EnergyConnect
Connecting Community through Micro-Grids

Muralug Microgrid

Feasibility Study

April 2023

Acknowledgements

This report acknowledges the Traditional Owners, those people with historical association and all community members of the Muralug Island community and acknowledges that their customs and traditions have nurtured and managed the land and sea for centuries.

Ener-G, ITP Renewables, Missing Link and Planz as EnergyConnect thank the Kauri Group for their assistance in preparing the financial assessment of project options, and Energy Queensland for their advice during the development of potential power supply solutions for Muralug Island.

We also thank Torres Shire Council and Torres Strait Regional Authority for their interest in this project.

Finally, we thank the residents of Muralug Island who welcomed us into their community, invited us into their homes and gave us their time to discuss the challenges of living in their special part of the Torres Strait. We greatly appreciate the assistance we received in ferrying our team between Thursday Island and Muralug Island, arranging meetings with residents, and transporting us around the island while on site.

EnergyConnect

Email: projects@energy-connect.net.au

www.energyconnect.net.au

About the Partners

EnergyConnect

EnergyConnect is the brand name for microgrid projects being undertaken in regional Australia by the following businesses led by Ener-G Management Group.

Ener-G

Ener-G Management Group specialises in renewable energy, sustainability, and remote energy supply. We provide renewable energy project concept planning and feasibility studies, with specialities in off-grid and remote power station planning and management, grid connection assessment for embedded generation, opportunity evaluation for energy efficiency, and preparation and implementation of energy efficiency and demand management programs.

Ener-G Management Group has a broad range of experience in general management and senior management roles for over 30 years with electricity and gas energy distribution companies in Victoria and Queensland. Ken, Oscar and Geoff have undertaken many electrical engineering and asset management functions such as system specification, design, construction, procurement, standards, maintenance and project management for integrated grid networks, and including Isolated diesel/renewable generation sites in northern and western Queensland, and across the Pacific. Ken has also led large initiatives such as the introduction of mobile substations and mobile generators and providing standardised maintenance programs across Queensland.

ITP Renewables

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

ITP provides specialist services that encompass the full spectrum of project development, from project scoping and feasibility studies through to construction and monitoring, ITP has a strong track record providing specialist technical expertise and strategic advice on the development and implementation of microgrids in Australia and New Zealand. ITP have undertaken feasibility studies of microgrids for utilities and local/state government and been engaged to design, specify and provide construction supervision of projects at precinct scale, to entire developments and towns. ITP are known as experts in batteries and distributed energy technologies.

The Missing Link

The Missing Link - Resource Coordinators assist communities, businesses, government agencies and not-for-profit organisations to reduce their environmental impacts, improve their strategies for sustainability and to engage meaningfully with stakeholders. For over 20 years our knowledge and expertise has taken complex science, engineering or government policy and translated it into 'real language' helping clients to understand what applies to their operations and providing practical advice on how to make it work.

Focusing on the transition to low carbon economies we work with a wide range of clients across the energy sector delivering quality support to individuals and organisations, advancing communities and large-scale renewable generators.

Planz Town Planning

With over 25 years' experience in local government and private enterprise in the region, Planz has strong working relationships with Far North Queensland councils and regional communities. Planz have been involved in the drafting and review of many of the planning schemes in the region, including 14 Aboriginal Shire Councils, Hinchinbrook Shire Council, Cassowary Coast Regional Council, Tablelands Regional Council, Cairns Regional Council and Richmond Shire Council. We understand living and doing business in regional and rural areas and are committed to providing tangible, culturally appropriate outcomes for communities.

Planz has been awarded multiple times for public engagement and community planning by the Planning Institute of Australia (Qld). From public notification to workshop facilitation, we are experienced in engaging a diverse range of stakeholders to understand projects and participate in the planning process. Nikki Huddy is a Fellow of the Planning Institute of Australia, Australian Planner of the Year 2020–21, and Queensland Planner of the Year 2019.

About This Report

The Muralug Microgrid Feasibility Study aims to analyse the options and develop solutions to showcase Muralug as a self-reliant, sustainable community with renewable energy applications that can be applied to other similar remote and isolated communities. It considers both microgrid and individual standalone power supply opportunities.

This report was commissioned through the Australian Government's Regional and Remote Communities Reliability Fund administered by the Department of Climate Change, Energy, the Environment, and Water.

The work for this study has been led by Ener-G Management Group working in collaboration with ITP Renewables, Planz Town Planning, and The Missing Link.

This report complements microgrid feasibility studies prepared by EnergyConnect for the Yarrabah and Napranum communities.

Abbreviations

ABS	Australian Bureau of Statistics
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ARENA	Australian Renewable Energy Agency
BESS	Battery Energy Storage System
BoM	Bureau of Metrology
CSO	Community Service Obligation
DC	Direct Current
DERs	Distributed Energy Resources
DNSP	Distribution Network Service Provider
DOGIT	Deed Of Grant In Trust
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization
EQL	Energy Queensland Limited
ERP	Estimated Resident Population
FNQROC	Far North Queensland Regional Organisation of Councils
ILUA	Indigenous Land Use Agreements
IPS	Individual Power System
ISO	International Organization for Standardization
KAC	Kaurareg Aboriginal Corporation
kV	Kilovolt
kVA	Kilovolt-ampere
kW	Kilowatt
kWp	Kilowatt Peak
LGA	Local Government Area
LPG	Liquified Petroleum Gas
LRET	Large-scale Renewable Energy Target
MID	Ministerial Infrastructure Designation
ML	Megalitre
MVA	Megavolt-amperes
MW	Megawatt
MWh	Megawatt hour
NIAA	National Indigenous Australians Agency
NPA	Northern Peninsula Area
NREL	National Renewable Energy Laboratory (US)
O&M	Operation & Maintenance
PBC	Prescribed Body Corporate
PV	Photovoltaic
QCA	Queensland Competition Authority
RAMPP	Regional Australia Microgrid Pilots Program
RAPS	Remote Area Power System
RNTBC	Registered Native Title Body Corporate
RRCRF	Regional and Remote Communities Reliability Fund
SAPS	Stand Alone Power Supply
SEIFA	Socio-Economic Indexes for Areas
SRES	Small-scale renewable energy scheme
TSC	Torres Shire Council
TSRA	Torres Strait Regional Authority
VRE	Variable Renewable Energy

Contents

Tables

Figures

Executive Summary

This feasibility study assesses a range of options for a sustainable microgrid and alternative renewable energy solutions for residents of Muralug Island, a small community of about 110 residents, located in the Torres Strait near Thursday Island, in Far North Queensland, Australia.

The authors proposed a microgrid to link three of the four main residential areas at Muralug and compared this with an alternative solution using individual household standalone power supplies (IPS). The IPS deployment model was determined to be a more effective option for Muralug, and could easily be implemented at other, similar, isolated communities where it is not feasible to establish a microgrid.

The Muralug microgrid feasibility study was one of the successful projects in Round 2 of the Australian Government's Regional and Remote Communities Reliability Fund (RRCRF) and complements a previous feasibility study undertaken by EnergyConnect project partners for the Yarrabah community near Cairns, and another similar study for the Napranum community near Weipa.

Figure 1: Muralug Island locality map

Muralug Social Snapshot

Muralug is the largest Island in the Torres Strait, and the island remains mostly undeveloped, with a limited number of residential lots and existing houses. There are no significant development plans for the Island.

The Kaurareg people are recognised as the traditional owners of Muralug (Prince of Wales Island) and the Kaurareg Native Title Aboriginal Corporation RNTBC is the Registered Native Title body corporate that manages the native title and cultural heritage rights and interests of the Kaurareg people on determined native title land and sea country.

The four main communities at Muralug are Muralug Beach (35 lots), Country Women's Beach (15 lots), and Collis Beach (6 lots) located in proximity at the northern end of the island, and Long Beach (10 lots) which is located at the north-western side of the island, about 8km south-west of Muralug Beach.

There are approximately 50 dwellings on the island with 80% of them located within the four main communities and the balance scattered around the perimeter of the island at isolated sites.

All houses at Muralug Island are privately owned and are built to a range of standards from bungalows to large two-storey homes. The size and style of dwelling is influenced by the availability of electricity, and they are designed to take advantage of breeze and natural light, with outdoor living areas used for many functions including cooking.

Figure 2: Houses at Muralug Beach

There is no reticulated water supply or community sewerage system on Muralug Island and residents provide their own water from rooftops and bores and provide their own effluent disposal.

Children travel via a ferry service to attend school at Thursday Island or alternatively attend boarding schools outside the region. Many residents of Muralug commute by private boats, usually small dinghies, to Horn Island or Thursday Island for work, shopping, or to attend medical services as these services are not available at Muralug.

Existing Energy Snapshot

Muralug does not have reticulated power, although Energy Queensland owns and operates 16 diesel power stations and associated networks on other island communities in the Torres Strait. The nearest system is located at Thursday Island less than 1km to the north-east of Muralug. Muralug residents generate their own electricity and rely on small petrol or diesel generators or hybrid standalone Individual Power Systems (IPS) to meet their energy requirements. The IPS typically consist of a combination of rooftop solar PV systems, batteries and small diesel or petrol generators. Some small wind turbines are also utilised.

These systems range from basic combinations of second-hand components to more sophisticated systems designed to meet the requirements of a modern household. The capacity, condition, and level of sophistication of existing IPS at Muralug is dependent upon the residents' capacity to fund them.

Average daily energy consumption recorded over a 4-month period for four Muralug households with IPS ranged from 4.1kWh for a small system, to 16.2kWh for a larger-capacity IPS.

Muralug residents do not have access to uniform electricity tariffs, subsidies, and other consumer protections that are available to other Torres Strait residents that have reticulated electricity supply provided by Energy Queensland.

Previous studies have explored options to install an undersea cable connection between Thursday Island and Muralug, and to establish a diesel power station at Muralug but neither option was economically feasible.

Muralug residents are generally satisfied with the performance of their IPS systems but expressed concerns about insufficient capacity to run air-conditioners and other essential devices, and the substantial capital costs of establishing suitably sized systems.

Microgrid and IPS Definition

The Australian Energy Market Commission (AEMC) defines Microgrids and Individual power systems[1] as follows:

> *A microgrid is a SAPS that generates and supplies electricity to multiple customers. This could include anything from a large town to two farms connected to each other. Power may be supplied by a mix of local generation and storage, possibly combined with behind-the-meter generation and*

[1] Australian Energy Market Commission – Final Report – Review of stand-alone power systems 31 October 2019

storage. Remote communities, island resorts and remote mining towns are often supplied by microgrids.

An individual power system, or IPS, is a SAPS that generates and supplies electricity to a single customer. Typically, power is generated by a combination of renewable generation, energy storage and/or conventional diesel or gas generators.

Recent changes to the National Electricity Rules have incorporated provisions for inclusion of SAPS in the National Electricity Market where it is a more efficient and cost-effective alternative to grid-connection.

The isolated electricity systems in the Torres Strait and other remote locations in regional Queensland are not connected to the national electricity grid and therefore are not affected by the rule changes. However, it is noteworthy that DNSP-owned SAPS have been recognised as a viable alternative to reticulated electricity supply connections in fringe-of-grid locations where it is more economical than grid supply.

In the case of Muralug, the authors explored the potential to seek a microgrid solution for the three main residential areas of Muralug Beach, Country Women's Beach and Collis Beach. However, the high costs of establishing the centralised microgrid infrastructure and interconnecting networks, together with the number of IPS that had already been deployed determined that investing in a microgrid solution would be less cost-effective than a full IPS-deployment alternative. Additionally, this microgrid solution would not cater for residents at Long Beach and other isolated locations around the island.

A potential option to establish a separate small microgrid at Long Beach to service 10 lots was also initially considered but discounted due to the high costs of establishing the central generation facilities and distribution network to link the two housing clusters located at each end of the beach. On this basis it was determined that affordable IPS with sufficient capacity for normal household requirements is the preferred long-term energy supply strategy for Muralug.

Financial Summary

The estimated capital cost to establish a microgrid that interconnects Muralug Beach, Collis Beach and Country Women's Beach communities only is estimated to be $7–9 million.

A preliminary estimate of the expected uptake of IPS, based on discussions with residents and site observations, identified a potential demand for 56 new systems and 10 system upgrades. The budget cost of supplying and installing these systems is in the order of $2.8 million excluding GST and this cost would be incurred over a period of 5 to 10 years.

For the microgrid alternative to proceed the full capital cost would be incurred before any connections could be facilitated. The financial assessment of options is presented in Section 8 of this report.

This report has noted that a significant barrier to the deployment of high quality, reliable, IPS systems at Muralug is affordability.

The authors identified an opportunity for governments to consider providing financial assistance to establish IPS in isolated locations where reticulated electricity supply is not available. A reliable and affordable electricity supply is an essential service and Muralug residents cannot access the uniform tariff policy and other associated consumer protections generally available to other residents throughout the Torres Strait.

Due to the preliminary nature of the project concept, the financial assessment is indicative only and a more detailed financial assessment will be required when details regarding the quantity of IPS required is confirmed, and technical requirements, and commercial arrangements are refined.

Recommendations

The authors recommend that this report be referred to the Queensland Department of Energy and Public Works and Energy Queensland to investigate and progress appropriate actions. Detailed recommendations are presented in Section 9 of this report.

The report identifies that Muralug Island residents do not currently have access to affordable electricity supply and have no prospect of achieving a reticulated electricity supply connection. In these circumstances, providing technical and financial support for the deployment of IPS, may be a cost-effective means of providing access to what is an essential service.

This approach would address a known gap where remote and isolated communities cannot access the Queensland government's uniform tariffs and other associated consumer protections and support mechanisms.

This report recommends that more detailed investigation be undertaken, in consultation with Muralug residents, to prepare a detailed scope of requirements for full IPS deployment.

A low- or zero-interest loan scheme could be implemented at minimal overall cost to government, and providing access to subsidies that offset the additional costs of installing IPS in isolated and remote locations would promote and encourage the deployment of renewable energy systems in these areas, while contributing to achieving greenhouse gas emission reductions.

Deploying IPS to Muralug using a coordinated project methodology, would serve to reduce the overall cost of systems, ensuring quality control and facilitating on-going technical support and maintenance services to prolong the life of the systems and ensure that they remain fit-for-purpose.

Additionally, assisting residents of isolated communities, reliant on IPS for their electricity supply, to gain better access to energy-efficient electrical appliances, would enable the efficient and cost-effective design of IPS systems whilst providing a greater level of amenity for households.

This project will assist the Queensland government to realize several objectives of the recently published Queensland Energy and Jobs Plan, including:

- Achieving its published renewable energy targets.
- Supporting households to manage energy use and save on electricity costs.
- Continuing to implement the uniform tariff policy.
- Supporting deployment of more rooftop solar.
- Decarbonising remote communities.

This study delivers a realistic opportunity to improve the sustainability, reliability, and affordability of power supply to the Muralug Island community via deployment of IPS and identifies strategies that can be applied at other remote and isolated communities.

1

Introduction

1 Introduction

1.1 About the Regional and Remote Communities Reliability Fund

The Australian Government's Regional and Remote Communities Reliability Fund (RRCRF) was established in October 2019 to support up to 50 regional and remote communities to investigate whether replacing, upgrading, or supplementing a microgrid[2] 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 RRCRF are:

- Viable projects attract funding to support scale-up / implementation of 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.

1.2 About EnergyConnect

The project is led by Ener-G Management Group working in collaboration with ITP Renewables, Planz Town Planning and The Missing Link. This collaborative group uses the name EnergyConnect for the purposes of this study.

Key stakeholders for the study include:

- Torres Shire Council (TSC) – the local government authority for Muralug Island.
- Ergon Energy Network – responsible for the generation and distribution of electricity throughout the Torres Strait.
- Ergon Energy Retail – responsible for selling electricity to regional Queensland residents, including residents in the Torres Strait islands.
- Muralug Island residents – including both freehold property owners and lessees of leasehold property.

---

[2] The RRCRF uses the term microgrid to also include isolated power systems with their own network. Isolated power systems with a relatively small network are often used in areas away from the main grid, such as remote towns and islands. This study refers to these systems as isolated power systems or isolated 'microgrids' as they only have one mode of operation, i.e. they don't have a main grid-connected mode.

- Kaurareg Native Title Aboriginal Corporation RNTBC – responsible for managing the native title and cultural heritage rights and interests of the Kaurareg people at Muralug Island.

Ergon Energy Network and Ergon Energy Retail are subsidiary companies of Energy Queensland Limited (EQL) a Queensland Government Owned Corporation.

1.3 Microgrid and IPS Definitions

The Australian Energy Market Commission (AEMC) defines Microgrids and Individual power systems[3] as follows:

> *A microgrid is a SAPS that generates and supplies electricity to multiple customers. This could include anything from a large town to two farms connected to each other. Power may be supplied by a mix of local generation and storage, possibly combined with behind-the-meter generation and storage. Remote communities, island resorts and remote mining towns are often supplied by microgrids.*
>
> *An individual power system, or IPS, is a SAPS that generates and supplies electricity to a single customer. Typically, power is generated by a combination of renewable generation, energy storage and/or conventional diesel or gas generators.*

For the Muralug study a microgrid would consist of a central generation facility that may include a solar farm, wind turbines, battery energy storage solution (BESS), and a standby generator. Additionally, it would incorporate a network of high voltage and low voltage powerlines and transformers to transport energy to dwellings at the nominated locations.

IPS have previously been deployed at Muralug and are considered the "norm" at this location.

1.4 Study Scope

The scope of this study included assessment of individual household standalone power systems (IPS) as well as microgrid solutions. This is due to the small yet widely dispersed population, the significant cost of establishing and operating an electricity distribution network at Muralug, and residents' prior experience with IPS solutions.

Detailed technical and financial analyses were performed to assess the most viable options with a view to developing a business case for the deployment of the preferred solution.

[3] Australian Energy Market Commission – Final Report – Review of stand-alone power systems 31 October 2019

The study assumes that the communities of Muralug Beach, Collis Beach and Country Women's Beach could be connected to a centralised power generation site in the Muralug Beach area via an overhead distribution network (for the microgrid option), and that land can be made available to host the required infrastructure including powerline routes.

The study examines:

- Energy efficiency considerations.
- Renewable generation and energy storage technologies.
- Funding models.
- Social and financial impacts.

The study includes financial analysis of IPS options including assessment of potential funding support models.

This study excludes consideration of microgrid connections for remote individual installations located away from the main population centres. However, the alternative IPS systems considered in this report are also applicable to those outlying sites.

1.5 Project Delivery Plan and Methodology

RRCRF funding was made available for EnergyConnect to undertake joint studies of the feasibility of establishing microgrids at both the Muralug Island and Napranum communities.

An integrated project delivery plan was developed to undertake the Microgrid Feasibility Studies concurrently. This approach was adopted to efficiently allocate EnergyConnect project team resources, coordinate stakeholder engagement activities and undertake site visits to remote locations on Cape York Peninsula and in the Torres Strait in the most economical manner.

Regular stakeholder engagement was an essential component of the delivery plan, and many site visits were undertaken to Muralug to meet with residents and key stakeholders to provide background information on the project, to gather local input and feedback, to assess site conditions and requirements, to install data recording devices at selected premises, and to complete surveys and undertake energy audits at residences.

Check points were embedded within the delivery plan for focused stakeholder engagement activities at logical points during the project life cycle. The formal stakeholder forums were designed to engage a broad range of stakeholders to optimise the potential benefits for Muralug and to keep stakeholders informed of progress.

The project commenced in October 2021 with a target end date of April 2023.a timeline outlining the key project stages is presented in Figure 3 and a brief description of each phase of the delivery plan is outlined below.

1.5.1 Project Establishment

As the EnergyConnect project team had previously been established for the Yarrabah Microgrid Feasibility Study (July 2020 – February 2022), the team was able to rapidly mobilise for the Napranum – Muralug Microgrid Feasibility Study project.

Project establishment was focused on formalising project team membership, establishing partner engagement contracts, developing detailed delivery plans and budgets, and establishing project administrative and reporting arrangements.

1.5.2 Planning and Data Gathering

During the planning and data gathering phase preliminary stakeholder engagement activities were undertaken to identify and secure essential data and reports required for understanding the current state and for the development and assessment of options. This included acquiring data pertaining to housing, population and other demographic information, energy consumption and usage information, existing electricity supply infrastructure at Muralug, and other general background and site information.

Key stakeholders and residents were briefed on the scope of the project, the project team, project objectives and the delivery plan.

An initial site visit was undertaken to assess site conditions, existing infrastructure, and the layout of the community. This involved spending time at Muralug Island meeting residents and navigating around the perimeter of the island by sea.

WattWatcher energy monitoring devices were installed at selected residences at Muralug to obtain detailed data on daily energy consumption patterns within the community.

1.5.3 Stakeholder Engagement Stage 1

During Stage 1 of the stakeholder engagement phase the project focused on engaging with key stakeholders and community members to provide an initial overview of the project, introduce the project team, and to establish baseline data and community sentiment.

This activity operated in parallel with the Data Gathering activities described previously, and the establishment of appropriate communication protocols was essential to ensuring the timely and accurate provision of input data for the project.

Key stakeholders consulted during this period included:

- Torres Shire Council (TSC).
- Department of Seniors, Disability Services, and Aboriginal and Torres Strait Islander Partnerships (Queensland Government) (DSDSATSIP).
- Torres and Cape Indigenous Councils Alliance (TCICA).
- Torres Strait Regional Authority (TSRA).

- Department of Communities, Housing and Digital Economy (Queensland Government) (CHDE).
- Energy Queensland Limited (EQL).
- Department of Energy and Public Works (Queensland Government) (DEPW).

1.5.4 Technical Solutions Development

The project team developed a range of concepts for implementing a microgrid or microgrids at Muralug for technical and economic assessment during this phase of the project. It was also identified that IPS should be considered as part of the study scope as they were likely to be a more cost-efficient option.

Data collected during earlier phases of the project were further assessed and modelled using Min-E, optimisation software developed by ITP Renewables. This was to provide preliminary assessments of alternative renewable generation options to meet 100% of residents' current and future energy requirements for Muralug's four main residential areas of Muralug Beach, Country Women's Beach, Collis Beach and Long Beach.

The data assessed included:

- Potential electricity distribution network configuration and operating regimes.
- Energy consumption and load profiles derived from WattWatcher data and "standard" residential load profiles.
- Local site information, land tenure and geography.
- Weather patterns and an assessment of potential renewable energy generation sources.
- Future energy demand.
- Building configuration and orientation for rooftop solar photovoltaic (PV) systems.
- Residents' experiences with and knowledge of standalone power supply systems currently in use at Muralug.

During the technical solutions development phase, a preliminary review of energy efficiency initiatives was undertaken, based on energy audit results, observations, data measurements and community feedback. From this an assessment of potential electricity supply options was undertaken, and shortlisted options were identified for optimisation analysis.

A preliminary risk assessment was also completed including consideration of local constraints and barriers. This included land availability and tenure, weather and seasonal impacts assessment, and environmental and cultural heritage requirements, anticipated development costs and potential connection uptake rates.

Significant considerations at Muralug include:

- There is no existing public electricity supply available.

- Small residential cluster communities are separated by significant distances.
- Prior experience with and proliferation of IPS.
- A small permanent population.
- Lack of commercial/community service activity based at Muralug.
- Logistical issues associated with establishing and maintaining infrastructure.
- Land tenure and cultural heritage constraints.

1.5.5 Social Impacts Assessment

Developing a sound understanding of the potential social benefit or impact of a microgrid at Muralug was an essential component of determining the project's scope and feasibility.

An assessment of social factors including analysis of statistical data, consultation with stakeholders and residents as well as exploring the broader economic, educational and employment opportunities arising from the project was undertaken during this phase of the project.

1.5.6 Stakeholder Engagement Stage 2

Stage 2 of the stakeholder engagement phase focused on validating outcomes of the initial technical options analysis with key stakeholders, including:

- Preliminary designs, land requirements/availability and budget costs.
- Land tenure considerations, including Native Title and Cultural Heritage.
- Operational arrangements and constraints.
- Energy efficiency opportunities including housing design and appliance selection.
- Local residents' capacity to fund IPS.
- Potential future energy requirements and development opportunities.

A formal workshop was convened in Cairns with participation from a range of interested parties including stakeholders identified in Stage 1 activities, as well as representatives from:

- Community Enterprise Queensland.
- Energy Consumers Australia.
- University of Sunshine Coast.
- CA Architects.

1.5.7 Project Report Preparation

A period of five months was allocated to preparing the final report for this project. This enabled the project team to collate reporting resources, finalise feasibility study outcomes and business models, and for drafting and reviewing the final reports. Separate reports were prepared for each of the study sites – Muralug and Napranum.

Preparation of Financial Analysis of project outcomes was undertaken between November 2022 and February 2023.

Report preparation commenced in December 2022 with the establishment of the Table of Contents, and allocation of reporting responsibilities for relevant chapters to the appropriate project team members.

A project reporting coordination and review team was established to ensure timely drafting of sections of the report, for consistency and quality of the content of the report and to report back to the broader project team on progress.

The draft final report will be delivered by the end of March 2023 with key outcomes and recommendations presented to stakeholders during April 2023.

The final report will be completed by the due date of 30th April 2023.

1.5.8 Stakeholder Engagement Stage 3

Stage 3 of stakeholder engagement includes project closure, during which the final report is presented to government, key stakeholders and community via various media and face-to-face presentations.

The Muralug Microgrid Feasibility Study Report will be a key document to support funding applications for the delivery of appropriate energy supply solutions for Muralug Island and other similar remote and isolated communities.

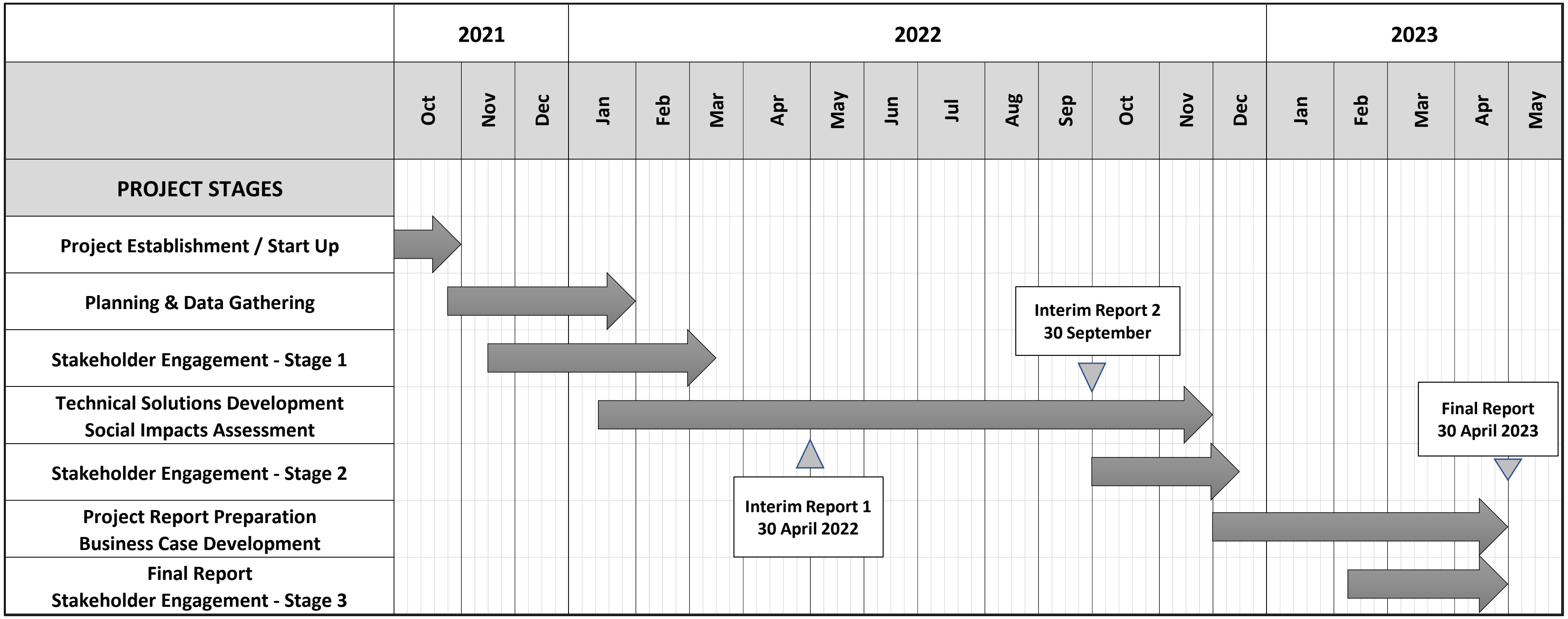

Figure 3: Napranum and Muralug Microgrid Feasibility Study project stages and timeline

2

Muralug Profile

2 Muralug Profile

2.1 Location and Climate

Muralug is the largest Island in the Torres Strait located just 20km north of mainland Australia (Muttee Heads). It is only 830m from Thursday Island (Figure 4) which is the most populous of the Torres Strait islands and is where the Torres Shire Council is located. Muralug has approximately 50 houses and Muralug Beach, which hosts the largest cluster of residential properties at Muralug, is located at the north-east of the Island (Figure 5). There is no school at Muralug but there is a daily school ferry service to Thursday Island. Many residents of Muralug commute by boat to Horn Island or Thursday Island for work.

Figure 4: Muralug Island locality map[4]

[4] https://dams.dsdip.esriaustraliaonline.com.au/damappingsystem/?accordions=SARA%20DA%20Mapping

Figure 5: Muralug Beach Community locality map[5]

The Torres Strait Islands are classified as having a *tropical savannah* climate on the Köppen climate classification[6] and has consistently hot temperatures all year round. Comparative data from the Australian Bureau of Statistics (ABS) shows that between 2013 and 2022, the average high and average low temperatures have increased by 0.1 – 0.2 °C. The area has an average daily temperature range of 23.2°C to 36.7°C and an average annual rainfall of 1,768mm.

Heat waves and above normal temperatures result in temperatures much higher than the long-term daily average (Table 1). Northern Australia experienced almost 3 weeks of heat wave conditions over 2 months during October-November 2022 (Figure 6). The average daily temperature was consistent with the long-term average and there is little relief from extreme temperatures. The Torres Strait Islands are affected by heavy rains between October and April each year and occasionally affected by tropical cyclones.

Table 1: Average daily temperature °C[7]

Average Daily Temperature °C												
Month	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Record High °C	36.7	35.4	34.8	33.9	32.0	32.4	31.8	31.8	35.8	35.2	35.0	37.9

[5] https://dams.dsdip.esriaustraliaonline.com.au/damappingsystem/?accordions=SARA%20DA%20Mapping

[6] https://www.researchgate.net/figure/Koeppen-Geiger-climate-type-map-of-Australia_fig4_311642844

[7] www.bom.gov.au/climate/averages/tables/cw_027058_All.shtml *Climate statistics for Australian locations*. Bureau of Meteorology. Retrieved November 2022.

Av. High °C	30.9	30.6	30.5	30.4	30.1	29.5	29.0	29.2	30.2	31.2	32.0	32.0
Av Low °C	25.2	25.1	25.1	25.3	24.9	24.0	23.2	23.1	24.0	24.9	25.8	24.7
Record Low °C	21.5	21.1	22.2	21.1	17.7	18.1	16.0	15.3	15.1	18.4	19.9	20.3

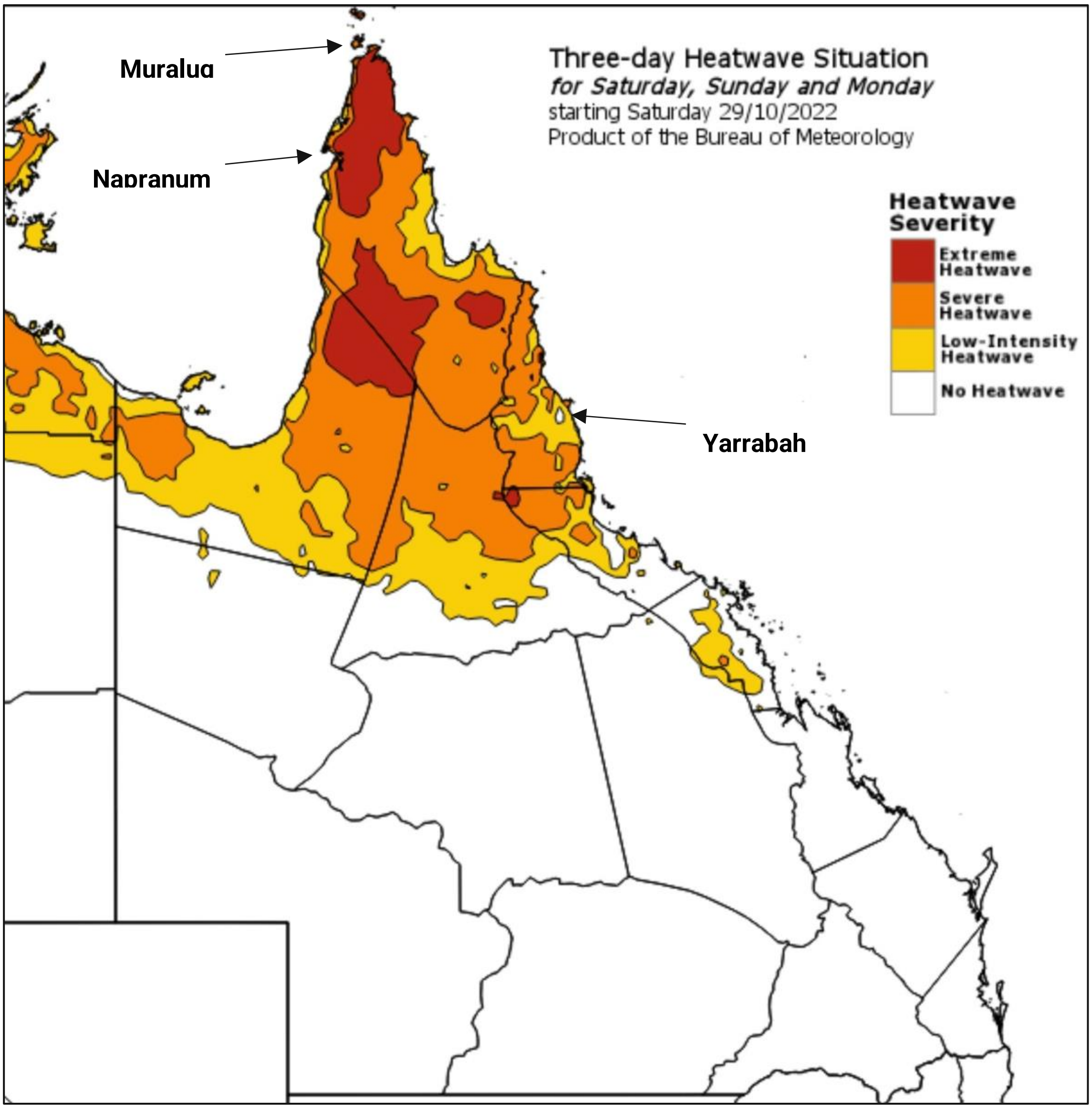

Figure 6: Heat wave warning map - Bureau of Meteorology October 2022

2.2 Population

Muralug Island and the Torres Strait Islands are classified ‘very remote Australia’ by the ABS. The Torres Strait Region includes 20 communities divided into five traditional Island groups and two Northern Peninsula Area (NPA) communities:

- Inner Islands
- Top Western Islands
- Western Islands
- Central Islands
- Eastern Islands
- Bamaga and surrounds (NPA community)
- Seisia (NPA community)

Just over one-third of Aboriginal and Torres Strait Islander people in the region lived in the Inner Islands (36.2%, up from 35.0% in 2016) which includes: Hammond Island, Horn Island, Muralug and Thursday Island[8].

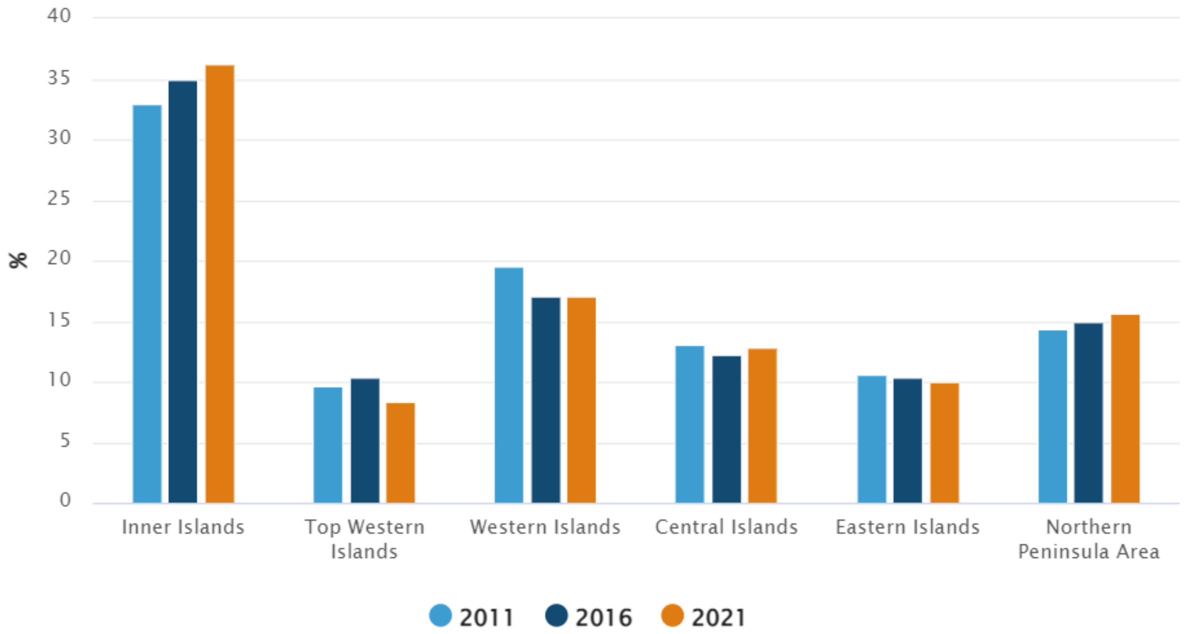

Figure 7: Distribution of Aboriginal and Torres Strait Islander persons, Torres Strait Region, 2011-2021[9]

The statistics provided by the 2016 Census detail the total population of the Torres Shire at approximately 3,455 people. The distribution of population is:

- Waibene (Thursday Island) – 2950
- Ngurupai (Horn Island) – 375
- Muralug (Prince of Wales Island) – 110

[8] https://www.abs.gov.au/statistics/people/aboriginal-and-torres-strait-islander-peoples/census-population-and-housing-counts-aboriginal-and-torres-strait-islander-australians/latest-release accessed December 2022

[9] Census of Population and Housing - Counts of Aboriginal and Torres Strait Islander Australians

- Other – 20

The available 2021 ABS data is for the Torres Strait Islands, or the Torres Shire Local Government Area using Estimated Resident Population (ERP) figures updated annually using a model which includes administrative data that indicate population change, such as registered births and deaths, dwelling approvals, Medicare enrolments and electoral enrolments. For this report, the ERP for Torres Shire has been used, as it is a smaller area than the Torres Strait Islands and allows for comparison with other Local Government Areas (LGAs).

TSC has a more frequent estimate and assumes a residential population higher than those shown in the 2016 Census. TSC estimates a residential population of 3,533 persons as of 30 June 2021, compared with a population of 3,799 in 2016 and 3,477 in 2011. With a more direct relationship to the region the estimates of the TSC are likely to be more accurate and these estimates translate to an average annual growth rate of -1.4% over five years; and an average annual growth rate of 0.2% over ten years. The state of Queensland has had an average annual growth rate of 1.5% over the same 10-year period[10].

The age profile of the recorded population is considerably different to that of Queensland, however it is similar to other remote areas and Aboriginal Shire local government areas. To provide context:

- Napranum Aboriginal Shire Council demographics have been included as Napranum forms part of this RRCRF-funded microgrid feasibility study.
- Australia's largest discrete Aboriginal community – Yarrabah Aboriginal Shire Council has been included in the statistics, of note this community has also been the subject of a microgrid feasibility study.

Compared to the rest of Queensland, Napranum, Torres, and Yarrabah have more people aged 0-24, a similar number aged 25-64, and fewer aged 65+. Torres' median age in 2016 was 29.9 (up from 28.2 in 2011), while Queensland's was 38.4 (up from 36.6 in 2011)[11].

The Demographic information indicates a community of young families with children and indicates poor health outcomes for the aging population.

Table 2: Estimated resident population by age, 2021[12]

Age Group

[10] https://statistics.qgso.qld.gov.au/qld-regional-profiles

[11] ABS 3235.0, Population by Age and Sex, Regions of Australia unpublished data and Queensland Treasury estimates

[12] Source: ABS 3235.0, Population by Age and Sex, Regions of Australia unpublished data and Queensland Treasury estimates

	0-14		15-24		25-44		45-64		65+	
	Number	%	Number	%	Number	%	Number	%	Number	%
Napranum	263	29.0	162	17.9	239	26.4	205	22.6	38	4.2
Torres	958	27.1	550	15.6	1,002	28.4	774	21.9	249	7.0
Yarrabah	789	30.4	497	19.1	703	27.1	493	19.0	116	4.5
Queensland	989,461	19.0	651,113	12.5	1,416,854	27.2	1,295,777	24.8	864,448	16.6

Table 3 shows Migration in and out of the three LGAs compared to Queensland. The comparison considers the usual address of household members on Census Night 2021 (10 August 2021) with their usual address one year earlier (10 August 2020) and their usual address five years earlier (10 August 2016). The figures show that Torres Shire residents are mobile and consistent with the Queensland levels of migration, compared to Yarrabah and Napranum residents who generally do not migrate (in or out of the LGA).

Table 3: Place of usual residents 1 year ago, and 5 years ago LGA and Queensland, 2021[13]

Place of usual residence over time 2021					
	Same Address	Within Qld	Rest of Australia	Overseas	Proportion with Different Address
	Number	Number	Number	Number	%
Napranum **1 year ago**	663	53	-2	0	6.3
5 years ago	553	73	10	10	11.0
Torres **1 year ago**	2,617	424	59	6	19.9
5 years ago	1,765	933	112	57	35
Yarrabah **1 year ago**	2,272	123	0	0	5.0

[13] Source: ABS, Census of Population and Housing, 2021, General Community Profile - G45

5 years ago	1,873	273	9	0	12.8
Queensland 1 year ago	3,909,222	719,541	97,770	34,773	17.0
5 years ago	2,348,034	1,635,871	276,658	215,572	44.8

The family composition of the Torres community presents a substantial difference when compared to Queensland for families with no children where Torres has substantially less (24.6%) of couples with no children compared to 40.3% of Queensland couples, and a substantially higher number of one-parent families (27.0%) compared to 16.8% of Queenslanders as shown in Table 4. The average number of people per household in Torres Shire is 3.5 compared to 2.5 for Queensland.

Table 4: Family composition 2021[14]

Family composition							
	Couple family no children		Couple family with children		One-parent family		Total
	Number	%	Number	%	Number	%	Number
Napranum	27	15.0	79	43.9	58	32.2	180
Torres	187	24.6	332	43.7	205	27.0	760
Yarrabah	71	12.5	223	39.3	255	45.0	567
Queensland	551,069	40.3	563,327	41.2	230.026	16.8	1,366,657

The 2021 Census indicates a near equal population of females and males, consistent with Queensland, with 90.6% of the population identifying as Aboriginal and/or Torres Strait Islander, compared to 4.6% for Queensland.

2.3 Home Ownership and Affordability

The dominant dwelling structure in the Torres Shire is separate private houses (94.3%) with the balance of the dwellings being semi-detached or apartments, which is comparable to Queensland which has 74.8% occupied private dwellings. Most of the Torres housing stock (89.4%) is rented, with a proportion of this housing provided by the Queensland Government

[14] Source: ABS, Census of Population and Housing, 2021, General Community Profile - G29

(social houses). The housing stock includes dwellings that have been erected without land ownership (tenure) or building approval.

The rate of homeless persons (i.e., living in a dwelling that is inadequate, has no tenure, does not allow a person to have control of space for social relations) is 280.4 people per 10,000 persons, compared to 280.1 persons per 10,000 for Napranum, 549 persons per 10,000 for Yarrabah and just 45.6 people per 10,000 persons across Queensland.

2.4 Housing Condition

There are no social houses on Muralug Island as all houses are privately owned and are built to varying standards and construction methods. These ranged from one and two storey modern cement block and timber constructions and older fibro highset houses to simple shacks and converted sheds (Figure 8, Figure 9, Figure 10, Figure 11).

The size and style of dwelling is influenced by the availability of resources including electricity. Most houses were 3- or 4-bedroom single storey with some two storey or highset. All dwellings were unique but primarily orientated towards the ocean, with large windows to harness breezes for natural cooling, and lighting.

The current housing design meets cyclone rating construction requirements. However older homes may not be constructed to these same standards.

Figure 8: House at Collis Beach, Muralug (May 2022)


Figure 9: Houses on the Esplanade, Muralug Beach


Figure 10: Houses on the Esplanade, Long Beach

Figure 11: House on Long Beach

2.5 Income and Employment

The median total personal income in Torres Shire was $877 per week compared to $787 for Queensland, with a median total family income of $1,951 for Torres compared to $2,024 for Queensland. The poverty line in Australia is $968.41 per week or $50,357 per year for a household with 2 adults not working and 2 children[15]. While it appears that many households in Torres Shire are above the poverty line, public servants from 37 state and federal agencies are likely to account for much of the higher incomes and occupy much of the available accommodation on Thursday Island.

Table 5 shows the medial, total personal income (i.e., the total of all wages/salaries, government benefits, pensions, allowances, and other income a person usually receives) in Torres is $45,604. This comparatively high personal income, associated with State and Federal Government employees, is reflected in the most recent Socio-Economic Indexes for Areas (SEIFA) from 2016 in which Torres Shire had a score of 932.5 compared to 650 for Yarrabah, 664 for Napranum and 1,060 for Brisbane. That is, Napranum and Yarrabah are in the bottom 20% (quintile position 2) (Table 6) on the index of social and economic advantage / disadvantage, compared to Cairns which has an overall quintile position of 2 and Brisbane which has an overall quintile position of 5 (top 20%)[16].

---

[15] Poverty Lines: Australia. Melbourne Institute of Applied Economic and Social Research December quarter of 2020.

[16] Source: Australian Bureau of Statistics, Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2016 (cat. no. 2033.0.55.001)

Table 5: Total personal income, 2021[17]

Total Personal Income											
	Less than $20,800 per year		$20,800 to $51,999 per year		$52,000 to $103,999 per year		$104,000 or more per year		Personal Income Not Stated		Median ($/year)
	Number	%	Number	%	Number	%	Number	%	Number	%	$
Napranum	191	30.3	82	13	57	9	19	3	156	44.7	17,784
Torres	591	23.4	660	26.2	702	27.8	300	11.9	241	10.7	45,604
Yarrabah	986	56.1	535	30.4	93	5.3	23	1.3	113	6.9	17,524
Queensland	999,942	23.9	1,316,078	31.4	1,084,654	25.9	461,162	11	301,223	7.8	40,924

Table 6: Population by index of relative socio-economic disadvantage quintiles(a) by LGA, custom region and Queensland, 2016[18]

Index of Relative Socio-Economic Disadvantage quintiles					
	Quintile 1 (most disadvantaged)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (least Disadvantaged)
	%				
Napranum	100	0.0	0.0	0.0	0.0
Torres	44.7	45.4	0.0	0.0	0.0
Yarrabah	100	0.0	0.0	0.0	0.0
Cairns	27.2	19.5	16.5	19.1	17.8
Brisbane	2.6	9.6	18.7	24.6	41.6
Queensland	20.0	20.0	20.0	20.0	20.0

[17] Source: ABS, Census of Population and Housing, 2021, General Community Profile - G02 and G17

[18] Source: ABS 2033.0.55.001 Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2016, (Queensland Treasury derived)

Table 7 shows the unemployment rate in Torres Shire for the June quarter 2022 is reported as being 10.6% which is significantly lower than Napranum (22.2%) and Yarrabah (56.8%) but is high compared to 4.6% for Queensland[19].

Table 7: Unemployment and labour force by LGA, Custom region and Queensland, June quarter 2022[20]

Employment			
	Unemployed	Labour force	Unemployment rate
Napranum	98	441	22.2
Torres	182	1,721	10.6
Yarrabah	182	713	56.8
Queensland	128,979	2,833,277	4.6

2.6 Energy Affordability

A review of energy consumption at four residences at Muralug with IPS identified estimated annual consumption ranging from 1,500kWh to 5,900kWh[21] with an average annual consumption of 4,211kWh. The average household energy consumption across regional Queensland is 5,880kWh[22].

Muralug residents are frugal with their energy use and are constrained by the capacity of their individual power supply systems. They are responsible for the full cost of their IPS systems[23] including on-going operating, maintenance, and replacement costs. The current installation costs for IPS can range between $35,000 for a small system to more than $60,000 for a system capable of supporting a basic family home without air-conditioning, excluding standby generation.

Routine operating and maintenance costs are minimal, so once the IPS are established, they are very economical to operate until major plant items, such as batteries and inverters require replacement.

[19] Australian Government, National Skills Commission, Small Area Labour Markets Australia, various editions

[20] Source: Australian Government, National Skills Commission, Small Area Labour Markets Australia, various editions.

[21] Based on actual energy consumption data recorded using WattWatcher energy monitors between July and December 2022

[22] AER Residential Energy Consumption Benchmarks December 2020

[23] Muralug residents that cannot afford a IPS system rely on small petrol or diesel generators for power supply

Those residents who do not have IPS rely solely on small generators for their power supply which they may operate for up to 12 hours per day or for as long as they can afford.

A range of different generators were observed at Muralug from small 2kW petrol inverter generators to power a few appliances to larger 8kW diesel generators for house supply.

High fuel prices in the Torres Strait are a key factor, the current prices being $2.49/litre for unleaded petrol and $2.79/litre for diesel[24] at Thursday Island.

The daily cost to run a 3kW petrol inverter generator[25] for 12 hours is estimated at $24.43 or $732.90 per month. Alternatively, an 8kW diesel generator[26] would cost approximately $82.86 per 12-hour day or $2,485.80 per month.

Considering fuel costs alone, this is equivalent to $0.90/kWh for the 3kW generator and $1.15/kWh for the 8kW generator. The current residential electricity tariff in regional Queensland is $0.249/kWh.

It is unsustainable from an economic perspective for a household at Muralug to rely on a generator for its sole electricity supply, and this option is also not preferred from an environmental perspective.

2.7 Economic Development Plans

There are no significant development plans for the Island which is primarily used for residential and recreational purposes. The Kaurareg people and the Kaurareg Land and Sea Ranger program work closely with other rangers, Australian, Queensland and local government agencies and departments to deliver on-ground ranger activities, reporting and asset management at Muralug.

The Torres Shire (particularly Thursday Island) is the government and service hub for the region. Some 56% of the employed population are involved in public administration and safety, education and training, or health care and social assistance.

Other areas of major employment include retailing, the fishing industry and the transportation industry, with the Horn Island airport providing a transport hub to and from the Torres Strait region, and Cairns.

Economic opportunities are dependent on internet connectivity. High speed internet connection is available in the larger centres, with wireless service available in the areas covered by 3G and 4G mobile telephone network, but dial-up or satellite-based access is still required in the more remote areas of the Torres Shire.

---

[24] Reference Petrol Spy App Thursday Island fuel prices 6th February 2023

[25] Honda EU32 specifications @1.09 litres per hour (at full load) – assume 75% loading for pro-rata calculation

[26] Kubota GL9000 specification @3.3 litres per hour (at full load) – assume 75% loading for pro-rata calculation

2.8 Council Services

2.8.1 Water Supply

There is no reticulated water supply on Muralug Island. Residents provide their own water from rooftops and bores.

The water supplied to most other residents within the Torres Shire is from the Loggy Creek Dam on Horn Island. It provides water to Wasaga Village, the main area of settlement on Horn Island, and via a submarine pipeline, provides water to the Millman Hill Reservoir on Thursday Island (which in turn provides a service to Hammond Island).

From a vulnerability perspective, the tropical location of the area will normally ensure that ample water supplies exist, and extreme conditions for a protracted period would be required to imperil those supplies, but a failure of the submarine pipeline or a lack of power for pumping could cause some concern for the supply to Thursday Island.

2.8.2 Sewerage

There is no reticulated sewerage on Muralug Island. Residents provide their own onsite effluent disposal system.

A reticulated wastewater treatment system is in place on Thursday Island and Horn Island.

2.8.3 Waste Management

Muralug has a communal waste transfer station (near Muralug Beach) and TSC has a regular barge service to collect waste from this location. However, a similar service is not available to other communities or isolated home sites at Muralug Island. There is evidence of disused batteries and other equipment being dumped at unregulated sites at Muralug.

2.9 Tenure

The Kaurareg people are recognised as the traditional owners of Muralug (Prince of Wales Island) and the KAC RNTBC is the Registered Native Title body corporate that manages the native title and cultural heritage rights and interests of the Kaurareg people on determined native title land and sea country. The RNTBC acts as trustee to hold the land in trust for the benefit of the Aboriginal people, particularly as concerned with the land and their ancestors and descendants, and under the Aboriginal Land Act 1991.

The RNTBC has over 400 members around Australia and is governed by 7 Kaurareg directors. It manages the Kaurareg Land and Sea Ranger program that protects and manages Kaurareg cultural heritage and natural resources.

Figure 12: Muralug Native Title area (in teal)

There are approximately eighty-six freehold or leasehold lots on Muralug of which about two thirds have some form of dwelling or structure built on them and one third being vacant lots. Sixty-six of these lots are in or near the main cluster communities of Muralug Beach, Country Women's Beach, Collis Beach and Long Beach, whereas the other twenty are scattered around the perimeter of Muralug Island.

Muralug is within the Torres Shire Council Local Government Area, and is subject to the Council's planning scheme, local laws and other regulations. There is no Deed of Grant in Trust (DOGIT) land on Muralug.

The Commonwealth *Native Title Act 1993* provides for Indigenous Land Use Agreements (ILUAs) between native title holders or claimants and other interested parties which outline how land and waters covered by an agreement will be used and managed into the future. As of November 2022, no ILUAs are registered over Muralug.

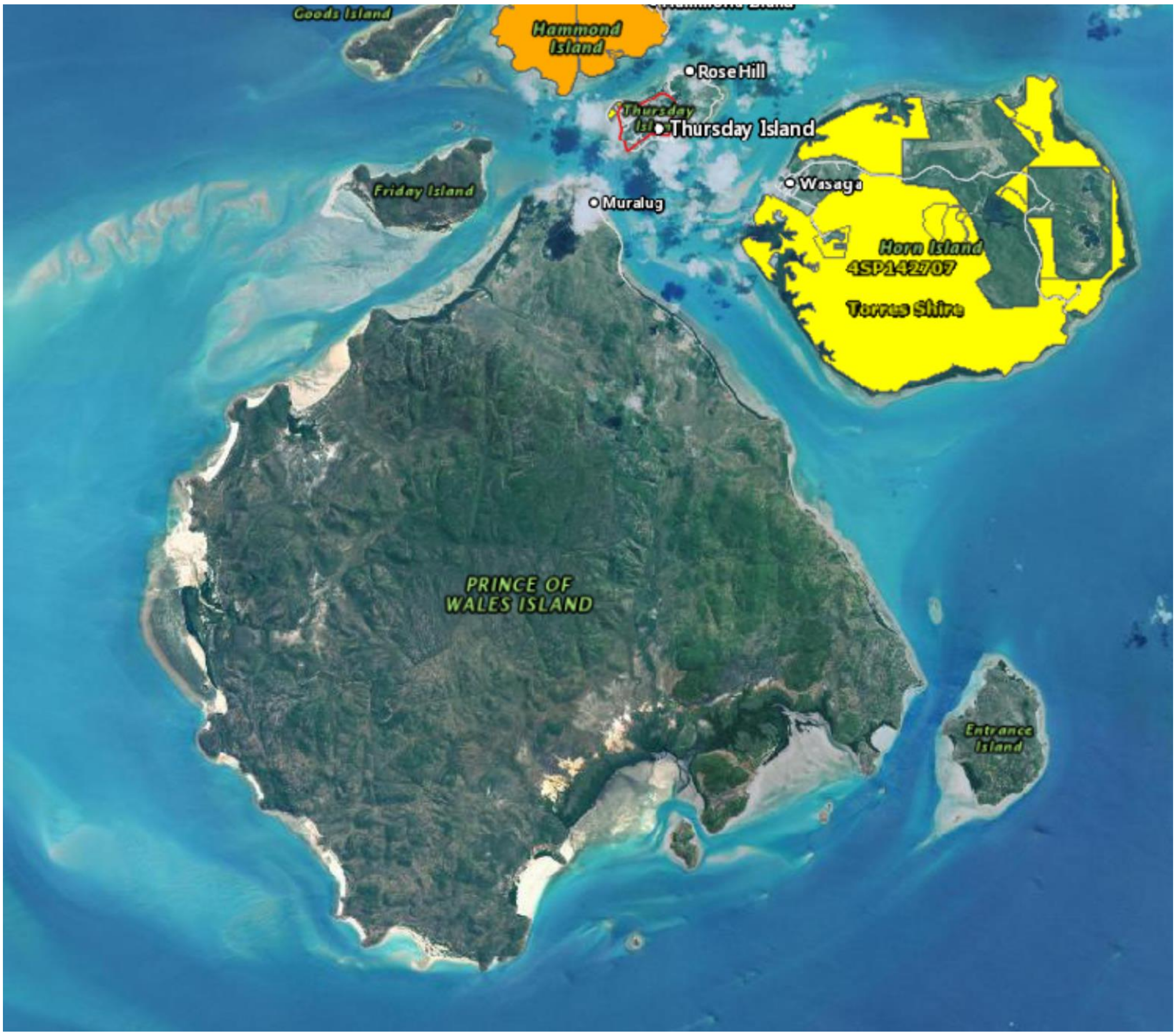

Figure 13: Surrounding ILUA areas in yellow and orange (none in Muralug)

2.10 Planning and Approvals

There are a range of approaches to obtaining a development approval for a microgrid at Muralug. Each has different timeframes and offers different levels of 'appeal rights' to the public.

No development of any form can be undertaken without landowner consent of the KAC RNTBC.

2.10.1 Ministerial Infrastructure Designation

The *Planning Act 2016* includes provisions for consultation by the Minister and the process for making (deciding) a Ministerial Infrastructure Designation (MID). The Minister for Planning is the decision maker for a MID.

A MID allows for the delivery of essential community infrastructure including electricity operating works (*Planning Regulation 2017*, *Schedule 5*, *Part 2*).

The MID provides an alternative process to lodging a development application with Council.

An approved MID does not directly authorise development; instead, the effect of the MID is to make specified work 'accepted development' under the *Planning Act 2016*, i.e., development that does not require a development approval.

A MID does not prevent other development from taking place on the designated premises, subject to the appropriate approvals being obtained.

There is no timeframe for the MID process. The assessment and decision-making process is likely to take 8-12 months and objectors do not have appeal rights in the Planning and Environment Court.

2.10.2 The Planning Scheme and Planning Act

Development of land in the Torres Shire is in accordance with the *Planning Act 2016*, which is consistent with all local governments across Queensland. Council has a Planning Scheme and to develop land or use it for a specific purpose, a development application is required to be submitted to Council for Planning approval.

Council is typically the Assessment Manager for land-based aspects of development. State interests are triggered through this process and these interests are assessed via the State Assessment and Referral Agency. However, the State may be the Assessment Manager for developments such as Wind Farms.

The assessment and decision-making process typically takes 4-8 months and objectors have appeal rights in the Planning and Environment Court.

2.10.3 Prescribed Project

A Prescribed Project is one which is of significance, particularly economically and socially, to Queensland or a region. Declaring a Prescribed Project enlivens the Coordinator-General's powers to ensure timely decision-making in relation to prescribed processes and prescribed decisions. The Coordinator-General is not bound to declare a Prescribed Project.

The project would be coordinated by, but not decided by the Office of the Coordinator-General. The Torres Shire Council will still be responsible for deciding the application.

This approach allows for an outcome focused approach across the State Agencies and allows Council to be involved in the decision-making.

The assessment and decision-making process typically takes 4-8 months and objectors have appeal rights in the Planning and Environment Court.

2.10.4 Co-ordinated Project

A Co-ordinated Project under the *State Development and Public Works Organisation Act 1971* would result in the State undertaking the complete assessment. This approach can be requested where the development has:

- Complex approval requirements, involving Local, State and Federal governments,

- Significant environmental effects,
- Strategic significance to the locality, region or state, including for the infrastructure, economic and social benefits, capital investment or employment opportunities it may provide, and
- Significant infrastructure requirements.

The Coordinator-General chooses the weight attributed to each of the above factors. The Coordinator-General is not bound to declare a project a coordinated project merely because it satisfies one or more of these characteristics.

Typically, there are no appeal rights for submitters. In making the declaration decision, the Coordinator-General must have regard to:

- Detailed information about the project given by the proponent in an initial advice statement,
- Relevant planning schemes or policy frameworks of Council, the state or the commonwealth,
- Relevant state policies and government priorities,
- A pre-feasibility assessment of the project, including how it satisfies an identified need or demand,
- The capacity of the proponent to undertake and complete the environmental impact statement or impact assessment report for the project, and
- Any other matter considered relevant.

3

Stakeholders and Community Engagement

3 Stakeholders and Community Engagement

3.1 Key Stakeholders

Stakeholders are defined in this study as people, groups or communities that may be directly or indirectly affected by the project or have an interest in it. This is a diverse group that comprise of locally affected communities or individuals and their formal and informal representatives, national, state, or local government authorities, political leaders, community organisations and groups with special interests, the academic community, and other businesses.

EnergyConnect's goal was to work closely with the Muralug community, its leaders, Energy Queensland, government department representatives, and a range of other important stakeholders to earn and maintain its social license to operate, and to deliver a project feasibility report that met community expectations and would receive broad support for project implementation.

Throughout the scoping stage and as the project progressed stakeholders were classified into one of three categories based on their level of interest and influence on the Microgrid Project, as outlined in Figure 14 below.

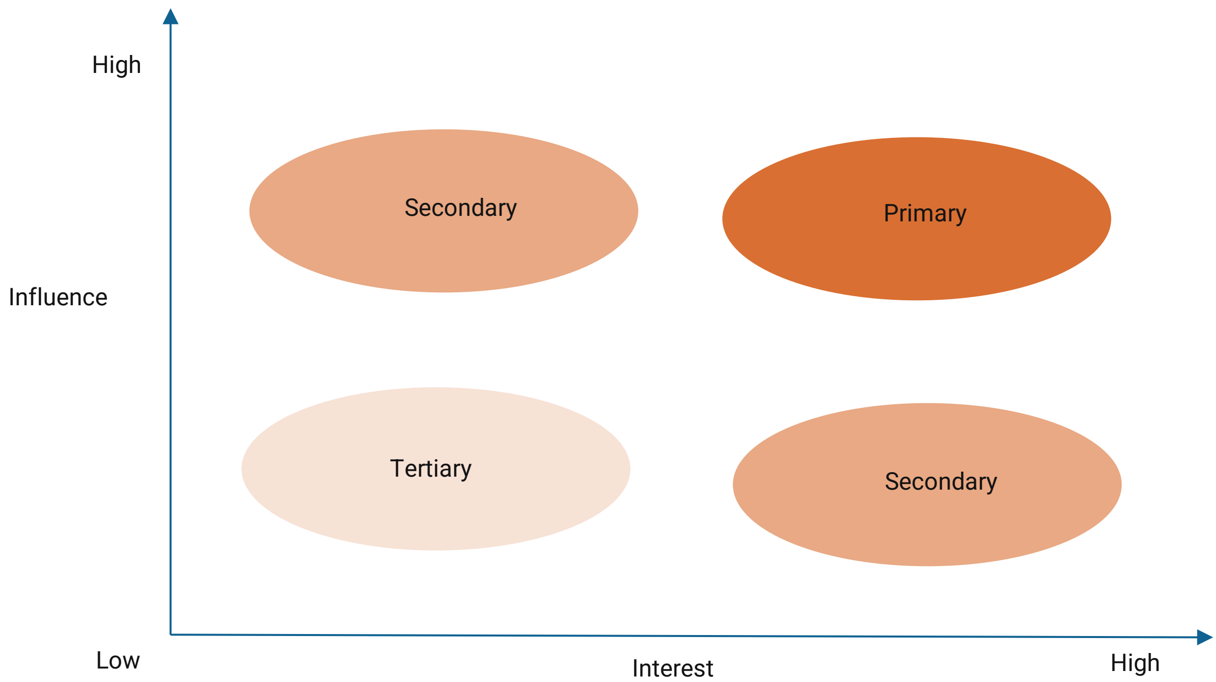

Figure 14: Stakeholder classification matrix

Based on the above framework, a broad stakeholder list for each category was developed. As the project developed through the lifecycle, stakeholders' interests may shift, which could potentially cause stakeholders to move their relationship and interest or influence on the project. For this reason, it was imperative to continue stakeholder identification and analysis throughout the project's life.

The primary stakeholder group with the highest level of influence and interest in the project included:

- Torres Shire Council
- Traditional Owners – Kaurareg represented by the Kaurareg Native Title Aboriginal Corporation
- Energy Queensland Limited
- Department of Climate Change, Energy, the Environment and Water

The secondary stakeholder group included:

- Elected State and Federal Members of Parliament
- Other local government councils, including The Torres Cape Indigenous Council Alliance
- Torres Strait Regional Authority
- State and federal government departments
- Local businesses and other community representative bodies
- Local, state and national media outlets

The third group of stakeholders identified as an interest group for the project included other residents.

These stakeholder groups formed the original basis of our stakeholder engagement strategy and stakeholder database.

Targeted communication strategies were developed for each of the stakeholder groups, and for individual stakeholders depending on their level of knowledge, understanding, interest and influence over project outcomes, or their ability and willingness to engage and inform EnergyConnect.

To track stakeholder engagement activity, a Register of Communications was maintained throughout the project, and statistical data on the number of stakeholder engagement sessions[27] undertaken is summarised in Table 8.

[27] Combined data for Napranum and Muralug stakeholder engagement activities

Table 8: Composition of engagement activities

Total No. of engagement sessions	98
Total duration of engagement sessions (hrs)	130
Total no. of stakeholders consulted	285

3.2 Community Engagement Strategy

Stakeholder and community engagement was recognised as a key determinant of success in this project, putting early and effective engagement with its stakeholders and 'interested parties' as a top priority. The Project Delivery Plan defined a clear program of community and stakeholder engagement, including a Stakeholder Engagement Strategy, to scope expectations and match potential microgrid solutions to community preferences.

The Stakeholder Engagement Strategy was developed to effectively coordinate communication, consultation, and engagement with the key stakeholders and the Muralug community. The strategy was developed in line with best practice principles from IAP2, Australian Federal Government and as described in ISO 14001:2018 Environmental Management Systems guidance.

The Community Engagement Strategy aimed to:

- proactively address and respond to stakeholder and community issues, concerns, ideas, and opportunities associated with the project through ongoing consultation and engagement
- identify stakeholders with a potential to influence the project and seek their input and involvement during the project
- provide factual, timely and relevant information to all stakeholders
- maintain and nurture existing stakeholder relationships and build new ones as opportunities arose
- profile EnergyConnect's capability to engage in sustainable energy generation practices
- continue to build and refine robust frameworks that manage potential and real stakeholder issues and opportunities effectively and in a timely manner
- provide engagement activities that meet or exceed community expectations.

The Stakeholder Engagement Strategy included a Communication Plan that served as the foundation for all project communication, allowing for the development and strengthening of relationships with key stakeholders. While all communication, consultation, and engagement were based on the Strategy, it evolved slightly over time, leading to enhanced engagement within the target community and creating a strong foundation for future project implementation activities after the feasibility study is completed.

To support the deployment of the Strategy, key themes, messages, and delivery protocols were developed to ensure timely and accurate information and to reaffirm EnergyConnect's commitment to the community and its approach to managing environmental, social, and economic impacts. Through its community and stakeholder engagement program, EnergyConnect gained a comprehensive understanding of the community context and social framework, as well as a clear understanding of concerns, desires, strengths, weaknesses, and opportunities related to potential project impacts.

The project team also established relationships with key community members, groups, and stakeholders. Regular site visits played a vital role in building these relationships and establishing effective communication links between the community and the EnergyConnect team. These visits ensured that feedback was timely and responded to promptly, communication mechanisms and protocols were followed effectively, and relationship-centric stakeholder engagement was prioritized and achieved.

EnergyConnect is proud of the relationships it has built with the community and appreciates the advice and support that it received.

3.2.1 Major Community Activities

A range of communications and community engagement activities were undertaken to ensure broad awareness of the Muralug microgrid feasibility study, including:

- Presentations to Torres Shire Council members.
- Presentations to TSRA members.
- Discussion with Kaurareg RNTBC members.
- Meetings with TCICA.
- Stakeholder engagement workshop (Cairns).
- Direct engagement with residents through household energy audits.
- One-on-one meetings with stakeholders.
- Meetings with Queensland Government Agencies:
    - Department Communities, Housing and Digital Economy
    - Energy and Public Works
    - Department of Resources

Several different types of media were developed and used to support the community engagement activities including:

- Project Update Newsletters.

- EnergyConnect website https://energy-connect.net.au/.
- EnergyConnect YouTube videos[28] to explain concepts and provide regional and cultural context to the project and provide educational information to local students,
- Muralug Power Needs Survey.
- PowerPoint Presentations developed for specific audiences and briefings.

Figure 15: Discussion with Kaurareg representatives and Muralug residents

A record of major communications activity was maintained in the Register of Communications. This was a shared document updated by all EnergyConnect team members on completion of engagement activities.

At each engagement activity an accurate record was made of attendees, the purpose of the meeting, duration, and venue. Records were also kept of the key points raised, and actions required to address concerns in a timely manner. Within the project team, actions were assigned to a responsible officer and a targeted resolution date was set. Progress on status of actions was reviewed at fortnightly team meetings. A stakeholder register, maintained throughout the process, recorded each of the key stakeholders engaged.

3.3 Community Attitudes and Current State Assessment

Community attitudes towards energy usage and supply and future aspirations were assessed through an initial series of meetings with Muralug leaders and key stakeholders throughout September and November 2021, including the Torres Shire Council. The project

[28] https://www.youtube.com/@energy-connect3739

team also undertook 14 targeted surveys of households to better inform the project of individual experiences from within the community.

The outcome of these activities provided essential information to the team that were used to guide and influence elements of the microgrid feasibility study.

From initial interactions with the Torres Shire Council the key benefits they saw from the project were:

- A showcase for sustainable and off the grid living.
- An improved higher quality of life for the residents.
- Increased equity of servicing land for approximately 100 lots.
- Increased opportunity for business and industry and in particular ecotourism.
- Long term and ongoing employment opportunities.
- Education in relation to energy and waste for the whole Shire.
- Improved community health through amenities facilities and infrastructure.
- The reduced reliance on fossil fuels and the move to local energy supply.

Subsequent meetings held with stakeholders and leaders, community survey interviews and discussions formed 4 key themes of community sentiment for Muralug. These key themes are outlined in Table 9:

Table 9: Key themes of community attitudes

Key Themes	Findings
Current state – energy challenges for Muralug community	Power supply inequality is due primarily to barriers of cost – each household is responsible for their own power supply and there is a significant variation in the quality, age and capacity of these electricity supply systems. Sparse distribution of residents - although most residents live in communities within the north-eastern portion of the island the remainder of the population of Muralug live in geographically isolated small groups spread along the peripheries of the Island. Lack of reliable power - even where systems meet basic energy needs many residents live and work on nearby islands and children often move away for work and study. Grants and funding programs have worked in the past - historical subsidies and funding support arrangements contributed to increased supply quality power systems (although many of these systems are now approaching end of life). Set up cost and access to skilled/licensed contractors are the primary barriers that residents face in power supply.

	The residents of Muralug have a heightened awareness of their energy supply and use, demonstrating an understanding of system capacity, maintenance requirements and operational limitations of their individual systems. Although some younger families live on the island many of the residents are approaching or of retirement age. The challenges of maintaining energy supply increases as incomes reduce and physical decline occurs become more significant as the population ages.
Development plans and future growth at Muralug	Muralug Island is not identified as a future growth area due to lack of services and availability of land for development. A small number of undeveloped lots within existing communities have potential for development for residential/tourism purposes. Some residents reported aspirations for future industry particularly in tourism and hospitality.
Sustainability and environmental factors, and	More advanced supply systems require minimal generator support leading to decreased reliance on fossil fuels while those without advanced systems rely entirely on petrol/diesel generators for power supply. The Torres Straits are in the far northern reaches of eastern Australia and as such present a significant challenge for transport and logistics. Muralug is an island separated from the main logistical hub of Thursday and Horne Islands by an additional stretch of water. There is no regular ferry service, and any delivery of equipment, fuel or parts requires residents to arrange specific services at their own cost. The same applies to skilled labour as even technicians based on Thursday or Horn Island need to make special trips to service the community on Muralug.
Exploring the potential for a centrally controlled energy network	Although Muralug covers a large area only limited pockets are available for development. Council holds operational leases near Muralug Beach that may be suitable for siting microgrid infrastructure but areas outside existing settlements present challenges for securing tenure particularly for distribution networks. Residents are accustomed to being self-sufficient and content to remain independent of a central network, although, with the appropriate network arrangements 50% of residents would be willing to export excess energy to a network

EnergyConnect has been guided by these findings and has provided a range of feedback mechanisms during the project to illustrate how community ideas have been incorporated into the feasibility study.

3.4 Community Awareness Over Project Lifecycle

During the feasibility study, the Muralug community gained an improved understanding of the opportunities presented by remote self-sufficient power systems, which they were already acutely aware of. As a result, both residents and key stakeholders have become more knowledgeable about what a microgrid solution would entail, as well as the potential benefits and challenges it would bring.

To maximise engagement and collaboration with interested or impacted community members and stakeholders, the project team encouraged community feedback. This not only helped to determine the most appropriate technical solutions and potential locations for microgrid elements but also explored an alternative opportunity for standalone individual power systems (IPS).

To facilitate the sharing of information between the project team and key stakeholders, community and stakeholder consultation was conducted through direct meetings, community surveys, energy audits of residences, and newsletters and updates. Feedback from stakeholders on the feasibility study was generally positive, with individuals who completed surveys or were part of the energy audits volunteering to be part of the program. As a token of appreciation, these individuals were rewarded with a small thank-you gift in the form of USB chargers used for small devices. Notably, there was no negative feedback received from any part of the project.

4

Existing Electricity Supply Arrangements

4 Existing Electricity Supply Arrangements

4.1 Torres Strait Islands Electricity Supply

EQL, through its subsidiary companies Ergon Energy Network and Ergon Energy Retail, generates, distributes, and provides electricity retail services to 16 island communities in the Torres Strait.

The local electricity microgrids consist of centralised local power stations with multiple diesel generators and associated high- and low-voltage distribution networks. There are no interconnections between islands and the systems are isolated from the national electricity grid.

Thursday Island is the commercial hub of the Torres Strait islands and has the largest electricity generation capacity at 9.55 MW whereas Stephen Island has the smallest system with 260kW of generating capacity. However, most of the systems are sized between 300kW and 1 MW generation capacity.

Approximately 16 megalitres of diesel fuel is consumed annually[29] for the generation of power in the Torres Strait. There are two 225kW Vestas wind turbines at Thursday Island and there is a 36kW solar farm at Poruma Island. These renewable energy generators operate to reduce diesel consumption at those communities.

Thursday Island is a major service hub for EQL in the Torres Strait, with a permanent staff of power station operators, linesmen and electricians who maintain EQL's assets at all Torres Strait communities. Power Station Attendants (PSAs) are also based at most of the island communities. The PSAs perform basic maintenance and inspection works at the power stations. EQL is well placed to service any additional electricity supply infrastructure deployed to Muralug Island in the future.

Technical, engineering, administrative, and other support services for the Torres Strait Island communities are provided by the EQL Isolated Systems and Asset Management teams based in Cairns, the Atherton Tablelands and other regional Queensland locations.

EQL also coordinates contract works throughout the Torres Strait for vegetation management, pole inspection and treatment, meter-reading, and specialist services for maintaining power stations and the Thursday Island wind turbines.

The electricity network is exposed to seasonal weather impacts, the effects of a harsh salty environment, and vegetation regrowth. EQL undertakes routine maintenance programs on its power stations and distribution systems and provides emergency response services to ensure the safety and reliability of the electricity network.

[29] Estimate based on annual energy production (reported in NGER) and 0.25 l/kWh diesel

At communities where EQL provides electricity services, residents have access to uniform retail tariff rates set by the Queensland Competition Authority on behalf of the Queensland Government.

The Queensland Government and the Queensland Competition Authority (QCA) provide a regulatory framework for the Remote and Isolated communities by monitoring safety, reliability, customer service standards and economic performance for these networks, outside the National Electricity Market.

In line with the Queensland Government's Uniform Tariff Policy, a Community Service Obligation (CSO) payment is provided to EQL to compensate Ergon Retail for the increased costs of operating in regional Queensland. This subsidy is provided to ensure Queenslanders, regardless of their geographic location, pay a commensurate price for their electricity. The budget estimate for 2022/23 fiscal year CSO[30] is $635 million[31].

EQL operates 33 Remote and Isolated power stations and associated networks across regional Queensland. There are 28 sites in North Queensland servicing remote communities located at the Gulf of Carpentaria, Cape York Peninsula, Mornington Island, Palm Island and Torres Strait Islands as shown in Figure 16.

[30] Queensland Government Budget Strategy and Outlook 2022-23 Table 8.7 (page 163)

[31] The average CSO for the 3 previous financial years is approximately $494 million p.a. Forecast CSO for 2023/24 is $514 million

Figure 16: EQL Isolated Power Systems - North Queensland including Torres Strait Islands

4.2 Muralug Island Electricity Supply

EQL does not currently provide electricity supply to Muralug Island and consequently Muralug residents do not have access to uniform tariff arrangements.

Residents rely on small petrol or diesel generators or privately-owned IPS to meet their energy requirements. The IPS typically consist of a combination of rooftop solar PV systems, battery energy storage and small diesel or petrol generators.

Hot water is generally provided by solar or LPG hot water systems. A mix of LPG stoves and cooktops, microwave ovens and small butane gas cooktops are used for cooking.

Power is also required for pumping water from underground bores into tanks, and for pressurising water services to dwellings. In some instances, capacity is available via the IPS. Alternatively, the bore pump motors are directly connected to small generators.

Current IPS in service at Muralug range from basic "home-built" systems that have been patched together over time, to sophisticated and modern systems that have been installed by qualified installers and electrical contractors.

The existing systems include combinations of 12- and 24-volt DC and 240-volt AC wiring configurations.

Figure 17: Non-professionally installed solar PV and batteries at Muralug

The project team has obtained copies of quotes[32] for sample IPS systems at Muralug incorporating solar panels, batteries and inverters, for a 3kW system and a 7.5kW system.

The quotes exclude standby generators which may be required to:

- charge battery systems when there is insufficient solar radiation at certain times throughout the year
- provide emergency backup in the event of IPS component failure
- operate equipment that exceeds IPS capacity (such as welders, power tools, pumps etc.).

The privately-owned IPS installations at Muralug are self-funded by residents. This includes the costs of purchasing and installing rooftop solar panels, batteries, inverters, and switchboards, as well as solar or gas hot water systems and small petrol or diesel generators.

Some residents accessed government-funded renewable energy rebates, that were available between 2000 and 2009, to offset the costs of their initial installations. Many of the original IPS have since been upgraded, refurbished or replaced without additional financial support. Batteries and inverters have an estimated lifespan of 7 to 10 years in Torres Strait due to the harsh operating environment.

The cost of installing new IPS, upgrading existing systems or replacing major components such as batteries, is a significant barrier for Muralug residents who have expressed a desire to have a similar level of amenity as neighbours living at other Torres Strait communities where EQL provides reticulated power supply and subsidised electricity tariffs.

[32] Prices based on 2020 costs inclusive of GST, freight and installation

As outlined in section 2, some residents rely solely on small petrol or diesel generators and the cost of fuel and noise considerations dictate how long the generators are operated, with many systems only being operated during daylight hours up to 12 hours per day.

Figure 18: Typical small, medium, and large generators installed at Muralug.

Fuel is significantly more expensive[33] at Thursday Island than at other major mainland locations. A comparison of retail fuel prices taken at Cairns and Thursday Island is summarised in Table 10 below.

Table 10: Fuel price comparison - Thursday Island & Cairns

Location	Regular Diesel ($/litre)	Regular Unleaded 91 ($/litre)
Thursday Island	$2.79	$2.49
Cairns	$2.039	$1.655
Difference ($/litre)	$0.751	$0.835

There are several concerns associated with individuals collecting fuel from Thursday Island in jerry cans and drums to transport back to Muralug, including:

- Logistical issues.
- Environmental issues.
- Safety considerations.
- Private vessels used for transportation.
- Potential for fuel spills.
- Personal injuries.

[33] Prices from *Petrol Spy* app obtained 23rd January 2023 at 12:30pm

The professionally designed and installed IPS in service at Muralug can provide 24-hour electricity supply, within the design capacity of the individual systems. Most residents with these systems indicated that they only needed to run their standby generators during a short window of a few weeks per year to assist with charging batteries.

Residents have adopted very energy-efficient lifestyles to accommodate the limitations of their IPS.

Figure 19: Professionally installed solar PV and solar hot water systems installed at Muralug

Figure 20: Professionally installed inverters and batteries installed at houses on Muralug

4.3 Previous Studies

A review of electricity supply options for Muralug (Prince of Wales) Island was undertaken in early 2012 by Evolve Energy on behalf of Ergon Energy and the Queensland Government's Office of Clean Energy[34]. This study considered options for providing electricity supply to between 30 and 46 dwellings in the Muralug Beach, Collis Beach and Country Women's Beach areas.

[34] Evolve Energy - Prince of Wales Island Energy Review - January 2012

Three options were discussed in the report, including two options previously considered by Ergon Energy, being:

Option 1

An undersea cable from Thursday Island to Muralug (Prince of Wales) Island and local distribution network at an estimated capital cost[35] of $7.92m or $264,000 per dwelling (December 2011), and

Option 2

Centralised power station at Muralug (Prince of Wales) Island and associated distribution network – estimated capital cost $10.54m or $351,300 per dwelling (December 2011)

Under either option 1 or Option 2 and based on estimated daily energy consumption of 24kWh per day (equivalent to the average consumption across the Torres Strait Islands) residents would also be expected to pay an average of $1,994.00 per annum at that time for energy consumption.

Option 3

A third option suggested by Evolve Energy was to upgrade existing Remote Area Power Supply (RAPS) systems to incorporate increased levels of renewable energy and to implement energy efficiency initiatives. The estimated cost of this option, at the time, was $3.89m for 46 dwellings or $84,570 per dwelling. This cost included provision for energy efficient appliances, training in RAPS system operation and installation of solar hot water systems.

This option was based on a RAPS system capable of supplying 11kWh per day and with 70% solar energy input.

The RAPS option with 70% solar was also expected to provide reduced operation and maintenance costs of $174,000 per annum, compared with RAPS systems with only 15% solar.

4.4 RAPS Funding Programs

The following information was extracted from a report prepared by The Australian Institute in 2010[36] following a review of the government's solar rebate program.

Between January 2000 and June 2009, the Australian government provided rebates for solar PV systems with the following aims:

- Promote uptake of renewable energy.

[35] Estimated costs of options were budget prices in 2020 including GST

[36] The Australian Institute – The Australian Government's solar PV rebate program – An evaluation of its cost-effectiveness and fairness – Policy Brief No. 21, November 2010

- Reduce greenhouse gas emissions.
- Help in the development of the Australian PV industry.
- Increase public awareness and acceptance of renewable energy.

Initially known as the *Photovoltaic Rebate Program* (PVRP), it was rebranded as the *Solar Homes and Communities Program* (SHCP) in November 2007.

A summary of the chronology of the programs in their various forms is provided below:

Jan 2000 – funding provided for half the cost of household PV systems, up to a maximum of $5,500 per household for 4 years. Rebate set at $5.50/Watt for systems of at least 450 Watts, up to a maximum of $8,250 per household. (i.e., 1.5 kW)
Oct 2000 – due to oversubscription the rebate was reduced to $5.00/Watt up to a maximum of $7,500 per household (1.5kW)
Feb 2003 – cap placed on monthly approval numbers to control costs
May 2003 – scheme extended to 1st July 2005 and the rebate reduced to $4.00/Watt and household limit reduced to $4,000 (1kW)
Feb 2004 – cap on monthly approvals was removed
May 2005 – program extended for a further 2 years (budget $11.4m)
Rebate rate reduced in $0.10 steps from $4.00/Watt to $3.50/Watt until program completion (June 2007)
May 2007- government announced rebate would be doubled to $8.00/Watt and $8,000 per household as a pre-election promise
Nov 2007 – change of government ensued – program name changed to SHCP - eligibility rules changed to grid-connected PV or very-near grid PV systems only
May 2008 – means test introduced to limit eligibility to households with taxable income of less than $100,000 per year
June 2009 – program closed at midnight 9th June due to oversubscription and rising program costs

The total cost of the program for the period January 2000 to 30th June 2009 was $879 million but was expected to increase to $1.1 billion after all rebates were processed.

It is reported that 109,634 successful residential applications were processed between January 2000 and 29th April 2010.

5

Microgrid Technology Options

5 Microgrid Technology Options

Muralug Island has no electricity grid, is sparsely populated and the small community is widely dispersed across the island. The Island's northern corner near Kiwain Point has the highest population density but there are still significant distances between individual customers in this area. IPS, which typically provide power to one off-grid customer or a household, have been determined as the most practical option for supplying electrical power to Muralug Island residents. Although the northern region has a more discrete group of loads and Distributed Energy Resources (DER), a microgrid would still involve distribution lines of around 5kms to connect all the load centres in that region, and such a distribution network would be at significant cost.

Given the spread and sparsity of population on the island and the lack of an existing electricity grid, installing new centralised generation and a distribution network is unlikely to be a cost-effective solution for electrification. A continuation of IPS would be the lowest cost method of providing electrification to the island.

5.1 Distributed Energy Resources

Distributed Energy Resources are generally small, distribution network-connected generation and storage systems. DERs also include load control functions that can be provided by devices such as batteries, controllers for hot water system boosters and air-conditioners, and timers.

5.2 Standalone Power Systems

The Australian Government's Large-scale Renewable Energy Target (LRET)[37] defines eligible renewable energy as hydro, wave, tide, ocean, wind, solar, geothermal-aquifer, hot dry rock, energy crops, wood waste, agricultural waste, food waste, bagasse, black liquor, biomass-based components of municipal solid waste, landfill gas, sewage gas and biomass-based components of sewage. Many of the generation technologies that utilise some of these energy sources are currently not economic at smaller scales, such as the electricity load of Muralug.

The Australian Government's Small-scale Renewable Energy Scheme (SRES)[38] extends the focus beyond electricity generation to also include solar thermal and air-source heat pump hot water systems.

---

[37] Renewable Energy (Electricity) Act 2000

[38] https://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/How-the-scheme-works/Small-scale-Renewable-Energy-Scheme

This section focuses on renewable energy technologies incentivised under the Australian Government's Large-scale and Small-scale renewable energy schemes in a Muralug context. Appendix B contains background information on each technology.

5.2.1 Solar Photovoltaic

Solar PV systems are cost-effective for both small-scale (kW) and large-scale (MW) installations in Queensland, as evidenced by the proliferation of the technology across the state over the previous 10 years. While the market was initially driven by generous government-backed feed-in tariff schemes, it now sustains itself using certificates from the LRET and SRES. This is helped by markedly lower equipment costs and increases in household electricity costs, both of which strengthen the financial case for installation of PV systems.

While PV can be installed on the roofs of households and commercial premises or as a ground-mount solar farm that is linked to the main grid, in mainstream communities rooftop PV is typically connected in a behind-the-meter arrangement which allows the PV generation to offset energy demand. Options for both rooftop and centralised ground-mounted arrays have been investigated within this project to provide for the energy needs of the Muralug community, noting that there is no grid connection available.

Muralug has an excellent solar resource by international standards and unlike most locations in Australia exhibits little annual variability, apart from intermittency during the wet season. Indeed, electricity supplied to Muralug residents is currently either from independent petrol or diesel generators and/or rooftop solar. For the modelling undertaken here, Bureau of Meteorology (BoM) data was obtained from the nearest weather station on Horn Island which is 9.9kms away[39]. The BoM Global Horizontal Irradiance (GHI) at Horn Island from 1990 – 2022 shows an annual average of 5.8 kWh/m^2/day, with the lowest annual mean of 5.4 kWh/m^2/day and the highest annual mean about 6.2 kWh/m^2/day. This represents an excellent resource, which helps to offset the high costs of installation on such a remote island.

Figure 21 below shows the annual variability and the seasonal nature of Muralug's reported monthly GHI.

[39] http://www.bom.gov.au/climate/data/index.shtml?bookmark=203

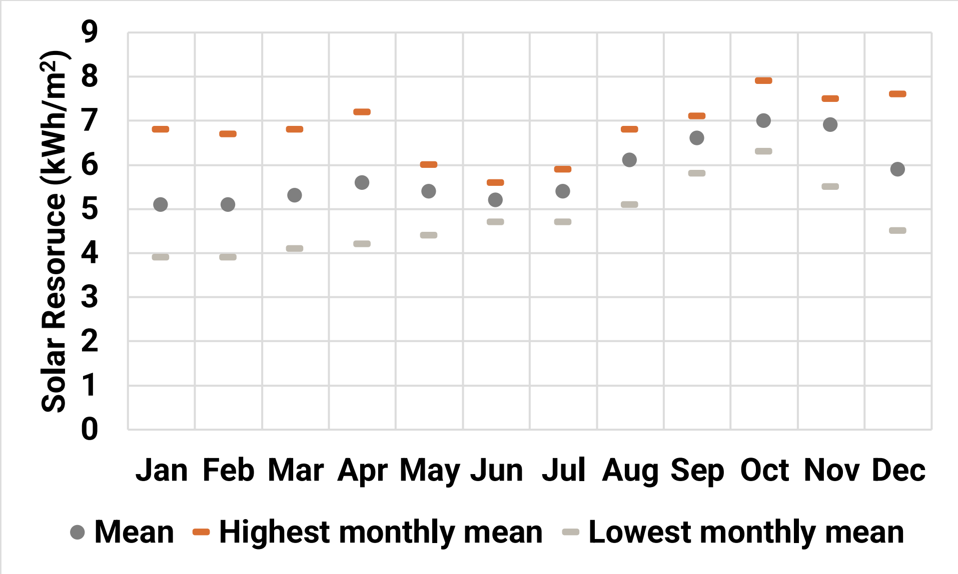

Figure 21: Annual variability and seasonal nature of Muralug GHI

PVWatts, a web-based application developed by the American National Renewable Energy Laboratory (NREL), that estimates the performance of a PV system, was used to simulate an indicative annual energy yield for a PV system installed at Muralug. The program uses algorithms to estimate the electricity production and cost of electricity from a PV system based on key inputs such as location, system size and module type. It also considers factors such as shading, system losses and the deterioration of solar panels over time.

To estimate solar electricity generation at Muralug, a 6 kW PV system was modelled on a roof with a standard gable tilt angle of 20°. The roofs on houses at Muralug rarely face north, and so different orientations were modelled. As expected, the roof facing north yielded the highest annual output of 9,521 kWh/year, while the roof facing south resulted in lowest output of 8,392 kWh/year, with the east- and west-facing roofs producing 9,006 kWh/year and 9,049 kWh/year respectively. This indicates that any PV system installed on a roof surface facing between due east or west in the arc including due north would produce at least 90% of the output of a PV system facing true north.

Table 11: PV Watts simulation energy output and specific yield of 6 kW rooftop system at Muralug

Module Orientation	Energy Output (kWh/year)	Specific Yield (kWh/kWp)
North	9,521	1,587
West	9,049	1,508
East	9,006	1,501
South	8,392	1,399

Most solar PV systems require no maintenance over many years of operation. PV panels lose some of their efficiency with time, but typically come with 20-year guarantees of 80% of the rated power output. Thus, over the course of 20 years, it is expected that the annual output of a rooftop 6 kWp PV array facing north with no shading will decrease to 7.6 MWh in the twentieth year from the initial 9.5 MWh annual generation. Inverters for PV systems must be replaced every 10 years on average.

Operation and Maintenance costs are minimal and involve occasionally washing the solar PV array (if rain has been inadequate), checking that the inverter, safety isolators and cables are operational (i.e., no water or insect ingress) and inspecting for any corrosion, animal interference, and other mechanical damage.

5.2.2 Solar Thermal and Heat Pump Hot Water Systems

Four different types of water heaters are commercially available in Australia: resistance water heaters, solar thermal systems, heat pumps and gas water heaters. Resistance water heaters are least efficient, using more than 10kWh to heat 200 litres of water to around 60°C, and so are unsuitable for IPS. Solar thermal and heat pump hot water systems can both reduce electricity use by around 70% to 80% compared to a resistance heater, depending on when and how much hot water is used.

An advantage of solar thermal systems over heat pumps is that, in tropical locations such as Muralug, they can provide a reasonable hot water service without using any electricity at all. However, if they have an electric booster, it is almost always a resistance heater. Thus, heat pumps may be a better option if a significant amount of boosting is required. Gas water heaters use no electricity and so present a good option for IPS however, they require a supply of gas. Replacement gas bottles need to be brought by boat to Muralug and combustion of gas also releases greenhouse gas emissions when used.

Currently the residents of Muralug use gas and solar water heaters that are not boosted from their IPS.

5.2.3 Household Batteries

Household batteries can reduce electricity costs by charging from a household’s rooftop solar PV during the day, and provide power to the house at night, or at other times when electricity demand is high. Household batteries can also be configured to provide power to adjacent households, operating together as a Virtual Power Plant (VPP).

There are many household batteries already in use on Muralug. Both lithium-ion and lead-acid batteries are used. Lithium-ion is the newer of these two chemistries and has lower maintenance requirements and longer liftetime, but a slightly higher cost per kWh of storage than lead-acid. Lead-acid batteries benefit from a much more developed recycling industry than lithium-ion, but this is quickly changing, with lithium-ion recycling becoming the focus.

Batteries, especially lithium-based, are critical to the roll-out of renewable energy across the world, as they provide a way to store power generated from solar PV and wind and release it at times of the day when it is more useful, such as the evening and morning peak.

5.3 Centralised Energy Generation

5.3.1 Wind

Wind turbines operate when wind turns blades around a rotor, and the rotational force is then used to turn a generator to create electricity. Depending on the type of wind turbine used, electrical output from the generator may require conditioning by power electronics to obtain the correct frequency and voltage before it can be exported to the grid.

The most common form of wind turbine has the rotor spinning around a horizontal axis and three blades. Vertical axis wind turbines also exist but they have a very small proportion of the wind turbine market.

Small wind turbines have been deployed in remote islands around the world. Two 225 kW wind turbines have been in operation on the Thursday Island since 1997 and Ergon Energy has previously investigated wind sites at Horn Island. Muralug is exposed to high winds on the north-east side of the island suitable for small-scale wind, but is not an ideal candidate for two main reasons:

- The maintenance cost of small- to medium-scale wind turbines as a percentage of capital cost per annum is higher than PV systems, particularly in remote island settings.
- Tropical weather, including cyclones, requiring regular monitoring and additional maintenance.

Due to the small number of residents at Muralug Island and low demand for energy, the implementation of wind generation is deemed impractical.

5.3.2 Hydro/Pumped Storage

Micro-hydropower systems can be as small as 5 kW, and up to 100 kW. Full-sized hydropower systems can produce almost any amount of power where there is an appropriate flow of water. The minimum flow required for a 50 kW micro-hydropower system is approximately 1m^3/second, with a height difference, or head, between the intake and outlet of 10m. This is equivalent to a river about 5m wide and 1m deep. Muralug does not have sufficient rainfall or flowing water for hydropower.

5.3.3 Bioenergy

A variety of bioenergy generation technologies are commercially available. However, most of the risk with bioenergy generation lies with the biomass supply and delivered cost. Relative to the purchase cost, biomass resources are expensive to transport. Thus, the lowest cost biomass resources are those local to the user. Bioenergy capital costs are strongly dependent on system size, with large systems being progressively more cost effective.

Muralug does not have sufficient local bioenergy resources or a large enough load to make bioenergy viable.

5.3.4 Tidal Power

EnergyConnect is aware of previous investigations into the potential application of tidal power in the Muralug area. Tidal energy production is still in its infancy. It requires a turbine to be installed in a fast-flowing tidal reservoir or lagoon, and careful planning is required to minimise impact to the surrounding environment from disruption to seawater flow. Pilot projects are being developed in several countries, but high production costs, high maintenance requirements, and costly technological studies and engineering work make it difficult to propose for remote island locations such as Muralug.

5.3.5 Energy Storage

A range of energy storage technologies are utilised for various applications around the world. These include various battery chemistries, pumped hydro, compressed air, thermal, flywheels and hydrogen.

Electricity storage can be categorised into two major types:

- Short-term energy storage.
- Bulk energy storage.

The parameters for energy storage will depend on its designed role. This can vary widely as requirements can be different depending on function and other generators.

For an isolated microgrid, a grid-forming Battery Energy Storage System (BESS) may be a suitable energy storage option. The primary purpose of the BESS is to store Variable Renewable Energy (VRE) generation, to be used later, when there is no or limited output from VRE generation.

However, as loads at Muralug are too dispersed and met using IPS, a central battery, co-located with the solar farm and standby synchronous generator, is not more cost-effective than distributed household batteries.

5.4 Distribution Network

The standard distribution network configuration throughout the Torres Strait islands consists of overhead high voltage (HV) network on wood pole structures, with overhead low voltage aerial bundled conductors (LVABC). Pole-mounted transformers are incorporated into the design.

If a central microgrid generation facility was established at Muralug Beach to service Collis Beach, Muralug Beach and Country Women’s Beach, a high voltage network would be required to link the three communities and central power station. The estimated route length is approximately 3.3km of HV network and 1.5km of LVABC network, and 6 pole-mounted transformers would be required.

Assuming that approval was obtained for the preferred powerline routes, including vegetation removal, it is estimated that the network costs would exceed $2 million.

The cost of this option, when combined with the cost of centralised microgrid generation assets, makes it an uneconomical proposition compared with the alternative IPS solution proposed.

5.5 Generator Efficiency

Typically, in existing isolated islands, diesel generation is used most of the day. The diesel generation regularly ramps up and down to cope with load fluctuations. Adding some VRE generation increases the diesel generation's load fluctuations, and this is manageable provided it is within the acceptable ramp rate of the diesel generation. As the VRE power fraction increases beyond a certain point, risks to power quality emerge and to manage this some form of energy storage is typically used.

Diesel generation could also play a primary generation role for isolated power and more cost-effective approaches with high renewable energy fractions are feasible. This includes designs where diesel-off operation occurs for most of the time when renewable energy and battery energy storage is available. The diesel generator is only occasionally required, usually after a day with extensive clouds or at night when the battery depth-of-discharge reaches certain set points. At these times the diesel generator would be auto-started and operated at its maximum efficiency to recharge the battery to the required state-of-charge for that period.

The cost of generating electricity with diesel generators is high due to:

- the low efficiency of internal combustion engine generators (~20% to 40% depending on loading)
- the high and fluctuating cost of diesel, around $2.80 per litre on Thursday Island.

The diesel generator is expected to only be required occasionally, when the battery state-of-charge reaches specific set points. The typical efficiency of a small, diesel generator is shown in Figure 22.

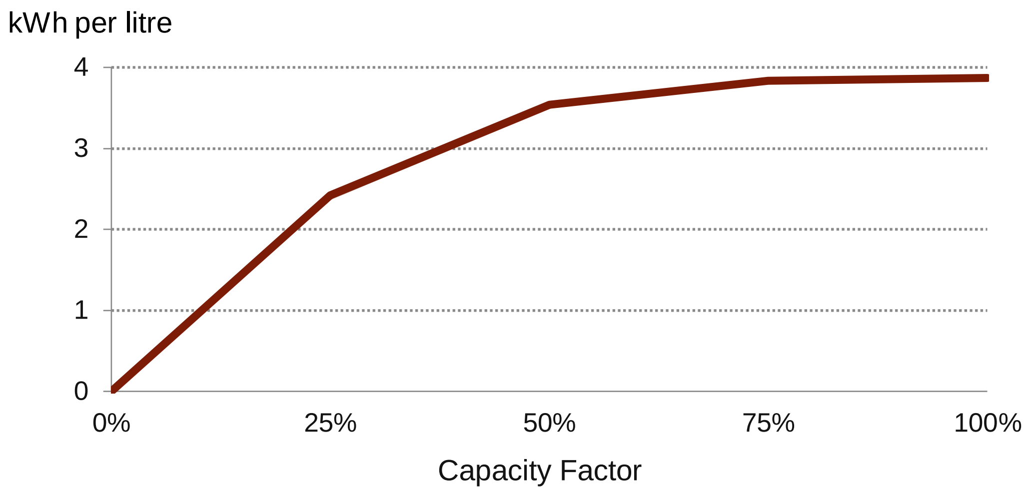

Figure 22: Typical efficiency curve for a small diesel generator at various loadings

When operational, the diesel generator would be run at peak efficiency at its optimum loading to recharge the battery, i.e., it is not required to load follow and vary its output with the associated efficiency decrease.

5.6 Fuel Substitution

Alternative fuels can be suitable for use in diesel engine generators including biodiesel, biogas, and hydrogen. Gas engines and turbines are also used as generators in some isolated locations with access to cheap gas. Common issues that are considered in determining suitability of these other fuels include cost, transport and storage logistics, generator unit sizes, costs of upgrading any existing power station equipment, network connection costs, maintenance requirements and the existence of regional supply chains.

The expected capacity factor for the engine generator is also a key factor for determining if the cost of other fuels is worth detailed investigation. As the diesel standby generator is relatively small and only used occasionally, it is unlikely that alternative fuels will be economically attractive. The following discussion is provided only as a high-level overview of the options.

5.6.1 Biodiesel

Biodiesel can be an attractive fuel if a local source is available at a competitive price. Biodiesel can be made from waste cooking oil, animal fats derived from tallow from cattle or vegetable oils. It can also be made from algae and pongamia trees, which are currently not commercially viable.

Since the source feedstock material can be replenished readily, biodiesel is considered a source of renewable energy. Biodiesel can be blended with normal automotive diesel at various percentages and can typically be used as a direct replacement for diesel fuel with little or no modification to the diesel generator. Although coconut oil fuels are more common in the Pacific, the biodiesel market from all fuel sources is not well established in Australia and thus the availability and cost can vary significantly. The nearest commercial source of biodiesel is Brisbane, and it is expected the delivered cost to Muralug will be significantly more than that for diesel. Furthermore, the supply chain is separate to the automotive diesel supply chain resulting in high transportation costs.

Standard diesel generators can operate effectively using a B20 biodiesel alternative – a blended fuel source consisting of 20% biofuel and 80% diesel mix to reduce Greenhouse Gas emissions compared to a straight diesel fuel supply.

The shelf-life of biodiesel is much less than that of standard diesel fuel, biodiesel is not currently widely used in regional Queensland with the nearest manufacturing and distribution hub located in Brisbane.

The additional cost and reduced shelf-life combined with the small volumes required would potentially make this option uneconomical for use in the Muralug microgrid back-up generator.

5.6.2 Hydrogen

Hydrogen on-demand, diesel fuel-saving technologies are being developed. They either use electrolysis to split water to produce a gas comprised of hydrogen and oxygen, or a chemical reaction using sodium borohydride. There are several companies in the USA developing the technology for the automotive industry to be used in fuel cells or internal combustion engines.

Hydrogen on-demand is claimed to increase the efficiency of diesel engines by around 10% to 15%. It works by promoting the full combustion of diesel fuel in the engine (diesel engines normally have small amounts of unburnt fuel in the exhaust and carbon monoxide, which results from incomplete combustion). The energy cost in generating the hydrogen via electrolysis of water is more than offset by the power gains from the complete combustion of diesel fuel, hence the gain in fuel efficiency. However, commercial retrofit kits are available primarily for the automotive industry rather than utility engine generators.

The technology is at the early commercialisation stage. Ergon Energy Network is currently investigating options for reducing diesel fuel use in power stations across regional Queensland. Potential solutions may include renewables, energy storage, hydrogen, or biofuels.

Horizon Power is exploring hydrogen and fuel cells as options to assist meet their goal of no new diesel generators after 2025. The Denham Hydrogen Demonstration project is demonstrating a relatively small amount of dispatchable generation capacity and is expected to produce more than 220 MWh per year from a 100 kW fuel cell. While the Denham total project cost of $8.9 million includes a new 704 kW solar farm, 348 kW electrolysis unit and other equipment, this demonstration project highlights that this is currently an expensive option, so hydrogen generation has not been analysed for this study.

6

Demand-side Options

6 Demand-side Options

6.1 Energy Audits on Existing Facilities

Type 1 Energy Audits were conducted at households on Muralug between March and October of 2022. A Type 1 Energy Audit Report provides a detailed summary of the energy consuming processes that occur at a site, along with recommendations on how to reduce consumption, and includes the following steps:

- An on-site visit to discuss the occupant's energy use and inspect building fabric, type and usage patterns.
- List all energy consuming appliances on site and usage patterns.
- An assessment of annual energy consumption (gas and electricity) and eco-footprint per household and per person.
- Indication of potential energy efficiency measures available, including management options ranked according to their potential financial return.

Using an app designed for this project, the EnergyConnect team sought Muralug residents willing to participate in an audit. Audits were conducted during scheduled times and aligned with survey times to minimise disturbance to household routines. A report was collated for each site, which identified potential savings for householders via changes to operating regimes or recommendations of more energy efficient replacements for appliances. For the households audited, the eco-footprint was well below the average for Australia. This can be attributed to residents being accustomed to living within the capacity of their energy supply systems.

6.2 Energy Efficiency

6.2.1 Housing

The houses audited showed a mix of construction materials and methods. These included modern cement block and timber construction, highset fibro houses, simple shacks and converted sheds. Insulation was present to varying degrees. More modern houses had insulation installed in ceilings and/or walls. Older dwellings were lined but not insulated while others were constructed of unlined fibro or iron sheeting. All dwellings were unique but primarily orientated towards the ocean, with large windows to harness breezes for natural cooling, and lighting.

Although a tropical climate, air-conditioning use is limited, attributed by residents to limited energy supply capacity. Instead, most houses use natural breezes, ceiling and/or pedestal fans for cooling.

The unique housing designs featured indoor–outdoor living areas with shaded external verandas and patios orientated to receive natural breezes. These features and the open plan of many of the dwellings were supportive of the typical space usage of residents in tropical environments.

Most houses have solar hot water systems, and residents are responsible for their own water supply. Many of these were supported by a Torres Shire Council program to provide polyurethane water tanks to residents. Pressure pumps are operated by residents to supply buildings with water from rainwater tanks in cases where gravity is insufficient.

Houses are generally occupied by 1 to 3 residents with regular visitors and family returning intermittently on weekends and holidays, often increasing household numbers by four or more, with associated changes to energy use.

6.2.2 Appliances

There was a significant variation in the household appliances within each residence. Those with higher incomes and suitable power supply were able to fit their houses with a range of energy efficient appliances, in contrast to lower-income households where there was a selection of essential items including second hand or older less efficient appliances.

Most residents reported sufficient energy supply to operate essential appliances such as refrigerators, lighting and fans. However, those operating solely on generators chose to switch them off overnight.

Although no energy bills are received by residents, the cost of installation and operation of energy systems including fuel for generators is significant. Those lacking the resources to provide the upfront and ongoing maintenance costs of a renewable based IPS were subject to higher ongoing costs of fuel.

Cooking was primarily achieved through LPG and butane, contributing to ongoing fuel costs and emissions. Many houses had one or more large refrigerators, and many had a chest freezer or expressed a desire for one if power supply was sufficient. Very few had clothes driers and opted for air drying to limit energy consumption.

The Muralug community had a heightened awareness of energy consumption and the energy rating system for appliances. Transportation restrictions make selection, installation, and warranty claims on appliances difficult. The high cost of energy efficient appliances was also a factor for residents.

Many residents sought either to purchase second hand goods or were limited to the selections available from retailers on Thursday Island. The primary business for household appliances and warranty claims on Thursday Island is Col Jones Betta Electrical and a range of higher efficiency appliances were observed in stock (Figure 23).

Figure 23: Col Jones Betta Electrical store on Thursday Island

6.2.3 Energy Efficiency Education

Tailored education programs have been recognized by experts as an effective means of enhancing the implementation of renewable energy solutions. These multifaceted programs typically include information on energy efficiency, demand reduction, and maintenance requirements for renewable energy-based microgrid systems.

The Muralug community has long-standing self-supply arrangements, and therefore, many residents are already highly aware of energy efficiency measures. However, there may be some educational requirements for operating new IPS systems and for new community members who require skill development.

All appliances and energy systems require maintenance to ensure their longevity and effective functioning. This is especially important in tropical climates with high humidity and rainfall, as it can lead to the growth of mould and trees at a rapid rate. Therefore, an ongoing and regular maintenance regime is necessary, especially to ensure the optimal performance of solar PV systems.

Of significance to this project, an education campaign should address the following:

- Energy management and conservation principles.
- Optimising the number of appliances being operated at any one time.
- Choosing appliances with high energy efficiency (star) ratings.
- Turning off appliances at the wall and/or unplugging appliances not being used to reduce demand from standby power.
- Timing of use of high consumption appliances to when local renewable generation (i.e., solar) is at its peak.

- Design of houses to minimise the demand for air-conditioning and other cooling appliances and to maximise the use of natural light.
- Regular and proactive/preventative maintenance.
- Keeping seals on fridges and freezers clean and in good repair to keep them working properly.
- Cleaning filters in air conditioners.
- Removing dust and mould from solar panels.
- Maintenance and monitoring of battery systems.

Ergon Energy has previously implemented sustainability initiative programs like PowerSavvy, which was tailored to Indigenous communities on Cape York and Torres Strait Islands. This program would be an excellent resource for developing future energy efficiency education programs for Muralug and other communities where IPS may be the preferred household energy source.

Although educational programs that explain the benefits and savings of high consumption activities (cooking, washing, drying, and air-conditioning) during peak solar generation times are useful, it is likely that Muralug households are already aware of these issues.

7

Analysis of Options

7 Analysis of Options

7.1 Introduction

This section presents a financial screening of two options for electricity generation at Muralug – Individual Power Systems (IPS) at each household, and a central microgrid. As explored in section 5, the most suitable technologies for household IPS at Muralug are rooftop solar PV and residential-scale batteries. For a microgrid, the same technologies are suitable, with the addition of centralised solar PV and batteries and a distribution network.

7.2 Assumptions

7.2.1 Energy Usage

Energy monitoring systems have been installed at four houses in Muralug, with 3 months of data available at the time of analysis. A typical day from these load profiles is shown in Figure 24. This data was used to create a 12-month load profile, with seasonal variation adapted from similar data available for the Napranum community. This average household consumption was also adjusted to account for anticipated increases due to the larger capacity IPS systems that could be deployed at Muralug in future. The resultant average daily energy consumption value used for the Muralug system modelling is 20 kWh per household. This is 8 kWh lower than the average for Napranum, but higher than the average household consumption currently recorded at Muralug.

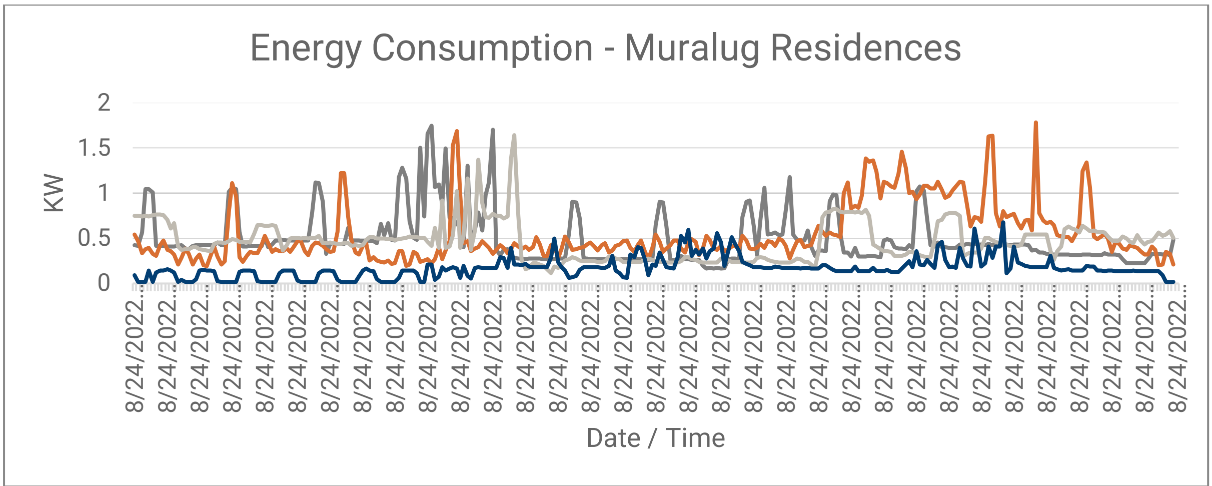

Figure 24: Typical 24h load profiles for 4 houses on Muralug

Muralug residents are expected to continue to use less energy than those at Napranum, as they have lower cooling requirements from generally smaller residences with better natural ventilation, and the absence of electric hot water systems at Muralug.

7.2.2 Weather and General Maintenance

Minimal maintenance will be required for solar PV systems in the short- to medium-term. As the system ages, refurbishments to inverters and cabling may be required after 10 years.

Solar PV panels commonly have a life expectancy of up to 25 years, at which point they may require replacement. Regular cleaning of panels is also recommended to ensure the system maintains its optimal efficiency throughout its life.

It was assumed that future weather patterns will remain consistent with the data used at the time of modelling. This particularly affects solar PV output due to cloud cover.

Batteries generally require little maintenance; however, general upkeep and cleanliness is recommended. Periodic inspections by an accredited technician are also recommended to prolong the life of the battery.

7.2.3 Installation Locations

IPS

Using satellite imagery, 67 structures were identified that could potentially host a rooftop solar PV system averaging 16 kW in DC capacity. 32 larger buildings on the island could potentially accommodate an average of 40 kW. Solar PV systems are assumed to be fixed at an angle of 20 degrees for rooftop solar in this analysis. A physical assessment of rooftop suitability has not been undertaken at this time.

A detailed survey of all properties and existing energy systems is needed to properly scope requirements.

Microgrid

At Muralug Beach there is a large parcel of council land (Lot73 TS263) that is reserved for TSC Operational and Utility Services. This was identified as a potential development site for a solar farm and community BESS should a microgrid solution be considered for Muralug. Further discussions with TSC and other stakeholders would be required to confirm availability of this site for use as part of the microgrid solution should it be progressed.

Figure 25 shows a concept plan for microgrid facilities at this site, with connection to Muralag Beach residences.

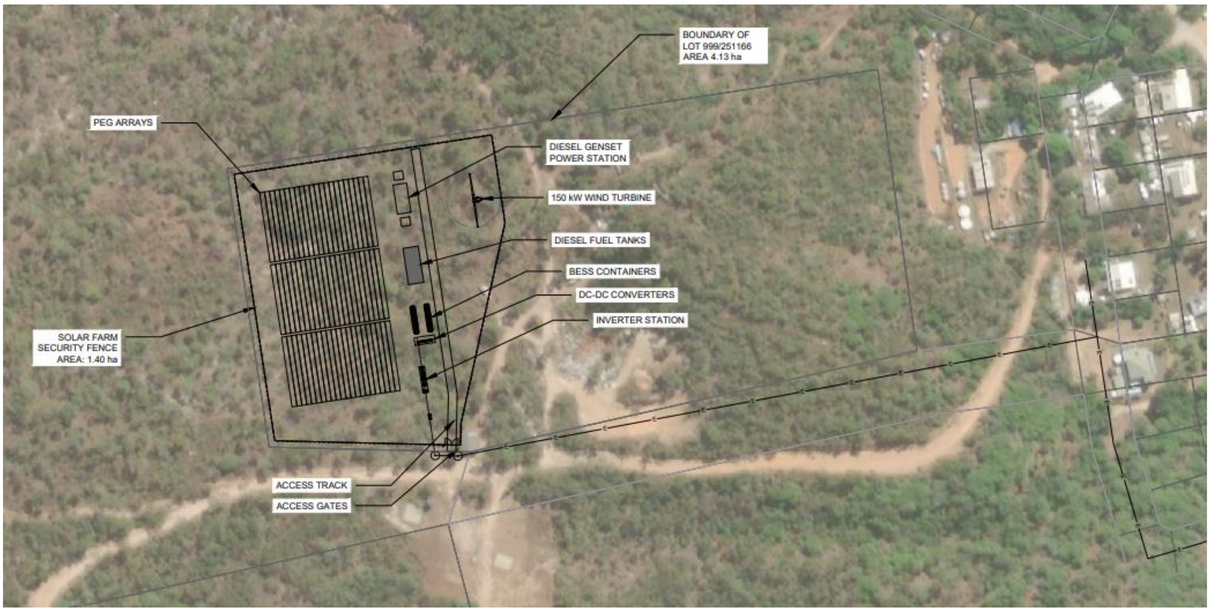

Figure 25: Microgrid concept plan for Muralug Beach

7.2.4 Installation Costs

IPS

Solar PV

Costs were calculated from two recent quotes for residents that had solar systems installed at Muralug. One installation had a 4.2 kW rooftop solar PV system and 34.8kWh battery while the other installation had a 10.2 kW solar PV system and 69.6 kWh battery. From these quotes, the build cost of PV on Muralug was estimated at $1.33 per watt for systems from 4 kW to 50 kW. Fixed operation and maintenance cost was set to $25.10 per kW installed per year, and the variable operation and maintenance cost $0.0013 per kWh dispatched.

Batteries

For modelling purposes, lithium-ion batteries are used for this analysis. There is a range of battery technologies currently in use at Muralug, including lithium-ion. Most IPS installations at Muralug currently have sufficient battery capacity to power critical appliances throughout the night. For this modelling, it was assumed that all future installations and a potential microgrid should provide at least 8 hours of battery storage capacity. Generally, lithium-ion batteries become cheaper per kWh as storage depth increases, so opting for longer durations is sensible for applications where overnight power is required. Based on two recent residential installations at Muralug, a battery cost of $4,400 per kW with 8 hours of storage was assumed.

In practise, an 8-hour battery can provide much more than 8 hours of power if users reduce their consumption below the maximum kW the battery can deliver. For example, a household with a 1 kW, 8 kWh battery could get 16 hours of power if they reduce their consumption to an average of 500W over that period by switching off non-essential appliances during extended periods of low solar generation.

Standby Generators

The servicing and maintenance requirements of standby generators depends on the brand, size, fuel type, and usage. It is expected that servicing every 3 to 6 months may be required to ensure optimal performance. Regular maintenance is also expected to prolong the life of the generator. Only fuel costs and capital cost of the generators was included in this modelling, as it is assumed that residents will continue to service their own generators with existing resources on Muralug.

Microgrid

Installation costs for a microgrid must include all equipment shown in Figure 25, including fences, access routes, fuel tanks, inverter and monitoring equipment, and transmission.

Costs for solar PV, diesel, and 4h BESS were sourced from industry partners and adjusted for remote island locations.

7.2.5 Technical Constraints

Unserved Energy

Unserved Energy is a measure of downtime in electricity delivery. Usually, DNSPs have very strict requirements for generators, allowing only 0.18% downtime. In remote locations where a DNSP does not control generation assets, increasing the allowed unserved energy results in significant build cost savings. For this modelling, unserved energy of 0.1% was assumed. This is within the minimum service standard for long rural feeders in regional Queensland, which is approximately 0.18%.

Discount Rate

A discount rate of 4% was used for future costs throughout the years modelled.

Renewable Energy Fraction

This is the ratio of power delivered by renewable energy sources to the total power delivered by a system. In this modelling, diesel generation is used to meet the non-renewable fraction. Two scenarios with a renewable energy fraction of 95% and 100% were modelled.

7.3 Modelling Tools

The modelling technology used for this analysis was min-E—optimisation software developed by ITP Renewables. Min-E calculates the most efficient combination of generation and energy storage capacity based on input parameters including hourly electricity demand for a year, the cost of building and maintaining different technologies, solar irradiation, and wind speeds.

Min-E can use input data to operate energy storage and generation in anticipation of future weather and demand spikes. For example, charging a battery fully before a few cloudy days, rather than only storing enough energy for a regular evening. Devices that use weather forecasts and past consumption to provide a similar service for real systems are commercially available, but if these systems are not installed, the resulting designs should be viewed as conservative. Our analysis suggests, however, that the difference between a perfect foresight "smart" controller and a simple controller is less than 5% in real-world sizing requirements.

7.4 Modelling Results

Min-E modelling results reveal the most economical system configuration that meets the constraints specified.

7.4.1 Individual Power Systems

Based on the assumptions outlined above, the least-cost options for IPS produced by Min-E are shown in Table 12.

Table 12: Min-E modelling results for IPS

Renewable energy fraction	PV size (kW)	Battery power (kW)	Battery energy (kWh)	Diesel yearly dispatch (kWh)	Cost per household
100%	16	5.3	42.4	0	$69,536
95%	7.1	1.9	15.2	436	$42,630

Costs begin to increase significantly at renewable energy fractions beyond 95%, because much more battery storage and solar PV is needed to provide power for long periods of low sunlight. In systems with diesel generators, it is more economical to reduce reliance on solar PV and batteries for these periods and use diesel instead. In the future, other forms of backup energy, including biodiesel, may allow systems with diesel generators to become 100% renewable.

7.4.2 Microgrid

The least-cost options for a microgrid are shown in Table 13. Various diesel generator sizes were investigated using HOMER, which found that a 60 kW generator would meet the requirements of a microgrid operating on 95% renewable energy.

Table 13: Min-E modelling results for microgrid

Renewable Energy Fraction	100%		95%	
System Configuration				
	Size (kW)	Dispatch (MWh)	Size (kW)	Dispatch (MWh)
Solar	815	606	642	572

Battery	219	303	155	281
Diesel	0	0	60	56
		Costs		
Generation	$3,385,000		$2,415,000	
Transmission	$2,500,000		$2,500,000	
Fuel	$0		$550,000	
Logistics and engineering management	$1,400,000		$1,400,000	
Total	$7,285,000		$6,865,000	

Total system costs do not decrease significantly at renewable energy fractions lower than 95% because the cost of diesel consumption begins to increase significantly.

Build and logistics costs are very high for a microgrid project as plant equipment must be transported by barge from the mainland, contractors must stay at neighbouring islands for the duration of the project, and other contingencies for remote island work, including bad weather, must be accounted for.

A microgrid solution requires 5 km of high- and low-voltage power line to connect the centralised generation plant to individual premises at Collis Beach, Muralug Beach and Country Women's Beach. It is anticipated that 6 pole-mounted transformers would be required.

These estimated costs also include a provisional amount of $360,000 for installation of switchboards, metering, and household wiring upgrades to facilitate connection to the microgrid network. Budget estimates for distribution network components were validated against standard EQL estimating rates for the Torres Strait area.

Figure 26 below provides a concept plan of the distribution network linking Muralug, Collis and Country Women's beaches.

Figure 26: Distribution network linking Muralug, Collis and Country Women's beaches.

7.5 Conclusion

Individual Power Systems have a lower cost per household, have lower regulatory and maintenance requirements, and are logistically easier to implement than a microgrid at Muralug.

Despite being less costly per household, not all residents on Muralug can afford to pay for an IPS, and the responsibility for maintaining an IPS falls entirely on the owner. This, however, has the potential to make maintenance easier in the long term, using local businesses instead of larger teams required to maintain a microgrid.

Microgrids can be expanded when more generation capacity is required, with all residents benefitting simultaneously. With an IPS solution, expansion is more incremental, and again, implementation depends more on residents.

Even the relatively short 5 km of cabling between the major load centres in Muralug contributes significantly to the cost of a microgrid. Additionally, management and regulatory requirements for a microgrid make development and approval costs higher than for an IPS solution.

A microgrid solution can only service those residents located within a reasonable distance of the central generating station, and there are several isolated dwellings at Muralug that will continue to rely on IPS for their energy supply requirements should a microgrid be developed.

Diesel is a significant cost in systems where renewables contribute less than 95% of electricity. In contrast, in systems with more than 98% renewables, much more solar PV and battery capacity is required to deliver reliable power during cloudy periods. This is changing, however, as the cost of renewables decreases.

It should be noted that this assessment is of a preliminary nature for comparison purposes between an equivalent centralised microgrid and individual power supply systems, and more detailed analysis of costs will be required to inform a detailed financial analysis of the preferred solution.

8

Financial and Economic Analysis

8 Funding Options

This section examines relevant government policies and programs, funding options for IPS systems, and detailed cash-flow analysis.

8.1 Individual Power Systems

It is expected that funding for a Muralug IPS project would be sourced through a direct Government grant or the provision of low- or zero-interest loans. Such a program would be designed to address the disparity in energy costs and reliability faced by residents of Muralug compared to the mainland, and to incentivise residents to subscribe to new or upgraded systems.

In a separate analysis beyond the scope of this project, ITP compared the per household cost to the government of subsidising electricity on the nearby community of Thursday Island with the cost of a range of hypothetical low and zero interest loan scenarios for IPS. While difficult to compare, because the level of service provided by the IPS is not equivalent to a fully serviced reticulated system, it was found that providing loans for IPS was the lower cost option. In addition to capital cost or loan value, consideration should also be given to the administration and management of the program.

Relevant alternative funding programs are listed below, and more detail on government programs is in Appendix C.

Affordable Energy Plan – Interest Free Loans for Solar and Storage Program

Over a three-year period from 2018 to 2021, the Queensland Government in accordance with the Affordable Energy Plan invested $21 million to support Queenslanders manage the upfront costs of solar and battery technologies with interest free loans.

While this program is now closed, opportunities for similar programs may exist to support remote and disconnected communities such as Muralug to address the cost of installing IPS solutions for the resident landholders.

ARENA – Community Battery for Household Solar Program

This Program aims to deploy community batteries across Australia to lower bills, cut emissions and reduce pressure on the electricity grid by allowing households to store and use the excess power they produce.

ARENA are currently preparing funding application materials, including funding guidelines, and are undertaking an extensive market consultation process to inform the conditions that will attach to the funding program. Expressions of interest for the program are expected to open in the first half of 2023.

NIAA – Indigenous Advancement Strategy

The National Indigenous Australians Agency (NIAA) administers the Indigenous Advancement Strategy (IAS). The IAS is the way the Australian Government funds and delivers a range of programs for Indigenous Australians.

The IAS is focused on providing positive impact to Indigenous communities through improvement of education, employment, economic development and social participation, and growing healthy and safe communities.

In the 2019-20 Budget, the Australian Government allocated $5.2 billion to the IAS, over four years to 2022-23, for grant funding processes and administered procurement activities that address the objectives of the IAS.

Applications are assessed on their contribution to improving the lives and outcomes for Indigenous Australians against key priority areas. The program is currently open for applications.

Energy Queensland – Community Service Obligation

For communities such as Muralug that are not connected to the broader power network, there may be an opportunity to redirect some of the CSO funding that would ordinarily have been allocated to a network connected community, to alternate power solutions (such as subsidisation of IPS for individual properties).

Negotiation of such funding would need to be completed on a collective basis with Energy Queensland, supported by a robust business case underpinning the rationale for such a proposal.

8.2 Microgrid

Potential funding sources for a microgrid are described below.

Queensland Microgrid Pilot Fund (QMPF)

As part of the Queensland Energy and Jobs Plan, the QMPF will invest up to $10 million over two years to boost the resilience of regional and remote communities to extreme weather events, through supporting the development and delivery of microgrids across Queensland.

The QMPF provides grant funding under two streams. Stream 1 allows for between $250,000 and $750,000 to support feasibility studies into the development of microgrid projects. Stream 2 provides funding up to $5 million in relation to the construction of microgrid infrastructure and supporting assets.

Grant funding is available for microgrid projects that meet the QMPF program objectives. The total funding allocated for QMPF is up to $10 million, which can at any point be reduced at the discretion of the Queensland Department of Energy and Public Works (DEPW).

It is noted that this program is currently only applicable for "grid-connected" communities, of which Muralug would not currently satisfy the criteria. Notwithstanding there may be an opportunity in the future for the application of the program to also include non-grid connected communities.

Queensland Renewable Energy and Hydrogen Jobs Fund (QREHJF)

Investment proposals may be submitted for consideration and will be assessed against the following criteria:

Renewable energy – development of additional renewable energy generation and storage capacity and how this contributes to the State's renewable energy targets.

Commerciality – level of commercial value demonstrated by the project.

Employment and Jobs – the extent to which the project creates new employment opportunities and training.

Applications to the fund are assessed progressively as proposals are received.

ARENA - First Nations Community Microgrid Fund

As part of the 2022-23 Federal Budget, ARENA was allocated funding of up to $83.8 million for the First Nations Community Microgrids Program. While the specific details of the program are yet to be released, the objective of the program is to increase access to cheaper, cleaner, and more reliable energy for the identified communities. It is expected that the funding may be used to assess, design and construct microgrid projects to support the identified communities.

ARENA – Community Battery for Household Solar Program

This program is described in Appendix C. It is for IPS deployment and may also be applicable for a microgrid development.

ARENA – Regional Australia Microgrid Pilot Project (RAMPP)

As part of the 2020-21 Federal Budget, $50 million of funding was allocated over a six-year program that aims to improve the resilience and reliability of power supply for regional and remote communities. The RAMPP builds upon the Australian Government's Regional and Remote Communities Reliability Fund (RRCRF), which funded feasibility studies for regional and remote communities to investigate deployment of local microgrid technologies.

Funding under the RAMPP will be made available over two stages. Stage 1 (launched in CY22) included $30 million in funding and Stage 2 (to launch in CY23) will include $20 million in funding. Grants of between $1 million and $5 million may be provided, with projects exceeding $5 million requiring demonstration of significant and broad industry benefit.

The program assesses applications across a range of criteria including alignment with program objectives, capacity and capability of the applicant, design and delivery methodology and financial viability and co-funding. In addition, all projects and applications must be supported by a robust feasibility study. Applications for funding are now open.

ILSC – Our Country, Our Future

ILSC partners with Indigenous Australians to provide economic, environmental, social, and cultural benefits through acquisition of land or water rights and assistance in managing these rights. The Our Country. Our Future funding program is central to achieving this objective.

Through the funding program ILSC offer direct funding, provides advisory and capability development services, and facilitates connections with technical advisors to enable projects to progress.

While the program does not directly focus on the development of renewable energy projects, there is clear alignment in supporting Indigenous communities to build capacity and to deliver economic growth through the creation of enabling land-based utility infrastructure. Furthermore, the development of microgrid infrastructure will progress initiatives towards preserving the environment and improving outcomes for the community. The program is currently open for expressions of interest.

NIAA – Indigenous Advancement Strategy

This program is described in Appendix C. It is for IPS deployment and may also be applicable for a microgrid development.

Minderoo Foundation

The Minderoo Foundation was established to address tough and persistent issues in society with the objective to drive significant change in the community. As a philanthropic organisation, Minderoo directs funds to a diverse range of causes to effect change. The foundation contributes to initiatives that seek to create parity with and for Indigenous Australians and to build resilience within communities. Opportunities may exist for the Project to seek funding under these initiatives where notable advancement towards achieving the objectives of these initiatives can be demonstrated.

8.3 Recommended Funding Source

The recommended solution for Muralug is Individual Power Systems (IPS), as described in section 7. Two funding options are considered appropriate for an IPS solution:

Government grant – public funding, through Federal or State Government programs, for the full or partial capital cost of establishing the IPS for landholders/ property owners.

Zero or low interest loans – debt funding with concessional or non-interest bearing provided by Federal or State Government to fund the full or partial cost of establishing the IPS for landholders/ property owners.

These are explored in further detail in the following section.

8.4 Cashflow Analysis

A desktop assessment provided the total number of vacant and developed lots across the island. This also provided an estimate of the number of properties that maintained existing IPS. From this, an estimation of the number of systems requiring investment was developed. It was assumed that all vacant lots would require an IPS and only a proportion of the existing IPS would require upgrades. Table 14 outlines the outcome of this assessment.

Table 14: Assessment of the total number of lots

Location	Total Lots	Vacant Lots	Developed Lots	No. of IPS[40]	No. of Lots Requiring Investment
Muralug Beach	35	15	20	16	25
Collis Beach	6	1	5	2	6
Country Womens' Beach	15	3	12	9	9
Long Beach	10	3	7	7	6
Isolated Lots	20	10	10	5	20
Total	86	32	54	39	66

8.4.1 Government Grant

The Project team suggests that providing direct grant funding for the capital cost of privately held IPS should be considered by the government to provide equal access to reliable energy supply for Muralug residents. The government may offer a grant funding pool accessible only to Muralug residents to subsidise the capital cost of installing or upgrading a specified IPS solution. The grant application would have specific criteria to ensure the system is fit for purpose and achieves a sustainable power solution for the landholder.

The government may appoint preferred system suppliers and installers as a panel to access the funding program. Based on the estimated capital cost for the modelled solution for

[40] Estimated number based on site assessments and discussions with residents available for interview.

Muralug, the total funding program cost would be $2.86M, with additional administrative and program management expenses to be included in the funded amount.

8.4.2 Zero-interest Loan

An alternative funding option is zero-interest loans for purchasing or upgrading IPS for landholders. This approach has been used in Queensland through the *Affordable Energy Plan - Interest Free Loans for Solar and Storage Program*. Households could apply for interest-free loans of up to $10,000 to purchase a solar and battery storage system, with specific criteria and a 10-year repayment period. To estimate the financial outcomes for a zero-interest loan program for the Muralug community, a model based on the previous Queensland Government *Affordable Energy Plan* is used as an example.

Program Assumptions

This analysis assumes the following:

- Interest rate – 0%
- Loan term – 10 years
- Maximum loan per applicant – $10,000
- Annual repayment – $1,000
- Cost of capital – 2.5% (compounding annually)

All funds are assumed to have been drawn down in Year 1. In practice, it is likely that the funds will be drawn down throughout the program term and the net cashflow impacts will vary from those presented.

Total Funded Amount

Based on the total systems that may be purchased or upgraded, Table 15 outlines the potential total funded amount through the program.

Table 15: Potential total funded amount for zero-interest loan

IPS Description	Large IPS	Medium IPS	Small IPS	Upgrade	Total
Total Number	5	27	24	10	66
Loan Amount per IPS ($)	10,000	10,000	10,000	10,000	
Total Capital Cost ($)	50,000	270,000	240,000	100,000	660,000

Cashflow

Based on the outlined assumptions, and considering the total funded amount for the program, Table 16 outlines the expected net cashflow impact of the program for Government. It is noted that the impact of costs related to the administration and management of the program have not been reflected in this example.

Table 16: Expected net cashflow impact for zero-interest loans

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Total
Total Drawdown	(660,000)										
Repayment	66,000	66,000	66,000	66,000	66,000	66,000	66,000	66,000	66,000	66,000	660,000
Net Cash flow	66,000	66,000	66,000	66,000	66,000	66,000	66,000	66,000	66,000	66,000	-
Cumulative Cashflow	(594,000)	(528,000)	(462,000)	(396,000)	(330,000)	(264,000)	(198,000)	(132,000)	(66,000)	-	
Interest Cost to Government	(14,850)	(13,571)	(11,889)	(10,197)	(8,505)	(6,813)	(5,120)	(3,428)	(1,736)	(43)	(76,153)

To the extent that all loans are repaid in accordance with the stated loan terms, the net cost/ cash outflow for Government in respect of the program would equate to approximately $76,153. This reflects the assumed total interest charges (based on the stated cost of capital percentage).

8.4.3 Low-Interest Loan

As the capital cost of many of the IPS to be installed are expected to exceed $35,000, an alternate option for incentivising landholders to proceed with the proposed solution may be through the provision of higher value loans on a low interest basis. Under such an arrangement, the program may fund a higher amount of the capital cost, however, to manage risk a co-contribution or funding cap may be applied. An indicative example of this option has been provided in the below analysis.

Program Assumptions

The core assumptions underpinning the example are as follows:

- Interest rate – 5%
- Loan term – 10 years
- Maximum loan per applicant – lesser of $30,000 or 50% of total system capital cost
- Cost of capital – 2.5%

As with the previous example, the below example assumes that all funds will be drawn down in Year 1. In practice, the funds are likely to be drawn down progressively across the program term, and therefore the cashflows presented may vary. Furthermore, the interest rate applied to customer lending and the cost of capital for Government may also vary from those amounts presented. These will also impact the final cashflow outcome for Government.

Total Funded Amount

Based on the total number of systems that may be purchased or upgraded, Table 17 outlines the potential total amount that may be funded through the program.

Table 17: Potential total amount that may be funded for low-interest loan

	Large IPS	Medium IPS	Small IPS	Upgrade	Total
Total	5	27	24	10	66
Cost per IPS ($)	75,000	50,000	35,000	20,000	
Total Capital Cost ($)	375,000	1,350,000	840,000	200,000	2,765,000

Maximum Amount Funded by Program ($)	30,000	25,000	17,500	10,000	
Total Amount Funded by Program ($)	150,000	675,000	420,000	100,000	1,345,000
Annual Repayment Per Loan	3,885	3,238	2,266	1,295	
Total Annual Repayment	19,426	87,416	54,392	12,950	174,184

Cashflow

Table 18 outlines the approximate net cashflow impact for the government based on the outlined assumptions and the total amount funded through the program. Note that the costs related to program administration and management have not been included in this example, and the timing of loan drawdowns may vary, affecting the overall cashflows presented.

The assessment shows an approximate net return of $227,930 to the government over the loan period due to the difference between lending interest to consumers and the government's cost of capital. The net return can offset program management costs or lower the lending rate for a cost-neutral program.

This analysis is based on estimated data and various assumptions and should not be relied upon for investment purposes. Further assessment and analysis are necessary once technical requirements and participant numbers are confirmed.

Table 18: Approximate net cashflow impact for government for low-interest loan

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Total
Opening Loan Value	-	(1,238,066)	(1,125,786)	(1,007,892)	(884,103)	(754,124)	(617,647)	(474,345)	(323,879)	(165,889)	
Loan Drawdown	(1,345,000)										(1,345,000)
Interest Accrued	(67,250)	(61,903)	(56,289)	(50,395)	(44,205)	(37,706)	(30,882)	(23,717)	(16,194)	(8,294)	(396,837)
Repayment	174,184	174,184	174,184	174,184	174,184	174,184	174,184	174,184	174,184	174,184	1,741,837
Closing Loan Value	(1,238,066)	(1,125,786)	(1,007,892)	(884,103)	(754,124)	(617,647)	(474,345)	(323,879)	(165,889)	-	
Net Annual Cashflow	(1,170,816)	174,184	174,184	174,184	174,184	174,184	174,184	174,184	174,184	174,184	396,837
Cumulative Annual cashflow	(1,170,816)	(996,633)	(822,449)	(648,265)	(474,082)	(299,898)	(125,714)	48,469	222,653	396,837	
Interest Cost to Government	(30,952)	(28,918)	(25,920)	(22,751)	(19,422)	(15,927)	(12,257)	(8,403)	(4,357)	-	(168,907)

9

Recommendations

9 Recommendations

This study has identified that the development of a microgrid at Muralug is not economically feasible. However, the expanded deployment of individual household power supplies (IPS) is a practical and economical means of meeting household energy requirements.

The main barrier to the deployment of high-quality, reliable IPS at Muralug is cost, with many residents unable to afford to install systems of adequate capacity to meet household needs. Additionally, where systems have previously been installed, the cost of upgrading or replacing major components is beyond the financial capacity of some residents.

Accordingly, there is a mix of technology solutions in place, ranging from small petrol or diesel generators alone, to hybrid systems with various combinations of solar panels, inverters, batteries, and generators. Many systems have been patched together with sub-standard or recycled equipment. Those residents that have the means, have installed high quality systems designed for their individual requirements.

This report recommends progressing actions that will address the disparity between regional Queensland residents who have access to reticulated electricity supply and regulated electricity tariffs and those that live in isolated locations with no prospect of a reticulated power supply connection.

It is recommended that governments consider providing access to financial support for people living in remote and isolated locations like Muralug, to assist with the installation of IPS and to facilitate the deployment of energy-efficient appliances.

Recommendation 1 – Stakeholder Engagement

A project team be established to work with residents, and coordinate engagement with government agencies, stakeholder groups, IPS installers and maintainers, to progress the deployment of privately-owned IPS as the preferred energy solution at Muralug Island.

The project team should be led by an appropriate government department or agency that can liaise with energy and finance sectors to advocate outcomes for equitable access to an affordable electricity supply on behalf of the Muralug community, whilst seeking solutions for other similar communities in isolated locations.

Recommendation 2 – Scope

Undertake a detailed survey of household energy needs and timeframes for the deployment of IPS to Muralug. This survey should capture individual household requirements, existing energy supply infrastructure, and quantify future requirements.

It should also be utilised to capture expressions of interest in participating in an IPS deployment program.

The survey results will inform detailed budgets and enable scoping of a deployment program, potentially facilitating a bulk purchase and installation program.

Recommendation 3 – Policy Review

Queensland Department of Energy and Public Works, in consultation with Energy Queensland should review the application of the uniform tariff policy and CSO subsidy to create a support system for people living in isolated locations where there is no access to a public electricity supply, to encourage the deployment of privately-owned IPS.

This approach would be consistent with the government's stated objective of maintaining a uniform tariff policy for regional Queenslanders.

Recommendation 4 – Funding

Governments should investigate the establishment of a zero- or low-interest loan scheme for IPS deployment at Muralug and other similar isolated communities where there is no prospect of a standard grid connection.

Additionally, a subsidy scheme should be implemented to offset the capital cost of designing and installing IPS systems or replacing major system components like batteries, inverters, and solar panels. This subsidy would offset the additional costs of freighting materials, plant and people to remote locations like Muralug.

Recommendation 5 – IPS Implementation

A coordinated program should be developed to undertake IPS installation works at Muralug to optimise cost benefits that can be achieved through bulk purchase and freight arrangements.

Further, a pre-qualified panel of IPS designers, installers and maintainers should be established for delivery of isolated systems in locations where funding support is provided. Pre-qualification would require participants to meet quality standards and demonstrate the experience and capacity to successfully deliver installation services and provide on-going support and system maintenance services to remote residents.

Recommendation 6 – Energy Efficiency

Develop and deploy guidance material on the most energy efficient appliances suitable for installation in isolated communities that rely on IPS for their electricity service. Financial incentives should be provided to ensure the deployment of energy-efficient appliances at affordable prices.

Muralug residents are very aware of energy conservation and demand management principles, ensuring that they operate appliances within the constraints of their IPS.

However, there is a need for access to a broader range of energy-efficient appliances backed up with appropriate warranty support. Generally, the higher the energy-efficiency star rating of an appliance the more expensive it is to purchase, placing greater pressure on household budgets in remote and isolated locations.

Recommendation 7 - Develop Training and Awareness Programs

Governments should create training programs to help local businesses that install and maintain IPS, as well as public awareness campaigns to educate residents on the benefits of IPS and energy-efficient equipment, and maintenance and operation of key components. This could assist to create local jobs, ensure residents have access to dependable and high-quality installation and maintenance services, and encourage behavioural changes that reduce overall energy use.

10

Challenges and Implementation Barriers

10 Challenges and Implementation Barriers

10.1 Challenges

Muralug residents face many challenges in realising a sustainable, reliable and affordable electricity supply solution that will meet the needs of a dispersed, remote and isolated community.

The cost of establishing a traditional power supply solution for Muralug, like other nearby Torres Strait Island communities, is a significant barrier. The absence of such a system denies Muralug residents access to other benefits such as regulated electricity tariffs, minimum service standards, and rebates that are currently be available to other regional Queenslanders.

The key considerations include:

- Meeting community expectations for affordable and reliable electricity supply with adequate capacity.
- The effects of climate change currently being experienced in the Torres Strait, especially with sea-level rise, temperature rise, and the need to encourage deployment of renewable energy solutions rather than fossil-fuel based systems.
- Residents' capacity to fund electricity supply establishment costs and purchase energy-efficient appliances.
- Logistical considerations, access to services, materials and equipment.
- Land Tenure and Native Title.
- Government policy and strategy aimed at supporting and encouraging innovative energy supply solutions in remote and isolated communities.
- Technology suitable for the harsh Torres Strait environment.

10.2 Barriers to Uptake

10.2.1 Community Expectations

Whilst it was not possible to meet with all residents and property owners at Muralug, discussions with those that were available revealed that the most significant issues for them included:

- The high capital cost of establishing IPS prevented many residents and property owners from having an adequate system installed. In some cases, available funds were diverted to purchasing small generators and fuel to meet immediate power requirements. The cost of running small generators had a significant impact on household budgets and the ability to save funds to invest in a more appropriate long-term energy solution.

- Residents who were able to afford a modern IPS benefitted from the low on-going energy costs, only utilising generators for very brief intervals throughout the year due to inclement weather or for a specific activity, such as welding.
- Most existing IPS systems at Muralug do not have sufficient capacity to support air-conditioning, which is becoming a necessity, as summer temperatures rise.
- While many residents that had IPS were happy with their systems, some would prefer the convenience of "unrestricted" capacity so that they could operate electrical appliances like air-conditioners, electric jugs, welders etc at the flick of a switch. Those that had invested significant funds in IPS would not contribute towards a connection to a reticulated system.
- Some residents noted that Thursday Island experienced regular power outages on the reticulated electricity system and that it would be uneconomical to build a similar system at Muralug, with IPS being a better option.
- Government financial support for the initial establishment of an IPS and for replacement of major components like batteries was seen as a means of addressing financial hardship barriers for residents.

10.2.2 Climate Change

- Muralug residents had first-hand experience of the impacts of climate change outcomes, with sea-level rise incidents in neighbouring island communities, and hotter summer conditions. The absence of an adequate power supply to provide air-conditioning and support the operation of medical equipment has forced some residents to relocate temporarily or permanently from Muralug to other islands where there is a more adequate power supply system.
- There was a strong preference for renewable energy-based systems to address greenhouse gas emissions, noise concerns, and environmental sensitivities.
- There was a high level of understanding of energy efficiency and energy conservation principles amongst residents which could be supported with local advisory capability and access to additional education and information on energy efficient appliances.
- The impacts of climate change are seen to be a facilitator for the deployment of renewable energy-based systems in the Torres Strait, transitioning from the traditional fossil fuel-based energy systems.

10.2.3 Cost and Funding Considerations

- The estimated capital cost of an IPS at Muralug can range from $35,000 for a basic system to more than $70,000 for a system capable of meeting most household requirements (including air-conditioning). Battery replacement costs range from $10,000 to more than $20,000. These costs are beyond the capacity of many Muralug residents. Some existing systems have remained inoperable following battery failure due to personal funding constraints.

- Some long-term residents were able to access solar rebate schemes that were available between 2000 and 2009. However, many of the original systems require upgrades or component replacement and the original scheme is no longer available.
- To implement a microgrid system at Muralug would cost between $7–9 million to service about 80% of the island's population. However, there would still be outlying residents that would be too remote to access the system. Additionally, the microgrid option would require a large upfront capital investment compared with IPS which could be funded over time on an as-required basis.
- Whereas most regional Queenslanders have access to an affordable and reliable power supply that is subsidised by government through its CSO scheme, including residents of nearby Torres Strait Islands, Muralug residents do not.

IPS would be privately-owned and maintained by property owners as there are no alternative energy supply options available to Muralug residents.

10.2.4 Logistical Issues

Infrastructure development including housing construction and provision of electricity supply services is more complex and expensive in the Torres Strait due to logistical considerations.

These include:

- Equipment must be freighted either by sea or air from Cairns or other ports to Horn Island.
- Inter-island transfer is via sea, and this can be by privately-owned dinghies or barge, at the residents' expense.
- IPS installers/maintainers – these services are sourced from outside the region at additional expense due to the lack of local service providers.
- Fuel for generators can be sourced from Thursday Island or Horn Island but is much more expensive than in major centres such as Cairns. Fuel is normally transported to Muralug in jerry cans or drums in private dinghies.
- Batteries are very heavy and solar panels are bulky which can incur high freight charges.

10.2.5 Land Tenure and Native Title

Whilst residential land at Muralug is either freehold or leasehold tenure, most of the island is subject to Native Title which is held by the Kaurareg Aboriginal Corporation (KAC) RNTBC. Torres Shire Council holds title to land at Muralug Beach reserved for community purposes and public services.

The development of a microgrid and associated electricity distribution infrastructure would require negotiation with the KAC RNTBC and Torres Shire Council. Sufficient lead times would need to be allowed for consultation with landholders and Native Title holders to address property issues like ownership, access, and operational requirements associated with implementing and maintaining microgrid infrastructure.

As the development of a microgrid is uneconomical and considered not suitable for Muralug at this time, it is proposed that IPS would be the most appropriate energy supply option. Each IPS would be installed at the property owner or lessee's property and therefore would have no impact on Native Title Lands or Council reserves.

10.2.6 Regulatory and Government Policy considerations

As previously noted in this report, Muralug does not have access to a public electricity supply system that is connected to the national electricity grid.

National Electricity Rules pertaining to standalone power supply systems at fringe-of-grid locations are not applicable at Muralug. EQL has no existing generation or distribution infrastructure at Muralug, and privately-owned IPS are not subject to the Queensland government's regulatory framework applicable for isolated and remote communities with public electricity supply systems.

The cost of providing electricity supply in regional Queensland is subsidised by the Queensland government via a CSO payment to EQL. It would not be economically feasible to establish a public electricity supply system at Muralug without substantial government financial support including increases in annual CSO funding to offset establishment and operational costs.

This feasibility study has not assessed the potential impacts that developing a public electricity supply at Muralug would have on the CSO. However, given that Muralug residents do not currently receive any financial support to offset their electricity supply costs it may be appropriate for government to consider how an alternative, lower cost, subsidy scheme could be applied to provide equity with other Torres Strait Island and regional Queensland residents.

Government and community agencies will have obligations to show compliance with, and progress to achieving regional, state, national and international commitments on climate change. Encouraging and supporting investment in renewable energy IPS in remote and isolated communities like Muralug, reducing reliance on petrol and diesel generators, would be consistent with these objectives.

10.2.7 Technology-based

The Torres Strait Islands, including Muralug, are subject to corrosive conditions associated with the humid and salty environment. Muralug residents have many years' experience operating renewable-energy based IPS and are aware of the need to invest in systems that are appropriate for the local conditions.

It is important to select equipment and materials designed for this type of environment to ensure longevity. This is particularly relevant to rooftop solar panels and solar hot water systems. Sensitive equipment such as solar controllers, inverters and battery systems need to be protected in suitably designed enclosures.

These special design features and considerations mean that systems are more expensive and will require replacement or refurbishment on a more frequent basis than in other less corrosive environments.

Muralug residents are early adopters of renewable energy and energy storage technologies which have been an integral part of their household energy systems for many years. They have developed energy efficient homes and adapted their lifestyles to accommodate the limitations of living "off-grid."

11

Implementation Approach

11 Implementation Approach

11.1 The Opportunity for Muralug

By assisting residents in isolated communities like Muralug to invest in renewable energy systems, governments can promote greenhouse gas emission reduction strategies whilst improving overall community amenity and living standards.

A reliable power supply is necessary to ensure healthy and resilient communities and could be provided to Muralug residents with well-designed IPS using quality components that are suited to the harsh Torres Strait environment. To ensure optimal life expectancy of the systems, establishing an appropriate maintenance and inspection regime that supports the IPS deployment will create employment opportunities and reduce whole-of-life costs.

Providing financial support for isolated households at Muralug to invest in quality IPS systems can address affordability barriers and provide equity with other regional Queenslanders who benefit from subsidised electricity costs.

National electricity regulations are evolving, recognising that it is more efficient in remote locations near the fringes of electricity networks, to replace network connections with IPS. There is an opportunity for governments and regulators to establish safety and quality standards for household IPS in isolated locations like Muralug, linked to funding support schemes. This outcome can be supported by engaging pre-approved contractors for IPS installation and maintenance.

11.2 Queensland Government Priorities

The implementation of an innovative funding model to support the deployment of IPS in isolated and remote communities like Muralug where residents cannot access the uniform tariff policy could meet the objectives of numerous Queensland Government priorities including:

- Queensland Energy and Jobs Plan
    - 50% renewable energy by 2030; 70% by 2032; 80% by 2035.
    - Support households to manage their energy use and save on electricity bills.
    - Continuing to implement the uniform tariff policy.
    - Supporting the deployment of more rooftop solar.
    - Decarbonising remote communities.
    - Deliver real and lasting benefits for regional communities – strategic planning and community engagement.
- Queensland Plan

    - Nobody gets left behind.
    - Regional development and delivery reflects the needs of that region.
    - We invest in and adopt sustainable and renewable solutions.
- Queensland Reconciliation Action Plan 2018-2021
    - Maintain and leverage mutually beneficial relationships with ATSI peoples, communities and organisations to support positive outcomes.
- State Infrastructure Strategy 2022
    - Encourage jobs, growth, and productivity.
    - Enhance sustainability and resilience.
    - Develop regions, places, and precincts.
    - Adopt smarter approaches.

11.3 Proposed Solutions

In assessing suitable alternatives for improving the resilience of the Muralug community via a microgrid, and in addition to meeting the required technical standards, EnergyConnect sought solutions that were consistent with the principles of:

- Self-determination – by empowering the community to determine the most appropriate energy supply solution for their requirements.
- Reliable local energy supply.
- Building community resilience and transition from a position of vulnerability.
- Reducing reliance on fossil fuels.
- High demonstration value for other remote and isolated communities.

It was concluded that it would be uneconomic and inefficient to establish a microgrid at Muralug. However, the deployment of high-quality IPS designed to provide grid-quality power supply for individual residences would be the most appropriate solution to meet the community's needs. Key considerations for installing and maintaining high quality IPS for Muralug are:

- Rooftop solar PV is the most economical and suitable technology for household renewable energy generation at Muralug.
- Household battery systems are currently utilised within existing IPS at Muralug – battery technology and maintenance regimes are important to ensuring longevity of battery lifespan.
- Small generators are required to recharge batteries in inclement weather or where there is insufficient solar capacity or to operate larger electrical appliances.

- The capital cost of establishing a grid-quality household IPS is a significant barrier for many Muralug residents.

11.4 IPS Implementation Plan

It is anticipated that the Muralug IPS deployment program would be implemented as follows.

11.4.1 Stage 1 Pre-implementation Activities

The proposed Stage 1 pre-implementation activities include:

- Ongoing community engagement.
- Engagement with system suppliers, installers, and maintainers.
- Engage with government stakeholders to develop policy for supporting IPS in isolated communities.
- Detailed scoping of requirements for new systems and existing system upgrades.
- Prepare budget costs.
- Confirm funding strategy.

In Stage 1, a project team would be established within the relevant Queensland government agency or department, to engage with Muralug residents and other relevant government agencies, stakeholder groups, and IPS installers and maintainers, to advance equitable access to affordable electricity supply infrastructure, utilising privately-owned IPS as the preferred system solution.

The scope of the project team would also include providing access to affordable energy-efficient appliances that are suitable for installation in households that rely on IPS for their energy supply.

A priority activity of the project team would be to identify and facilitate funding support mechanisms including zero- and low- interest loans and subsidies, to assist residents to establish a reliable, grid-equivalent standard electricity supply via IPS.

During this phase, detailed scoping of requirements for new or upgraded IPS at Muralug would be undertaken. Data gathered would be used to scope a bulk purchasing and installation program to ensure the most cost-effective outcome.

Expressions of Interest for “scheme” participants would also be established during Stage 1.

The output of stage 1 works would include a detailed budget and forecast of required funding, a funding support strategy, and implementation plan.

11.4.2 Stage 2 Deployment

The proposed Stage 2 Deployment activities are:

- Establish funding program, eligibility requirements, fund administration arrangements and application guidelines.
- Prepare standard specifications for IPS of a range of sizes.
- Establish bulk purchasing or tendering requirements.
- Establish a register of preferred suppliers and installers.
- Facilitate access to funding.
- Establish maintenance and inspection contracts.
- Coordinate IPS installation program.

In Stage 2 a funding program would be established with relevant guidelines and administrative arrangements to support Muralug residents, and potentially other similar remote and isolated communities, to progress the installation of modern, reliable IPS energy solutions.

A register of pre-qualified installers would be established to ensure that fit-for-purpose, quality systems are installed at the most cost-effective price.

Bulk purchasing and logistical arrangements would be established for the initial deployment program.

An on-going maintenance, inspection and system support program would also be established as part of the installation program to ensure that systems achieve optimal life-expectancy outcomes and provide reliable and efficient whole-of-life outcomes for the residents.

Appendices

Appendix A. Renewable Energy Technologies

A1. Solar

The processes for converting sunlight into useful energy to generate electricity and heat water are outlined below.

A.1.1 Photovoltaic

Solar photovoltaic (PV) cells are semi-conductors that create a Direct Current (DC) voltage when exposed to light within a certain wavelength range. This wavelength range is broadly similar to the spectrum that is visible to the human eye. Hence, a solar cell can be assumed to create a voltage when exposed to visible light.

Solar PV cells are connected in series within PV modules (also called panels), which allow sunlight to reach the cell surface, but otherwise protect the cells from direct exposure to the environment. PV modules can be connected together in an array. The PV array is connected to an inverter, which draws the optimum DC current from the PV array and converts it to AC current at an appropriate voltage for use by the customer or export to the grid.

A PV system's power output is dependent on the instantaneous intensity of the solar radiation incident on the plane of the array and the system efficiency. The solar radiation hitting the PV array can fluctuate rapidly throughout the day due to passing cloud and shading by nearby trees. It also varies more slowly over the course of a day and year owing to the changing sunlight hours and the angle of the sun relative to the PV array.

Higher PV cell temperatures reduce efficiency slightly. Typically, good solar resources tend to correlate with high ambient temperatures. Nevertheless, annual PV system output correlates well with increasing annual radiation.

Ground mount PV can be fixed, single or dual axis tracking. Tracking increases annual output with an increase in maintenance costs. Tracking is not suitable for areas within cyclone regions.

PV systems can be cost-effective at small-scale as well as large-scale. It can be used in grid-connected systems that feed power into the electricity network at domestic, commercial and larger, utility scale applications. PV can also be used in isolated power systems to supply power at various scales, from fuel-saving designs (low annual contribution) to more complex systems that include energy storage to achieve fossil fuel free-off operation (high annual contribution).

Solar PV is exceptionally reliable with minimal maintenance requirements. A PV array can be expected to operate for 25 years or more. Typically, the inverter does not last that long and inverter replacements every 10 or so years are factored into financial analysis. Otherwise, there are minimal maintenance costs for fixed PV systems arising from washing panels, checking cabling and isolators.

A.1.2 Solar Thermal

Solar thermal systems are technically proven for most ranges of temperature use. Lower temperatures for residential and commercial hot water are available from simple flat plate and evacuated tube collectors. More complex, concentrating solar collectors that track the sun are needed for higher temperatures, such as the generation of steam.

The performance of solar thermal systems is strongly linked to the average level of direct normal irradiation (DNI) at a site. The fluids heated by solar thermal systems provide a form of energy storage. For example, an insulated, residential water tank can hold its heat for many cloudy days, if the hot water is not discharged.

Flat plate collectors consist of a metal sheet with passages for fluid flow, mounted in an insulated case with a glass cover sheet. They can heat fluid to 85˚C, making them suitable for heating water (for example domestic hot water systems), but can also be connected in large arrays for commercial and industrial use.

Evacuated tube collectors consist of a series of individual tubes mounted together in panels. An evacuated space between two concentric tubes minimises heat loss and allows the inner surface to reach higher temperatures and then exchange heat to a fluid. Evacuated tubes can heat fluid to between 50˚C and 150˚C and are a suitable for domestic and commercial solar hot water, especially in cooler climates. Addition of an appropriately curved mirror behind an evacuated tube collector can boost the energy absorbed allowing higher temperatures (up to 200˚C) and more efficient operation.

Commercial concentrating solar technologies include:

- Parabolic trough collectors – a curved reflective surface in the shape of a parabola that tracks the sun along one axis throughout the day. This focuses the sun's rays into a tubular receiver that contains a heat transfer fluid, such as synthetic oil, which can be heated to 100°C to 450°C to generate steam for process heat or power generation.
- Linear Fresnel systems – long mirror strips laid out in parallel rows that are each tracked independently to focus direct beam radiation onto the receiver. This provides heat over a similar temperature range to parabolic trough collectors.

Commercial solar thermal systems have a size-dependent capital cost that makes larger systems progressively more cost-effective. Also impacting on capital cost are site-specific aspects, such as the amount of energy storage needed, integration costs and the quality of solar resource available. Concentrating solar systems require clear sky days because clouds result in diffuse radiation that cannot be focused onto the receiver. The design of solar thermal systems also needs to factor in the seasonal nature of the resource and the loads it would be supplying.

Larger-scale solar thermal technologies may be an alternative to gas used for process heat or industrial processes, depending on gas prices, temperatures required, quality of solar resources at the site and space to host an installation. Rigorous economic evaluation is very site and process specific. Predicting the performance can be more complex process than it is for other technology options. Flat plate and evacuated tube technologies are off-the-shelf technologies and may be attractive for sites where there is a requirement for hot water or steam for process heat.

Typically, residential electric heat pump hot water systems have a co-efficient of performance of between 3 and 4.5. Thus, their peak electric power draw for boosting is, usually, significantly less than electric boosted, solar hot water systems. This makes heat pumps more suitable for islandable microgrids than electric boosted solar hot water systems. Heat pump hot water systems also generally come with built in timers which can be used to maximise self-consumption from rooftop PV systems.

A2. Wind

Wind turbines operate when wind turns blades around a rotor, and the rotational force is then used to turn a generator to create electricity, or in the case of windmills mechanically turn a water pump. Depending on the type of wind turbine used, electrical output from the generator may require conditioning by power electronics to obtain the correct frequency and voltage before it can be exported to the grid.

The most common form of wind turbine has the rotor spinning around a horizontal axis and three blades. Vertical axis wind turbines also exist but they have a very small proportion of the wind turbine market.

A.2.1 Horizontal

Wind turbine technologies are available at small and large scale. In both instances, the quality of the wind resource is critical to viability. The wind resource (i.e. annual wind speed distribution, wind shear) is highly site-specific and a thorough assessment is required to ensure turbine performance and lifetime will be sufficient to warrant the investment.

Wind speed increases with height and wind turbulence increases maintenance costs, hence the preference for high nacelle heights to minimise ground terrain effects.

Small wind turbines can be sized to meet a range of annual energy contributions for stand-alone power systems. Typically, they are installed at remote homes and farms along with batteries and a diesel generator. These wind turbines are significantly smaller than those used in large-scale wind farms.

All wind turbines have a cut-in, rated and cut-out wind speed as shown in Figure 27: Wind turbine power curve. In very high winds, wind turbines use various protection mechanisms which means no power is produced.

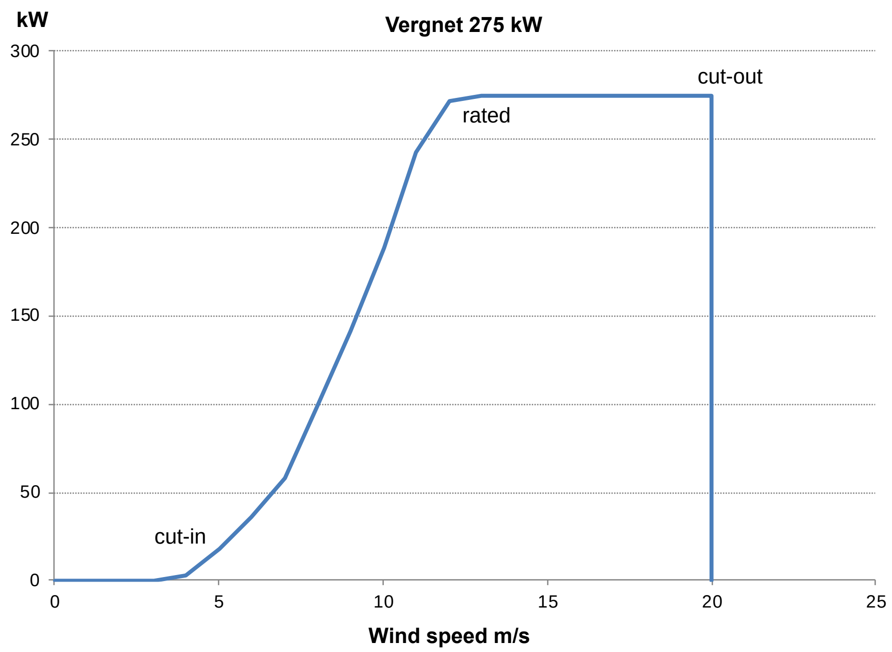

Figure 27: Wind turbine power curve

It is worth noting that a 2 MW wind turbine designed for central desert conditions will have a different rated wind speed to a 2 MW turbine designed for an island in the Bass Strait. A wind turbine will generate less than its rated power output when the wind speed is below its rated wind speed. It only generates its rated power output when the wind is between the rated and cut-out wind speed.

Small scale wind turbines are available in various designs and sizes. Typically, a stand-alone power system for a home in a windy area would use a wind turbine in the 2 to 10 kW range. Very small, wind turbines can be rated as low as 50 Watts. These are often used for auxiliary power for small, recreational boats.

Typically, small-scale wind turbines achieve lower capacity factors than large wind turbines due to the lower height of the tower. The physics for wind generation mean the potential power available is proportional to the swept circular area of the rotor's blades and the cube of the wind speed.

Historically, large-scale wind turbines have been the dominant form of large-scale renewable generation deployed worldwide. Wind turbine generation benefits from economies of scale, so developments in turbine and blade size as well as technology continues. Typically, the output of multiple wind turbines is aggregated through a central connection point to the electricity grid.

Wind farm projects also experience strong economies of scale. Typically, cost-effectiveness increases rapidly with increasing turbine size and the number of turbines, up to the power limit of the grid-connection point. New onshore projects can use turbine capacities of more than 3 MW, blades around 50 to 60 metres in length and tower heights of more than 110 metres. New offshore projects use larger turbines of around 6 MW or more, with blade lengths over 80 metres. In 2021, the largest offshore wind turbine being built has a blade length of 108 metres. As such, the logistics of construction (i.e., materials and container handling, locally available cranes) are critical considerations for large wind projects.

In most parts of Australia, large wind projects typically generate more power in winter than summer and generation is higher overnight than during the day. Maximum, instantaneous wind turbine power output can occur at any time of the day. Project developers usually select sites with the highest average wind speeds. Recent advances in designs however mean lower speed wind resources can also be used for generation. Typically, this would have higher overall costs per kWh generated.

Owing to the harsh operating conditions in which wind turbines operate, maintenance requirements are higher and more critical than for solar PV. Nevertheless, where a suitable wind resource exists, and where maintenance requirements are adhered to, wind turbines can deliver clean energy at low cost, and can operate outside of sunshine hours.

A.2.2 Vertical

Typically, vertical axis wind turbines require more maintenance due to wind shear effects and the potential for vibration issues to arise. They are a specialised technology, not widely deployed and have unique design approaches to attempting to survive cyclones. Some vertical axis turbines have a maximum survival speed of 60 m/s, which is 216kms per hour. Wind speed gusts above this can occur in Category 4 cyclones.

The power curve for vertical axis wind turbines can have a gradual reduction in power output in very high winds which declines to zero at the cut-out wind speed.

Typically, detailed wind monitoring is undertaken before deciding on the optimal wind turbine for a particular location. The costs of grid-connecting small wind turbines will also affect the economic viability.

A3. Bioenergy

Bioenergy refers to the potential energy stored within biomass that can be converted to thermal energy. Biomass is organic matter originally derived from plants and animals, (not fossilised such as coal), and can be used to provide heat, electricity, transportation fuels or as a chemical feedstock.

Biomass feedstocks, their components and moisture content are varied. The specific feedstock will affect efficiency as well as the type of technology used to extract useful energy. Feedstocks can be solid or liquid, and include wood, bark, bagasse, agricultural crops (e.g. straw and rice husk), energy crops (e.g. mallee), and waste products (e.g. wood or paper waste, black liquor, sewage sludge). Biomass can be combusted, gasified, pyrolised or digested to make biogas.

Owing to the complexity of efficiently converting thermal energy to electrical energy, it is assumed that small locations such as Yarrabah would use internal combustion engines driving synchronous alternators for generation. This is because the working principles and maintenance requirements of internal combustion engines are widely understood, and because such systems can be cost-efficient at some scales.

Internal combustion engines can run on liquid or gaseous fuels, with only minor differences from the common diesel generator. Hence, provided sufficient biomass feedstock is available and can be secured long term, electricity can be generated on demand from processed biofuels.

Most of the risk with a bioenergy solution lies with the biomass supply and delivered cost. Relative to the purchase cost, biomass resources are expensive to transport. Thus, the lowest cost biomass resources are those local to the user. Bioenergy capital costs are strongly dependent on system size, with large systems being progressively more cost effective.

A.3.1 Biogas

Biogas is produced when bacteria break down organic matter in suitably controlled conditions in the absence of oxygen in a process called anaerobic digestion. The biogas is mainly composed of methane with some carbon dioxide and other trace gases. Feedstocks to produce biogas include livestock effluents and meat processing waste, the organic components of landfills and any other source of 'wet waste' biomass (e.g. wastewater treatment sludge or food and beverage industry wastes). This biogas can be combusted for process heat or used in engines or, with extra investment, purified and in principle used for chemical feedstock or sensitive combustion applications.

Biogas can be produced at small-scale using simple materials, with larger, more sophisticated digesters used for production at large scale. Digesters can be:

- Covered effluent ponds for liquid waste, where biogas accumulates under an impermeable cover and is piped for processing, or
- Digestion tanks where semi-liquid wastes are mixed and the digestion process can be controlled by temperature, or by adding bacteria to enhance the process.

Solids which settle at the base of the digester are a by-product from biogas production and can be used as fertilizer.

Anaerobic digestion is often selected as a waste treatment option for wet wastes, to be installed where the waste occurs. For example, where large-scale sewage treatment is anaerobic, the installation of capture and generation equipment is almost always cost-effective, and the electricity is generally used entirely on site. Anaerobic digesters can be used to treat waste streams in a wide range of industries, from food and beverage to livestock.

Anaerobic digestion occurs in landfill sites, where methane is produced from the organic element of the waste and requires control to prevent explosion. In this case energy generation is the alternative to flaring the gas. However, anaerobic digesters are more commonly an active waste management strategy. The digester element may require little additional expenditure, for example it may only require fitting a cover to an existing waste treatment lagoon to capture gas or may require the installation of a purpose made tank where digestion and gas capture occurs. Anaerobic digestion may also be used at a central waste processing site for liquid wastes, such as slurries from livestock or food and drink industries.

A.3.2 Ethanol

Renewable ethanol is produced from biomass feedstocks that contain large amount of sugar (sugar cane, sugar beet and molasses) or from materials that can be converted into sugar such as starch (corn, wheat, grains) or from cellulose (crop residues and wood). The main steps in the production of ethanol are extraction of glucose (sugars) from feedstocks, fermentation, distillation and dehydration. Where conversion to glucose is necessary, pre-treatment and pre-processing of the feedstock is required before fermentation and distillation.

Ethanol transport fuel blends range from 5% (E5) to 100% pure ethanol. E10 is the most widely used around the world. Where ethanol is produced from waste products, it does not interfere with food production. Commercialisation efforts continue with the development of other feedstocks, such as algae, cellulosic biomass, trees and grasses.

Ethanol is produced where abundant supply of feedstocks exist. (e.g., in the US, ethanol is mainly made from corn, and the ethanol plants are concentrated in areas where corn is farmed, in Australia, ethanol is produced near sugarcane mills). The availability of land for farming of suitable feedstocks affects the opportunity for local production of ethanol.

A.3.3 Biomass Boilers

Direct combustion involves burning a fuel (such as wood pellets or bagasse) and using the heat to drive a steam turbine. Combustion systems can be configured in various ways and are primarily used for steam and hot water production. The biomass must be progressively fed to a grate where combustion takes place or in smaller particles to a fluidised bed. In either case, fan systems introduce air and automated feed systems are incorporated. Heat is extracted usually via water/steam passing through boiler tubes that surround the combustion region.

An established supply chain for biomass material such as wood pellets is important to project viability.

Combustion may also be used for mixed waste streams, such as municipal solid waste. In this case the capital expenditure will be dominated by waste handling and treatment, as the waste requires sorting to extract the organics, may require some material diversion for recycling, and the plant will require considerable effort on the flue gas treatment, which is more complex with a mixed feedstock. Gate fees for the waste treatment are likely to be required to make the project financially viable.

A4. Hydropower

The use of large dams for power generation is widely used in areas with suitable geography and reliable rainfall. These systems can be cost-effective due to the predictability and consistency of their dispatchable output as well as the long design life of the assets. The systems involve major civil works primarily made of concrete that do not degrade and have a useful life of around 50 years. They also benefit from significant economies of scale and are relatively more land intensive.

Small hydro generation turbines are also commercially available. There is no widely used definition for the distinction between large and small hydro generators. For the purposes of this study, an indicative size range for small hydro is around 5 MW to 30 MW.

Hydro generators below 5 MW are often described as mini hydro. The term micro hydro is also used for even smaller systems, usually in the kilowatt range.

Appendix B. Energy Storage

A range of energy storage technologies are utilised for various applications around the world. These include various battery chemistries, pumped hydro, compressed air, thermal, flywheels and hydrogen.

Electricity storage can be broadly categorised into two major types:

- Short-term energy storage and
- Bulk energy storage.

The primary purpose of short-term energy storage is generation ramp rate control, so relatively high instantaneous power outputs are required for short periods. Thus, only a relatively small amount of energy is required to be stored. The primary purpose of bulk energy storage is to store large amounts of VRE generation, to be used later, when there is no or limited output from VRE generation.

The parameters for energy storage will depend on its designed role. This can vary widely as requirements can be different depending on function, other generators and whether it is an isolated or an islandable microgrid.

For isolated microgrids:

- Short-term storage can be used to maintain power quality by smoothing VRE output to keep power ramp rates within certain bands, and
- Bulk storage can be used to power loads when there is no output from the VRE source (e.g., At night for PV, during periods of no wind for wind turbines).

B1. Short-term Energy Storage

The primary purpose of short-term storage in an isolated microgrid is to store relatively small amounts of energy to be able to deliver enough power to smooth out fluctuations in output from a VRE generation. Examples of short-term storage technologies include flywheels, ultracapacitors, lithium-ion, lead acid and other batteries with high MW output capacity and low MWh storage duration. These systems are designed for a high power-to-energy ratio, as fluctuations are generally short in nature.

The system design manages any prolonged increase/decrease in power output from the VRE source by changing the power output from the diesel[41] generators. Smoothing out VRE power output can manage rapid voltage sag/rise on the network to acceptable limits and provide a smoother load profile with manageable ramp rates for diesel generators to follow.

[41] Isolated microgrids can also use gas engines or turbines, bioenergy and/or hydro power with diesel generators or instead of diesel generators. However, diesel generators are the most common for isolated microgrids.

Given the relatively small amount of energy stored, short-term energy storage alone cannot be used where there are high amounts of VRE annual contribution, although it can allow for instantaneous power proportions above 30% of total supply.

Short-term energy storage can absorb limited amounts of VRE overproduction; beyond a certain point, dumping is required (e.g., limiting production from the VRE system or diverting surplus energy to a deferrable or dump load). Underproduction by the VRE system is met in the short-term (a few seconds to several minutes) by the short-term energy storage system, and in the long-term, by diesel generation.

All these systems require inverters to control their power output/input, and as such the network protection equipment must be designed with the inverter's limited current delivery in mind.

B2. Bulk Energy Storage

For isolated microgrids, if the VRE instantaneous power proportion and annual energy contribution is to be increased beyond what short-term energy storage and the associated diesel generation can support, bulk energy storage is required. Bulk storage is used to capture any excess electricity generated to use it at a later time when the VRE generation has decreased.

Examples of bulk electricity storage include pumped hydro, compressed air, thermal, hydrogen and a variety of battery technologies including lithium-ion, flow and lead-acid. Bulk electricity storage technologies become economical when the cost of curtailed or dumped (i.e. wasted) electricity from the VRE generators exceeds the cost of storing it.

Depending on the scale of the bulk electricity storage required, there may be potential for larger systems that achieve economies of scale (e.g., pumped hydro). Careful dispatching of this stored electricity will affect the economics of the system. Where diesel generators are used, electricity should be released from the bulk energy storage such that the diesel generators are loaded to operate at their peak efficiency (roughly 80% loading), or not operating at all (diesel-off mode). Operating in only these two regimes is not always possible, but it should be aimed for.

The efficiency of a bulk energy storage system is important, especially on an isolated microgrid where the marginal cost of electricity used by customers is the cost of diesel-fired electricity (which is generally quite high). This is because losses are made up at the marginal cost. Where space is limited, storage technologies offering a high energy density are required.

Appendix C. Funding Programs

C1. Federal Government

Powering Australia and National Energy Performance Strategy

The Australian Government's Powering Australia plan is focused on creating jobs, cutting power bills and reducing emissions by boosting renewable energy. Under Powering Australia, the government seeks to reduce Australia's emissions and to achieve a net zero 2050 target.

To support this plan, the Federal Government announced the National Energy Performance Strategy (NEPS). The NEPS is designed to be a national framework that will improve energy performance across the economy. The NEPS is focused on reducing energy costs for households and businesses, lowering the demand pressure on Australia's whole energy system and contributing to the efforts to meet the legislated emission reduction goals.

A consultation paper was released in 2022 providing context to the elements that will inform the NEPS. Critical to the strategy will be a transition to renewable energy, and direct household and commercial actions towards improving energy efficiency.

Specific funding commitments were made under the Powering Australia Plan as part of the 2022-23 Federal Budget. Certain commitments under this have been discussed in the following sections, and include:

$224.3 million for the Community Batteries for Household Solar grants program, to deploy 400 community-scale batteries for up to 100,000 Australian households.

$83.8 million to develop and deploy First Nations Community Microgrid projects. Remote communities will benefit from improved security and affordability of energy supply.

Australian Renewable Energy Agency

Australian Renewable Energy Agency (ARENA) was established by the Australian Government on 1 July 2012. ARENA operates with the purpose of supporting the global transition to net zero emissions by accelerating the pace of pre-commercial innovation, to the benefit of Australian consumers, businesses and workers. ARENA's strategic priorities include:

Priority 1. Optimise the transition to renewable electricity.

Priority 2. Commercialise clean hydrogen.

Priority 3. Support the transition to low emissions metals.

Priority 4. Decarbonise land transport.

To support the delivery of the above strategic priorities, ARENA administers grant funding on behalf of the Australian Government to improve the competitiveness and supply of renewable energy in Australia.

As part of recent Federal Budgets, the Australian Government has committed over $300 million to deliver targeted programs, including: Future Fuels Fund, Industrial Energy Transformation Studies Program and Regional Australia Microgrids Pilot Program, First Nations Community Microgrids and Community Battery program.

Regional and Remote Communities Reliability Fund (RRCRF) and Regional Australia Microgrid Pilots Program (RAMPP)

In October 2020, the Australian Government announced the $50 million Regional Australia Microgrid Pilots Program (RAMPP) to support pilot demonstrations of microgrids in regional and remote areas. Run over a six-year period, the RAMPP aims to improve the resilience and reliability of power supply for regional and remote communities.

RAMPP builds upon the Australian Government's $50.4 million Regional and Remote Communities Reliability Fund (RRCRF), which funded feasibility studies for regional and remote communities to investigate deployment of local microgrid technologies.

In the 2022-23 Federal Budget, the Federal Government announced $83M under the First Nations Community Microgrids Program to develop and deploy microgrid technology across First Nations communities. The intent of the program is to increase access to cheaper, cleaner and more reliable energy.

ARENA – First Nations Community Microgrids Program

Administered by ARENA, the program will facilitate the development of microgrid projects in consultation with Aboriginal and Torres Strait Islander groups, First Nations clean energy experts and the states and territories.

Community Battery for Household Solar Program

The Community Batteries for Household Solar Budget Measure was announced in the October 2022 Commonwealth Budget. Funding of up to $171 million is to be administered by ARENA over 4 years (until 2025-26). The focus of the program is to deploy 400 community batteries across Australia to lower bills, cut emissions and reduce pressure on the electricity grid by allowing households to store and use excess power they produce.

Appliance Purchase Loan Assistance

The Department of Climate Change, Energy, the Environment and Water (DCCEEW) provides a range of rebates and assistance to Australian households to support energy saving initiatives and to improve the overall uptake on renewable energy systems.

The Appliance Purchase Loan Assistance - No Interest Loans Scheme (NILS) offers individuals and families on low incomes access to safe, fair and affordable loans for purchasing appliances and some other essential household expenses. NILS is offered by more than 175 local community organisations in over 600 locations across Australia. The NILS applies to essential appliances up to a value of $1,500.

Renewable Energy Target (RET) Program

The Renewable Energy Target (RET) scheme encourages renewable electricity generation. Administered by the Clean Energy Regulator, the scheme aims to reduce greenhouse gas emissions from the electricity sector.

The Small-scale Renewable Energy Scheme (SRES) incentivises households and businesses to install small-scale renewable energy systems. These include rooftop solar panels, solar water heaters and small-scale wind or hydro systems. System owners can create small-scale technology certificates (STCs) when an eligible system is installed. The relevant STCs may be sold to an energy retailer.

National Indigenous Australians Agency (NIAA)

The National Indigenous Australians Agency (NIAA) is committed to improving the lives of all Aboriginal and Torres Strait Islander peoples. The NIAA works to influence policy across the entire Australian Government. NIAA works closely with State and Territory governments, Indigenous peak bodies, stakeholders and service providers to ensure that Indigenous programs and services are delivering for Aboriginal and Torres Strait Islander peoples as intended.

The NIAA funds projects aimed at helping Indigenous Australians. Funding is allocated through the Indigenous Advancement Strategy (IAS), National Partnership Agreements, Special Accounts and Special Appropriations.

Under the IAS, the NIAA considers grant proposals that address a need for Aboriginal and Torres Strait Islander people. Proposals must be developed with the community or group who will be impacted by the activity.

Indigenous Land and Sea Corporation (ILSC)

The Indigenous Land and Sea Corporation (ILSC) is a corporate Commonwealth entity established under the Aboriginal and Torres Strait Islander Act 2005 (ATSI Act). ILSC's long-term vision for meeting its ATSI Act mandate is for Aboriginal and Torres Strait Islander people to enjoy the rightful entitlements, opportunities and benefits that the return of country and its management brings.

ILSC's primary grant program – Our Country Our Future – provides assistance for acquiring and managing rights and interests in land, salt water and fresh water country in order to achieve this vision. Assistance through the program is provided through investment in projects, advice and capability support and facilitating connections with technical experts and support networks.

Clean Energy Finance Corporation

The Clean Energy Finance Corporation (CEFC) supports energy efficiency, renewable energy and low emissions technology projects through the provision of loans and other equity investments.

CEFC is an Australian Government-owned “Green Bank” that was established to facilitate increased flows of finance into the clean energy sector. The CEFC invests in accordance with its legislation, the Clean Energy Finance Corporation Act 2012 (CEFC Act) and the prevailing Investment Mandate.

The CEFC may make debt or equity investments into eligible clean energy or renewable energy projects that provide an appropriate commercial return to the Australian taxpayer.

C2. State Government

Queensland Energy and Jobs Plan

The Queensland Energy and Jobs Plan outlines the Queensland State Government’s plan to deliver clean, reliable and affordable energy. Specifically, the plan is focused on:

Building a clean and competitive energy system for the Queensland economy and industries as a platform for accelerating growth.

Delivering affordable energy for households and businesses and support more rooftop solar and batteries.

Driving better outcome for workers and communities as partners in the energy transformation.

The Powering Queensland Plan delivers $1.16 billion investment to support the transition to a cleaner energy sector and create new investment and jobs.

Under the Queensland Energy and Jobs Plan, certain initiatives have been announced that have specific application to the proposed microgrid project at Napranum. These initiatives include the Queensland Microgrid Pilot Fund and the Queensland Renewable Energy and Hydrogen Jobs Fund. Both have been discussed in further detail below.

Queensland Microgrid Pilot Fund (QMPF)

The $10 million Queensland Microgrid Pilot Fund (QMPF) will support Queenslanders living in regional and First Nations grid-connected communities by giving them access to more resilient electricity as part of the state’s energy system transformation. The program aims to:

increase energy and network resilience in regional and remote communities; and

contribute to the decarbonisation of these communities, which are generally reliant on diesel generation.

As one of the first programs to be delivered under the Queensland Energy and Jobs Plan, the two-year program offers grants for feasibility studies and projects to develop and deliver microgrid projects across regional and remote areas of Queensland, boosting the network resilience of these communities against extreme weather events.

Queensland Renewable Energy and Hydrogen Jobs Fund (QREHJF)

The Queensland Renewable Energy and Hydrogen Jobs Fund allows Government owned corporations to increase ownership of commercial renewable energy and hydrogen projects, as well as supporting infrastructure, including in partnership with the private sector.

The Fund complements the commitment of $145 million to establish three Queensland Renewable Energy Zones – the northern, central and southern QREZs – to support significant renewables investment. In these areas, the Queensland Government will undertake strategic network investments, streamline the development of new renewable energy projects, and work to match new and existing industrial energy demand with our low-cost renewable energy.

As outlined in the Queensland Energy and Jobs Plan, this funding will ensure publicly owned energy businesses can continue to invest in renewable energy, storage and hydrogen projects in the QREZ regions, and will help deliver on the long-term targets for these regions to reach at least 25GW of total renewable energy by 2035.

Decarbonising Remote Communities - Solar for Remote Communities

As part of the $3.6 million Decarbonising Remote Communities program, 4 Indigenous communities in Queensland's far north had renewable energy systems installed to reduce the use of diesel power. Participating Aboriginal and Torres Strait Islander Councils were key project partners in planning and delivering these projects.

Using renewables such as solar and battery storage directly benefits remote communities that run on diesel by creating jobs and power savings, as well as bringing the environmental benefits of reduced emissions.

The communities that benefited from the program included Doomadgee, Mapoon, Pormpuraaw and Northern Peninsular Area. In total almost 1,000 kW of new solar generation was installed across Council owned building rooftops or through the establishment of community solar farms.

Affordable Energy Plan

The Affordable Energy Plan invested more than $300 million in a range of pilots and programs to assist households to reduce their energy use and costs. Specific initiatives under this plan included:

Energy Efficient Appliance Rebate - $20 million provided to householders that purchase certain energy efficient appliances.

Energy Savvy Families - invested $9 million to help low-income families learn about their electricity use and manage their bills by providing digital meters.

Solar for Rental Properties program - provided $4 million to incentivise landlords to install solar for their tenants to reduce their household electricity bills.

Interest-free Loans for Solar and Storage program - provided $21 million to support Queenslanders manage the upfront costs of solar and battery technologies with interest free loans.

Business Energy Savers program - provided $20 million for energy efficiency audits and grants to fund energy efficiency upgrades.

CleanCo Queensland

CleanCo Queensland is a Queensland government-owned electricity generation and trading company. The entity, fuelled by a mix of renewable energy and innovative energy solutions, is tasked with delivering reliable clean energy solutions with a target to support 1,400 MW of new renewable generation by 2025.

CleanCo holds a strategic portfolio of low and no emission power generation assets, and will build, construct, own and maintain renewable energy generation in Queensland. CleanCo has a commercial mandate to increase competition to the energy market at peak demand times when wholesale electricity prices are at their highest. In turn, CleanCo aim to reduce the overall wholesale price of energy for all Queenslanders.

Ergon Energy - Community Service Obligation

As part of its commitment to keep regional Queensland power prices on par with the southeast, the Queensland Government provides a subsidy to meet the additional costs involved in supplying electricity to regional Queensland. This subsidy is called the Community Service Obligation (CSO) payment, which is around $500 million each year.

C3. Local Government

Queensland Climate Resilient Councils program

The Queensland Climate Resilient Councils program was a unique partnership between the Local Government Association of Queensland (LGAQ) and the Queensland Government to support local governments to plan for and respond to climate change. Funded to 30 June 2022, the program sought to deliver services and products that would strengthen skills and capacity to plan for and respond to the challenges and opportunities arising from climate change.

Torres Shire Council – Corporate Plan 2018 – 2023

In 2018, the Torres Shire Council enacted their five-year corporate plan extending from 2018 to 2023. The corporate plan outlines a range of initiatives focused on advancing the community economically, whilst addressing a range of social, environment and cultural matters.

The Corporate Plan specifically outlines a range of actions focused on environmental consciousness and management of climate change. These actions are specifically focused on promoting, improving and supporting sustainable environmental practices, applying innovative strategies to mitigate environmental impact and proactively engaging with community, Government and other stakeholders to address the impact of climate change and support adaption and resilience within the community.

Of specific relevance is implementing strategies to improve the energy management system that is embedded within the community, with a particular focus on enhancing the uptake and utilisation of renewable energy.

Torres Strait Regional Authority – Land and Sea Management Strategy for Torres Strait 2016 – 2036

This Land and Sea Management Strategy for Torres Strait (2016-2036) aims to achieve the following vision:

"Empowering Torres Strait Islander and Aboriginal peoples to sustainably manage and benefit from their land, sea and cultural resources into the future, in accordance with Ailan Kastom, Aboriginal Lore/Law and native title rights and interests."

The Strategy sets out a framework for the sustainable community-based management of natural land and sea resources in the Torres Strait region and related cultural knowledge, beliefs, and practices – including conservation, consumption, management, reliance and use.

Central to the Strategy is upholding the cultural and environmental values that are integral within the Torres Strait community and recognising the importance of land and sea management in supporting a sustainable future for the region.

Adopting sustainable community development practices through use of low impact utility infrastructure, such as renewable energy solutions, presents opportunities for the community to achieve many of the desired outcomes identified within the strategy.

Cape York and Torres Strait Regional Resilience Strategy

The Cape York and Torres Strait Regional Resilience Strategy is a partnership between the Queensland Government and the Torres and Cape Indigenous Councils Alliance and the Torres Strait Island Regional Council.

Published in 2022, the strategy is focused on developing a framework for the enhancement of resilience across the region, particularly in response to natural disaster events that impact the region. The strategy also provides a framework against which local action plans can be developed and actions implemented at a community level.

The strategy identifies a range of core resilience needs for the region, including (but not limited to) improved facilitated infrastructure or innovation in water and energy, support to transition to renewable and independent energy technologies and development of local industries.

Torres Strait Regional Authority- Torres Strait Regional Adaptation and Resilience Plan 2016-2021

Climate change will have a range of impacts in the Torres Strait. The key direct impacts include sea level rise, heat impacts, extreme weather and ocean acidification. Aspects of the region most exposed to these impacts include low-lying settlements, water security, community health and ecosystem health.

This Torres Strait Regional Adaptation and Resilience Plan details how climate change will impact the region's communities and land and sea country, and what steps can be taken to reduce the likely impacts to ensure the region has a strong viable future. The Plan was developed in conjunction with the communities of the Torres Strait, and with an understanding of the environment and its role in supporting the future of the region.

While the plan expired in 2021, many of the actions and recommendations are still in place across the region. In particular, the focus on building resilient communities, through adoption of innovative community development approaches is a core part of planning in the region. Furthermore, the unwavering commitment of the region Councils towards reducing the overall impact on the environment, through the integration of sustainability practices such as implementation of renewable energy, remains strong.

C4. Non-Government

Investment in renewable energy generation has increased markedly in Australia over recent years, driven by a combination of factors including Government policy incentives, elevated electricity prices and declining costs of renewable generation technology. Importantly, non-Government investment in renewable energy projects, such as that proposed for the Muralug community, may come from a range of sources including:

- Direct corporate sector investment
- Renewable energy investment funds
- Social enterprise investments
- First Nation and Indigenous community investment programs and funds.

Non-Government investment programs commonly adhere to an investment mandate that seeks an appropriate commercial return on monies invested in capital infrastructure. While the investment mandates will vary across each funding source, these mandates often require clear and reliable revenue streams that are assured over the long term.


EnergyConnect
Connecting Community through Micro-Grids