following study scenarios were simulated:

- 1 – Zero generation systems in Mullewa and Mullewa supplied by the grid only.
- 2 – Turn on all Mullewa Microgrid renewable generation facilities with full renewable export output power, and synchronise this with the grid. This is to simulate a maximum output condition during high sun and wind times.
- 3 – Turn on renewable generation and simulate solar and wind power generation at 20% of capacity, synchronised with the grid. This is to simulate the condition where renewable generation approximately matches the Mullewa load.

The power flow results of the above three scenarios are shown in the table below:

Geraldton to Halfway Loss (kW)	Halfway to Mullewa Loss (kW)	Total Loss (kW)	Loss Reduction (kW)	Diesel Generator (kW)	PV Array (kW)	Wind Generation (kW)	BESS (kW)	Notes
329	1	330	0	OFF	OFF	OFF	OFF	1 - External Grid Only
120	48	168	162	OFF	1000	1200	OFF	2 - 100% of Microgrid renewables
272	0.4	272	58	OFF	200	240	OFF	3 - 20% of Microgrid renewables

Table 5: Summary of Overhead Line Loss – With 4MW of load located half-way between Geraldton and Mullewa

What this table shows is that when a single lumped load of 4 MW was placed half way between Geraldton and Mullewa, the impact of the Mullewa Microgrid on 33kV distribution system losses is significant. For this simulated scenario, 162kW of line losses was calculated when all of the Mullewa Microgrid generation is at full output. This reduced to 58kW of line losses with only 20% of the Mullewa Microgrid generation.

Hence, the impact of the existing loading on the Geraldton to Mullewa is significant. At the time of this FEED, the data of 33kV line impedances and distributed loading along the Geraldton to Mullewa town was unavailable. This information will be required to accurately model the impact of the Mullewa Microgrid on distribution system losses.

APPENDIX H

Planning Report (for Development Application)

PLANNING REPORT

PROPOSED RENEWABLE ENERGY FACILITY

LOTS 4 & 5 MULLEWA AGRICULTURAL AREA, MULLEWA

APPLICATION TO CITY OF GREATER GERALDTON / REGIONAL JDAP

17 AUGUST 2023

Hidding.
URBAN PLANNING

This Planning Report has been prepared by **Hidding Urban Planning** for an Application for a Proposed Renewable Energy Facility (Solar/Wind) at Lots 4 & 5 Mullewa Agricultural Area, Mullewa.

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DOCUMENT HISTORY & DETAILS

AUTHOR	REVISION	DATE	REVISION TYPE
Nik Hidding	R01	17/08/2023	Final

File No. C2538
Client: Sunrise Energy Group
Project: Mullewa
File Name: C2538appln01
Document Revision: R01

TABLE OF CONTENTS

APPLICATION DETAILS

Table 1: Application Details

Property Location	Lots 4 & 5 Mullewa Agricultural Area, Mullewa
Applicant	Hidding Urban Planning
Proponent	Sunrise Energy Group
Landowners	Lot 4: Mullewa Football Club Lot 5: Wonyarra Land Pty Ltd
Local Government	City of Greater Geraldton
Determining Authority	Regional Joint Development Assessment Panel (Optional)
City of Greater Geraldton Zoning	Rural
Planning Scheme	City of Greater Geraldton Local Planning Scheme No. 1
Proposed Use	Renewable Energy Facility ("A" use)
Proposed Development	1MW Solar Farm & Battery Energy Storage System (BESS) 2x Wind Turbines Connection Point Infrastructure
Existing Use	Rural Activity
Estimated Construction Value	$10 million

1.0 INTRODUCTION

Hidding Urban Planning has prepared this Planning Report on behalf of Sunrise Energy Group as part of an Application for Development Approval for a Proposed Renewable Energy Facility comprising a Solar Farm and Wind Turbines and associated infrastructure including battery, inverter, underground power lines, above-ground power lines and a microgrid connection point (grid connection container and back-up diesel genset).

The Solar Farm, battery, inverter, power lines and connection point including connection container and back-up diesel genset are proposed on Lot 4 on Plan 235009 which has frontage to Old Mingenew Road and Darlot Road.

The 2x Wind Turbines and power lines are proposed on Lot 5 on Plan 235009 which sits to the south of Wubin-Mullewa Road.

This report provides a detailed Town Planning assessment of the proposed development against the relevant State and local Planning framework. The information contained in this report confirms that the proposed Renewable Energy Facility is appropriate for the site and reflects the applicable planning framework.

1.1 DEVELOPMENT ASSESSMENT PANEL (DAP) DETERMINATION

As the anticipated construction cost of the project is **$10 million**, this Application is being lodged as an Mandatory Development Assessment Panel (**DAP**) application for determination by the Regional Joint Development Assessment Panel.

Accordingly, please find ***attached*** our completed City of Greater Geraldton Application for Development Approval Form and DAP Form 1, all authorised by the relevant landowners.

1.2 PRE-APPLICATION DISCUSSIONS

Sunrise Energy Group and Hidding Urban Planning have held prior discussions with the City of Greater Geraldton about the proposed Renewable Energy Facility.

2.0 SITE DETAILS

2.1 LEGAL DESCRIPTION OF LAND

This Development Application is made in respect of Lots 4 & 5 Mullewa Agricultural Area, the details of which are provided in **Table 2** below.

Table 2: Legal Description of Land

Lot	Plan	Vol/Folio	Area	Address	Proprietors
4	235009	1506/572	57.8236ha	No street address on title	Mullewa Football Club Inc
5	235009	2998/530	57.9108ha	No street address on title	Wonyarra Land Pty Ltd

The Certificates of Title for the two lots are attached at **Annexure 1**.

2.2 SITE DETAILS

The subject land is located within the rural area in the town of Mullewa.

The location of the two lots in the context of the town of Mullewa is shown on the Site Context Aerial at **Figure 1** below.

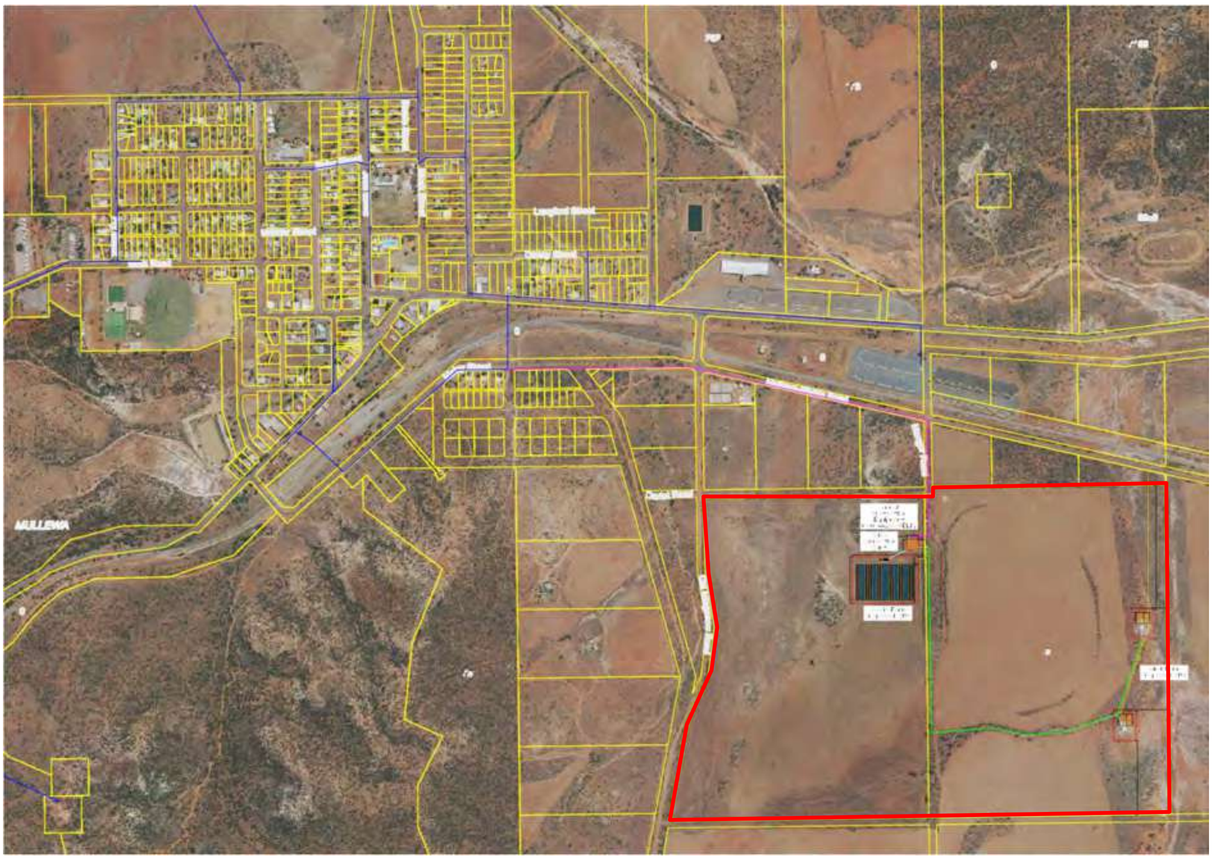


Figure 1 Site Context Aerial

An Aerial Photograph showing Lot 4 and 5 is shown in **Figure 2**.

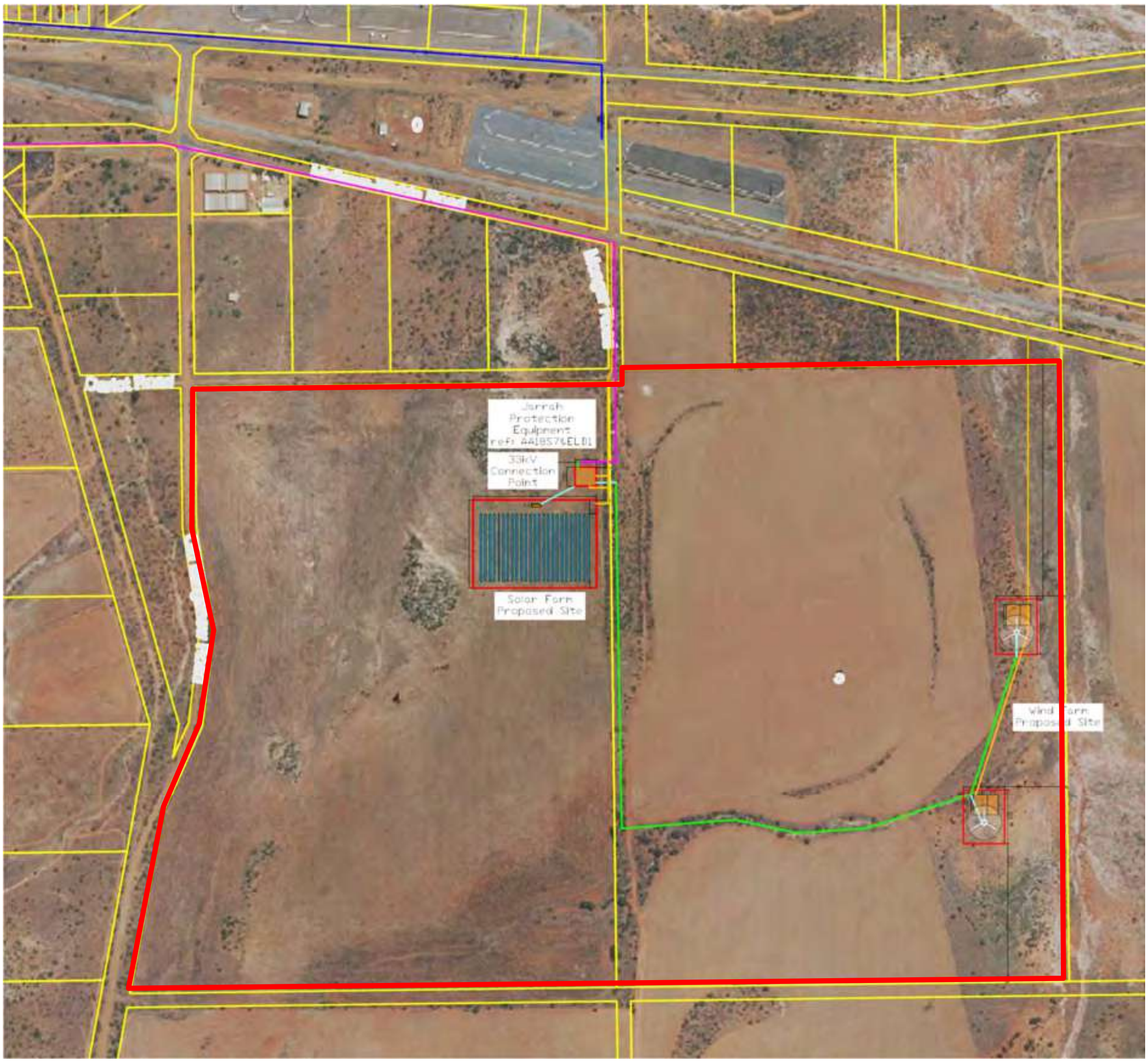


Figure 2 **Aerial Photograph of Lot 4 & 5**

The proposed development components will be developed on cleared open pasture or cleared land with no impact to any flora or ground-dwelling fauna.

Photographs showing the existing landscape of the sites are attached at **Annexure 2** of this report.

3.0 THE PROPOSAL

The proposal for Mullewa is to develop a commercially sound, technically, and economically feasible microgrid solution (repeatable for other fringe-of-grid towns) with the prime objective of improving energy reliability and amenity for Mullewa residents and to retain and attract business to the town. It is required because Mullewa (and other fringe-of-grid towns) experience excessive levels of unreliability (compared to the average South West Interconnected System (SWIS) customer), for which the current system to date, has not produced a reasonable long-term solution.

Other features associated with a microgrid in Mullewa would be:

- No higher costs to Mullewa residents/businesses than they would otherwise incur;
- No loss of customer protections;
- Reduction in overall line losses; and
- Increase in the overall renewable content of the energy supply in WA.

The definition of a microgrid in relation to the SWIS is:

a sub-section of the Western Power network that:

a) is still connected to the meshed network (grid)
b) has the ability to be islanded as an autonomous system, and
c) Includes local renewable generation and storage

What this would represent in terms of hardware is:

1. “Large” Battery:
    - Primary purpose being short-term storage for improving reliability.
2. Renewable generation from a solar farm and wind turbines:
    - To charge the battery and support a significant proportion of the town’s load under normal operation.
    - When the grid connection is down for longer periods, support continued operation of the town up to battery maximum storage capacity.
    - Enhancing reliability by reducing the power that has to be carried on the Geraldton to Mullewa power line.
3. Diesel generator:
    - Provides longer term energy storage, aiding reliability for medium to long duration grid outages, when local supply options (e.g. solar/wind/battery) are exhausted.

Implementation of the microgrid will require agreements with Western Power and Synergy, which are currently being explored as part of a feasibility study conducted by Sunrise Energy Group, funded by a Federal Government grant and to which Western Power and Synergy are paid contributors. For implementation, funding would be sought from the ARENA “Regional Australia

Microgrid Pilots Program" to help offset typical costs associated with "a first-of-its-kind" type project and pave the way for a repeatable model that can implemented in other towns under its own commercial merits.

The proposed Renewable Energy Facility would provide significant benefits to the local community.

3.1 PROPOSED INFRASTRUCTURE DETAILS

The infrastructure proposed as part of this application will include:

- A 1MW Solar Farm, battery energy storage system, inverter and power line infrastructure on Lot 4.
    - The Solar Farm is proposed to cover an area of approximately 2.2ha (178m x 127m), comprising 25 rows of solar arrays.
    - The solar array development area will be set back approximately 160m from the northern boundary and 20m from the eastern boundary of Lot 4.
    - A 3 MWh battery and inverter are proposed to be located within the solar array development area on the northern side of the solar array infrastructure.
    - Power lines will extend out from the inverter, extend east into Lot 6 and then extend north to the unsealed road reserves, then extend west along Wubin-Mullewa Road to connect with existing power infrastructure.
- 2x Wind Turbines and power line infrastructure on Lot 5.
    - Wind Turbine 1 is proposed to be sited 340m from the northern boundary and 40m from the eastern boundary of Lot 5. The Wind Turbine will be developed within an envelope measuring 60m x 80m.
    - Wind Turbine 2 is proposed to be sited 300m from the southern boundary and 90m from the eastern boundary of Lot 5 and will also be developed within an envelope measuring 60m x 80m.
    - Each Wind Turbine will be 100m tall with a rotor blade diameter of 44m.
    - Underground 33kV power lines will extend out from each turbine for a length of 72m.
    - New 33kV overhead power lines will extend south inside Lot 5 and then cut across Lot 5 to the west to connect with the other new power infrastructure associated with the solar farm on Lot 4.
    - The Wind Turbine facility will require a crane pad and lay down area for construction.
    - A 725m long, 4m wide access road will be required.
    - The closest resident to both Wind Turbines is 1.50km away to the direct west.
- A Microgrid Connection Point (Grid Connection Container & Back-up Diesel Genset) on Lot 4, just north of the proposed solar farm.
    - The connection point will be accommodated within a 28m x 31m envelope, set just north of the proposed solar farm, with a 20m setback to the eastern boundary of Lot 4.

The proposed development is detailed on plans attached at **Annexure 3** of this Report.

3.2 ASSESSMENT OF RELEVANT IMPACTS

3.2.1 Environmental Impacts

Given that the proposed solar farm, wind turbines and associated infrastructure will be located in existing cleared land and no vegetation clearing is proposed, it is considered that the overall environmental impact is acceptable.

3.2.2 Visual Impacts

The visual impact of the proposed development is not considered to be adverse or detrimental to the surrounding area for the reasons below:

- The proposed heights of the solar array, battery storage and connection point infrastructure mean that this infrastructure will maintain a low profile. In addition, the large setbacks to site boundaries and road reserves minimises the visual impact.
- The large setbacks to site boundaries and road reserves and the separation distances to surrounding land uses and dwellings minimises the visual prominence and views to the proposed wind turbines. Importantly, the proposed wind turbines are well distanced away from Wubin-Mullewa Road and Geraldton-Mount Magnet Road, which are the main trafficked roads in the locality.
- The existing landscapes are illustrated in the photographs at Annexure 2.

3.2.3 Noise Impacts

Possible noise impacts from the development are mainly limited to the wind turbines and the construction phases of the overall development.

Ongoing operation noise impacts associated with the solar farm are considered to be minimal.

Ongoing operation noise impacts associated with the wind turbines should satisfy acceptable levels. The proponent has undertaken noise contour modelling (refer Annexure 3 plans) and has demonstrated that noise levels do not exceed 30dB(A) at two relevant receivers in the immediate locality.

In any event, the proponent must comply with the requirements of the *Environmental Protection Act 1986* and the *Environmental Protection (Noise) Regulations 1997* in regard to noise for both the construction and operational phases of the proposed facility, and this can be imposed as a condition of development approval.

3.2.4 Construction Impacts

The development is likely to be constructed over a period of 12 months. During construction, additional vehicles, construction equipment, construction personnel, and cranes will be on-site. All access for the construction phases of the solar farm and wind turbines will be derived from Wubin-Mullewa Road and through unsealed road reserves to the relevant sites. Internal access roads will be constructed to the development envelopes.

During construction there may be 20 vehicles per week visiting the site. The peak construction period is anticipated to require up to 10 personnel, with a likely average of 5 people throughout the construction phase.

A construction laydown area will be developed adjacent to each development envelope to store construction equipment, portable amenities and car parking areas.

The main impact during construction will be air quality through the generation of dust. Mitigation measures are likely to be necessary and could include the watering down of construction areas during earthworks and monitoring forecast wind levels. A Dust Management Plan can be required as a condition of development approval, or otherwise, it can be a component of an overall Construction Management Plan.

4.0 STATE PLANNING FRAMEWORK

4.1 STATE PLANNING STRATEGY 2050

The proposed Renewable Energy Facility accords with the vision and relevant energy planning objectives of the *State Planning Strategy 2050* (**SPS 2050**).

In particular, the Strategy highlights the need to encourage the use of natural energy renewable resources as a measure to reduce the intensity of greenhouse gas emissions from energy production.

This Application seeks approval to construct a Renewable Energy Facility which will connect to existing power infrastructure and provide enhanced power reliability to the town of Mullewa.

The construction of the proposed development will reduce the overall energy demand of traditional non-renewable sources.

Sunrise Energy Group is adopting an environmentally sensitive approach to generating electricity and through this action is actively assisting the City in reducing greenhouse emissions, in accordance with the objectives of SPS 2050.

The proposed development therefore complies with the energy planning objectives of the SPS 2050.

4.2 POSITION STATEMENT: RENEWABLE ENERGY FACILITIES (WAPC, 2020)

The WAPC *Position Statement: Renewable Energy Facilities (March 2020)* provides guidance to local governments on introducing renewable energy facilities into their local planning frameworks.

The City has responded by introducing a “Renewable Energy Facility” land use into its local planning framework, in accordance with the measures stated in this policy, as follows:

- The *Local Planning Strategy* (**LPS**) identifies renewable energy facilities as being suitably located on rural land.
- At *Part 6.2 – Land use terms used in Scheme* of *Local Planning Scheme No. 1* (**LPS 1**), the land use definition for a Renewable Energy Facility is described, as follows.

Renewable Energy Facility	*means premises used to generate energy by a renewable resource and includes any building or other structure used in, or in connection with, the generation of energy by a renewable resource. It does not include a renewable energy facility principally used to supply energy for a domestic property or existing use of premises.*

- The land use classification of “Renewable Energy Facility” is included at *Table 14 – Zoning Table* of the City’s operative LPS 1. It is identified as being an ‘A’ use in the Rural zone, which means that this proposal can be considered for approval on the subject lots, after advertising of the proposal in accordance with cl. 64, Part 8, Sch. 2 of the *Planning and Development (Local Planning Schemes) Regulations 2015.*

This Application seeks approval to use a small area of two (2) landholdings for a Renewable Energy Facility comprising a solar farm, connection point site and 2x wind turbines, which lots are zoned “Rural” in LPS 1 and identified in the local planning framework as being suitable for this specific land use, as required by this Position Statement.

4.3 MID-WEST REGIONAL PLANNING AND INFRASTRUCTURE FRAMEWORK

The Mullewa Townsite is identified in *Mid-West Regional Planning and Infrastructure Framework (2015)* as being a ‘Major Local Centre’.

The Framework recognises that the primary SWIS transmission infrastructure in the Mid-West is severely constrained, which limits opportunities for new development to establish in the region.

The Framework refers to the abundant source of solar and wind renewable energy sources which are available in the Mid-West region and recognises the benefit of introducing renewable energy facilities in reducing carbon greenhouse emissions.

The proposed development will assist in alleviating some of the existing pressure on the existing transmission infrastructure by reducing the reliance on the SWIS grid, which accords with the overarching vision of the Framework to encourage the establishment of renewable energy resources in the Mid-West.

4.4 STATE PLANNING POLICY 2.5 – RURAL PLANNING

The proposed development on the subject land accords with the Planning Objectives of *State Planning Policy 2.5 – Rural Planning*, which seeks to support sustainable land uses which will protect rural land and cater for the future economic, environmental, and social needs of Western Australia.

The proposed development is proposed to provide an alternative energy-generating source for the town of Mullewa.

The development is proposed to be located on two (2) small, cleared portions of the subject landholdings and is considered to comply with the relevant Policy Objectives 5.1 of SPP 2.5, as detailed in the following **Table 3**.

Table 3: Compliance with the Policy Objectives 5.1 of SPP2.5

Policy Objectives for Protection of Rural Land and Land Uses	Response
(a) *requiring that land use change from rural to all other uses be planned and provided for in a planning strategy or scheme;*	The use of two separate small areas of the landholdings for the Renewable Energy Facility is identified in the City's local planning framework as being a suitable land use on rural land. This proposal is therefore compliant with this objective.
(b) *retaining land identified as priority agricultural land in a planning strategy or*	The proposed Facility is proposed on land which is identified as "other rural land' on the Rural Land Strategy Plan, being land immediately adjacent to the Mullewa Townsite on the Mullewa Strategy Plan. It does not form part of the priority agricultural area. Notwithstanding this, the proposed installation of the Renewable Energy Facility on these landholdings does not impact on the ability for the land to be utilised for other suitable agricultural pursuits in the future. This proposal is therefore compliant with this objective.
(c) *ensuring retention and protection of rural land for biodiversity protection, natural resource management and protection of valued landscapes and views;*	The landholdings to be used for the Facility comprise of cleared rural land. There will not be any impact on the land in terms of biodiversity protection, natural resource management or the protection of valued landscapes and views. This proposal is therefore compliant with this objective.
(d) *protecting land, resources and/or primary production activities through the State's land use planning framework;*	The use of this land as a Renewable Energy Facility will have no impact on the ability for the land to be utilised in the future for primary production activities. This proposal is therefore compliant with this objective.
(e) *creating new rural lots only in accordance with the circumstances under which rural subdivision is intended in Development Control Policy 3.4: Subdivision of rural land;*	The proposed use does not involve subdivision. The objective is therefore not applicable to this application.
(f) *preventing the creation of new or smaller rural lots on an unplanned or ad-hoc basis, particularly for intensive or emerging primary production land uses;*	The proposed use does not involve subdivision. The objective is therefore not applicable to this application.
(g) *comprehensively planning for the introduction of sensitive land uses that may compromise existing, future and potential primary production on rural land.*	The Facility will not compromise the use of the landholdings for primary production.
(h) *accepting the impacts of well-managed primary production on rural amenity.*	There will be no impact on primary production. The Facility is proposed to assist in generating power for the town of Mullewa.

4.5 STATE PLANNING POLICY 3.7 - PLANNING IN BUSHFIRE PRONE AREAS

The proposed solar farm, battery and connection point infrastructure (Lot 4), and the proposed wind turbine infrastructure (Lot 5) are all located completely outside of any mapped bushfire prone areas, pursuant to the Department of Fire and Emergency Services (DFES) Map of Bushfire Prone Areas (refer to **Figure 3**: Maps of Bushfire Prone Areas).

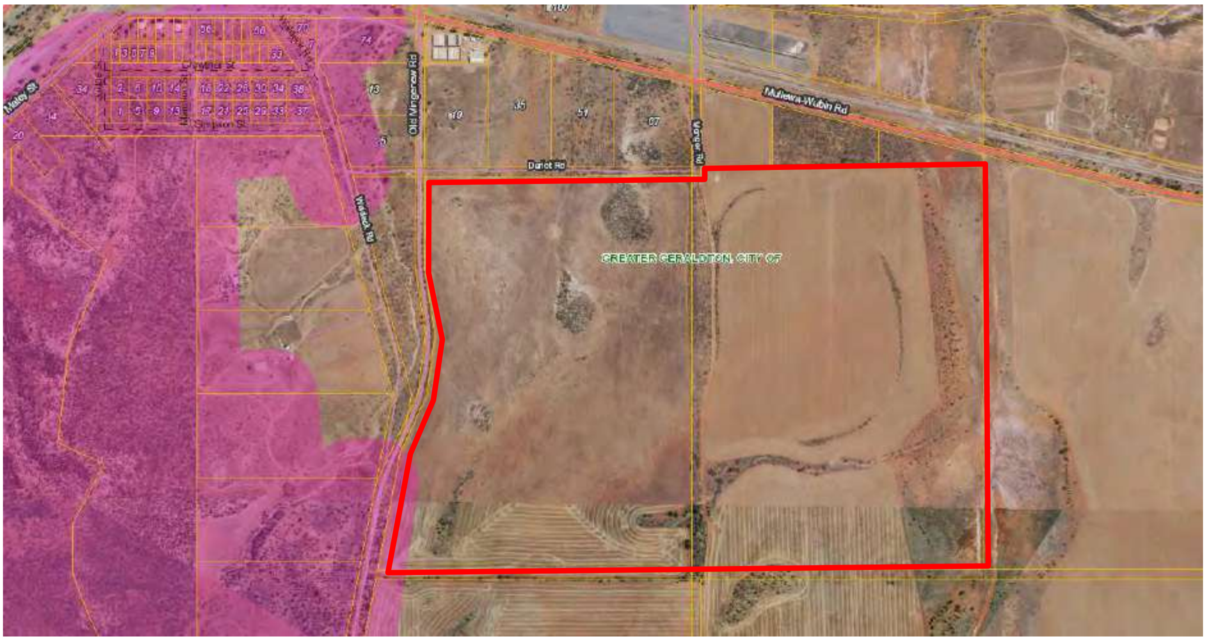


Figure 3 DFES Maps of Bushfire Prone Areas

Given that the proposed development components are well outside bushfire prone areas, no Bushfire Management Plan has been prepared for this application. The advice we have received is that it is not necessary for any bushfire investigation or management plan to be prepared.

4.6 STATE PLANNING POLICY 5.4 - ROAD & RAIL NOISE

The Lot 4 and Lot 5 sites are identified as being located within the trigger distance of the strategic freight rail and traffic route. The proposed Renewable Energy Facility land use is not a sensitive land use and therefore will not be impacted by the noise associated with the rail and traffic routes.

5.0 LOCAL PLANNING FRAMEWORK

5.1 CITY OF GREATER GERALDTON LOCAL PLANNING SCHEME NO. 1

5.1.1 Zoning & Land Use

Lot 4 and Lot 5 are both zoned "Rural" pursuant to the City of Greater Geraldton *Local Planning Scheme No. 1* (**LPS 1**). Refer Zoning Map below at **Figure 4.**

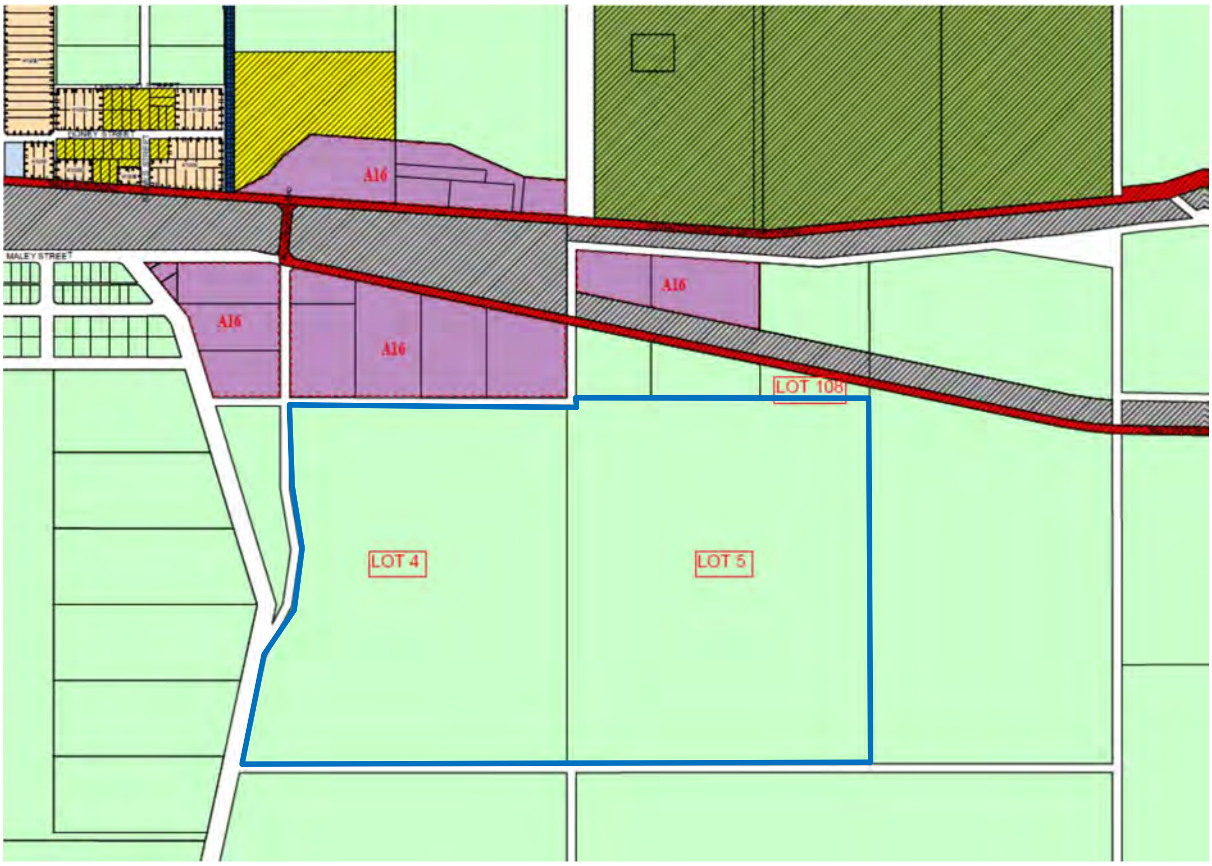


Figure 4 Zoning Map

At Table 14 – Zoning Table of LPS 1, the land use classification of "Renewable Energy Facility" is identified as being an 'A' use, which means that the use is capable of approval, following public advertising of the Application.

The proposed "Renewable Energy Facility" fits comfortably with the objectives of the "Rural" zone as described at cl. 3.11.1 of LPS 1, as justified in the following **Table 4**.

Table 4: Compliance with the Rural Zone Objectives of LPS 1

Objectives of Rural Zone	Response
a) *provide for the maintenance or enhancement of specific local character.*	The land will remain rural in character, with the proposed Renewable Energy Facility to utilise only a small portion of the overall land area of both landholdings.

Objectives of Rural Zone		Response
		The low visual impact of this proposal will ensure that the local rural character is maintained.
b)	*protect broadacre agricultural activities, such as cropping and grazing, and intensive uses, such as horticulture, from incompatible uses and minimise land use conflicts.*	The proposed land use is identified in the Local Planning Strategy as an appropriate use for rural land. The structures of the Facility will have a low impact on the rural landscape and will not result in any land use conflict with the use of nearby land for agricultural activities. The use of this land for the Facility will only extend over a small area of the site, which ensures that the properties remain available for other rural type activities in the future.
c)	*provide for a range of non-rural land uses where they have demonstrated benefit and are compatible with the surrounding rural uses.*	The proposed Renewable Energy Facility will provide enhanced reliability of power source for the town of Mullewa which is considered to be a significant benefit. The areas of the land not utilised for this purpose can remain available for other rural activities.
d)	*protect and provide for existing or planned key infrastructure, public utilities and renewable energy facilities.*	This proposal seeks approval to utilise portions of the landholdings for a Renewable Energy Facility, which meets this objective of the zone.

5.1.2 Development Standards

In addition to the proposed development complying with the general objectives of the "Rural" zone, the development is designed to ensure it complies with the relevant site and development requirements for the zone, as prescribed at *Table 11 – Rural zone site and development requirements* of LPS 1.

Table 5 below provides a response to the development standards of LPS1.

Table 5: Compliance with the Site & Development Requirements of LPS1

Requirements	LPS 1	Proposal
Lot size (min)	Variable	Lot 4 – 57.8236ha Lot 5 – 57.9108ha
Primary street setback (min)	20m	Lot 4 microgrid – 160m setback to northern boundary Lot 5 wind turbine – 340m setback to northern boundary
Secondary street/side boundary setback (min)	10m	Lot 4 microgrid – 20m setback to eastern boundary Lot 5 wind turbine – 40m setback to eastern boundary
Rear boundary/other setback (min)	10m	Lot 5 wind turbine – 300m setback to southern boundary
Plot ratio (max)	variable	n/a

Requirements	LPS 1	Proposal
Building height (max)	As per the R Codes for residential development	Lot 5 wind turbine – 100m tall
Landscaping (min)	variable	n/a

At Cl 3.11.2.3 of LPS 1, the City is to take into consideration when assessing development applications on rural zoned landholdings the following requirements as listed at **Table 6**.

Table 6: Compliance with Requirements of Cl 3.11.2.3

Requirements	Proposal
(a) the Department of Agriculture and Food's studies into identification of high quality agricultural land, to protect the economic and agricultural viability of this land.	The Local Planning Strategy identifies the subject landholdings as 'other rural land' and suitable for the Renewable Energy Facility as proposed.
(b) the need to protect the economic viability of the rural land use generally.	The proposed Renewable Energy Facility is intended to provide enhanced power reliability to the town of Mullewa, thus improving the economic viability of the town and other uses generally.
(c) the need to preserve the rural character and a rural appearance of the area.	The development footprint required for the facility extends over only a small portion of the total land area, which ensures that the rural character and visual landscape is preserved.
(d) the need to ensure that the existing standard of roads, water and electricity supply and other services is sufficient for the additional demands that the proposed development would create.	The proposed development will not generate any demand on the existing infrastructure services.
(e) the need to consider the existence of basic raw materials, mineral resources and the impact of the proposal on existing and potential extractive industry operations in the area.	The proposed use will not impact on any existing or potential extractive industry operation in this location.

5.2 LOCAL PLANNING STRATEGY (2015, PART 1 UPDATED MARCH 2021)

The subject lots are identified on the Regional Townsite - Mullewa Strategy Plan in the City of Greater Geraldton *Local Planning Strategy* as being situated to the immediate south and east of the Townsite boundary. These peripheral lots are identified as 'Other Rural Land' on the strategy plan.

The Strategy states at section *3.9 – Rural Land* that the rural area is suitable to support a range of land uses, including renewable energy.

At Part 6.1 – Mullewa, a range of strategies and actions are identified as being to: consolidate the housing activity; provide a safe, convenient, and attractive town centre; accommodate a range of mixed use, commercial and industrial uses; recognise the role of the town centre in the regional road and rail network and seek maximise the benefits and minimise the negative impacts on the community; and to recognise wastewater management as a priority.

The subject properties are abutting the Town Centre and are identified as ‘Other Rural Land’ in relation to it.

The strategies and actions identified in this table relate specifically to protecting, enhancing and retaining the existing function of this Townsite. The Other Rural land buffering the Town Centre is therefore to be retained for its Rural use. No expansion of the Townsite into the open rural landscape is envisaged for the future.

The proposed Renewable Energy Facility is considered an ideal use for the rural land abutting the Townsite, as it has a small development footprint, which ensures that the open rural landscape is maintained and that this use will in no way impact on the ability for this landholding to be utilised for a wide range of other rural pursuits, in the future.

The proposed facility therefore complies with the fundamental principles of the Local Planning Strategy as well as the more specific strategies and actions identified for the Mullewa Townsite.

6.0 CONCLUSION

Hidding Urban Planning seeks Development Approval for a Proposed Renewable Energy Facility (Solar/Wind) at Lots 4 & 5 Mullewa Agricultural Area, Mullewa on behalf of Sunrise Energy Group.

In summary, the proposed development warrants approval for the following reasons:

- The proposed development accords with the State Planning Framework;
- The proposed development is generally compliant with the development standards and requirements of the City of Greater Geraldton Local Planning Scheme No. 1;
- The proposed Renewable Energy Facility use is capable of approval in the “Rural” zone as an “A” use and is appropriate for the site and location; and
- The proposed development will provide benefits to the Mullewa locality.

Having regard to the above, the proposed Renewable Energy Facility should be supported and approved.

For these reasons, and in-light of the assessment contained within this report, we respectfully request that the City of Greater Geraldton have regard to the merits and broader benefits of the proposal when undertaking its assessment of the application, and to recommend approval to the Regional JDAP, subject to reasonable conditions.

Hidding.
URBAN PLANNING

0424 651 513
PO Box 920 Subiaco WA 6904
hidding.com.au

ANNEXURES

ANNEXURE 1

CERTIFICATES OF TITLE

REGISTER NUMBER	
4/DP235009	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
N/A	**N/A**

WESTERN AUSTRALIA

VOLUME **1506** FOLIO **572**

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

The person described in the first schedule is the registered proprietor of an estate in fee simple in the land described below subject to the reservations, conditions and depth limit contained in the original grant (if a grant issued) and to the limitations, interests, encumbrances and notifications shown in the second schedule.

BGRoberts

REGISTRAR OF TITLES

LAND DESCRIPTION:

LOT 4 ON DEPOSITED PLAN 235009

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

MULLEWA FOOTBALL CLUB INC OF MULLEWA

(T C234946) REGISTERED 14/10/1981

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:
(SECOND SCHEDULE)

1. TITLE EXCLUDES THE LAND SHOWN ON O.P. 14840.
2. C290273 MORTGAGE TO BANK OF NEW SOUTH WALES REGISTERED 21/1/1982.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
* Any entries preceded by an asterisk may not appear on the current edition of the duplicate certificate of title.
Lot as described in the land description may be a lot or location.

--END OF CERTIFICATE OF TITLE--

STATEMENTS:

The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND: 1506-572 (4/DP235009)
PREVIOUS TITLE: 1057-842
PROPERTY STREET ADDRESS: NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY: CITY OF GREATER GERALDTON

NOTE 1: A000001A LAND PARCEL IDENTIFIER OF MULLEWA AGRICULTURAL AREA LOT 4 (OR THE PART THEREOF) ON SUPERSEDED PAPER CERTIFICATE OF TITLE CHANGED TO LOT 4 ON DEPOSITED PLAN 235009 ON 25-JUL-02 TO ENABLE ISSUE OF A DIGITAL CERTIFICATE OF TITLE.
NOTE 2: THE ABOVE NOTE MAY NOT BE SHOWN ON THE SUPERSEDED PAPER CERTIFICATE OF TITLE OR ON THE CURRENT EDITION OF DUPLICATE CERTIFICATE OF TITLE.

REGISTER NUMBER	
N/A	
DUPLICATE EDITION 1	DATE DUPLICATE ISSUED 18/2/2021

WESTERN AUSTRALIA

VOLUME 2998 FOLIO 530

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

The person described in the first schedule is the registered proprietor of an estate in fee simple in the land described below subject to the reservations, conditions and depth limit contained in the original grant (if a grant issued) and to the limitations, interests, encumbrances and notifications shown in the second schedule.

BGRoberts

REGISTRAR OF TITLES

THIS IS A MULTI-LOT TITLE

LAND DESCRIPTION:

LOTS 5, 6, 7, 8, 9, 10 & 11 ON DEPOSITED PLAN 235009

REGISTERED PROPRIETOR:

(FIRST SCHEDULE)

WONYARRA LAND PTY LTD OF PO BOX 251 MULLEWA WA 6630

(T O627620) REGISTERED 29/1/2021

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:

(SECOND SCHEDULE)

1. THE LAND THE SUBJECT OF THIS CERTIFICATE OF TITLE EXCLUDES ALL PORTIONS OF THE LOT DESCRIBED ABOVE EXCEPT THAT PORTION SHOWN IN THE SKETCH OF THE SUPERSEDED PAPER VERSION OF THIS TITLE. SEE VOLUME 1520 FOLIO 460 AS TO LOT 6 ON DP 235009 ONLY
2. N282677 LEASE TO STATE OF WESTERN AUSTRALIA EXPIRES: SEE LEASE. AS TO PORTION ONLY REGISTERED 22/3/2016.
3. *O710488 MORTGAGE TO RABOBANK AUSTRALIA LTD REGISTERED 22/4/2021.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
* Any entries preceded by an asterisk may not appear on the current edition of the duplicate certificate of title.
Lot as described in the land description may be a lot or location.

--END OF CERTIFICATE OF TITLE--

STATEMENTS:

The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND:	1520-460 (5/DP235009), 1520-460 (6/DP235009), 1520-460 (7/DP235009), 1520-460 (8/DP235009), 1520-460 (9/DP235009), 1520-460 (10/DP235009), 1520-460 (11/DP235009)
PREVIOUS TITLE:	1520-460
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY:	CITY OF GREATER GERALDTON

END OF PAGE 1 - CONTINUED OVER

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING O710488

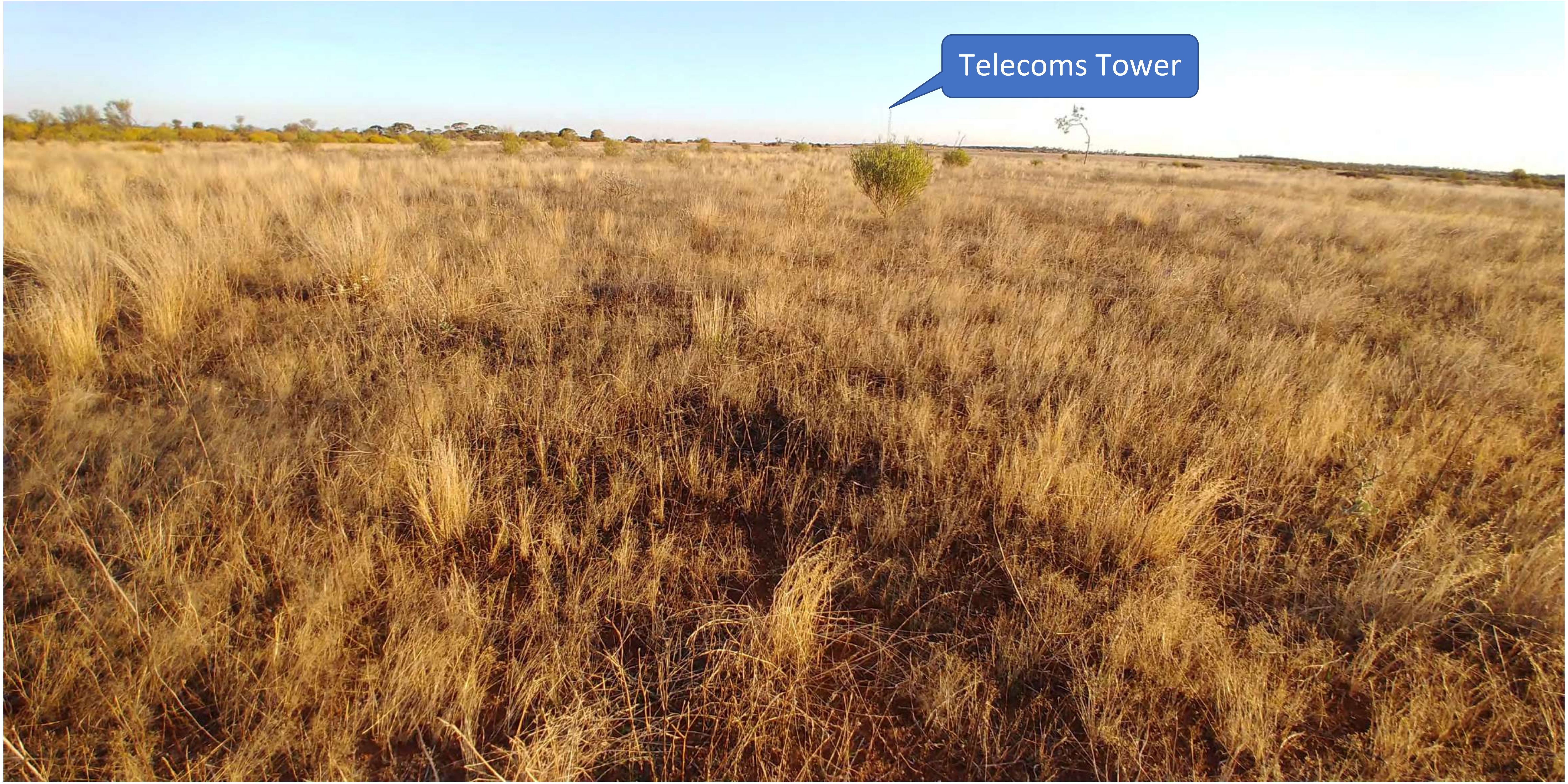
ANNEXURE 2

PHOTOGRAPHS OF EXISTING SITES

Grain Storage (as seen in Photo 173827)
Connection Point Site
(Approx. Location)
Lookout
Photo 20230406_173451 (Looking South)
1MW Solar Array
(Approx. Location)
Photo 20230406_173827 (Looking North)
Telecoms Tower (as seen in Photo 173451)

Photo 173827 Looking North

Photo 173451 Looking South

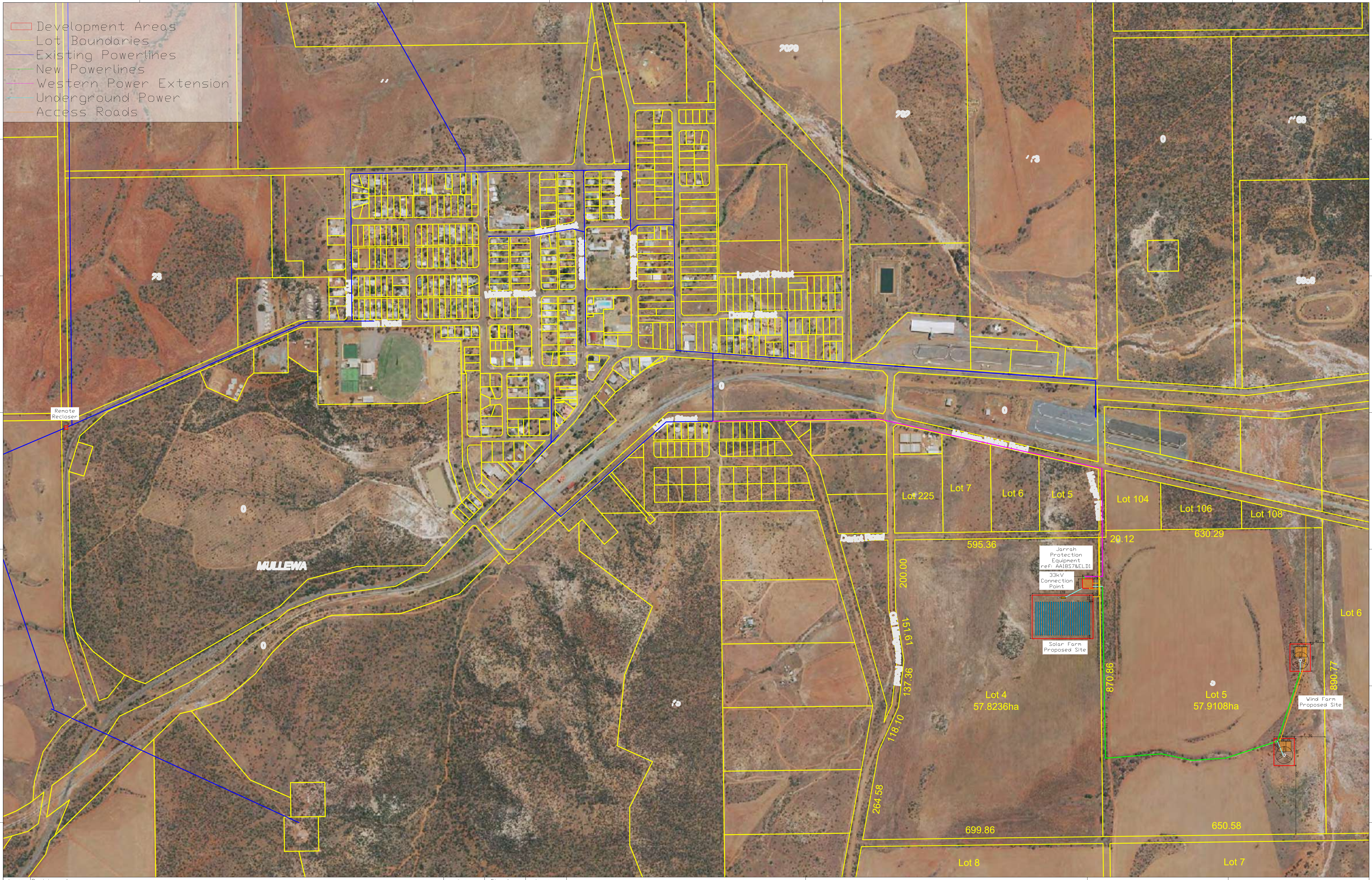



Approximate location from where photo looking south taken
Wubin-Mullewa Road
Wind Farm Proposed Site

Photo from Wubin-Mullewa Road looking South towards where wind turbines will be placed

ANNEXURE 3

DEVELOPMENT PLANS



RevNo	Revision note	Date	Signature	Checked
I	Changed Locations, Rerouted Powerline to New Connection Point	26/07/2023	CY	
J	Additional Labelling, Highlighted Western Power Extension	27/07/2023	CY	

Avora ENERGY

FILE NAME MullewaLayoutDrawing RevJ.dwg

SCALE 1:10000

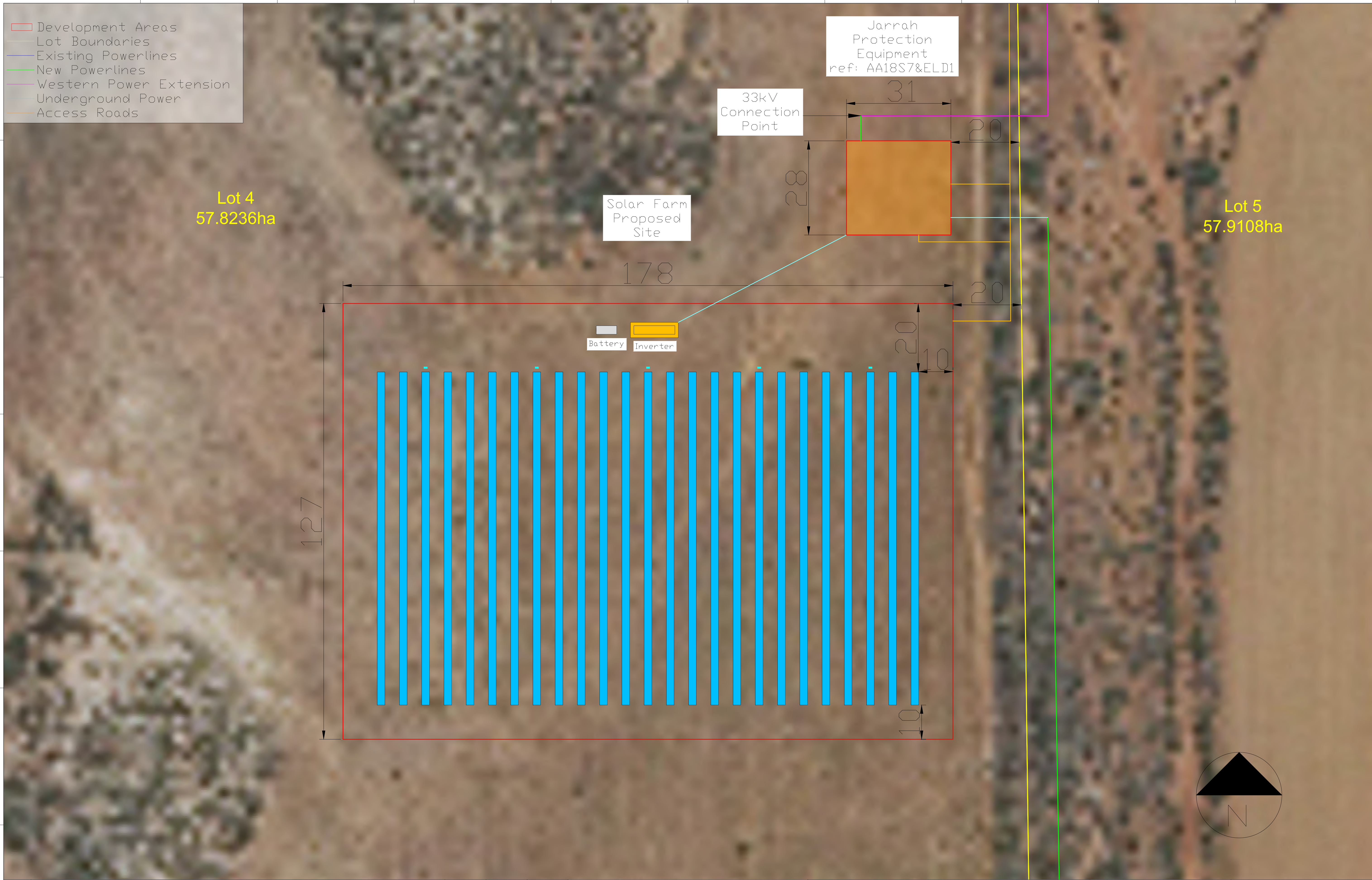
SHEET

SIZE A3

DRAWN 27/07/2023

ISSUED

DWG NAME Site Overview



RevNo	Revision note	Date	Signature	Checked
I	Changed Locations, Rerouted Powerline to New Connection Point	26/07/2023	CY	
J	Additional Labelling, Highlighted Western Power Extension	27/07/2023	CY	

Avora ENERGY

FILE NAME MullewaLayoutDrawing RevJ.dwg

SCALE 1:100

SHEET

SIZE A3

DRAWN 27/07/2023

ISSUED

DWG NAME Array Layout

RevNo	Revision note	Date	Signature	Checked
I	Changed Locations, Rerouted Powerline to New Connection Point	26/07/2023	CY	
J	Additional Labelling, Highlighted Western Power Extension	27/07/2023	CY	

Avora ENERGY

FILE NAME MullewaLayoutDrawing RevJ.dwg

SCALE 1:200

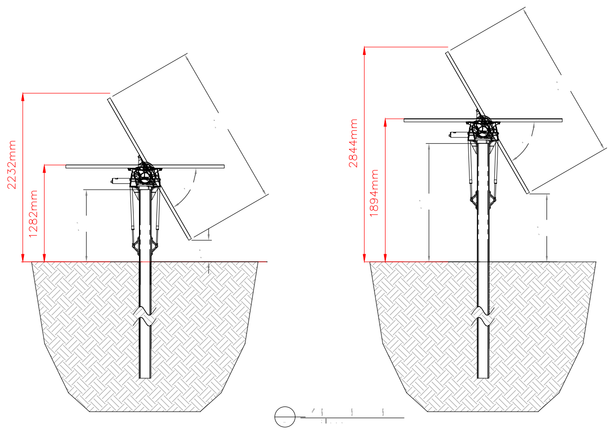
SHEET

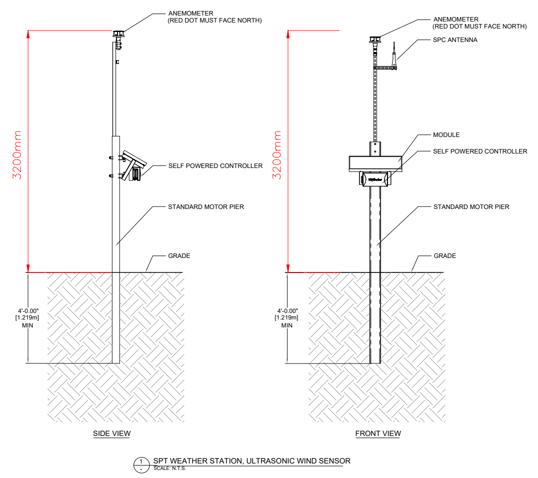
SIZE A3

DRAWN 27/07/2023

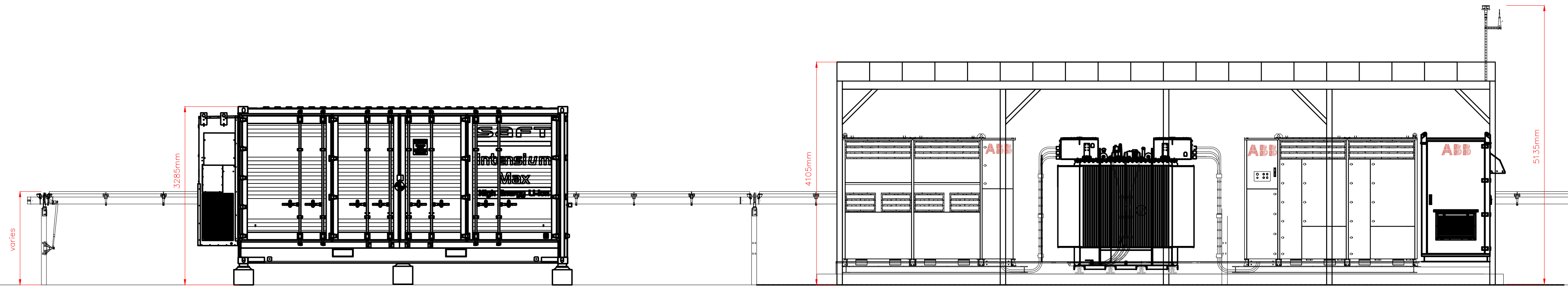
ISSUED

DWG NAME Turbine Layout





Typical View Only
Details Subject to change

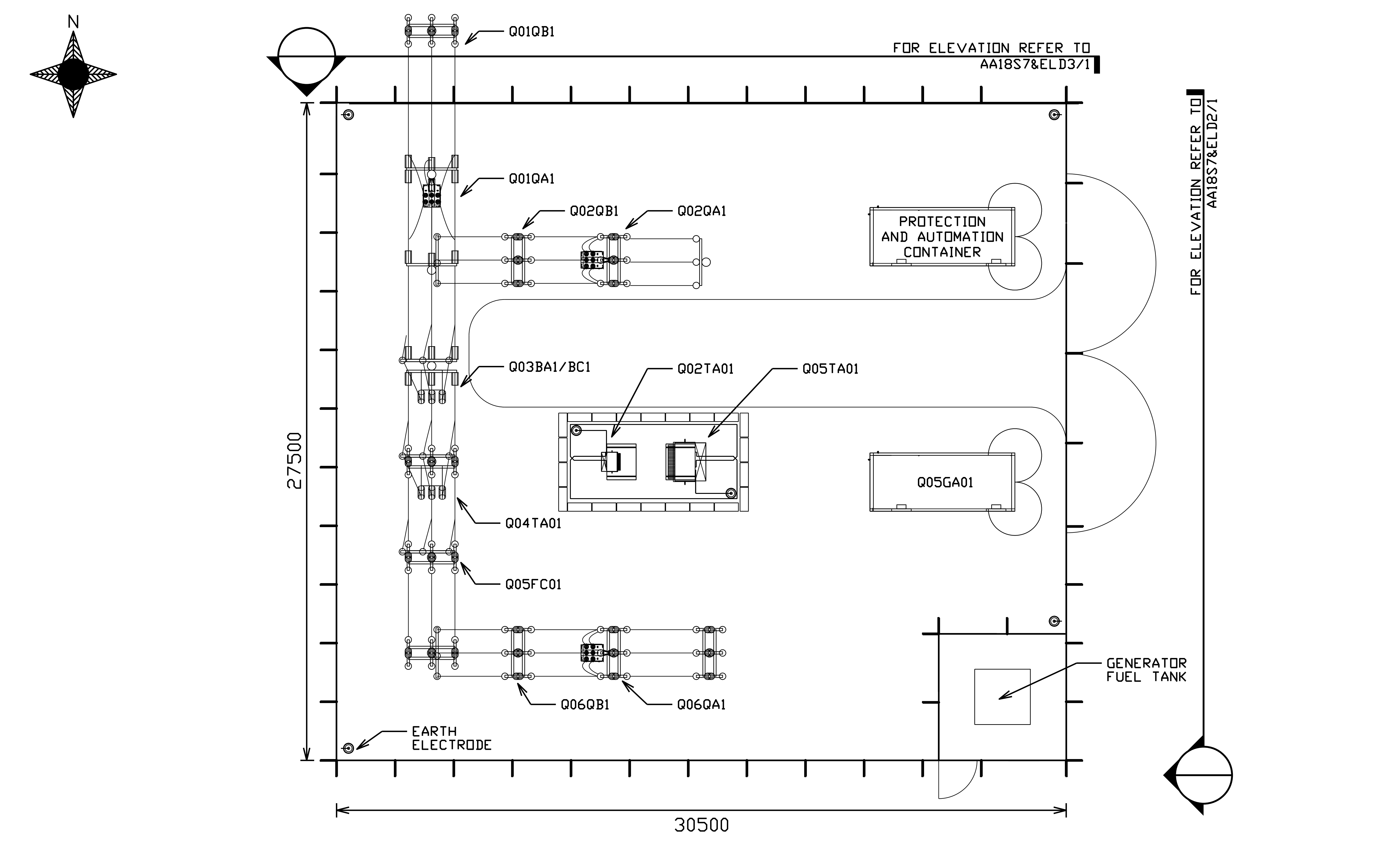


TYPICAL ELEVATION OF SOLAR ARRAY, INVERTER & BATTERY

RevNo	Revision note	Date	Signature	Checked
A	FIMER / NEXTracker System	2/11/2022	CY	
B	FIMER / SAFT / NEXTracker System with heights	7/11/2022	CY	

Avora ENERGY

FILE NAME	Typical Elevation View RevB.dwg	SCALE 1:100	SHEET ddd
SIZE	A3	DWG NAME Typical Elevation View FIMER / SAFT / NEXTracker	
DRAWN	02/11/2022		
ISSUED	02/11/2022		



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A	JH	07/23	ISSUED FOR FEED	JS	JS	AA18S7&EFA1/1 REV D	MULLEWA MICROGRID HV SLD

REFERENCES

JARRAH SOLUTIONS PTY LTD

© JARRAH SOLUTIONS

PROJECT ID C100248

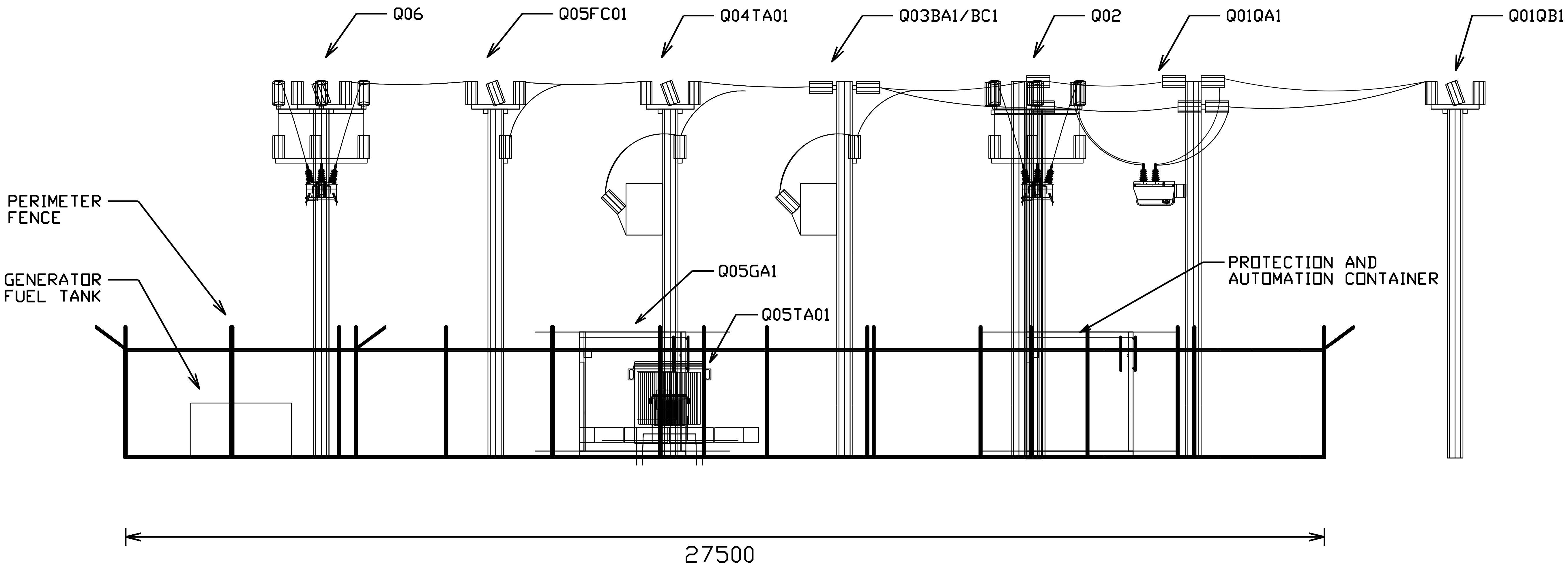
CREATOR	J HITCHINS
REVIEWER	J STOKES
TECH REF	J STOKES
APPROVED	J STOKES
DATE	07/23

DOCUMENT ID

SUNRISE ENERGY GROUP

MULLEWA MICROGRID
HV CONNECTION POINT
GENERAL ARRANGEMENT

SCALE	SIZE	DOCUMENT DESIGNATION	SHT	REV
1:150	A3	AA18S7&ELD1	1	A



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A	JH	07/23	ISSUED FOR FEED	JS	JS	AA18S7&EFA1/1 REV D	MULLEWA MICROGRID HV SLD
REVISIONS						REFERENCES	

JARRAH SOLUTIONS PTY LTD

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PROJECT ID C100248

CREATOR	J HITCHINS
REVIEWER	J STOKES
TECH REF	J STOKES
APPROVED	J STOKES
DATE	07/23
SCALE	1:150
SIZE	A3

DOCUMENT ID

SUNRISE ENERGY GROUP

MULLEWA MICROGRID
HV CONNECTION POINT
ELEVATION 1

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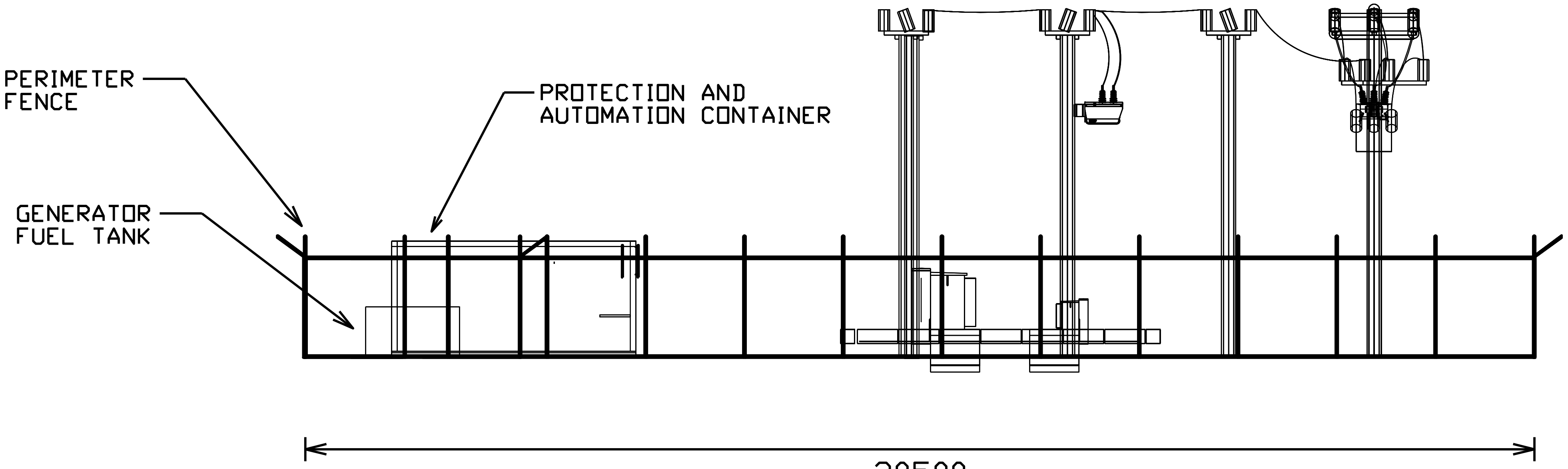

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A		07/23	ISSUED FOR FEED			AA18S7&EFA1/1 REV D	MULLEWA MICROGRID HV SLD

REVISIONS | REFERENCES

JARRAH SOLUTIONS PTY LTD

© JARRAH SOLUTIONS

PROJECT ID C100248

CREATOR	J HITCHINS
REVIEWER	J STOKES
TECH REF	J STOKES
APPROVED	J STOKES
DATE	07/23
SCALE	10:1
SIZE	A3

DOCUMENT ID

SUNRISE ENERGY GROUP

MULLEWA MICROGRID
HV CONNECTION POINT
ELEVATION 2

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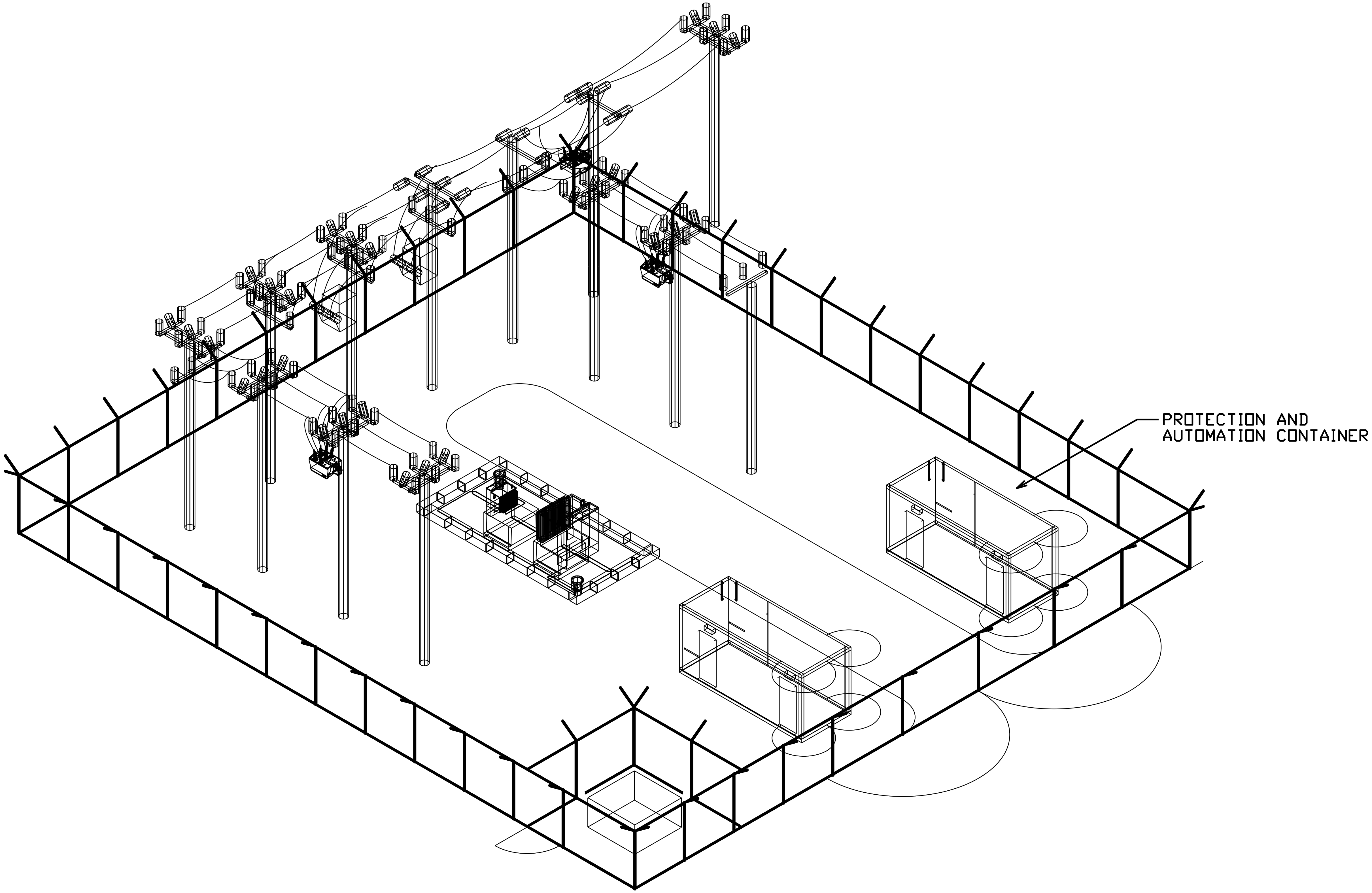

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REVISIONS						REFERENCES	

JARRAH SOLUTIONS PTY LTD

PROJECT ID C100248

CREATOR	J HITCHINS
REVIEWER	J STOKES
TECH REF	J STOKES
APPROVED	J STOKES
DATE	07/23

DOCUMENT ID

SUNRISE ENERGY GROUP

MULLEWA MICROGRID
HV CONNECTION POINT
ISOMETRIC

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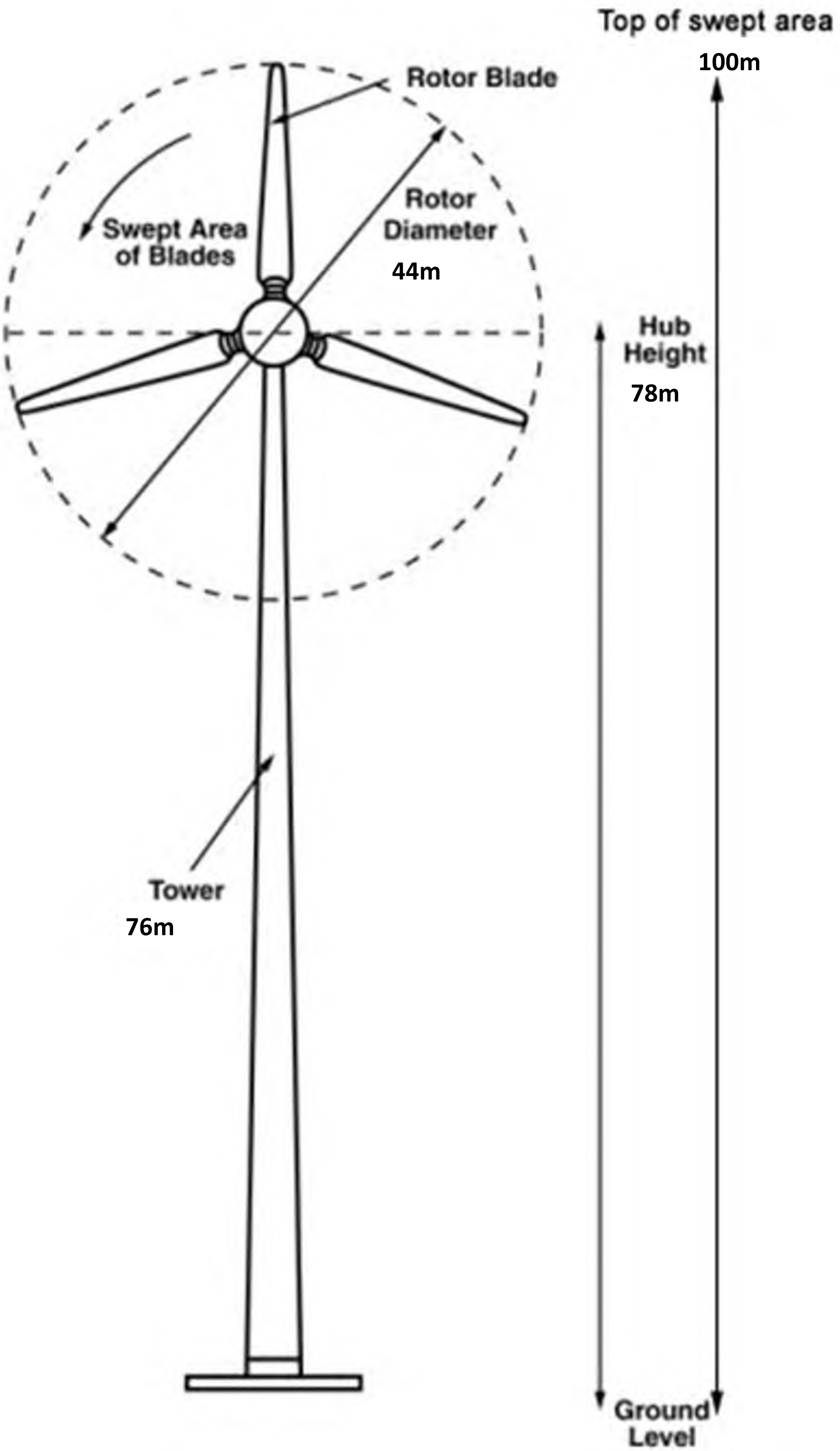
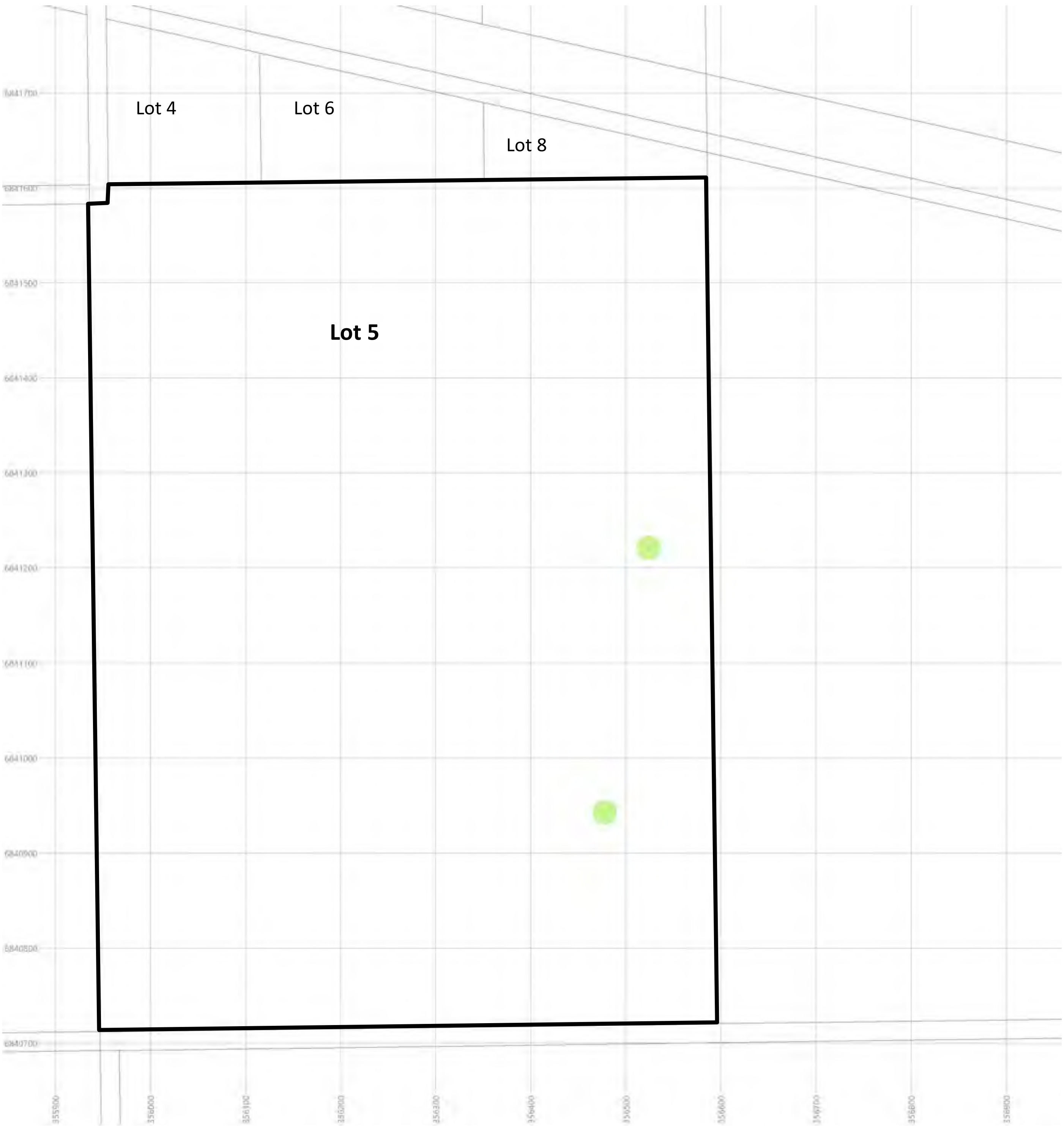


WIND TURBINE ELEVATIONS

Turbine dimensions are shown.

- Tower — 76m
- Hub height - 78m
- Rotor Diameter — 44m
- Top of swept area — 100m

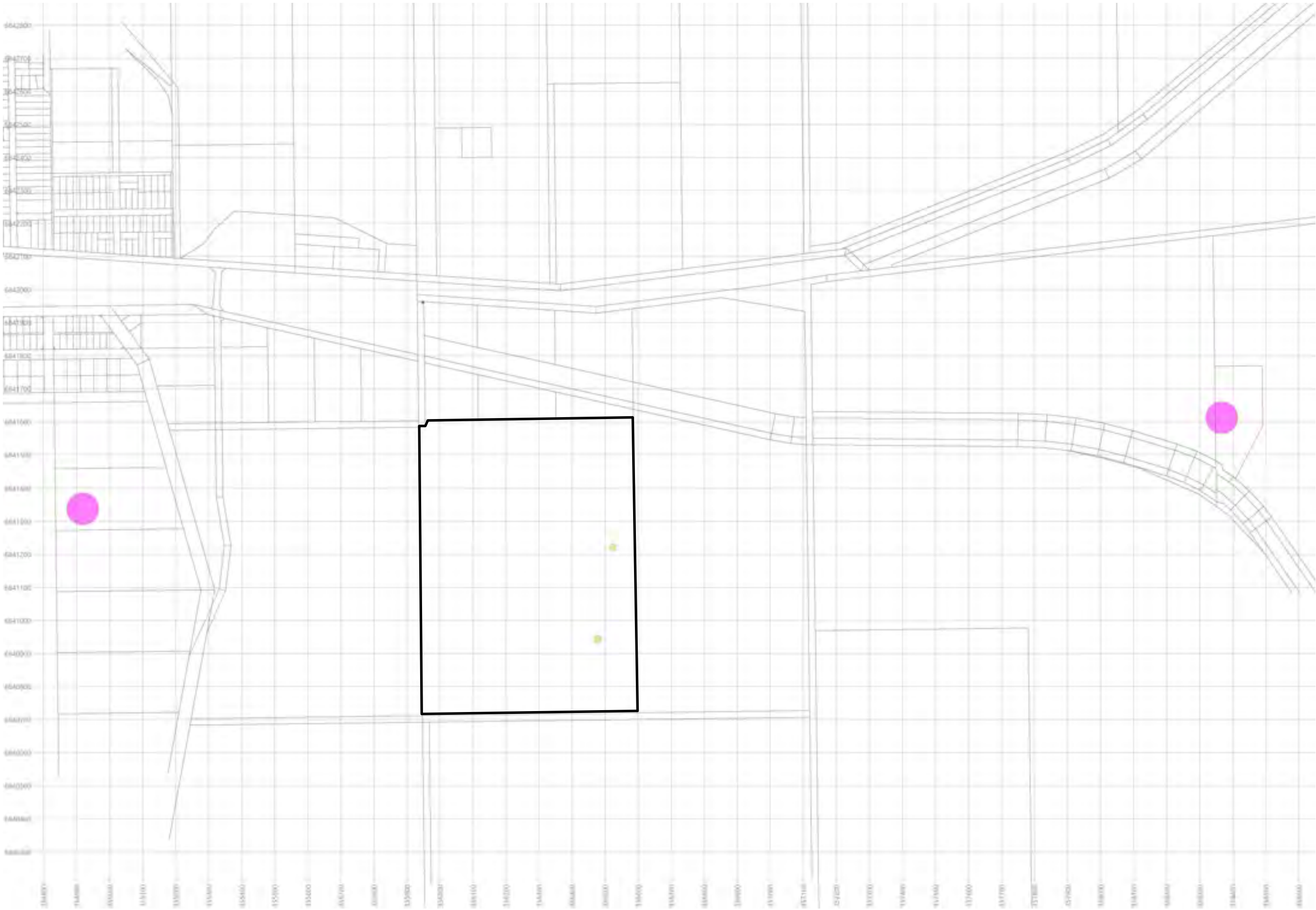
PROJECT Mullewa Wind Farm WA			
TITLE Enercon E-40 / E2 – 600 KW-78m Dimensions			
CREATED BY: MR	DATUM	DATE 28/04/2023	
CLEARANCE BY MR	SCALE	DRAWING NO. MUL 001	REV 001
APPROVED M. Rosser	BlairFox Building the connections	Unit 2, 33 McDonald Crescent Bassendean WA 6054 mrosser@blairfox.com.au	



Coordinates	X(m)	Y(m)
Turbine 1	356524	6841221
Turbine 2	356478	6840943

100m

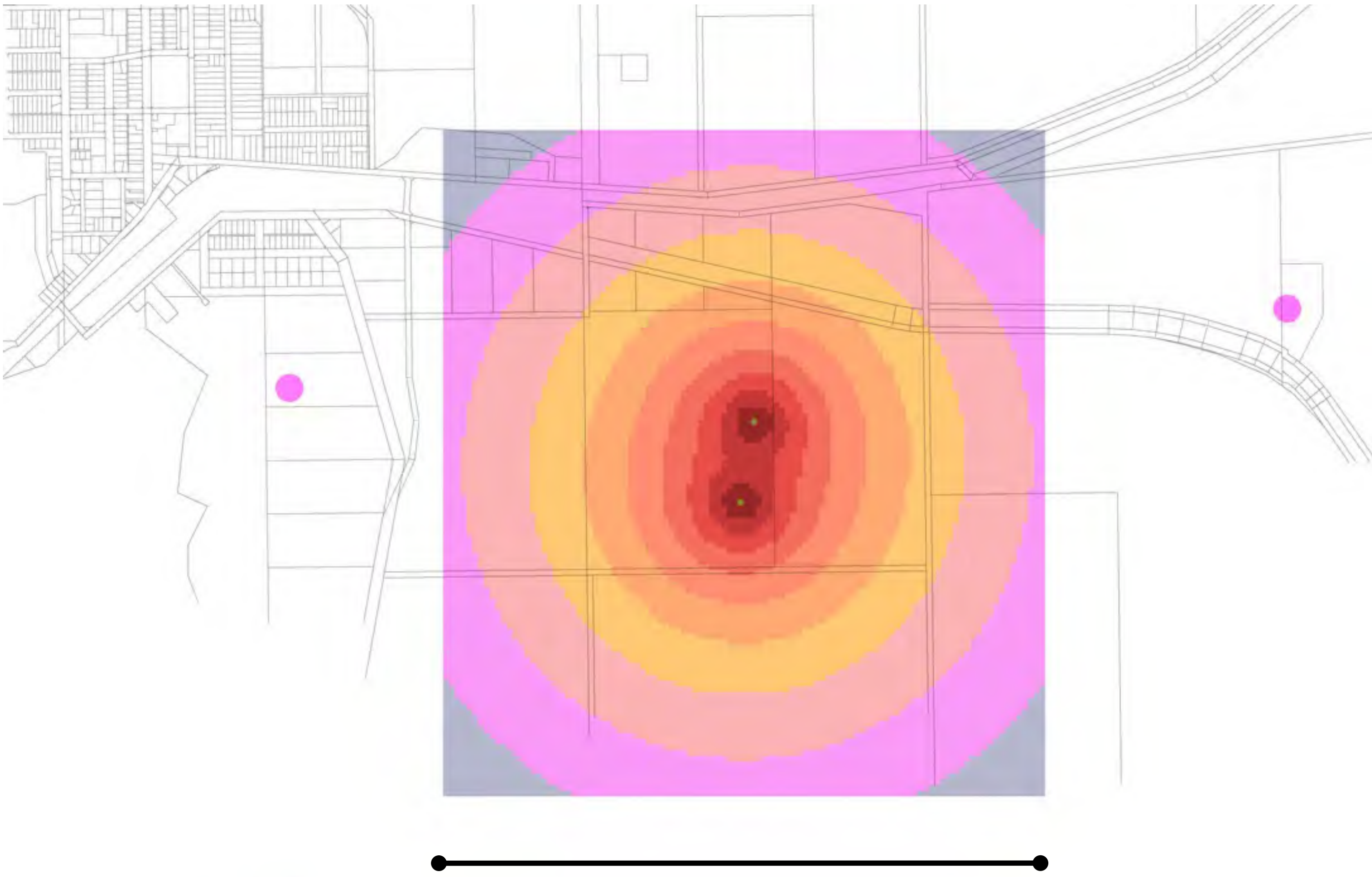
Proposed Turbines Property Boundary	PROJECT	Mullewa Wind Farm			
	TITLE	Turbine Layout and Coordinates			
	CREATED BY: MR	DATUM GDA94, MGA 50	DATE 29/04/2023		
	CLEARANCE BY MR	SCALE	DRAWING NO. MUL 003	REV 001	
	APPROVED M. Rosser	BlairFox Building the connections	Unit 2 McDonald Crescent, Bassendean WA 6054 mrosser@blairfox.com.au		



100m

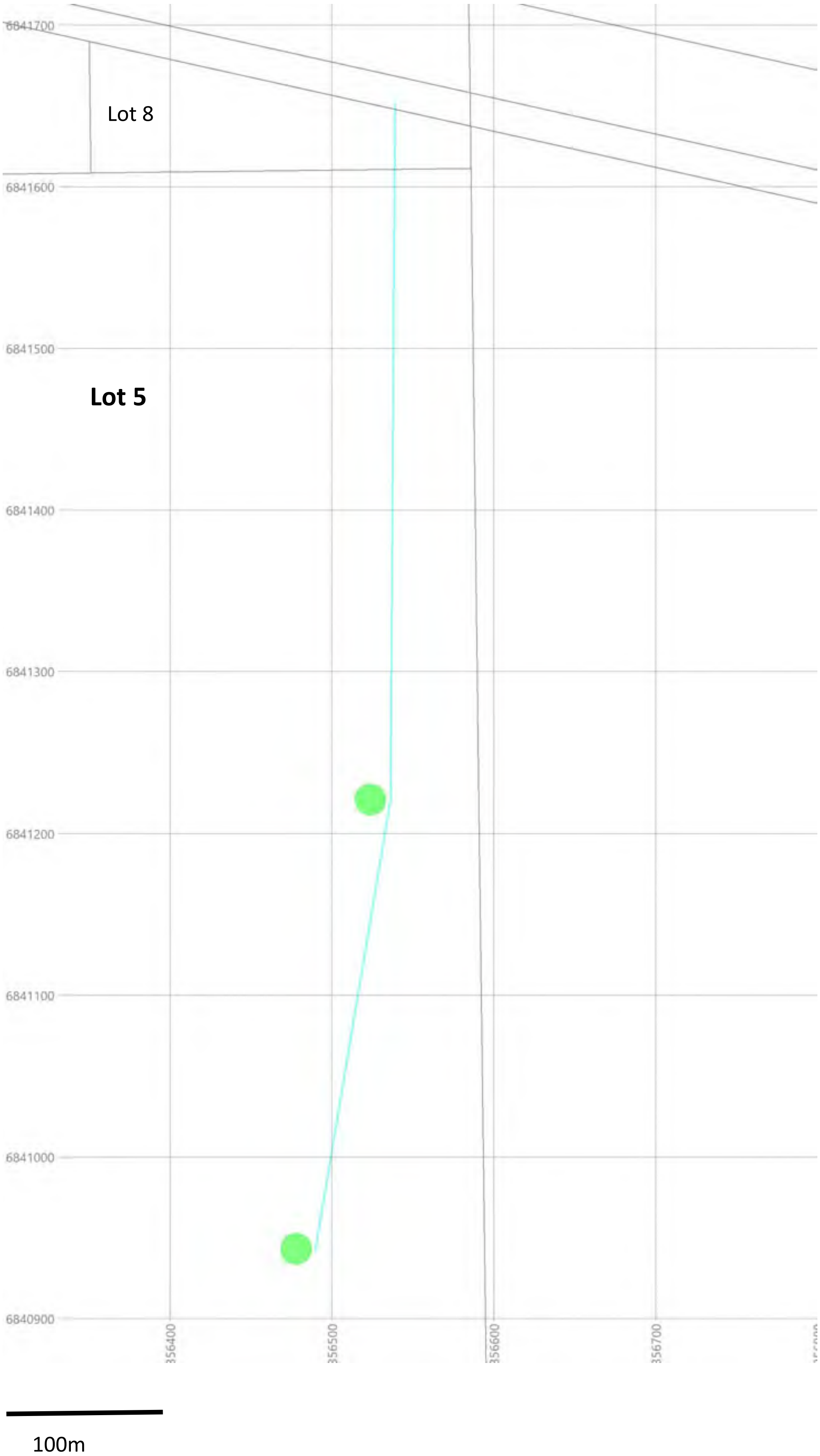
● (pink)	Nearest Dwelling
● (green)	Turbine Location
▬	Lot 5—Property Boundary

PROJECT Mullewa Wind Farm			
TITLE Nearest Dwelling			
CREATED BY: MR	DATUM GDA94, MGA 50	DATE 29/04/2023	
CLEARANCE BY MR	SCALE	DRAWING NO. MUL 002	REV 001
APPROVED M. Rosser	BlairFox Building the connections	Unit 2 McDonald Crescent, Bassendean WA 6054 mrosser@blairfox.com.au	



■	> 55.00
■	52.23 < Noise [dB] < 55.00
■	49.46 < Noise [dB] < 52.23
■	46.69 < Noise [dB] < 49.46
■	43.92 < Noise [dB] < 46.69
■	41.15 < Noise [dB] < 43.92
■	38.38 < Noise [dB] < 41.15
■	35.62 < Noise [dB] < 38.38
■	32.85 < Noise [dB] < 35.62
■	30.08 < Noise [dB] < 32.85
■	27.31 < Noise [dB] < 30.08

● Nearest Dwelling	PROJECT Mullewa Wind Farm		
	TITLE Noise Contours		
	CREATED BY: MR	DATUM GDA94, MGA 50	DATE 29/04/2023
	CLEARANCE BY MR	SCALE	DRAWING NO. MUL 004 — REV 004
	APPROVED M. Rosser	BlairFox Building the connections	Unit 2 McDonald Crescent, Bassendean WA 6054 mrosser@blairfox.com.au

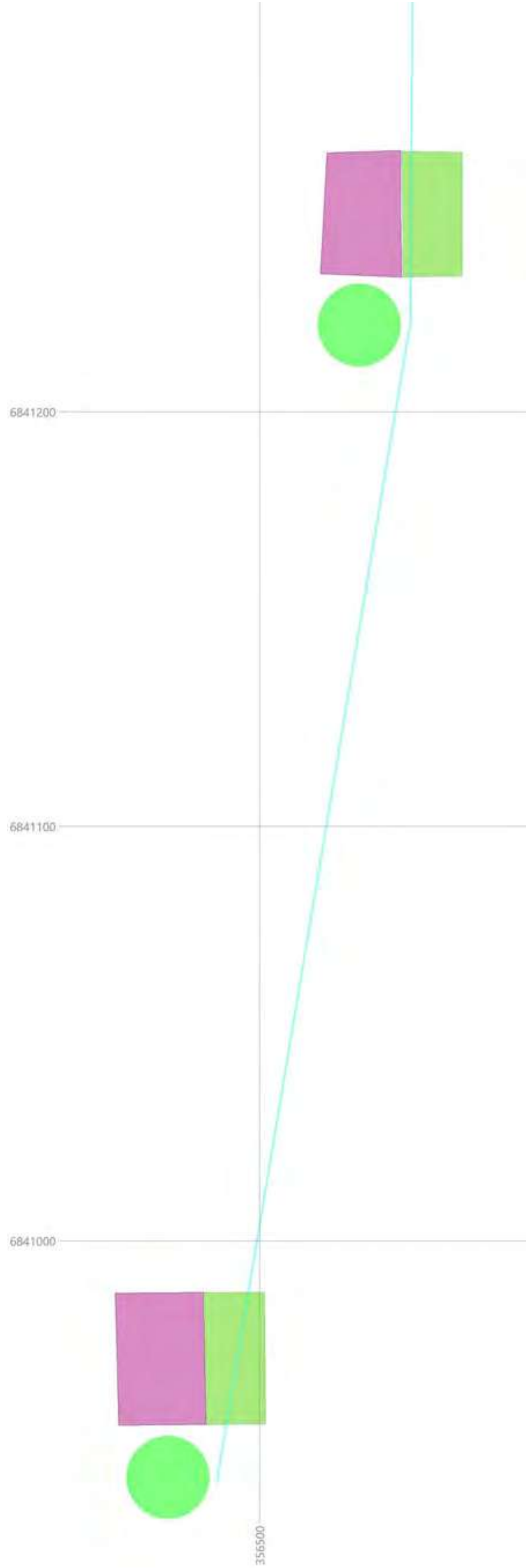


Road Details	
Length	725m
Road width	4m
Clearance width	5m
Clearance height	4.6m
Radius of external curve	28m
Able to withstand axel load	12t
Able to withstand overall vehicle weight	120t

Proposed Turbines

Access Road

PROJECT Mullewa Wind Farm			
TITLE Access Road			
CREATED BY: MR	DATUM GDA94, MGA 50	DATE 07/05/2023	
CLEARANCE BY MR	SCALE	DRAWING NO. MUL 003	REV 001
APPROVED M. Rosser	BlairFox Building the connections	Unit 2 McDonald Crescent, Bassendean WA 6054 mrosser@blairfox.com.au	



Details	
Crane pad dimensions	20m x 30m
Lay down dimensions	15m x 30m
Distance crane pad from turbine centre point	9.5m
Crane pad withstand pressure	185kN/m2
Laydown Area able to withstand axel load	12t
Material	gravel

100m

Proposed Turbines
Access Road
Crane pad
Laydown area

PROJECT Mullewa Wind Farm			
TITLE Crane Pad and Laydown Area			
CREATED BY: MR	DATUM GDA94, MGA 50	DATE 07/05/2023	
CLEARANCE BY MR	SCALE	DRAWING NO. MUL 0037	REV 001
APPROVED M. Rosser	BlairFox Building the connections	Unit 2 McDonald Crescent, Bassendean WA 6054 mrosser@blairfox.com.au	

APPENDIX I

Western Power Alternative Options Proposal

MULLEWA RENEWABLE MICROGRID

Improving the reliability of power supply to the town of Mullewa

An Alternative Options Proposal to Western Power

Document Revision: 1.0

Dated: 31 August 2023

sunrise
energy group

31 August 2023

Sunrise Energy Group Pty Ltd
65 Hay Street
Subiaco
WA 6008
Australia

Head of Grid Transformation
Ben Bristow
Western Power
363 Wellington Street, Perth
WA Australia 6000

Dear Mr Bristow,

RE: Alternative Options Proposal

Please find following Sunrise Alternative Options Proposal for improving the reliability of Power Supply to the town of Mullewa and it's downstream spur line.

The basis of this proposal is to offer a reliability service at a comparable or lower cost that what is estimated Western Power could achieve itself via an automated diesel generator solution, and has the added benefit of contributing to the decarbonisation of the SWIS and reducing line losses.

We look forward to discussing this proposal with you further and welcome any comments or queries.

Yours Sincerely

Neil Canby
Managing Director
Sunrise Energy Group Pty Ltd

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1 INTRODUCTION

Sunrise Energy received funding to complete a Microgrid Feasibility Study for the town of Mullewa with the primary objective to find a solution that could improve the reliability of power supply to the town and downstream spur line and would provide a blueprint for a repeatable model that could be applied to other “fringe-of-grid” towns.

Mullewa is a town in the City of Greater Geraldton located in the mid-western Region of WA, approximately 450km north of Perth. The location (relative to the SWIS) and the network connections of the Mullewa township can be seen in Figure 3-1.

The study involved a 21 month examination into the viability of deploying a renewable energy microgrid in Mullewa as well as the development activities to bring the selected solution to an investor ready stage. The study has been completed by Sunrise Energy Group Pty Ltd (Sunrise), in collaboration with Enzen Australia Pty Limited (Enzen), a developer of a digital twin for the Mullewa network.

Western Power and Synergy have also been involved in the study, however collaborating and providing support to the study has in no way been a commercial commitment or solution preference on Western Power's part, particularly given its work on other regional reliability and network augmentation projects. Similarly, Synergy is not a party to the Project and has made no commercial commitment. Its role in the Project is only to provide data, engage the community (as requested), and to provide support to Sunrise.

As part of the study there has been engagement with the Mullewa township, local city council (the City of Greater Geraldton), the mid-west development commission, MEEDAC, EPWA, the ERA and the Minister for Mines and Petroleum; Energy; Hydrogen Industry; Industrial Relations, the honourable Bill Johnston.

The study reviewed several options for a Microgrid solution, investigating the technical configuration and various commercial models. The conclusion from these investigations and engagement with the numerous parties mentioned, was that there was positive support for a renewable microgrid that would reduce the outages associated with loss of the grid supply at Mullewa.

The outcome from the study was that the commercial feasibility of the recommended solution rested on Western Power entering into an agreement for supply of a reliability service offered by the microgrid. Based on discussions with EPWA the best means of negotiating such an agreement would be via the submission of a proposal under the Alternative Options Strategy, which was introduced as part of the changes made to the Access Code in September 2020 to support the delivery of the State Government’s Energy Transformation Strategy which includes providing greater opportunity for third parties to provide efficient non-network solutions to Western Power. It is on these grounds that we submit the following proposal to Western Power for consideration.

The proposal has been prepared with reference to Western Power’s “Alternative Option Strategy Paper” (2021) with the purpose of presenting the proposal in a format the follows the general intent of that document.

2 PROPOSAL

The proposal is for a reliability service for the town of Mullewa and its downstream spur line that would enable the demobilisation of the existing Western Power Emergency Response Generator's (ERG) that are temporarily located in Mullewa. The ERG's are currently manually started and then manually switched on to restore power to Mullewa at times when the grid supply is down. This process can take considerable time leaving the town of Mullewa without a power supply. Furthermore, the two ERG's are rented to Western Power at an estimated cost of [redacted] per annum.

The reliability service we are offering would consist of microgrid for the town of Mullewa that will feature an automated detection and switching system at the connection point. The automated connection point is proposed to be located upstream of the town of Mullewa so it can be islanded and will have the following features:

- Detection of an unplanned outage of the grid supply.
- Starting of the Microgrid and automated establishment of a 33kV earth reference.
- Disconnection of Mullewa from the grid (a new Western Power recloser will be required).
- Restoration of power to Mullewa from the Microgrid.
- Watch and wait for the restoration of supply from the grid. Following restoration, and after waiting a period of time to check for stability, the Mullewa Microgrid will automatically synchronise back onto grid supply in a seamless manner, and then isolate the 33kV local earth reference.

With this microgrid configuration, if there was a power outage to Mullewa the system would be able to automatically restore it in less than the one minute limit, so as not to be deemed an interruption.

The microgrid has been designed to include in-front of the meter renewable generation (solar and wind), battery and back-up diesel that would have the capability of forming an islanded microgrid supporting the town on loss of the grid supply coming from Geraldton. Under normal operating conditions, the solution has been designed to allow the electricity distribution network to operate as it currently does when connected to the grid. When grid connected the renewable energy generation would be sold via a bi-lateral take-off agreement with an energy retailer or at WEM balancing market price via a 3rd party service.

In the event of a power fault on the distribution line from Geraldton to Mullewa, the proposed solution will enable automatic islanding and provide reliable power. This therefore addresses the gaps in the existing ERG service provided for the town which is a manual operation that takes time to engage, leaving the town with interruptions, even if the actual downtime is reduced once the ERG is operational and engaged.

With the use of renewable generation this proposal also has the added benefit of contributing to the broader State objective of decarbonising the SWIS. Other benefits from a Microgrid would include reducing overall line losses in the SWIS (ref. Jarrah Solutions Line Loss Calculations, Appendix E), potential to provide voltage and frequency support and increase Western Power capacity available in Mullewa. This service would capture not only the Mullewa town customers but also those on the downstream spur line beyond Mullewa.

The intent is to treat implementation of this solution at Mullewa as a pilot to prove both the technical and commercial viability and identify areas for improvement prior to adopting it (if proven successful) as a repeatable model for other fringe-of-grid towns experiencing low reliability.

3 Technical Description

3.1 Location

The microgrid will serve the network downstream the proposed isolation point, the extent of which is indicated in Figure 3-1.

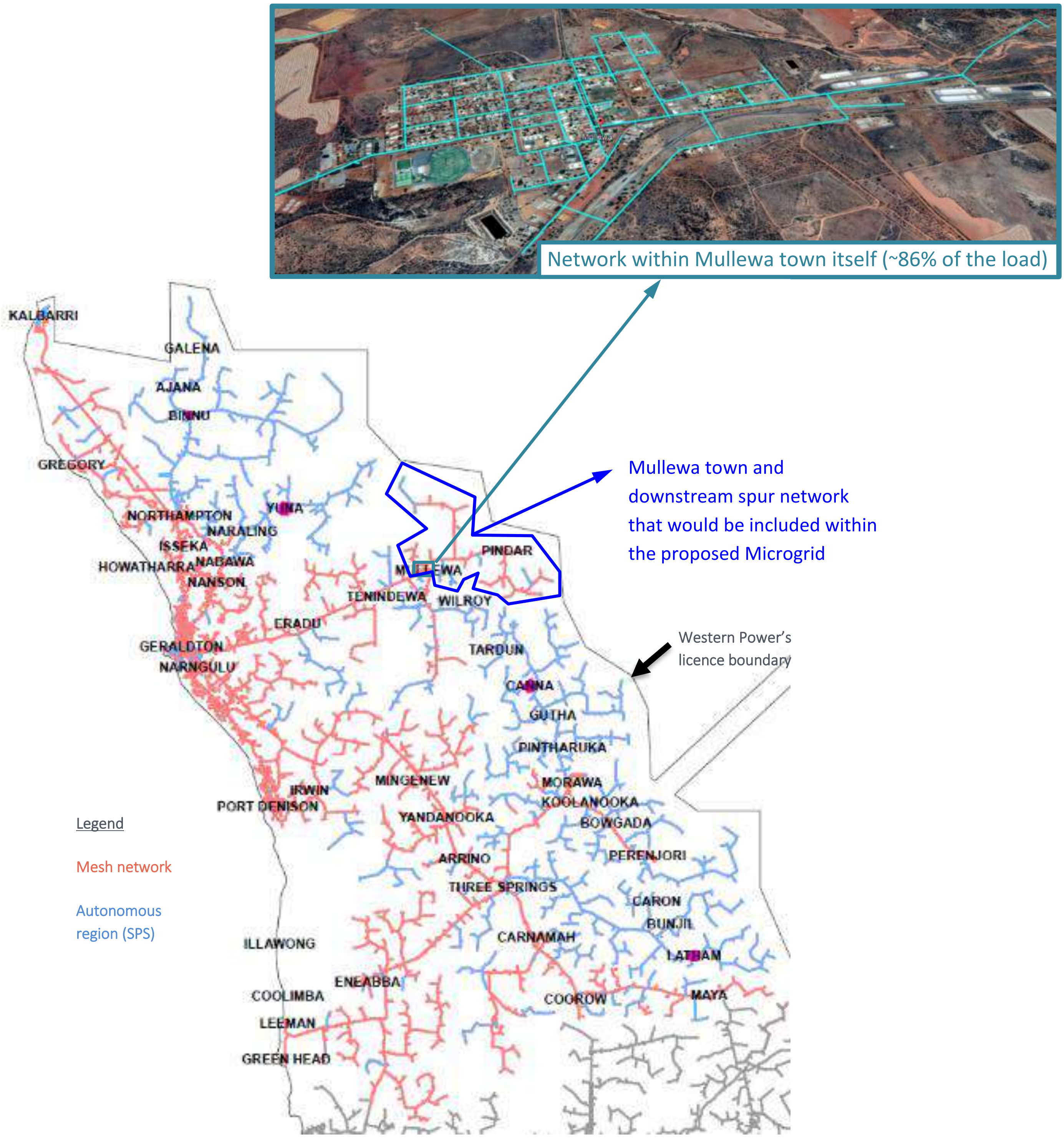


Figure 3-1: Mullewa town and network in relation to the SWIS

The new infrastructure that will enable the Microgrid will be located nearby the town as identified in Figure 3-2. For further detail on the specific locations and layout arrangements, ref. layout drawings in Appendix C.

Figure 3-2: Location of Microgrid Infrastructure around the town of Mullewa

3.2 Infrastructure

The new infrastructure proposed as the basis of the microgrid reliability service is:

- 1.1MW DC single-axis tracking solar array
- Two x 600kW Wind Turbines.
- 1.5MW/3MWh BESS
- 750kVA Diesel Generator
- Protection, Automation and Controls “Connection Container”
- 33kV overhead powerline connecting the wind turbines to the Connection Container
- 33kV overhead of powerline (including a Western Power metering unit) to extend Western Powers 33kV existing Mullewa network to the designated connection point (Western Power scope).
- Remote controlled grid recloser with radio communications installed upstream of the town for islanding the town and spur line network (standard NOJA type recloser by Western Power, with protection settings, design, configurations and interface equipment, e.g. radio communications for automation by the Project).

The possible total microgrid generation capacity is 4,300kW

For detailed data on main equipment ref. Appendix D.

3.3 Operating Modes

The Mullewa microgrid will be designed and created to provide the following two services (extracts from Jarrah Solutions FEED Report in Appendix E):

Grid Up Mode

The Mullewa microgrid will operate in an arrangement that is typical of a renewable grid-connected generation site. A connection point will be required, and the ERA technical rules requirements will apply at this grid connection. A DSOC (export limit) will be sought from WP to allow renewables from the microgrid (and on occasion, when called on by AEMO, from battery and diesel as well) to export power into the grid. Hence if there is an excess of power, over and above the town of Mullewa's needs, then this Microgrid will supply power to other customers between Mullewa and Geraldton. Neither the battery or diesel generator will be supplying (generating) power at the time of full solar and wind generation. The CMD (import limit) will be selected as a negligible amount to supply auxiliary loads at the microgrid. The CMD will not need to be selected to charge the battery as the charging of the battery will be performed by a combination of wind and solar generation. In grid-up mode, the source of power to the grid will be through a retail supply agreement or 3rd party service selling the energy at WEM balancing market price.

Grid Down Mode

In the event of a power outage, the Mullewa microgrid will automatically become islanded from the grid and power will be supplied from a combination of the BESS, solar farm, wind turbines and diesel generator. The BESS will be utilised for frequency control and system stability services. Figure 3-3 below shows the location of a new Western Power recloser that the microgrid will interface with.

Figure 3-3: New recloser (crossed red circle) to be installed by Western Power

As previously detailed, the automated detection and switching system at the connection point for the Microgrid will have the following features:

- Detection of an unplanned outage of the grid supply.
- Starting of the Microgrid and automated establishment of a 33kV earth reference.
- Disconnection of Mullewa from the grid (a new Western Power recloser will be required).
- Restoration of power to Mullewa from the Microgrid.

- Watch and wait for the restoration of supply from the grid. Following restoration, and after waiting a period of time to check for stability, the Mullewa Microgrid will automatically synchronise back onto grid supply in a seamless manner, and then isolate the 33kV local earth reference.

The "Grid Down Mode" would typically be an unplanned event however it could also be a planned event. For an unplanned event, the high level control philosophy is describe within the logic diagram in Figure 3-4 below.

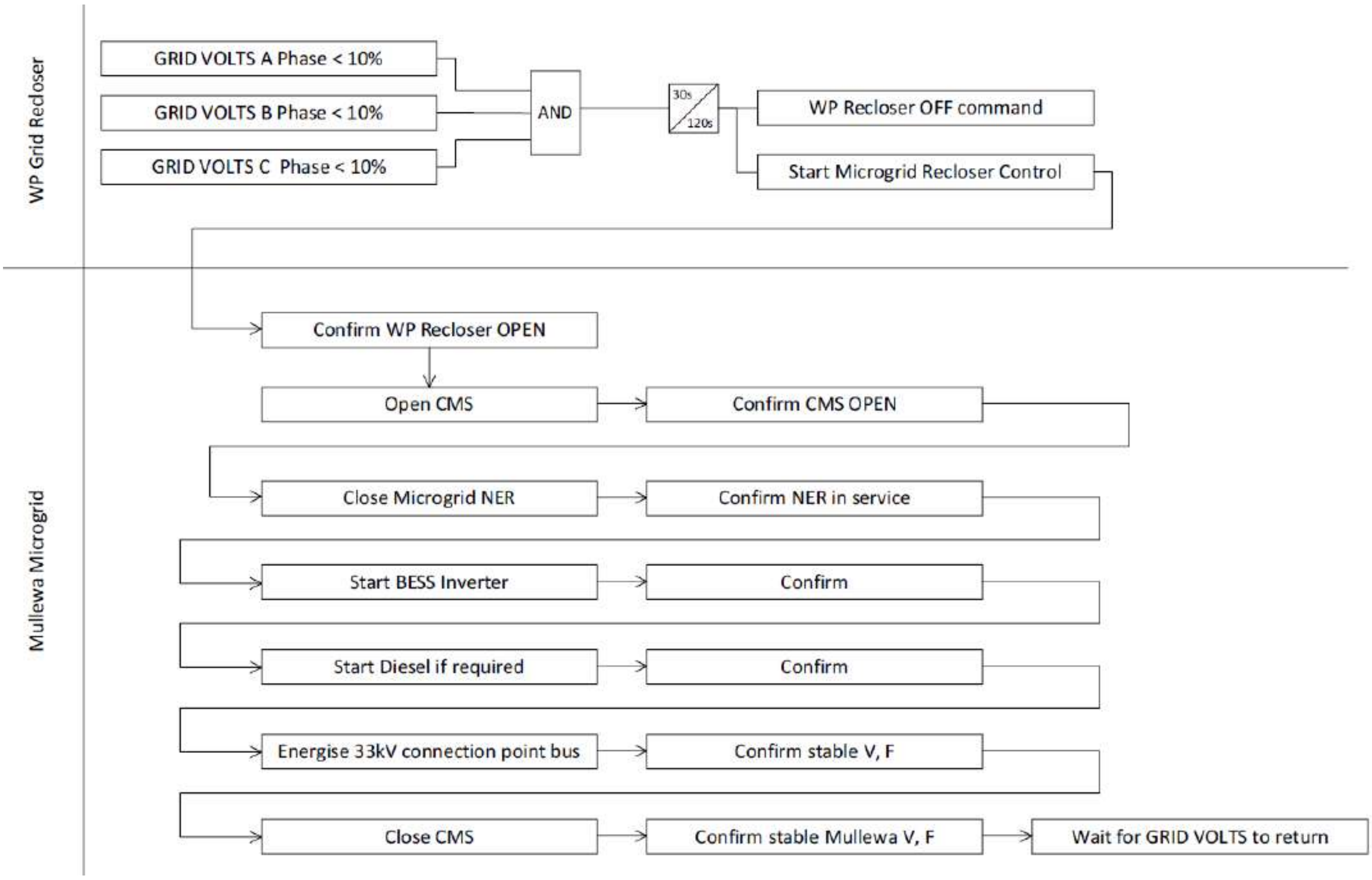


Figure 3-4: Mullewa Microgrid High Level Control Philosophy - Grid Down Mode

Two years of measured historical reactive power data of the existing Western Power recloser located upstream of Mullewa has been analysed as part of the microgrid design. The results, stratified based on the month of the year, are shown in Figure 3-5. With outliers removed (e.g., high reactive power inrush on energisation of lines), the reactive power demand of Mullewa is averaging less than 225kVA. This value is significantly less than the reactive power capacity of the Mullewa microgrid. The Microgrid reactive power capacity includes the solar inverter, BESS, inverter, wind turbines and diesel generator which are all controllable.

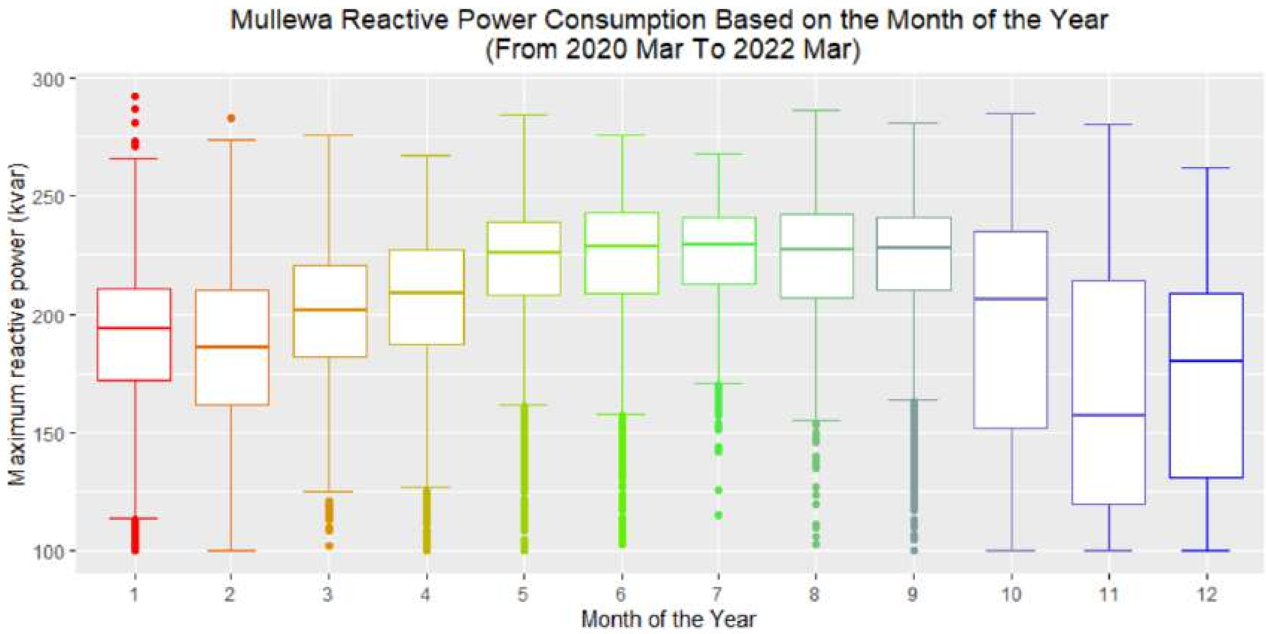


Figure 3-5: Mullewa Reactive Power Measurements - Based on the Month of the Year

Furthermore, when the Mullewa town is supplied from the Microgrid, there will be advanced reactive power control capability available from the system. Reactive power control is available from all generation sources (generator, BESS inverter, solar inverter, and wind turbines).

3.4 Electrical Layout

The electrical layout for the design is provided in the Jarrah Solutions Single Line Diagram (SLD) included in Appendix B.

3.5 Network Connection and Modifications

The proposed location of the network connection point to the Western Power 33kV network is defined in Figure 3-6.

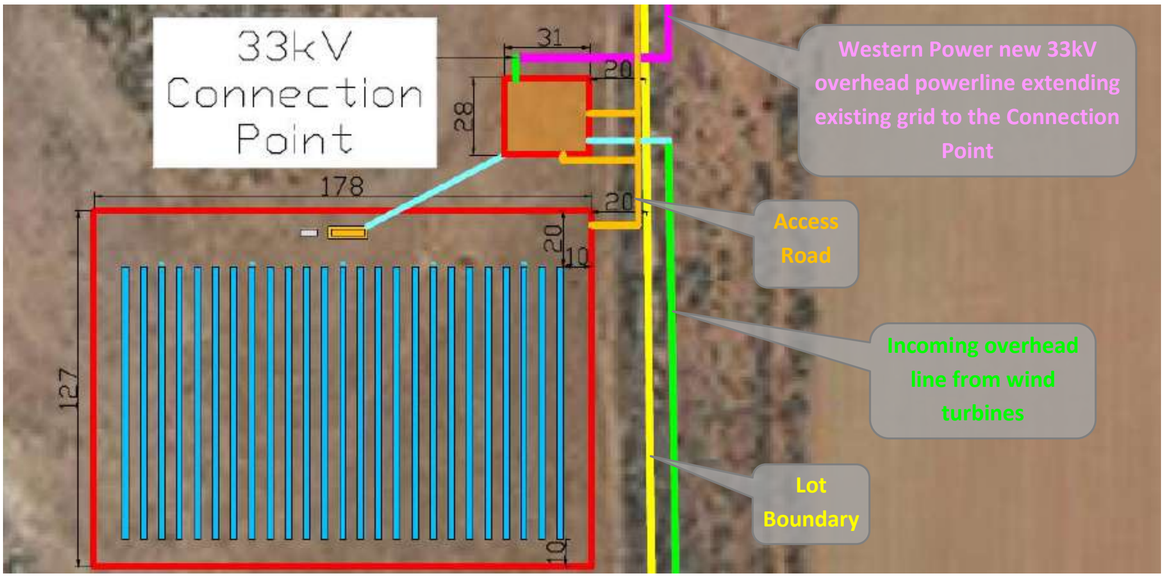


Figure 3-6: 33kV Network Connection Point

A connection point 33kV substation will be required to meet Western Australian technical rules requirements. This will also be used to provide the required protection and control systems. The single line diagram and general arrangements are attached to this proposal in Appendix B. The isometric drawing by Jarrah Solutions is shown in Figure 3-7 below.

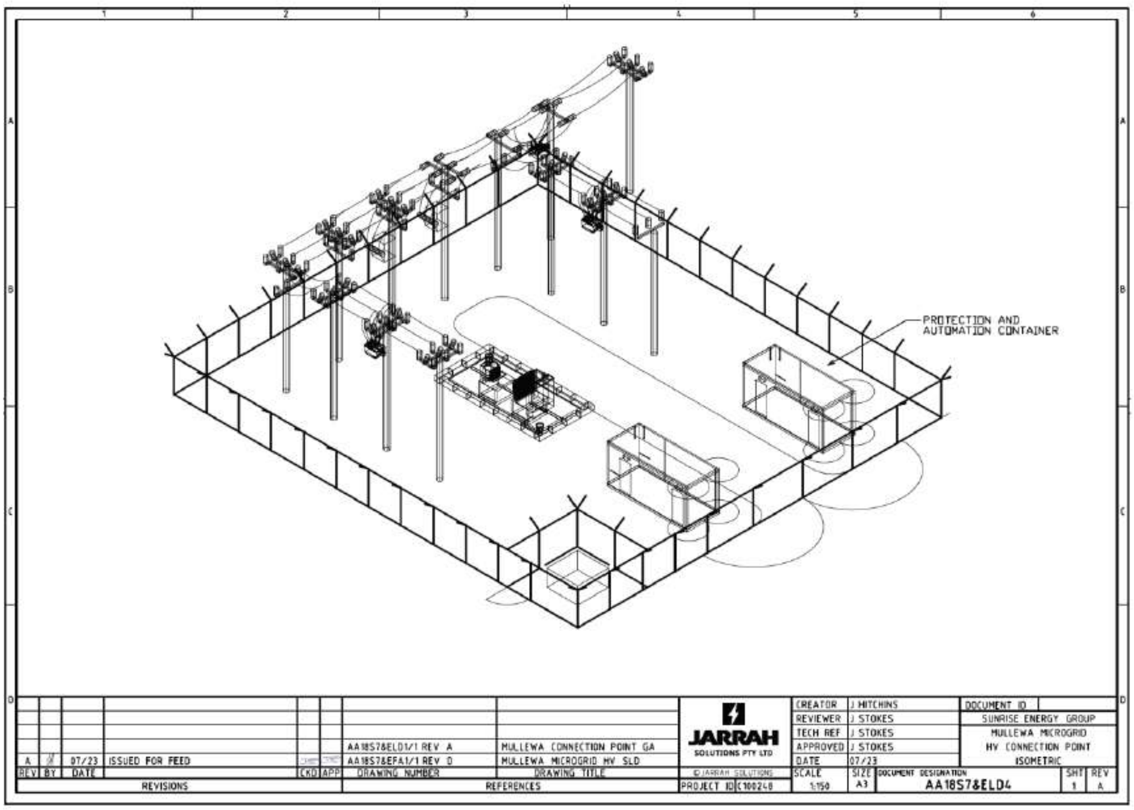


Figure 3-7: Isometric view of the Connection Point HV Substation (from Jarrah Solutions FEED Report – ref. Appendix E)

This HV substation (per Jarrah Solutions FEED Report, ref. Appendix E) will include the following equipment and features:

- A Customer Main Switch (CMS) as an interface between the Microgrid and Western Power, as required by the ERA Technical Rules.
- HV connection point metering for renewable energy credits and controls.
- A switchable Neutral Earthing Transformer to create an earth reference when the Microgrid is supplying power to Mullewa in island mode (grid disconnected).
- A 600kW diesel generator, step-up transformer, fuel tank and associated protections and controls.
- HV Switchgear for switching and isolation of the wind turbine supply.
- Protection, automation, and communications systems (housed in a 20-foot container that can be redeployed elsewhere, in the future (if required).

The location of the microgrid connection is some distance from the existing Mullewa network and so Western Power would need to extend the existing Network up to the nominated connection point. It is understood that Western Power will make their own assessment of which point the existing network will be extended in order to tie-in to the connection point, however for the purpose of this proposal the location has been taken to be the point indicated in Figure 3-8.

Upstream of the Connection Point, as indicated in the SLD (ref. Appendix B), a Western Power Metering Unit would be installed.

To island the network for operation in Microgrid (grid down) mode during loss of grid supply, an isolation point is required upstream of the town and the spur offtake, as indicated in Figure 3-2. As per the SLD this would be implemented via installation of a “grid recloser” in the existing line, with a radio communication link provided between the Connection Point and the grid recloser.

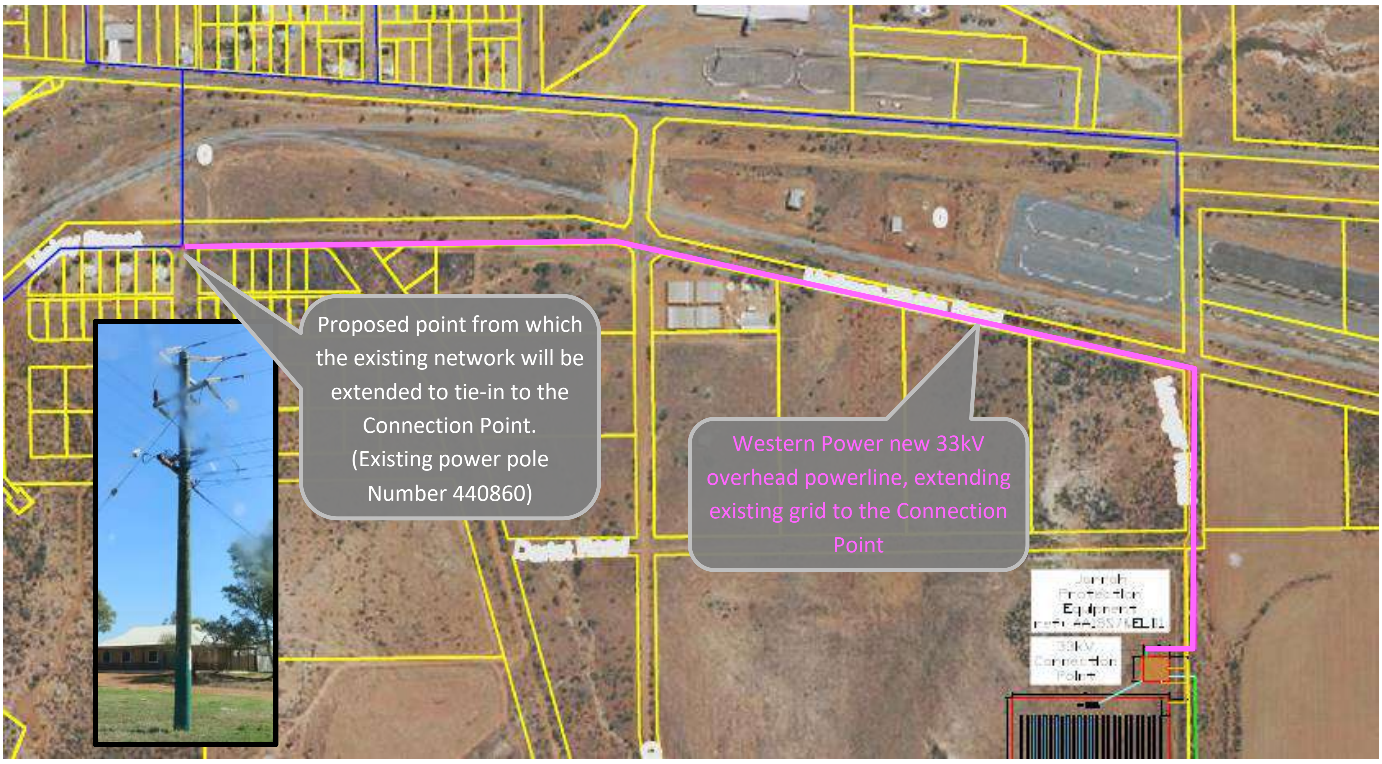


Figure 3-8: Extension of existing 33kV network to the Connection Point (proposal only, Western Power to define)

3.6 Microgrid Protection

The below is an extract from Jarrah Solutions FEED Report (ref. Appendix E)

Connection point protections will be required to meet ERA technical rules requirements. These protections will be located at the 33kV connection point and within the substation. When in grid-disconnected mode and the Microgrid is supplying power to Mullewa independently from Western Power, the protection system will adapt to a different mode of operation. The mode of operation (Grid Connected or Grid Disconnected) status will be provided automatically to the protection system. In Grid Disconnected mode, the fault levels will reduce, and fault detection and sensitivity requirements will become relevant and important. The protection systems will need to be designed for sensitive to short-circuit faults on the HV and LV networks. Detecting and selectively clearing for low level minimum fault currents will likely be the challenge to this project.

Directional overcurrent protections along with undervoltage backup protections will likely be required. The HV protection systems and input measurements (CTs and VTs) have been designed to allow for this flexibility. Protection studies have been allowed for in the FEED estimate, to be carried out during detailed design.

Lightning protection at the substation has not been allowed for as the overhead components (e.g. reclosers, air breaks, fuses, etc) are designed and commonly used for outdoor overhead operation. HV protection relays will be renowned international branded devices, and types SEL (USA origin) and Siemens (European origin) will be utilised.

3.7 Communications

3.7.1 Network Communications

According to AEMO there is currently a conflict between terms that set the conditions for establishing whether a generation connection is defined as scheduled or non-scheduled. This conflict comes from one requirement stipulating that connections with multiple technologies (e.g. solar, battery and wind) would classify it as a scheduled service and another condition that generation connections with less than 10MW can be classified as non-scheduled.

AEMO state that this conflict will be resolved in the near future, with applicable procedures updated accordingly, and on that basis the generation connection proposed for Mullewa could be assumed to be non-scheduled. Given that a non-scheduled service is not required to respond, then from AEMO perspective there would be no need for communications.

If Western Power require a communications link it is expected that an interface will be required to communicate with the Western Power Network control centre. This will provide visibility to Western Power and also facilitate controls (ON, OFF and export limit setpoints). This type of communication is known as Remote Monitoring and Control (RMC). The most efficient means will be a combination of mobile radio (4G) and satellite communications. A serial interface will be provided through hardware installed within the Geraldton substation. Similar to what has been trialed at the Sunrise Energy Boonanarring Solar Farm. Implementation of Communications via radio link would be cost prohibitive, particularly in terms of this solution forming the basis of a repeatable model.

3.7.2 Grid Recloser Communications

The below is an extract from Jarrah Solutions FEED Report (ref. Appendix E)

This communication link will need to be reliable as the township's power system reliability will depend on its functioning at times of need. The Western Power Grid Recloser location has been selected on high ground and to provide (close to) line-of-sight communications. A radio path analysis has been performed to check the expected reliability of this radio path (ref. Figure 3-9).

Figure 3-9: Radio Path analysed for communications reliability.

Analysis and calculations by Jarrah Solutions concluded that Rayleigh Fade calculation yields a radio path availability of 99.98% which equates to 1hr 33m a year of unavailability in the radio link. This is considered an acceptable level of reliability for the purpose of managing Mullewa being supplied by the new Microgrid and interfacing successfully with the Western Power disconnection location ie. grid recloser (ref. Jarrah Solutions FEED Report for the results of the analysis, Appendix E)

3.8 Contribution to Power System Security and Reliability

Beyond Mullewa reliability the microgrid would contribute to system security and reliability by reducing line losses in the system and could provide voltage and frequency support.

The microgrid will also be applying to AEMO for assignment of capacity credits based on the solar and wind capacity, battery capacity and diesel generation capacity. The microgrid can therefore contribute to system security and reliability by providing additional generation to the system when called on by AEMO during peak events.

Contribution to long term security and reliability would be in the context of a possible future where towns at the end of long rural feeders may be targeted for disconnection from the grid, in preference to replacing the powerlines supporting them. Given this scenario the microgrid infrastructure would make it possible to support the town off-grid.

3.9 Fault Studies

The Mullewa Microgrid has been steady-state power system modelled using DIgSILENT PowerFactory2019 SP4 (Build 19.0.6 (9043) / Rev 66182). The detailed results are included in the Jarrah Solutions FEED Report (ref. Appendix E) and includes the following summary.

The studies performed were of a level of detail sufficient for the FEED study. It is noted that, should the project go ahead, a more detailed power system model will need to be developed and a more detailed protection study performed for a larger set of fault locations and operating scenarios. These studies have been allowed for in the estimate. New information and recommendations may evolve from these studies, however fundamentally it is believed that the concept of an island mode backup protection system that trips the Microgrid, and isolates the township, will be the feasible outcome.

3.10 The Operating Profile of the Proposed Solution

During normal operation when the grid supply is available the connected renewable generation will operate as per any grid connected renewable generation, supplying energy to the SWIS.

On detection of loss of the grid supply the system would check set permissions for islanding the network and on positive response would initiate the changeover procedure for opening of the grid recloser and for the near instantaneous uptake of the load via the battery (in the first instance or diesel genset if battery not available) which is supported by, in terms of recharging, by the local renewable generation (primarily) and if necessary (e.g. for extended down-time durations co-incident with periods of low solar and low wind generation) a diesel generator as last resort.

The full battery capacity will be registered for capacity credits. The Alternative Options proposal is based on 50% of the battery capacity being reserved for the Western Power reliability service, with the exception of instances where it has been called on in relation to meeting the Microgrids registered capacity obligations. In the rare circumstance where there is an outage while being called on by AEMO to provide capacity from the battery, then the diesel generators will still be available to uptake the town load. The 50% of the battery capacity not reserved will be available to the Microgrid Operator for energy arbitrage during normal operation.

3.11 Reliability

3.11.1 Requirements

Reliability standards applicable to electricity network operators are set out in the Electricity Industry Act 2004 (the Code). The standards prescribed in the Code require reliability performance measures to include all interruptions greater than one minute in duration.

The Code requirement for reliability is based on an acceptable “average total length of interruption of supply to customer premises expressed in minutes (SAIDI)”, with a different acceptable level applied to discrete areas of the network. Mullewa resides in the discrete area known as “any other area of the State” and the requirement for this area is a SAIDI value below 290 minutes. As a SAIDI value is only created for each discrete area, there is no specific reliability metric for Mullewa. The SAIDI value of for the area containing Mullewa 2021/22 was 1078 minutes in 2021/22 (1220 minutes for the 4-year average) and so with Mullewa reported as one of the worst performing towns in the SWIS it is expected it would have a SAIDI greater than the area average.

In addition to the code, there are reliability performance standards required under Western Powers Access Arrangement approved by the ERA, which are lower than that for the Code. The difference however is just in the target values, and they do not provide any greater definition on performance requirements beyond the discrete areas.

3.11.2 Benefits to Western Power for Improving Reliability

Given it is on this aggregated performance metric that Western Power reliability performance is assessed, the incentive is not necessarily there to improve reliability in Mullewa alone (as that would not have significant impact on the averaged reliability result for the area), which is why this proposal is intended for a pilot project to demonstrate the feasibility as a template for a repeatable model for the numerous towns at the end of long rural feeders that experience reliability issues. Having said this there is also shorter-term value for Western Power in improving the reliability initially just in Mullewa.

As part of the AA5[2] decision, the ERA will implement requirements for the annual service standard report prepared by Western Power under the access arrangement, to provide greater transparency of service standard performance across individual feeders or geographic areas. Separating out the performance of these lower reliability long radial feeders (such as that to Mullewa) from the average performance will likely expose WP to more scrutiny, that may lead to the ERA creating incentives for Western Power to improve performance in a more localised way. With incentives typically including penalties for poor performance, this could mean negative consequence for Western Power if it could not demonstrate improvements in reliability in the worst performing locations.

Further to this, In AA5[2] the ERA has accepted a capital allowance to be used to develop and implement an overall plan to address regional reliability including identifying and trialling solutions that improve reliability in pilot areas. Providing Western Power invests the allowance effectively to develop and implement an overall plan to address regional reliability, *including implementing solutions that improve reliability in pilot areas*, the service standard adjustment penalty relating to the difference between 290 minutes and the service standard benchmark proposed by Western Power (733.5 minutes) will not be imposed.

3.11.3 Current Reliability

Despite there being no formal published data on Mullewa alone, that can be used as specific metrics to measure Mullewa reliability performance against, outage data from January 2015 through to June 2023 was provided by Western Power for the customers in Mullewa and downstream Mullewa. This period includes the time at which the emergency response (diesel) generator (ERG) was installed (March 2019) and can provide some insight into the reliability performance for Mullewa pre and post installation of the ERG.

The outage data was analysed with the resulting interpretation shown in Table 1. Analysis of the data considered the following factors:

- Outage data included the number of customers affected and the cause of the interruptions. Based on the number of customers affected (noting there are approximately 290 NMI's - excluding extinct and vacant properties - associated with Mullewa and the downstream spur line), a judgement was made as to whether the fault was upstream or downstream of the town.
- Where the number of customers affected was less than the 290 NMI's, it was assumed the fault lay downstream the entry point of the town ie, within the town or on the radial network, and so these outages were discounted when considering outages that may be addressed through implementation of a microgrid.
- Planned outages were ignored.
- Outages associated with transmission or generation failures where the number of customers affected exceed 18000 and so evidently not associated with the reliability of the 100km radial feed to Mullewa, were also disregarded from a reliability review perspective (although a Microgrid with local renewable generation and storage would also solve outages related to those causes as well).

Table 1: Interpretation of outage data in terms of reliability pre and post installation of the Emergency Response Generator (ERG)

	Pre ERG		Post ERG	
Data period (days)	1525 (Jan 2015 – Mar 2019)		1466 (Mar 2019 – Apr 2023)	
No. of outage events over the data period	68		58	
Ratio of events to the data period	4.5%		4%	
Event Durations *	Until Initial Restoration	Until Final Restoration	Until Initial Restoration	Until Final Restoration
Total outage hours over the data period	180	459	199	633
Average outage hours per event	2.7	7	3.4	11
Max during the period (hrs)	15	24	30	94
Max difference between Initial and Final (single event)	23		78.4	
No. of events as % of total below 1 hr duration	49%	25%	70%	49%

* Note, as an outlier event, the outage resulting from Cyclone Seroja in April 2021 was not accounted for in the durations data

Evaluating the outage data in terms of reliability, Table 1 expresses this from the perspective of number of outage events, and also in terms of outage durations. In terms of the number of events there is no significant change pre and post the ERG installation. Similar for most of the outage duration metrics, there is nothing to suggest any improvements since the ERG installation, in fact it could be argued the data suggests a possible decline in reliability. If however these two perspectives aren't looked at in isolation, and the number of outage events that have a duration below 1hr considered, it appears that this is where the provision of the ERG may have resulted in some positive results.

The ERG can only react to an outage and so in essence doesn't solve reliability but can mitigate the consequences. This is evident in that essentially there is the same number of outages of the main 100km radial feed supplying Mullewa pre and post ERG. Even though there is not a reduction in total outage hours is observed, the number of instances where outages have been kept below 1 hour has increased since the ERG was installed.

It is understood that there has been significant maintenance works performed on the line from Geraldton to Mullewa over the last months, however how much that can improve overall reliability is limited. According to Western Power

NOM2022 [1] generally less than a third of outages are directly controllable by Western Power and the remainder due to windborne debris, extreme weather events or caused by a 3rd party.

The main thing that can be concluded from this, is that the ERG has a limited effect on reliability, only reducing the consequences of outages, without solving the reliability issue and infrastructure upkeep can only contribute so much – meaning there is an opportunity for implementing a more effective reliability service.

What is not evident from this data is what the reliability would have been like if the ERG had not been installed. ERG operating data that was provided gives an indication of this. It showed that between March 2019 and March 2022 it operated for a total of 611 hrs across the two generators, 416 hrs of which are assumed to be associated with cyclone Seroja in April 2021. The ERG has therefore clearly had a positive impact on the town of Mullewa, even if it is not a complete reliability solution. It also reinforces the value of local generation in whatever form it takes.

3.11.4 Reliability Improvements from Proposed Solution

When talking of improving reliability with this proposal, it is in relation to overcoming the loss of supply via the feed from Geraldton that supplies Mullewa and the downstream spur. So solving this means providing power to the town and spur when a fault somewhere along the 100km of line from Geraldton to Mullewa disrupts the grid supplied power. Faults within the town, that may impact a portion of the town, or faults downstream the town which may impact customers on the radial line, are not solvable within the scope of this proposal. As can be seen from Table 1 however there is still significant scope for improving reliability in the context of overcoming upstream faults and the proposal achieves this, fundamentally via the automation of the islanding process and less than one minute uptake of the load via the battery or diesel genset.

The reliability value for Western Power is therefore in the form of the automation. Accordingly, this service could essentially be provided via an automated reliability service based on a diesel genset alone. The premise of this proposal however, is that the reliability service can be offered at a comparable or better price when combined with local renewable generation and battery storage.

Assuming the proposed solution mitigates against outages associated with the upstream supply, the reliability of power supply for Mullewa comes down to the reliability of the Microgrid system infrastructure and design, ie. it's ability to perform when called on.

In terms of hardware failures, the reliability of the Microgrid infrastructure would be orders of magnitude higher than that for the 100km of ageing powerline infrastructure, with high susceptibility to its environment, e.g. from storms, lightning and impacts from foreign objects.

The proposed wind turbines are second hand units from Europe, however they are inspected and refurbished, with BlairFox (the supplier) having proven this approach in other wind farm installations.

In terms of the design, all of the equipment is from reputable manufacturers with proven service records. The control, automation and protection solution provided by Jarrah Solutions delivered as a containerised unit is based on similar designs that have been proven in service in the SWIS at installations for the PEEL Renewable Energy Microgrid and Image Resources Boonanarring Solar Farm.

It will be the first time Jarrah Solutions has utilised a radio system for communications, however the equipment selected is from a reputable manufacturer, it meets the necessary Western Power specifications/standards, has been proven in service through numerous other applications, and has been tested as part of the FEED development work.

Despite the stand alone reliability of the individual assets, there is also another level of reliability built into the design in terms of redundancy. There are four available sources for charging the battery; solar generation, wind generation, diesel-genset generation and the grid supply (although do not plan to utilise charging from the grid). Any of these charging sources are available (with exception of grid supply when islanded) and capable of charging the battery independent of the others, in the event that one or more are lost. In terms of taking up the load on initial loss of grid supply, if the battery is not available then the diesel genset is available as a back-up measure.

3.12 Consistency with Western Power Technical Specification/Scope and Statutory Requirements

The proposal is consistent with Western Power technical specifications and statutory requirements.

4 Implementation Timeline and Key Milestones

Key milestones that have been completed to date are:

- Front End Engineering Design (FEED)
- Planning application submitted
- Alternative Options Proposal submitted to Western Power

Key milestones to be completed prior to execution phase and following in principle agreement with Western Power to proceed:

- Submission to ARENA for funding (to de-risk the project) from their Regional Australia Microgrid Pilots Program
- Pass FID, ie. finalise agreements with investors for project financing.

An indicative schedule for the project execution is provided in Appendix A. This identifies a total period of 13 months to complete the project. The planned start date currently assumed is February 2024.

Based on the indicative schedule, key milestones and the time at which they occur beyond the planned start date, are:

- 1 month - Major Procurement orders placed
- 2 months - Geotech survey and foundation design for wind turbine commence
- 4 months - Civil works for wind turbines commence
- 6.5 months - Wind turbines received in Australia and refurbishment commences
  - Wind turbines electrical/comms work commences on site
- 8 months - Solar farm and battery long lead deliveries received on-site
  - Site works for solar farm commence
- 8.5 months - Wind turbines installation commences
- 9.5 months - Site works for connection site commence
- 11 months - Wind turbine installation complete
  - Connection site installation complete
- 12 months - Solar farm construction and battery installation complete
- 13 months - Commissioning complete

5 MEASUREMENT AND VERIFICATION PROCEDURES

The control system implemented by Jarrah Solutions will be capable of monitoring and recording all of the applicable metrics necessary for assessing the reliability performance of the service provided to Western Power.

The system will log all of the grid outage events, including the system response times to achieve load uptake and then details of the time in island mode and energy supplied to the Microgrid during this time from each of the generating assets.

This data can then be shared with Western Power so that they can compare to previous reliability performance enabling them to demonstrate that the AA5[2] requirement for reliability improvements from a pilot program have been met.

6 PROPOSED OPERATION AND CONTRACTUAL COMMITMENTS, INCLUDING FINANCIER COMMITMENTS

The proposal for how the reliability service would be priced and the associated commitments are as follows:

- As a general principle the service has been costed as less than the estimated cost of Western Power providing a reliability service itself using installed diesel generation combined with automation and protections to achieve a similar reliability outcome for the town and spur.

- The cost to provide the service in terms of a network tariff applied to the generation is accounted for in the service price. The proposal is that this is done as a net cost to Western Power, i.e. the network tariff is not charged to the service provider and the service provider then simply charges the cost for the NCESS service

  Note 1: would be willing to consider doing this as a gross cost, if this was preferred by Western Power, where the service provider is charged the network tariff and then recoups this by adding it to the AOS service fee.

  Note 2: the estimated cost for an RT11 distribution entry tariff if applied to the Microgrid, based on a 2MW DSOC and 92km to Geraldton substation would be in the order of $150,000 per year, of which about $127,000 is contributed from the variable demand length charge based on distance to closest zone substation (Geraldton).

- The terms are a fixed annual price (paid quarterly in advance) based on a 10 year contract, with the possibility to extend.

- The pricing is independent of the number of times it is called on.

- The service is subject to a maximum grid outage duration of 3 days in one outage period and a total of 30 days over a year. If grid outage extends beyond either of these limits, then Western Power would be subject to an additional payment (which is predetermined and included in the contract) to cover the cost associated with operation of diesel generation assets.

- Penalties to apply to the service provider if they cannot support the load when called on.

- The basis of a DSOC accounts for the town load. DSOC proposed is 2MW. During normal operation a 1.5MW would be sufficient, however 2MW is requested to enable generation of potentially all available generating assets (ie. wind, solar, battery and diesel) on the few occasions where the Microgrid may be called on by AEMO to meet its capacity credits obligations during system peak events.

- Return to investors is based on a 20 year asset life.

7 ITEMISED PROPOSAL

Service:

- On loss of the grid supply to the town of Mullewa and downstream spur line, the town and spur network will be automatically islanded and the load automatically taken up by the Mullewa Renewable Microgrid within the one minute limit to ensure it is not logged as a power supply interruption.

- Once in island mode, operation of the resulting islanded microgrid will be by The Microgrid Operator (MO) who will be responsible for managing the generation/storage to support the load, until such time that the grid supply is restored and Western Power confirm that operational control and support of the load can be returned to them.

Service Fee: [redacted] per annum, adjusted annually in accordance with the CPI as defined in Western Power's Alternative Options Contract template. The basis for this fee is [redacted]

Conditions:

- The network costs for connection of the Microgrid generation and storage are accounted for in the service fee and so a network tariff is not charged for the connection.

- For single grid outage events exceeding 3 days in duration WP will be charged for costs associated with running diesel for extended periods (based on actual diesel genset kWh generated), using a price of [redacted] adjusted annually based on the average annual WA diesel price for the financial year in question (to be clear, if the diesel genset doesn't run then there will be no cost).

- For grid outages where total duration over a financial year exceeds a total of 30days/720hrs (excluding outages in excess of 3 days covered in the point above) WP will be charged a 10% uplift on the annual fee to cover increased operational expenses associated with "excessive use" of the service.

- Failures that occur within the islanded network that prevent the Service Provider from meeting their service obligations are the responsibility of Western Power and will not constitute a "failure to meet service obligations" as described below.

Penalty for failure to meet service obligations:

- Service Provider will cover the cost of any validated customer compensation claims against Western Power resulting from the associated grid outage.

- Service Provider will refund to Western Power a % of the annual fee equivalent to the number of hours per year the service fails to meet its obligations relative to the total number of hours in that year that it has operated when called on, up to a maximum of 20%.

8 POTENTIAL RISKS

Event	Risk	Mitigation Options	Residual Risk Level
Estimated Risks to Western Power (WP)			
Project Delays	Would delay timeframe in which reliability improvements would be seen and potentially impact on WP's ability to sufficiently demonstrate improvements sufficient to avoid penalties	Set realistic execution schedule with sufficient contingency to manage unforeseen events. Set commitment based on agreed FID date that allows time for pre-execution activities to be completed.	Low
Service Fails to Perform when called on	WP may incur penalties by not being able to demonstrate sufficient reliability improvements	Ensure designers have suitable qualification and experience to complete a robust design and conduct design review	Low
Service Provider Operates at a Loss	Risk of increase costs for the service in response to ultimatum from service provider that service costs must increase or risk losing the service altogether if the service provider goes out of business	Set WP as the operator of last resort so they can continue operation of the service in the event the Service Provider goes out of business	Low
Incident Occurs in Mullewa Network while operating is islanded mode	Arguments over responsible party when WP not in operational control leading to litigation	Ensure assignment of responsibilities under these scenarios are thought through and captured in the service agreement contract	Low
WP reject the Reliability Service Proposal	WP don't meet their obligations under AA5[2] to demonstrate improvement in reliability in pilot areas exposing WP to the possibility of commercial (and potentially reputational) penalties	Seek out alternative solutions for improving reliability for fringe-of-grid towns	Medium
WP seek out competitive reliability solutions via a tender process	Risk not receiving an offer with any improvement in price or performance over this proposal and have lost that time and money associated with a tender process	Proceed with the Mullewa Renewable Microgrid Proposal pilot and consider a second pilot to be sought via expressions of interest and tender process	Low
WP propose to do in house	With the current WP work load may lack the resources to execute in an acceptable timeframe	Proceed with the Mullewa Renewable Microgrid Proposal pilot and consider a second pilot executed in house	Low
Project Risks – Pre FID			
WP reject the reliability service proposal	Project no longer viable	Put the project on-hold until the environment is more open to an embedded network commercial model	High

Event	Risk	Mitigation Options	Residual Risk Level
WP insist on a radio communications link back to Geraldton substation	Project no longer viable due to excessive capital cost	Enter discussions with Western Power to understand what is driving this requirement and investigate viable alternative solutions that satisfy the same requirements	Medium
Can't get an off-take agreement with Synergy	Unable to sell the energy, such that the project is no longer viable	Seek offtake agreements with other retailers Look at selling to WEM at balancing market price via 3rd party service	Low
Not accepted by ARENA for funding	Unable to de-risk the project to a sufficient degree to attract a financier	Look at other funding options	High
Can't secure an investor	Project is no longer viable	Put the project on-hold until the environment is more open to an embedded network commercial model	High
Can't secure a reasonable DSOC	Reduces commercial return expectation such that can't secure an investor	Look at other means of grant funding to compensate for this. If related to line capacity investigate with WP possibility of dynamic capacity rating	Medium
Aren't assigned capacity credits in line with expectations	Reduced commercial performance	Submit application to AEMO as soon as possible. Look for expressions of interest for Supplementary Reserve Capacity that could be applied for	Low
Project Risks - Execution			
Site access delays	Schedule delays, cost overruns, unable to meet the target date	Coordinate site access with land owners	Low
Western power delays for connection approvals and/or construction of the extension of the WP network to the connection point	Schedule delays, cost overruns, unable to meet the target date	Start approval process well in advance of required date. WP consider sub-contracting construction of the extension to the project, given the project will already have assets on-site to build the projects powerline scope	Low

Event	Risk	Mitigation Options	Residual Risk Level
Project Estimate for WP network extension exceeded	Greater than expected costs impacting commercial performance	Allow for additional contingency. Discuss possibility of project executing the work on behalf of WP in order to keep costs down	Low
Aboriginal Heritage	Evidence of Aboriginal heritage discovered during site works requiring works to stop	Organise Aboriginal heritage assessment of the sites (and possible survey if required) prior to project commitment	Low
Loss of key personnel	Schedule delays, cost overruns, unable to meet the target date, market conditions currently resource constrained	Maintain healthy working environment so personnel are happy to remain engaged with project, replace key personnel with alternative personnel as required	Low
Project Risks - Design			
Delays in detailed design of system	Schedule delays due to delays in placing procurement orders	Start detailed design well in advance of required date so procurement is not impacted	Low
2nd Hand Wind Turbines	Older 2nd hand turbines may pose challenges in meeting new technical rules and obtaining approval to connect them to the network	Select turbines that comply with the required rules and regulations and has a proven track record. Check the selected turbine with Western Power. With battery incorporated into the overall system this can assist in meeting necessary technical requirements	Low
Project Risks - Procurement			
Volatility of currency exchange rates	Australian Dollar continue to fall below $0.60 to USD, cost escalation	Hedge USD or EUR	High
Volatility of panel pricing	Currently volatile due to world conditions	Place order when possible and manage closely	Medium
Volatility of cable pricing	Currently volatile due to world conditions	Place order when possible and manage closely	Medium
Logistics pricing and delays	Currently volatile due to world conditions and overseas items subject to delays. Procurement items with highest risks include: Panels, Tracking System, Inverter Stations, HV switchgear and. Transformers	Place order when possible and manage closely	High

Event	Risk	Mitigation Options	Residual Risk Level
2nd Hand Wind Turbines	Used turbines typically lack guarantees and manufacturer support. Purchasing used turbines from overseas involves responsibility for dismantling them which can led to runaway costs.	Look for Turbines that have been operated under a manufacturers service agreement to ensure reliability and support. Conduct thorough due diligence by performing inspections on the turbines. Purchase operating turbines and identify worn components that may require refurbishment while they are on the ground. Visit the site in person to meet the owners and gain a comprehensive understanding of the turbine service history. Choose a trusted partner with a proven track record in selecting, purchasing and dismantling used turbines	Medium
Wind Turbine Transport	Significant logistical challenges as well risk of biosecurity issues as the turbines mat be contaminated from agricultural properties and navigating through different countries permits and transport rules	Use partners with a proven track record who are familiar with the potential challenges that may arise. Initial early planning and ensure a proactive presence on the ground	Medium
Project Risks - Construction			
Rock Present	Piling and trenching delays	Piling will require pre-drilling, trenching will be trialled	Low
Contamination	Risk of dieback or fungal contamination when brining vehicles and imported fill into site	Establish appropriate measures for vehicle and material entry to site	Low
Manual Handling	Personal injury	Experienced installers and purpose built installation aids will be used to handle racking, panels and cable	Low
Electrical	Personnel injury & plant/equipment damage	Experienced electricians will be used to install electrical system	Low
Lifting	Crane overload/collapse, Personal Injury, & damage to plant, equipment, environment	Experienced crane operator and riggers will be used, minimal number of lifts	Low
Rubbish	Control of rubbish from site, in particular panel packing	Establish separate panel staging area to unpack panels in order to control and contain rubbish	Low
Dust	Airborne dust interferes with construction operations	Appropriate PPE, depends on time of year	Low

Event	Risk	Mitigation Options	Residual Risk Level
Labour Market	Labour difficult to find and retain given current market	Use known personnel and sub-contractors to maintain experienced personnel	Low
Vandalism/theft	Construction close to town will require additional security provisions for materials and equipment	Cameras, security guards	Low
Weather	Risk of Solar panel damage from extreme weather events (beyond design limits), e.g. hail, flooding etc. In particular during construction before tracking system has come on-line	Put in place appropriate insurance. During construction ensure panels are secured in "stowed" position.	Low
2nd Hand Wind Turbines	Degree of uncertainty during construction when 2nd hand turbines involved	Involve the team who dismantled the turbine.	Low
Project Risks - Operations			
Fail to meet service obligations when called on	Commercial risks due to penalties associated with not meeting obligations	Use experience and qualified design and construction personnel Ensure thorough commissioning process	Low
Wind Generation does not perform as expected	Commercial risks as income will be reduced		Medium
Vandalism	Damage to assets that prevent the service from meeting its obligations	Limit access through fencing and implement deterrents such as video surveillance Have insurance in place to cover this possibility	Low
Change in contract prices at end of initial contract terms	Commercial risk as may not be able to renew reliability service contracts and energy take-offs for the same prices as the initial terms.	Allow for reduced return in the commercial model for the period after the initial term contracts	Low
Microgrid Instability	This is a complex network with integration of diesel, batteries and renewables in an islanded (off-grid) remotely located context. There is a risk of unplanned outages caused by Microgrid instability.	Use Experienced design, construction and commissioning personnel Electrical system protections will be in place to ensure that Mullewa customers are disconnected and isolated if the Microgrid does not meet the required power quality requirements Monitoring over time will be provided and compliance monitoring can be performed.	Low

Event	Risk	Mitigation Options	Residual Risk Level
Equipment Failures	Commercial risks due to possible penalties associated with not meeting service obligations and cost injections associated with breakdowns.	Procure equipment from reputable manufacturer's with proven service records. Put it place planned maintenance schedule in accordance with manufacturers recommendations. Monitor equipment performance to identify potential issues so they can be rectified prior to resulting in breakdowns	Low

9 Applying The Repeatable Model

As discussed, the Mullewa proposal is presented as an opportunity for a pilot project in the context of becoming a repeatable model for a number of towns at the end of long rural feeders on the SWIS that experience reliability issues. If proven successful in Mullewa the ambition would be to roll out this model to other locations. A list of towns that may be considered as suitable candidates is provided in Table 2. The first five towns are taken from the Western Power "Network Opportunity Map 2022" (NOM2022) [1], which identifies towns that have a reliability focus from WP. As stated in the NOM2022 "*these localities are typically characterised by supply via long overhead network feeders, that are susceptible to both frequent and longer duration supply interruptions and a step change in the network's topology supplying these locations is needed to remove their dependence on the long radial overhead network, where this action proves economic".*

Table 2: List of some potential candidates for a reliability service based on the Mullewa Microgrid Model

Town	Sub-Station	Population	Customer Number
Western Power Reliability Focus			
Port Denison	Geraldton	1452	1098
Dongara	Geraldton	1393	1258
Lancelin	Regans & Yandin	786	1068
- Nilgen		229	
- Karakin		246	
- Ledge Point		235	
Denmark	Albany	6467	1579
Other Towns for Consideration			
Morawa	Three Springs	459	
Carnamah	Three Springs	407	
Corrigin	Kondinin	903	
Ravensthorpe	Katanning & Kondinin	580	
Dalwallinu	Moora	826	
Jurien Bay	Eneabba & Moora/Yandin	1985	
Quairading	Cunderdin	619	
Cervantes	Cunderdin	480	

The estimated capital cost of the Mullewa Renewable Microgrid is relatively high as it reflects the "first-of-its-kind" nature and the inherent risks and teething work associated with this. Once proven and the lessons learnt from Mullewa could be integrated into a repeatable model, the expectation is the capital cost to implement at other locations would come down. This will offset the requirement for ARENA support in this first instance but could then result in a lower cost service to Western Power (on a per customer / per MW basis).

10 About Sunrise Energy Group

10.1 Company Information

Sunrise Energy Group (Sunrise) is a renewable energy project developer, but unlike most project developers, Sunrise seeks to have a "whole of Life" relationship with its customer. In our opinion, this is a necessary requirement when delivering projects either via a direct corporate PPA/offtake arrangement or capex purchase. This is because we aim to develop and grow relationships so that we can work together to deliver success throughout the entire project life, including the operations and maintenance phase.

Project delivery, operations and maintenance and ongoing value enhancement all matter to Sunrise, as they are core to a successful "whole of life" relationship. Sunrise has therefore taken a significant amount of time over the past 5-6 years to pull together a suitable delivery model for the construction, operation and ongoing value enhancement for the projects we develop or assist in developing.

10.2 Experience

Sunrise has valuable experience in delivering renewable solutions, providing consultancy advice and developing high level concept models for a variety of clients. The following summaries provide an overview of some of our most recent work:

Image Resources - 3MWp Boonanarring Solar farm

The customer is Image Resources who have a PPA for the offtake from the solar farm "behind the meter". The asset owner is Climate Capital. The below aerial photo of the solar farm was taken shortly after the successful commissioning in September 2020. The solar farm uses high efficient Longi solar panels and a NEXTracker single axis tracking system to ensure optimal performance.

The 3 MW solar farm is constructed in 3 arrays each of around ~1 MW, all connected to a single 2.5 MVA SMA inverter/transformer. The powerline connecting the solar farm to the connection point container is around 1.9 km and must traverse 2 gas pipelines and abide by environmental constraints (avoiding TEC vegetation) as well as going under the main mine access road. This project was delivered on time and on budget within the constraints and challenges provided by the Covid19 pandemic, including impacts to logistics and construction operating protocols.

Photo: Aerial shot of the solar farm shortly after commissioning in September-20

Image Resources

We have been working with Image Resources in a consulting role since July-21 to help them develop renewable solutions for their new mine site and to project manage a new grid connection. The new mine located approximately 130km North of Perth requires a new 25 km overhead network to be installed for the main processing plant. The mines camp and bores however will not be able to be grid connected therefore we have been working with the client to design suitable off-grid stand-alone power systems (SPS) to accommodate their power requirements.

Image Resources has also engaged Sunrise to assist with developing an energy strategy and execution plan for its other projects currently under development as each project moves through to FID.

Peel Business Park 1.2 MWdc/1 MWac Solar Farm and 1 MW/2 MWh Battery Storage

The Peel Business Park at Nambeelup, approximately 68kms south of Perth, is a strategically located industrial estate designed with a focus on agri-innovation and sustainability. This project is our first joint development with Peel Renewable Energy and Synergy – a consortium established to build, own and operate the industrial park's renewable energy embedded microgrid.

Photo: Solar farm shortly after installation of panels Dec-2020

The initial ground mounted 1.2MWp Solar Farm, 1MW/2.5MW Battery Energy Storage System (BESS) and smart sub-station for the renewable energy microgrid operates "behind the meter" and is scalable as energy demand within the park grows. This Australian first renewable energy industrial microgrid now supplies customers at the Peel Business Park with safe, reliable and renewable power at a meaningful cost saving to regulated electricity tariffs.

Using high efficiency Longi mono-PERC bifacial solar PV panels, a NEXTracker single axis tracking system, FIMER skid mounted inverters and transformer and a SAFT BESS, we are providing a renewable solution that can be expanded upon utilizing additional warehouse rooftop mounted solar arrays as the park grows.

Peel Renewable Energy operates the microgrid as they are licensed by the Economic Regulation Authority (ERA) of WA as both an Electricity Distributor and Electricity Retailer.

The smart substation was energised in August 2020, the solar farm was installed in late 2020 and the BESS was installed in February 2021. The system was commissioned and energised in March 2021. This project was delivered on time and on budget within the constraints and challenges provided by the Covid19 pandemic, including impacts to logistics and construction operating protocols.

Photo: Government of WA media statement photo pertaining to jobs growth created by renewable energy microgrid

Wildwood Estate: 230kW Solar PV, 250kW/600kWh BESS & 176kVA Generators

Wildwood Estate is the holiday estate for a wealthy mining family, south east of Yallingup in Western Australia. Sunrise identified an off-grid stand-alone power system (SPS) solution as an opportunity to avoid the high costs associated with the required network connection upgrade.

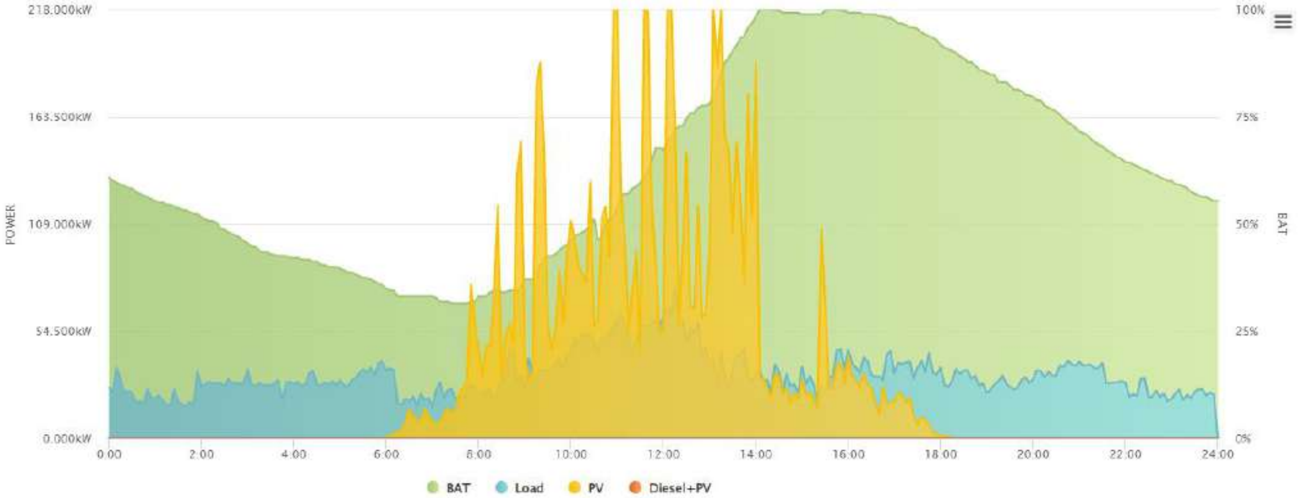
Through consultation and analysis of the energy options available, Sunrise designed, supplied and installed a "small commercial solution". The solution comprises of a 600kWh AlphaESS battery with a 250KW Sinexcel battery inverter, a 230kW solar PV array with 4x50kW GoodWe solar inverters and two 176kVA backup diesel generators.

The system was commissioned in September 2020 and has been running well since. The solar and battery can accommodate the maximum daily consumption without the use of diesel during reasonable weather conditions. In the first year of operation the system has provided more than 85% renewable content to the owners saving them electricity costs and creating a positive environmental impact.

The 230kW Solar Array

The 250kW / 600kWh BESS

Real time monitoring and control of the system is achieved through the energy management system (EMS). The below image shows an example of the EMS dashboard showing the generation and consumption data as well as the state of charge of the BESS.



Koobeja – Log Cabin: 40kWp Rooftop Solar PV array, 50kW/100kWh BESS & 50kVA Generators

In July 2021, we completed the installation of another SPS for the Wildwood owners at their Koobeja property in The Lakes, Western Australia. The solution comprises a 50kW Sinexcel hybrid inverter and 100kWh of battery storage capacity using AlphaESS batteries and 40kWp of solar PV. The solar is mounted on a shed at the property and connected to the hybrid inverter that is housed in a custom-built plant room that was added to the back of the shed. A 50kVA diesel generator is also connected to the system and a second 50kVA diesel generator is available for backup or maintenance via a manual transfer switch.

Koobeja – House: 65kWp Ground Mount Solar PV array, 50kW/195kWh BESS & 88kVA Generator

In March-23, we commissioned a stand-alone power system (SPS) for a newly built home on the Koobeja estate. To maintain aesthetics, a custom plant room to house the battery and associated electrical equipment was designed and built. The 65kWp north facing ground mount solar array was installed, consisting of three rows with the plant room and diesel generator situated at the south end.

The client wanted high renewable content for this system, ideally as close to 100% as possible. They also wanted us to design the system so that it could support EV charging and make provisions so that the system can be expanded in the future. To help achieve this we created a load profile for the property which was then extrapolated into a 12-month synthetic load. Using this data, we modelled the solar generation and battery storage so that we could define the system requirements to achieve high renewable content. An 88kVA diesel generator was installed so that during winter when lower solar irradiance is expected the generator can support the house load and quickly charge the battery, reducing diesel run time and consumption.

The 65kWp Ground Mount Solar Array

Custom Built Plant Room for the BESS

Koobeja - Shed: 34kWp Rooftop Solar PV array, 50kW/68kWh BESS & 50kVA Generator.

Another SPS at the Koobeja estate for the new farm shed is due to be commissioned in April-23. Another custom plant room to house the battery and associated electrical equipment has been designed, built, and installed for this system.

PNX Metals: 4.6MWp Solar Farm, 2.3MW/2.3MWh BESS & 3,000kVA Generators

In December 2021, PNX Metals made an ASX announcement that Sunrise are the preferred supplier for their power plant at their Fountain Head Gold Mine project in the Northern Territory. We completed preliminary analysis and modelling of the mines forecast load requirements and proposed that a 4.6MWp Solar Farm, 2.3MW/2.3MWh BESS and three 3,000kVA diesel generators would offer the best value. We now look forward to being contracted in mid-2023 to complete the FEED study report for the proposed power plant.

Murray Engineering – FEED Report for a 1MWp Solar Array

We completed the preliminary modelling and analysis of Murray Engineering's new warehouse load requirements and proposed that a 700kW to 1MW rooftop solar system would provide them with the greatest value for money. In October 2021, we were contracted by Murray Engineering to complete the FEED study report for the system. In addition to the FEED report we have been helping the client navigate their way through the connection process with Western Power.

Collgar Wind Farm (CWF) – Front End Engineering Design Report for a 7MWp Solar Farm and 4MWh BESS

In August 2022, CWF awarded Sunrise the contract to complete the FEED for a 7MWp solar farm. The FEED includes the activities and engineering design work that needs to be undertaken to accurately cost the capital investment of the project. Integral to this FEED report is the design of the control system so that the solar PV can be integrated with the existing Vestas control system and AMSC's reactive power units whilst maintaining technical compliance.

The FEED report also includes such things as the preliminary electrical drawings, solar farm grid connection, integration and communication report and a procurement and construction schedule.

Our report also documents the key risks that remain on the project, the likelihood, and consequences of them occurring and the proposed mitigation measures we can undertake to reduce them. We expect CWF to make an investment decision on the project in Q4, 2023.

Infinite Green Energy (IGE): Arrowsmith Green Hydrogen Plant

Sunrise have been providing consultancy services to IGE since 2017 to help develop their hydrogen processing plant concept. In early 2020, IGE contracted us to complete the Front-End Engineering Design (FEED) report for the renewable power supply for stage 1 of their proposed Arrowsmith hydrogen plant.

The plant has been designed to scale up as demand for hydrogen grows making it one of the world's largest renewable hydrogen production facilities. In collaboration with Avora Energy and Jarrah Solutions we designed a 65MW solar farm, a 90MW wind farm and smart sub-station for the plant. We also provided modelling and analysis as to whether a battery energy storage system (BESS) could add value to the project. Included in this modelling was analysis of the economic value of market participation in regard to selling and buying energy at WEM balancing rates.

REFERENCES

1. Network Opportunity Map 2022 (NOM2022), Western Power, 1 October 2022
https://www.westernpower.com.au/media/6282/network-opportunity-map-2022.pdf

2. 2022-2027 Access Arrangement for the Western Power Network (AA5), ERA, 31 March 2023
Access Arrangement 2022-2027 - Economic Regulation Authority Western Australia (erawa.com.au)

APPENDIX A

Indicative Schedule

APPENDIX B

Electric Layout - Single Line Diagram

APPENDIX C

Layout Drawings

Includes:

1. Overall Site Layout
2. Solar Array Layout
3. Turbines Layout
4. Connection Site Layout Drawings – Plan, Elevations and Isometric

APPENDIX D

Equipment Data

Includes:

1. Solar Panel Datasheet
2. Tracking System Datasheet
3. MV Power Station and Inverter Datasheet
4. Battery Datasheet
5. Diesel Generator Datasheet
6. Wind Turbine Size Data

APPENDIX E

Studies

Includes:

1. Jarrah Solutions FEED Report
2. Jarrah Solutions System Line Loss Calculations