Sustainable Energy for Mallacoota Feasibility Study

Draft Report for the Sustainable Energy for Mallacoota Working Group (SEMWG)

File Reference: P1331-C001-010

Date: 17/01/2013

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Document Revision Status & Approval Log

Date	Status for Purpose	Authors	Reviewer	Authoriser
29/11/2013	Draft report	ENHAR Demian Natakhan Aaron Donoghue Jack Bruce Trent Hawkins	Trent Hawkins	Demian Natakhan
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17/01/2013	Second draft report	ENHAR, AECOM, RDC As above	Trent Hawkins	Demian Natakhan
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Acknowledgements:

The Mallacoota Sustainable Energy group provided key statistics about Mallacoota and its current number of solar installations, as well as data from solar systems.

SP AusNet provided information about local power network infrastructure and electricity demand data.

Lester Wharfe of East Gippsland Shire Council provided analysis of biomass resource. Megan Dennett of East Gippsland Shire Council provided information on environmental and planning issues in relation to specific sites.

Nola Anderson, Regional Education Officer at Gippsland Regional Waste Management Group, provided information about the Mallacoota Kitchen to Compost scheme.

Frank McShane and Daniel Marsden of East Gippsland Water provided much useful information about sewage quantities, backup diesel generator capacities and land areas at the sewage treatment plant site.

Mark Bertoncello of Diamond Energy provided some overview commentary on business models and the financial modelling. Diamond Energy provided the commentary to the consulting consortium through an unpaid peer review.

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This is a study for consideration by the client parties SP AusNet, East Gippsland Shire Council and the Mallacoota Sustainable Energy Group. The client parties have no obligation to proceed with the recommendations provided, in whole or in part by this study.

Executive Summary

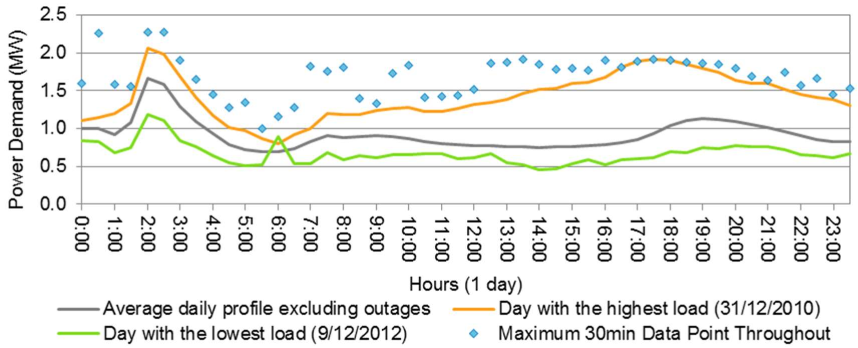
Mallacoota is a coastal town of around 1,000 residents at the end of the 22kV grid line in the far east of Victoria. Energy supply reliability has been an issue due to natural weather events such as fire and flood which has led to extended periods of time without power.

The community is a resilient one with a keen interest in sustainability as well as improvements in power supply reliability. The concept of a renewable energy generating system and other novel approaches including energy demand management to resolve the town's power issues have been developed through a collaboration of the Mallacoota Sustainable Energy Group (MSEG), SP AusNet and East Gippsland Shire Council (EGSC).

Following a competitive tendering process, this group commissioned a consortium led by Enhar Pty Ltd to undertake a feasibility study into sustainable energy options for Mallacoota.

Demand Profile Analysis

The town's electricity demand was analysed in detail as a key input to the development of the projects generation options.



This analysis showed that there were two peak times in the area.

The first of these peaks is driven by the overnight heating of water using offpeak hot water heaters, while the second of these peaks is as a result of the population using more power in the afternoon. This is displayed in the graph above of maximum half hourly demand in the area.

It is anticipated that the overnight peak will be reduced with the introduction of smart meters into the township during 2014 and the afternoon peak will continue in similar form to that shown.

The analysis also indicated that January is the peak demand month driven by the holiday season. Although the monthly demand is only around 20% above the other monthly averages, holiday makers in January swell the population to several times the average level. To this end, the average daily usage for January 2012 was set as the demand curve for the design of the system.

One key aspect of the design of the generation system is to understand the number of hours where a peak is seen in the demand. This analysis showed that the number of peak hours and the peak demand has been gradually decreasing over the past 4 years. For 2012 it was found that on only 5 occasions did the demand reach a value greater than 1.8MW. For this reason the maximum demand of the generation system was set at between 1.8 and 1.9 MW. Up to 200kW of demand management was identified as viable, and the generation capacity required is therefore 1.6MW.

By including automation into the backup generator system, a solution can be identified which could prevent the majority of outages greater than 1 minute in duration. These are termed 'sustained' outages. The solutions considered would not prevent the momentary outages (lasting a few seconds), however the majority of concerns among local residents at Mallacoota are in relation to the long outages.

Energy Generation Options

The goal was to identify an energy technology which could deliver power to the town at any time when a grid outage occurs. The project aims to identify sustainable and renewable fuel sources, therefore intermittency and storage considerations are important. A wide range of renewable resources available at Mallacoota were analysed, as listed below:

Summary of Renewable Resources available at Mallacoota

Resource Type	Quantity and comments
Solar resource	Annual average daily solar radiation on a horizontal surface is 4.3 kWh/m²/day.
Wind Resource	Long term annual average wind speed is 3.9m/s at 8m at Mallacoota Airport. With shear extrapolation an estimated range is 6.0-6.5m/s at 50m and 6.8-7.9m/s at 100m.
Digestable organic wastes suitable for biogas production.	At least 700,000 tonnes per year of sewage waste plus 350 tonnes per year of other digestable wastes including Kitchen Compost Waste, Abalone Waste, Meat Trimmings and Green Waste.
Biomass	Sawdust waste at Cann River is estimated around 2,000 tonnes per year and sawmill waste (chipped) is up to 6,000 tonnes per year.
Wave	The wave resource is around 20kW/m at nearshore locations.
Tidal stream	The tidal stream resource is up to 130W/m^2 at nearby locations.

The study considered a range of generation technologies and a range of storage technologies. Evaluation criteria were established in consultation with the client stakeholders and each option was considered against the same criteria. Criteria included technical, social and environmental feasibility. Vital criteria included providing emergency proofing and community acceptance. Very important criteria included ability to generate for extended periods during outages, providing an equal benefit to all community members and use of proven robust technology.

As a first step, all options were screened for economic affordability based on existing published price reviews, and also evaluated against the vital criteria. A summary of this process is provided below:

First Evaluation matrix

Options / Evaluation	Potentially economically viable?	Vital Criteria		
		Emergency Proof	Community Acceptance	Total Score: Vital criteria
Decentralised solar photovoltaic, with decentralised storage	Possibly	5	4	**9**
Centralised solar thermal, with storage	No	4	3	7
Centralised solar photovoltaic with centralised battery storage	No	4	5	**9**

Centralised solar photovoltaic with backup generator	Possibly	4	5	**9**
Centralised wind turbine with centralised battery storage	No	4	1	5
Centralised wind turbine with backup generator	Possibly	4	1	5
Centralised biogas generator	Possibly	4	5	**9**
Biomass	Possibly	4	1	5
Wave generation (with storage or backup generator)	No	4	3	7
Tidal power (with storage or backup generator)	No	4	3	7
Concentrating solar photovoltaic (with storage or backup generator)	No	4	3	7

KEY		**Merit**
Suitable	5	**High / Best**
Adequate	4	
Marginal	3	
Questionable	2	
Possible Showstopper	1	**Low / Worst**

Energy Storage

It was considered that energy storage could enable a much higher proportion of local demand to be met by renewable generation. Most renewable sources are intermittent and if cost effective storage could be included then continual power generation could be achieved even when the 22kV grid connection is lost. The integration of storage technology may also improve the availability of the grid in the Mallacoota area.

The majority of storage used in the Australian context is Pumped Hydro storage whilst the development of battery and other storage sources is in its infancy. Key barriers for the uptake of large scale energy storage in Australia include:

1. Economics – Project viability is highly site specific
2. Technology maturity –As the industry matures, confidence will grow in the technology.
3. Market – Real case studies are limited
4. Technical – There are concerns regarding the technical integration of battery storage with local grid operation.
5. Regulatory – The regulatory framework and local standards do not currently provide clear guidance for the implementation of energy storage.

With these aspects in mind, a market analysis of the likely suitable storage techniques for this project was completed. This analysis found that the most commercially viable and available technology would be advanced lead acid batteries. This technology has the benefit of having fast reaction times to system disturbances as well as being able to supply support when the network was not available for short times. Given the current costs of this technology however, it is not currently financially viable to provide long term coverage of network outages using battery storage. For this reason, a diesel generator is considered to be required. Methods to minimise the diesel usage during outages using a hybrid renewable supply were investigated, especially solar and biogas.

Community Consultation

Community consultation was given a high priority throughout the process and was designed with input from EGSC and MSEG. A series of articles were published in the local paper, a community website and the EGSC website to share information about the project. Community information sessions were held in Mallacoota in November 2013.
ver 60 local people attended these sessions and the feedback from participants informed the research and assessment of the options against the selection criteria

The community has shown a willingness to embrace a solution to improving energy reliability if it does not negatively impact on visual and general amenity.

This consultation was conducted as part of a feasibility study. If a proposal is further developed as a concept and then further consultations would be required to test more specific details and potential impacts.

Identifying Recommended Solutions

Once the options which are significantly uneconomic or do not meet the vital criteria were ruled out, further assessment of the remaining options could be conducted:

Second evaluation matrix

Criteria / Option		Decentralised solar photovoltaic, with decentralised storage	Centralised solar photovoltaic with backup generator	Centralised biogas generator
Vital Criteria	Emergency Proof	5	4	4
	Community Acceptance	4	5	5
	Total Score: Vital criteria	**9**	**9**	**9**
Very Important Criteria	Ability to supply electricity for extended periods	3	5	5
	Equity	2	5	4
	Proven robust technology	4	5	4
	Operation and maintenance	2	3	4
	Planning permission	5	4	5
Important criteria	Economics	2	4	3
	Construction - technically feasible	3	5	5
	Resource abundance	4	4	3
	Intermittency protection	5	3	3
	Total Score (all criteria)	**39**	**47**	**45**

KEY		Merit
Suitable	5	**High / Best**
Adequate	4	
Marginal	3	
Questionable	2	
Possible Showstopper	1	**Low / Worst**

It was found that an option which scored highly against all vital and important criteria was a solar photovoltaic system at a central location, coupled with a backup generator. A solar-diesel solution could provide a potential solution both day and night and would ensure power during outages. Outages occur for only 1% of the year on average, however a fuel storage with sufficient fuel for an extended outage would be required which is designed for peak load and minimum solar radiation.

The solar generation available during daytimes significantly reduces the amount of fuel required during outages.

One of the findings in off-grid solar/diesel hybrid mini-grids is that when operating with diesel and solar generators, there is a need to provide a form of ramping support to the generators for the possible sudden reduction in solar generation. In some locations this is completed by using fly wheel technology and others utilise batteries for this requirement. The recommended solar solution includes a small amount of advanced lead acid battery technology to supply the ramping requirement as well as assist the network in minimising voltage fluctuations in the area.

A biogas digestion system also scored highly against most criteria and could be a second phase of development, relying on the solar-diesel having already proceeded. By using biogas instead of diesel the first project could further improve its environmental footprint, requiring just a conversion of the diesel generator to allow biogas as the fuel source. The solar-diesel business could invest in a conversion of the diesel generator or an additional gas-fired or dual fuel generator. This would enable the solar-diesel business to purchase biogas from the biogas project and use biogas in preference to diesel.

The peak instantaneous demand is at night time. Once the storage tank is full, surplus biogas could be used to generate more renewable electricity or compressed and bottled for sale to the town.

If biogas can be refined and sold as cooking fuel, it could earn a higher value than through conversion to electricity. Sufficient biogas could be produced to meet the entire bottled gas market in Mallacoota and some of the regional market. A biogas-only system was also considered and if the revenue from sale as heating/cooking gas is confirmed, a biogas system with a large generator for the town could be a viable alternative option.

Public funding could be sought for the biogas project based on to the waste-management benefits of a digester. Benefits include reducing the sewage volume at source. Other benefits include reducing greenhouse emissions from methane gas generated from the kitchen compost project already planned at the sewage treatment plant site.

The site which was found to be most suitable for both developments is the sewage treatment plant. This site offers low impact on amenity, a large area of cleared flat land and a continuous supply of digestible wastes.

Financial viability

A series of the more viable options were compared to assess their financial viability:

Business scenario	Items included in scenario
1	1.6MW peak diesel genset and 15,000L diesel tank, 4.5MW solar PV array, 500kW/100kWh advanced lead acid battery, controller, grid upgrades, 4 transformers, circuit breakers and protection systems
2	Biogas digester, refinery equipment, storage tank, dewatering equipment, pipework
3	1.6MW peak diesel genset and 15,000L diesel tank, dual fuel conversion, Biogas digester, refinery equipment, storage tank, gas compression equipment for bottling, dewatering equipment, pipework, grid upgrades, circuit breakers and protection system

A summary of financial indicators is shown below:

Comparison of Economic Indicators for 3 scenarios

		Business 1	Business 2	Business 3
Total Capital Cost		$12.78M	$2.14M	$5.08
Grant % and grant total		50%, $6.39M	50%, $1.07M	50%, $2.54M
Annual costs, 1st year of operation	Annual operational costs, Year 1	$123,000	$160,000	$154,000
	Annual diesel fuel costs	$32,000	n/a (covered by business 1)	$13,000
	Total annual costs	$155,000	$160,000	$172,000
Annual Income, 1st year of operation	Minimum power purchase price required, rising annually with CPI	7c/kWh	17.9c/kWh	4.5c/kWh (but still works at 0c/kWh)
	Power purchase volume required	8 GWh/yr	1.3 GWh/yr	n/a
	Annual income, sale of electricity	$560,000	$237,000	$3,400
	Annual Large Generation Certificate income	$272,000	$45,000	$2,000
	Biogas purchase price required	n/a	$33/MMBtu	$43.03/MMBtu
	Income from sale of biogas	n/a	$12,000	$523,357
	Income from sale of fertiliser	n/a/	$7,000	$7,000
	Network support payment / year	$125,000	$125,000	$125,000
	Total annual income	$997,000	$301,000	$661,000
Simple payback, after grant		7 years	7 years	5 years
Net present value, over 10 years, 6.5% discount rate		$337,000	$90,000	$1,261,000

Minigrid, islanding and networks Review of the ability to operate both in grid connected mode and in island mode is an interesting feature of this project. Mini-grids like this are not common in the Australian National Electricity Grid context. In some cases they have been developed as part of district heating and cooling systems however they have not in the past been developed for a situation like Mallacoota.

The benefits of being able to island a Mallacoota mini-grid from the SP AusNet network are significant in times when long outages are experienced in the Mallacoota area. This includes:

- Greater reliability of supply, particularly during peak demand periods,
- Provide islanding capability in the event of line outages,
- Improved power quality, and
- Allow the community to actively participate in the energy market.

Although not common on the national grid, mini-grids are however quite common in areas outside the main Australian grids, in outback and mining locations. These are generally operated using diesel or gas generation with an increased penetration of hybrid systems using solar PV, solar thermal and wind technologies alongside these fossil fuel generators.

One key aspect of the integration of mini-grids is the need for it to be able to safely operate the protection systems of the network whilst in islanded mode. To facilitate this, the presence of some form of rotating generating devices needs to be included in the solution. This was provided for this project with the inclusion of a diesel generation set.

A range of network arrangements will need to be in place in order for a new generation project to assure supply to the town during outages. These arrangements include such items as:

- Automatic Circuit reclosers
- Upgraded power lines to the site
- Transformers
- Control and Communication systems

These arrangements are expected to be technically feasible, and will rely on a detailed design and analysis process to ensure that they comply with the requirements of Victorian Electricity Law and the National Electricity Rules (NER).

The process for connection of any generation in Victoria needs to be completed in accordance with the Essential Services Commission (ESC) Guideline 15 and the NER. The technical performance of the installation will also need to comply with Section 7 of the Distribution Code, and as such the Service and Installation Rules. This will need to be further analysed in conjunction with SP AusNet and worked through the process outlined in the NER.

The other requirement from a network perspective is the need for the generator to register in both the National and Victorian jurisdictions to export energy to the National Electricity Market.

Funding Sources

The project is expected to require grant funding and specific Federal and State grant funding opportunities were identified during the course of this feasibility project. Public funding generally requires matched funding from private sources. The private investors in turn require a suitable return on investment hence the financial viability analysis presented above aimed to identify a means of obtaining a suitably short payback period (5-7 years).

Some level of network support payments could also be factored in, in relation to the value of avoided outages. Network support payments would be contingent on the system being able to safely operate in islanding mode i.e. supply power to the town and while meeting appropriate safety standards. Currently, 'guaranteed service level' payments are made to the residents as a statutory response to the duration and frequency of outages. The recent and historic level of these payments can be a consideration regarding the economic value of a backup generation solution if implemented at Mallacoota.

Business Models

The recommended business model for the development is a commercial model with a suitable degree of community representation. During operation the business should be financially sustainable without further grants, although may require capital grants for initial establishment.

A range of responsibilities must be fulfilled for the project to success, an overview of roles and responsibilities is shown below:

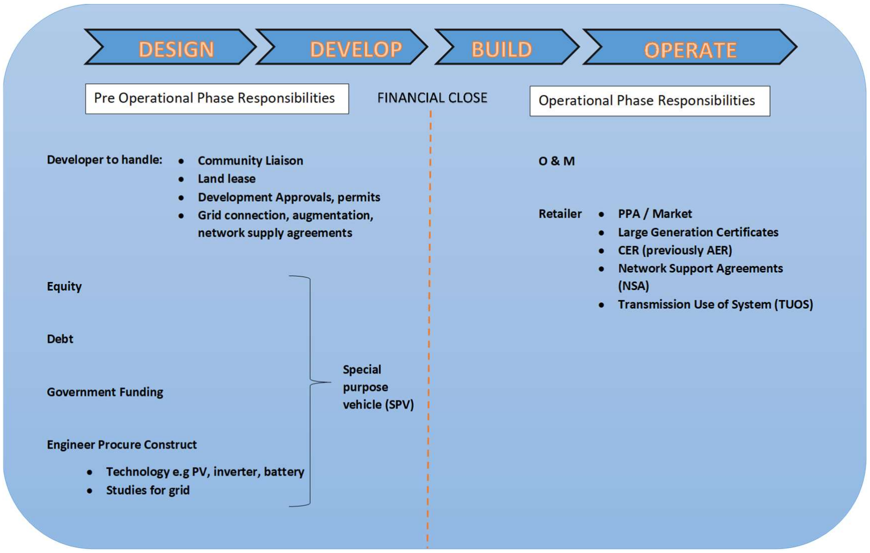


Figure: Business model responsibilities for a centralised generating plant

Applicability to other Communities

This report provides a model for assessing the possibilities for other communities in East Gippsland Shire. It is of particular relevance to other communities at the fringe of the electricity distribution grid where the nature of the environment may cause a similar frequency of outages.

This project provides a model for the things that need to be ascertained (Chapters 1 to 5) in specific communities. Chapter 6 and 7 identify a shorter list of generation and storage technologies currently likely to be feasible, and the rest of the chapters provide the process for testing feasibility and gaining funding.

This project may be applicable in other areas without piped natural gas. Opportunities to substitute bottled LPG with renewable biogas may exist more widely in the region.

Action Plan and Next Steps

This report has been prepared as part of the feasibility phase. To progress the project further, a number of steps would be important, including:

- Identifying experienced project developers with strong track records in implementing energy projects of the scale and type short-listed by this study. This may include a lead development partner with associated equity partner(s) and an energy retailer.
- Build links between any relevant private and public organisations who will be involved including memorandums of understanding between the parties.
- Maintain community consultation throughout the process and ensure community representation.

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Glossary of Abbreviations used in this report

Abbreviation	Definition
ACR	Automatic Circuit Recloser
ARENA	Australian Renewable Energy Agency
CPI	Consumer Price Index
EGSC	East Gippsland Shire Council
EGW	East Gippsland Water
IRAR	Industrial and Remote Australian Renewables, an ARENA program
IRG	Integrating Renewables into the grid, an ARENA program
kW	Kilo Watt, a unit of power equal to one thousand Watts
LGC	Large Generation Certificate, a credit for renewable energy
LCOE	Levelised Cost of Energy
LPG	Liquefied Petroleum Gas
MMBtu	Million Metric British Thermal Units, a unit of energy contained in
MW	Mega Watt, a unit of power equal to one million Watts
PPA	Power Purchase Agreement
PV	Photovoltaic

1 Introduction

1.1 Geography

The Mallacoota township has approximately 1,000 permanent residents. The town is in a remote location, in the far eastern corner of Victoria:

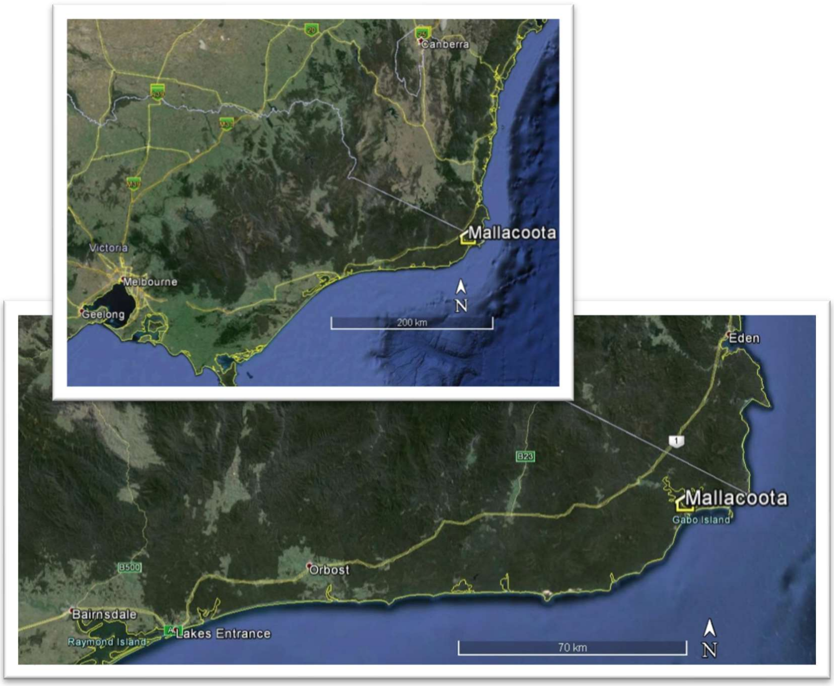

Figure 1-1: Mallacoota regional location

The town is 350kms from Canberra, 523kms from Melbourne and 526kms from Sydney. Travel distances and times are significant:

- 2 hours from the nearest Victorian town over 350 people
- 22kms (25 minutes drive) from the Princes Highway at the end of a narrow, winding road
- 83kms/60 minutes from the nearest town (Eden, NSW with a population of 3006)

The town is well loved as a holiday destination with many facilities available for tourism:

Figure 1-2: Mallacoota town map [source: http://www.visitmallacoota.com.au]

Mallacoota is bounded on land by the 87,500 hectare Croajingolong National Park (a Biosphere Reserve recognised by UNESCO) that extends for over 100km along Australia's Wilderness Coast (one of the Tourism Australia's 16 National Landscapes Programs).

Mallacoota is also bounded by the waters of Mallacoota Inlet and Bass Strait at the confluence of the Genoa and Wallagaraugh Rivers.

1.2 Current Electricity Supply

Due to its remote location the power supply to Mallacoota is exposed to natural events that adversely affect energy supply reliability and are costly to the community.

Mallacoota has a substantial up take of clean energy solutions with nearly 20% of households having purchased Solar PV installations feeding back to the grid however virtually all the grid connected solar PV systems are not functional during power outages, with the exception of a very small number of residences using on-grid battery storage. Many homes and businesses also have back-up generators that operate when the grid fails.

Mallacoota's electricity supply is fed by a radial network (66KV and 22KV lines) from Bairnsdale to Cann River via Newmeralla, a distance of approximately 165km. Then from Cann River to Mallacoota, a distance of approximately70km on a single 22KV line. This totals a distance of some 200 kilometres through the Australian countryside that is mostly forested.

In relatively stable weather and bushfire conditions, the community is well served by the existing grid power supply. However flooding and bushfire events between Bairnsdale and Mallacoota over the last few years have caused longer duration (3 to 4 day) outages of the supply causing significant disruption in the community.

This extreme weather exposure leaves few alternatives in Mallacoota other than small privately owned diesel generators or larger temporary generators being deployed by SP AusNet. These containerised generators need to be transported to Mallacoota from locations at least three hours away. These generators can only reach the site if the single access road is open during any service interruption. During imminent bushfire threats this road is closed to all but emergency services.

Examples of recent longer duration interruptions due to weather events have been:

• The June 2012 flooding event caused loss of supply and closed the Princes Highway between Genoa and Bairnsdale hampering restoration work for several days. The town was without power for over two days.

• In February 2011 the Tostaree bushfire caused a 25 hour loss of supply and the use of temporary diesel generation by SP AusNet.

In recent years there have also been a number of short-term interruptions to supply due to bark across the line, animals and other incidents along the considerable length of the power line.

1.3 About this study

Through a competitive tendering process, Enhar was selected by the Sustainable Energy for Mallacoota Working Group (SEMWG) to provide a Feasibility Study for Sustainable Energy for Mallacoota.

The project brief stated:

"The Mallacoota Sustainable Energy Group (MSEG), East Gippsland Shire Council (EGSC) and SP AusNet, forming the Sustainable Energy for Mallacoota Working Group…. is seeking proposals from suitably qualified organisations or individuals for the expert and innovative conduct of a Feasibility Study, to identify all relevant issues, and propose solutions to establish a community based sustainable energy facility for Mallacoota and District."

The objective of the Sustainable Energy for Mallacoota – Feasibility Study is to investigate and articulate the current context and feasible future options for low carbon dioxide and improved energy security and supply to Mallacoota.

A project as wide-ranging as this one required a multi-disciplinary team with a track record spanning renewable generation studies, community engagement projects, weak grid with energy storage technology and commercial structures for energy projects.

Due to the current electricity supply concerns this project has the capacity to not only directly affect the town's residents but also to influence the many thousands of visitors who holiday in Mallacoota each year. There is the potential for the town to become a model of sustainability and to showcase the positive impacts from this project in the broader community of East Gippsland and within Australia.

This skill set required for the project is extensive; therefore we selected leading firms from around the industry to form a strong consortium:

Enhar

Enhar Pty Ltd is a renewable energy consulting company with a track record in community-scale wind, solar and marine energy projects in the region. Enhar led the consortium. The Enhar team included an engineer from Mallacoota. See www.enhar.com.au for more information about Enhar.

AECOM

The network connections team within the global consulting firm AECOM provided the grid connection and network stability expertise required for this project.

The Regional Development Company

The Regional Development Company provides expertise in community engagement in Regional Australia. Their presence on the team ensures that community participation and acceptance of feasible options is strong.

Diamond Energy

Using their industry know-how of energy markets, Diamond Energy provided some unpaid peer review comments on the business models and financial viability components of the study.

2 Existing Baseline Assessment

This section considers the existing energy supply situation in Mallacoota, in order to gain a strong understanding before recommending changes or solutions.

2.1 Existing Energy Demand

2.1.1 Methodology

To fully understand the future requirements of the Mallacoota community, a comprehensive assessment of the current situation was required. There were a number of steps in establishing the current baseline.

- **Understand Demand Requirements** –
  Through consultation with SP AusNet and MSEG, a detailed understanding of the electrical demand requirements of the project and projected future demands was developed. We utilised half hourly interval data, over the last four years, as supplied by measurement devices located in the SP AusNet network to derive daily and seasonal consumption profiles for the region.

- **Review Supply versus Demand**
  The next step for understanding the energy baseline was a review of the supply and demand balance. This involved lining up the requirements of the demand from the local community with the current method of supply. This ensured that we fully understood where the options for local generation could meet the requirements of the demand as we moved through the study.

- **Network Data Review**
  SP AusNet provided information on the current state of the network for the Mallacoota area. This review involved looking at the types and frequency of network outages and the existing benchmark supply data. We also reviewed any changes that have occurred on the network to improve the benchmark data over the past three years.

2.1.2 Existing Demand Profile

This section includes developing an understanding of the

- Load characteristics
- Maximum Demand
- Existing and projected load profiles

2.1.2.1 Data Utilised

Data supplied by SP AusNet for the years 2009 to 2012 was utilised in the analysis, as these were the complete years in the data set. High level data cleaning/filtering was undertaken prior to the analysis to remove obvious data inconsistencies and blank entries. The graphs shown in the following sections are all developed after this data cleaning/filtering. The loading data utilised was recorded in 30 minute intervals and represents the highest instantaneous energy demand in that period.

2.1.2.2 Daily Profile Analysis

The first review completed was to analyse the daily energy usage profile for Mallacoota. Figure 2-1 below shows the average daily demand in conjunction with the maximum and minimum days within the data set and the overall maximum half hour demands for the years 2009 to 2012.

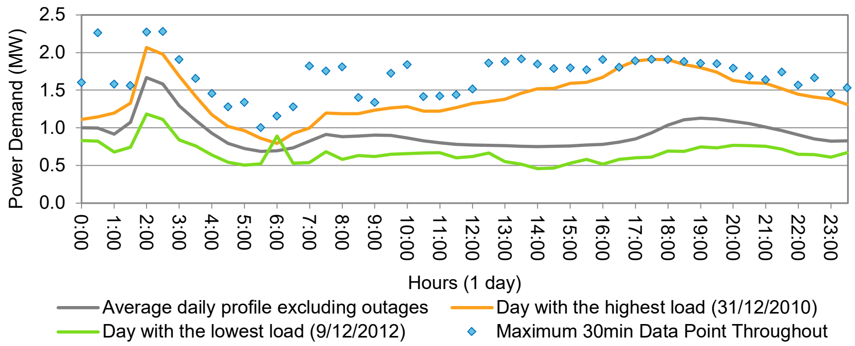

Figure 2-1: Maximum, Average and Minimum Daily Energy Profiles

From this graph the following key observations can be made:

- The average daily energy demand profile has a substantial peak between 2am and 3am (approximately 1.7 MW), which is most likely attributed to residential off-peak electric hot water systems. There are smaller daily peaks seen in the morning between 7am and 9am (0.9 MW on average) and in the evening between 6pm and 9pm (1.1 MW on average). These peak events are typical of areas with mainly residential energy usage and limited industrial loads.
- The day with the lowest recorded energy demand was 9 December 2012, which contained a daily profile similar to the average profile, with a 2am peak of approximately 1.2 MW.
- The day with the highest recorded energy demand was 31 December 2010, which contained an increased energy usage in the afternoon and evening. This increase is most likely attributed to seasonal tourism.
- The highest 30 minute energy demand throughout the dataset was at 2:30am on 10 June 2010 – reaching approximately 2.3 MW. It was not uncommon for the daily maximum demand to exceed 2 MW during 2009 to 2011. As noted below the excursions above 1.8 MW have reduced significantly over the analysis period.

Figure 2-2: below looks at the average daily demand curve for each month of the year.

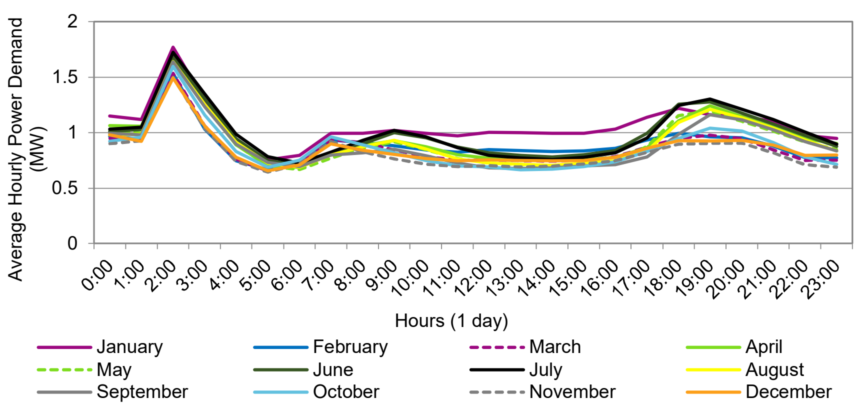

Figure 2-2: Daily Energy Profiles, Averaged Monthly Demand (2009-2012)

From this graph the following key observations can be made:

- The average daily energy profile is similar throughout the year.
- January has the highest average daily energy profile – particularly during the day (between 9am and 6pm), which is most likely attributed to seasonal tourism.
- November and December have the lowest average daily energy profile. This may show a limited air conditioning load in the area and a reduction in energy use for heating.
- The morning peak (between 7am and 9am) and the evening peak (between 6pm and 9pm) are highest between April and August. This usage pattern could be attributed to electric residential heating units.

Figure 2-3 below shows the average daily demand profile for the years of the analysis.

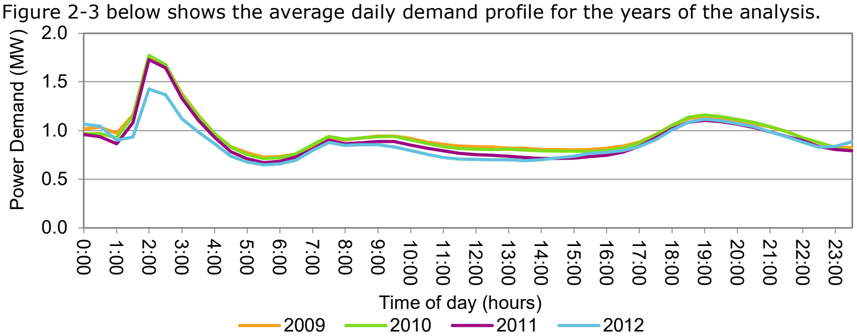

Figure 2-3: Daily Energy Profile, Yearly Average Demand (2009-2012)

From this graph the following key observations can be made:

- The average daily energy demand profile has not varied significantly between 2009 and 2012.
- The average daily energy demand peak (between 2am and 3am) has fallen in 2012, which is most likely attributed to the increased uptake of solar hot water systems and timing adjustments of existing off-peak hot water systems.
- In the near future, growth in the Mallacoota region is primarily expected in the domestic sector. The daily energy demand profile in the coming years is expected to be aligned with that of 2012 as the small increase in domestic usage is expected to be offset by increased uptake of solar PV and solar hot water systems. It is possible that a reduction in peak demand may be seen as the uptake of solar hot water increases, however this is likely to be offset by increases in afternoon demand as shown and further discussed with Figure 2-10.

Although an understanding of average demand profiles is very important for the development of this project, one key aspect of any generation system design is to understand the number of hours where a peak is seen in the demand profile. Table 2-1 below shows the yearly number of hours above certain demand steps.

Table 2-1 Number of hours exceeding peak demand levels

	2009	2010	2011	2012
Number of hours above 1.5 MW demand	363	351	375	81
Number of hours above 1.6 MW demand	275	285	289	43
Number of hours above 1.7 MW demand	186	196	182	14
Number of hours above 1.8 MW demand	98	90	81	3
Number of hours above 1.9 MW demand	35	27	26	1
Number of hours above 2.0 MW demand	11	7	14	0
Number of hours above 2.1 MW demand	2	2	6	0

	2009	2010	2011	2012
Number of hours above 2.2 MW demand	0	1	1	0

From this table the key observation is that:

- The number of hours where energy demand exceeds 2 MW decreases in 2012. This is in line with the peak reduction seen in Figure 2-3.

To further understand this change in more detail an analysis was conducted of when the hours of peak load occur. The scatter plots included below illustrate the *time of day* and *time of year* of the energy demand data points that exceed a specified peak energy demand. The peak levels analysed are between 1.5 MW and 1.8 MW.

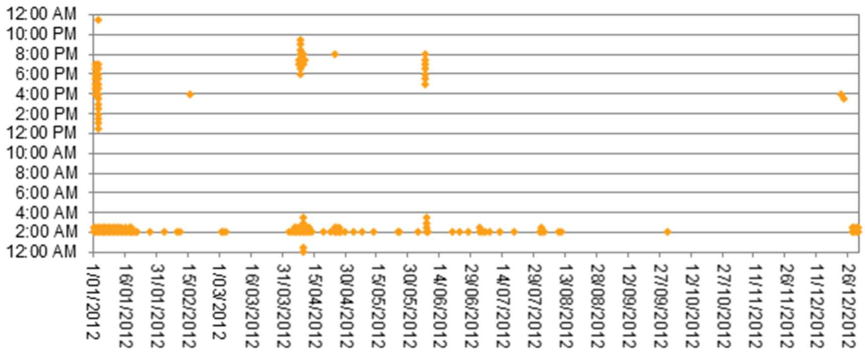

Figure 2-4 Scatter Plot Showing Half Hourly Demand Exceeding 1.5 MW (Time of Day and Time of Year) in 2012

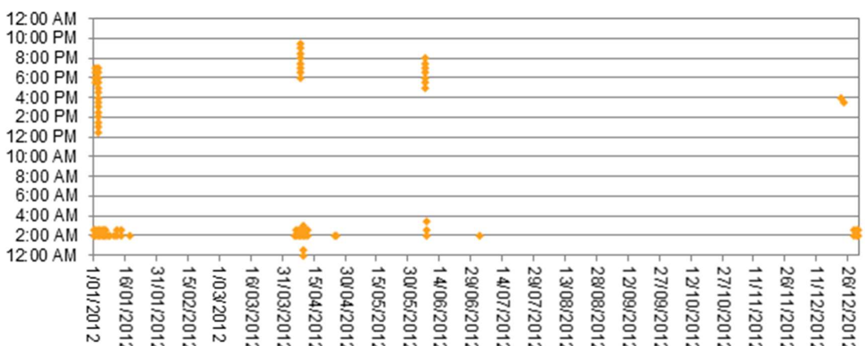

Figure 2-5 Scatter Plot Showing Half Hourly Demand Exceeding 1.6 MW (Time of Day and Time of Year) in 2012

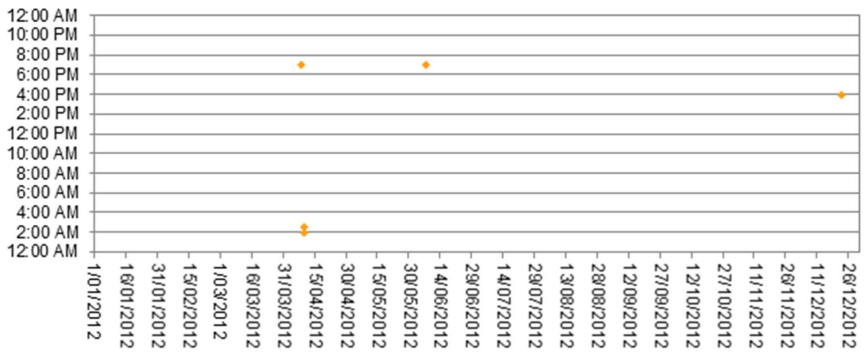

Figure 2-6 Scatter Plot Showing Half Hourly Demand Exceeding 1.8 MW (Time of Day and Time of Year) in 2012

From these plots the following key observations can be seen:

- The excursions are predominantly within the peak times of the hot water peak overnight and in the afternoon peak. This is consistent with the predominantly residential loading in the area.
- The January excursions are more spread out. This is anticipated to be due to the large numbers of tourists in the Mallacoota area at this time. A large number of these tourists will be camping or caravanning.
- The number of occurrences of demand excursions above 1.8 MW is limited.
- The maximum demand is now indicated at both the overnight and afternoon peak periods.

To show the overall spread of demand across the year a load duration curve for the 2012 data is presented in Figure 2-7 below.

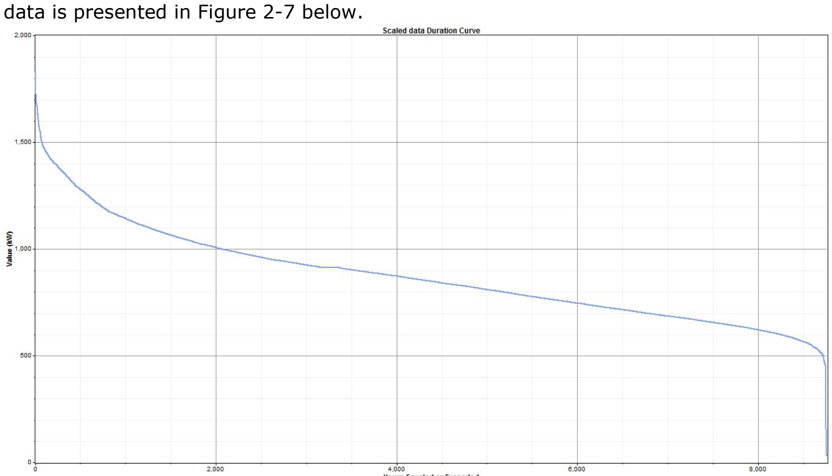

Figure 2-7: Duration Curve of Mallacoota Electricity demand, 2012

2.1.2.3 Monthly Profile Analysis

The next step in the analysis process was to review the differences in network demand between the different months of the year. This shows any possible seasonal and monthly difference in the demand pattern

Figure 2-8 below shows the average monthly energy usage profile for each month of the year, averaged over the four years discussed earlier.

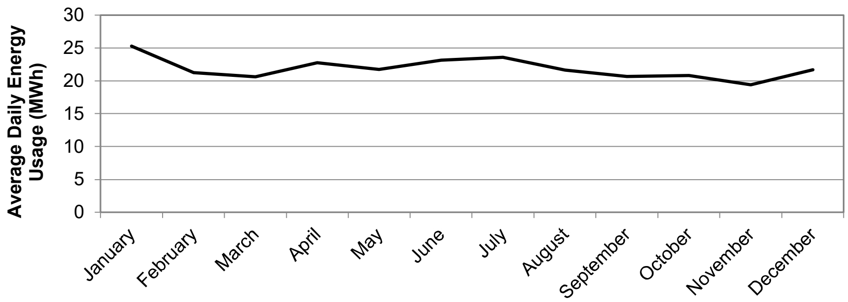

Figure 2-8 Average Monthly Energy Profile (2009-2012)

From this figure the following key observations can be made:

- The average daily usage per month (between 2009 and 2012) is fairly consistent. There is no significant seasonal trend observed.
- The highest average daily energy usage is seen in January, which is most likely due to seasonal tourism. Usage is also high in June and July, which could be attributed to electric residential heating units.

The next step was to review the different monthly demand patterns on a yearly basis and compare the monthly usage between different years. This is shown in Figure 2-9 below.

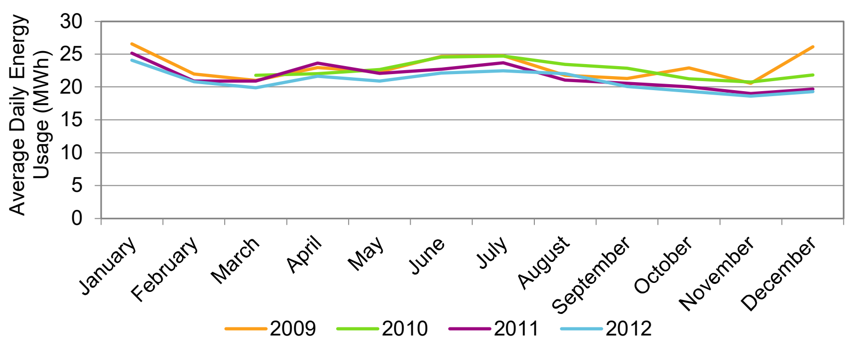

Figure 2-9: Monthly Energy Load Profile (2009-2012) *excluding outages and discrepancies

From this figure the following key observations can be seen:

- The average monthly energy usage profile does not vary considerably between years analysed.
- The average daily energy usage in January has decreased slightly between 2009 and 2012. This may be due to tourism decreasing over recent years or an increase in solar yield during peak sunshine periods as solar capacities increase.

2.1.2.4 Yearly Profile Analysis

The final level of demand analysis was completed on the yearly energy usage profiles. This is shown in Figure 2-10 below.

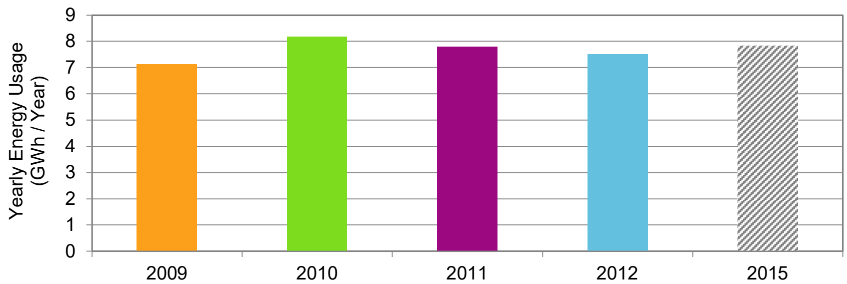

Figure 2-10 Yearly Energy Usage (2009-2012, including forecasted trend 2015)

From this figure the following key observations can be made:

- The yearly energy usage has been fairly consistent between 2010 and 2012. The slight reduction of overall energy usage in 2011 could be due to the high number of outages in this year.
- The forecasted yearly energy usage in Mallacoota is expected to remain stable in the near future. Any increased demand arising from any increases in the number of residences will likely be offset by increased uptake of solar PV, solar hot water systems and gradual improvement of efficiency of new appliances.

2.2 Sector-wise Electricity Consumption

Energy bill data was obtained from a number of consumers in Mallacoota. Based on samples of monthly bills from 2013, some annual and daily figures have been estimated and are shown below:

Electricity Consumer sample, 2013	kWh/year	kWh/month	kWh/day
Residence with electric hot water	6,731	561	18
Residence with solar hot water	2,604	217	7
Butcher Shop	24,812	2,067	67
Pharmacy	13,057	1,088	35
Abalone Co-Op	271,094	22,591	743
East Gippsland Water: water treatment plant at Mallacoota	189,378	15,782	509
East Gippsland Water: sewer pump stations	27,960	2,330	75
Street Lighting	46,274	3,856	127
Whole town, 2012 data	8,000,000	666,667	21,918

Street Lighting data for the whole Shire was provided by East Gippsland Shire Council, from information prepared to support recent grant applications. Enhar estimated the existing Mallacoota street lighting usage based on the number of street lights in Mallacoota (109) and total existing street lighting usage from the EGSC data.

SP Ausnet provided Enhar with some aggregated billing statistic graphs for January 2013 Mallacoota to Enhar. This graph shows 'CNR2' Feeder Demand (total billed amounts for the town), 'Commercial and Industrial', (C&I) demand and 'Residential' Demand. C&I data includes any interval meter installed at sites above 120 Amps. This includes the largest users in the town, however is not expected to include small shops.

The SP Ausnet data for January 2013 indicated that on that day in January 2013, around 10% of the town's load was Commercial and Industrial (excluding small shops) and 90% residential (including small shops).

January is peak holiday season and it is therefore expected that the annual average proportion of residential demand is lower than in January. Nonetheless the ongoing proportion of residential usage is likely to be higher than the national average statistics indicate, due to the relatively low amount of industry at Mallacoota.

On balance, it is estimated that around 85% of Mallacoota's electricity demand is residential, and the remaining demand is from shops, industry and public services.

The estimated contribution of each sector to annual energy consumption in Mallacoota is shown below:

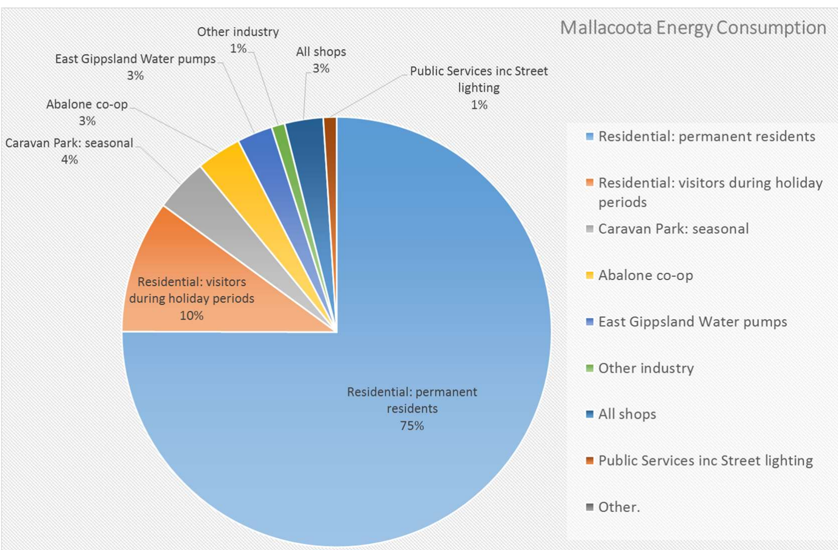

Figure 2-11: Estimated energy consumption in Mallacoota by sector

This estimated division is intended to be illustrative only and we advise readers that comprehensive monitored data was not available for all sectors therefore there is limited accuracy in the estimate above.

Australian electricity consumption data by sector are published in 'Australian Sustainable Energy – *by the numbers*'[1] . The Table below presents some data and analysis:

Table 2-2 Estimated sector wise energy consumption in Mallacoota

Sector	% of Australia-wide consumption, 2006-2007 [1]	Estimated kWh/year consumed in Mallacoota in 2012	Estimated % of Mallacoota consumption if at Australian average
Residential	27.8%	3,693,429	46.2%
Commercial	22.4%	2,976,000	37.2%
Metals	18.1%	None	
Aluminium smelting	11.6%	None	
Manufacturing	9.2%	1,222,286	15.3%
Mining	9.1%	None	
Transport and storage	1.0%	none	
Agriculture	0.8%	106,286	1.3%
Total	100%	7,998,000	100%

It can be seen from the above analysis that the proportion of residential demand in Mallacoota is significantly higher than the national average, and the commercial/industrial energy demand is lower than the national average.

2.3 Emergency Power Procedures

As noted in the earlier study [1], in the event of longer outages, and when access permits, SP AusNet has deployed temporary generation in Mallacoota to supply the community. This is in the form of containerised diesel reciprocating engines of an appropriate size connected to the local electricity network at a safe and accessible location. Generators deployed have included a 1.2 MVA diesel generator.

After the Tostaree fire on 1st February 2011, a 1.2MW Cummins Diesel generator was used, this was de-rated to 900kW. It ran the town for one and a half days, and was sited at the Caravan Park. It was connected directly at 415V. During this event, parts of the town were not connected, i.e. the generator did not supply the whole town load, therefore this is not a guide to suitable total generating capacity required for the whole town in peak load.

A permanent hardstand has been installed by SP AusNet at the Golf Course for temporary diesel generators to be operated. This has a 3 phase 22kV connection point for connection of generators:

Figure 2-12: Hardstand adjacent to Mallacoota Golf Course for Temporary Diesel generator [photo: Enhar]

SP AusNet has more recently purchased a number of diesel generators which are prepared for deployment in emergencies, however SP AusNet do not store a diesel generator at Mallacoota.

2.4 Existing small generators

As noted in the earlier discussion paper [1], local residents and small businesses have taken their own measures, with standby generators of various sizes, to keep power on to their property during outages. For longer duration outages this can become a problem because of limited local fuel supplies. The local generators range from 1kVa portable camping petrol units to more permanent 40kVa diesel units at the rear of a business. The water supply station has a 110kVA generator in place and East Gippsland Water have in total nearly 400KW of backup diesel generators around the Mallacoota area.

During outages, the standby generators are run in islanded mode (property is isolated from the network) and are switched off before the main supply is reconnected. The existing generators are a potential source of local standby power through demand management processes.

The larger local diesel generators could enable those operators to manage their grid demand by switching generators on during outages, reducing the remaining grid demand and thereby reducing the generation requirement for the town.

2.5 Gas Supply in Mallacoota

Mallacoota does not have a mains gas supply and gas is transported a considerable distance to the town by road. Gas is commonly purchased in Mallacoota in 45kg bottles for cooking purposes, this is true for both residential and commercial cooking. The relatively high cost of bottled gas means that space heating is mostly electrically based and some cooking is on electric cookers. A number of householders in Mallacoota were queried and he majority use bottled gas for cooking.

The price of bottled gas in Mallacoota in late 2013 is approximately $140 per 45kg bottle including GST, according to recent receipts sighted by Enhar during the preparation of this study.

The relevance of gas is that some renewable energy options, such as anaerobic digestion, produce biogas which can be refined to a similar methane content to natural gas.

Figure 2-13 Bottled gas at typical residence in Mallacoota, used for cooking

2.6 System Sizing Design: Current Profile

The forecasted yearly energy usage in Mallacoota is expected to remain stable in the near and medium term. To size an energy system to meet the energy needs of Mallacoota, it is recommended that an average daily energy profile in-line with the average profile seen in January 2012 be used. Utilising January is considered conservative, as January represents the month with the highest yearly energy demand. This profile is shown in Figure 2-14.

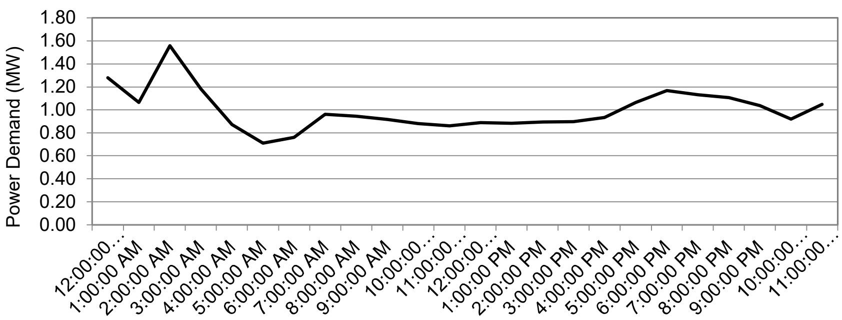

Figure 2-14 Daily energy profile from January 2012, recommendation for future system sizing

Although this shows an expected average demand profile a system capable of handling the peak requirements of the town is needed. If the profile were to remain the same as 2012, unchanged, then a maximum demand of 1.8 to 1.9 MW would be required for approximately five times per year as shown in Figure 2-6.

This however assumes that the existing demand is not altered as part of the project implementation. There are in fact several ways in which the demand profile could be improved and demand could be managed. This would lead to a cheaper and easier system solution, and these are discussed in Section 3 below.

2.6.1 2013 peak loading

It has been observed that the peak loading to date in 2013 occurred in January on the 4th day of the month between the hours of 4pm and 8pm. This is an anomaly to the analysis completed for 2009 to 2012, especially given the 2012 peak demand drop, and as such is further discussed here.

As discussed previously, January is historically a high demand month for the Mallacoota area. This is driven by the increased population during the peak tourist season in the area. During this time the demand rose to between 1.9 MW and 2.1 MW during the afternoon peak time.

The question is, how will this impact on the system design since the system is being designed to an average night time peak of 1.6 MW? To answer the question an analysis of the proposed solution as developed in Section **Error! Reference source not found.** was modelled to see if this situation created a new peak for the design. The first consideration was the amount of solar generation that would be available at this time to offset this demand with the second being what level of demand management would also be available.

With the inclusion of the solar generation, the peak was reduced to between 1.75 and 1.8 MW for the duration of this peak event, bringing this back in line with the analysis completed on 2012 maximum demand. If we then take into account the 200 kW of demand management anticipated for this project the maximum demand is between 1.55 and 1.6 MW which is comparable to the design maximum demand of 1.6 MW.

Given this analysis this peak event in 2013 is not considered to be significantly different to the analysis completed for 2009 to 2012.

In relation to night time peaks, a discussion of how smart meter and solar hot water systems may assist to reduce these peaks is given in Section 3.2 below.

2.7 References for Section 2

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[1] Australian Sustainable Energy *by the numbers* by Peter Seligman, published the Melbourne Energy Institute, 2010

3 Required System Sizing

3.1 Scenario development

It was requested to include Scenario development over 5, 10 and 20 year periods including the following data: population growth, energy use trends, climatic conditions, scalability, adaptability, distribution/integration of multiple technologies, low power warning systems, cost comparisons and emerging/future technologies.

The information presented in the SP AusNet Distribution System Planning report indicates that minimal growth is anticipated on the Cann River system over the next 5 years. The report indicates the system is likely to grow by 0.1 MW or less than 5% in maximum demand. It also notes that this is down on historical values of demand in the area, as noted in the analysis of demand for the Mallacoota area.

Population numbers provided by East Gippsland Shire Council show that the growth in population over the coming 20 years is limited to less than 8%. This is a likely increase of 73 people over the 20 year period.

In recent media reports, both the Australian Energy Market Operator and the Australian Bureau of Statistics indicated that demand at both household level and at a market level has decreased. This is being driven by the activities we are also seeing at Mallacoota namely increased solar hot water installations, increased numbers of solar PV systems and general demand management being undertaken at the household level.

Given this general downward trend in energy usage, with the low level of population growth, no growth in energy demand is anticipated in either the short or long term. It is more likely that an energy reduction is possible however this is difficult to estimate given that it is driven in the Mallacoota area by personal choice and the rapid change in technology in this area.

3.2 Demand Profile Improvements

As outlined in the Existing Baseline Assessment there is a significant daily energy peak between 2am and 3am attributed to electric hot water units making use of the off-peak tariff rates.

Given the town does not have reticulated gas, resistive electric hot water systems contribute to a significant proportion of energy use.

This is likely to be exacerbated over summer when large tourism numbers are in the town. In addition to the hot water peak it is observed that an evening peak occurs mainly in winter. This is attributed to inefficient electric panel heaters. In recent years increasing peak events are occurring in the evening during summer which can be attributed to air-conditioning use. There are some possible measures that could be considered for addressing these peak events and reducing overall supply requirements.

Commented [TH1]: Another paragraph in this section could include the savings from changing only our old style mercury vapour street lights to T5s. At minimum the savings of shifting to T5s) will be approx 25,000kwh per year. And, this is all in nighttime hours which is when we have our peak use so this will act to reduce our peak requirements. See also 2.2.

3.2.1 Smoothing of night time peak loading

Around 300 hot water units have already been reprogrammed in Mallacoota by SP AusNet. This has had the impact of reducing the night time peak loading arising from electric hot water systems. With further spreading of the hot water load, further reduction in night time peak loading could be achieved.

The Australian Standard for hot water AS 3500.4:2010 has been amended to allow for scheduled boosting to kill legionella. By moving to boosting less frequently than daily, this could help to further avoid hot water peaks.

Smart meters are not yet installed in Mallacoota but the State-wide schedule for roll out of Smart meters would imply that smart meters would be installed in 2014.

Smart meters have a 'diversity switch' which would enable timing of hot water loading to be further managed. The pairing of smart meters with In Home Displays and alternative tariff options could give households the necessary information to reduce this peak.

Use of smart-meters to facilitate time-of-day tariff incentives could allow domestic and business loads to be further controlled in the region.

3.2.2 More efficient hot water systems

Figure 3-1 below shows a photo of an electric hot water system taken by Enhar at Zachary Drive, Mallacoota in November 2013.

Electric hot water systems throughout the town could be replaced with solar hot water or air source heat pump systems, both of which would remove the night time hot water peak loading in the town.

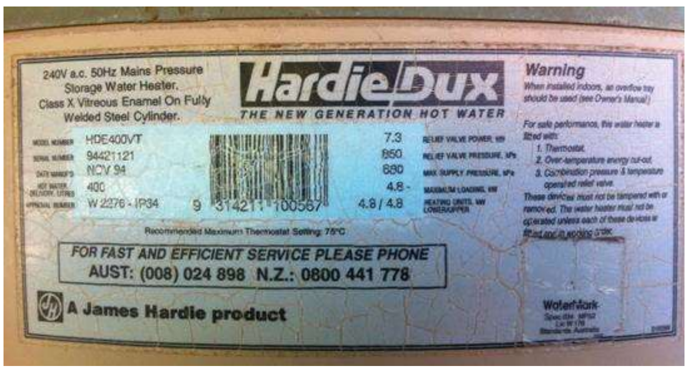


Figure 3-1: Electric hot water system typically used in Mallacoota

Electric resistive storage hot water systems are highly inefficient with large heating elements. Their peak electricity use is in the order of 2 – 3 kW per house. A scheme could be introduced to subsidise household uptake of standard solar hot water systems and heat pump hot water systems.

A heat pump hot water system uses a refrigerant which undergoes a phase change to absorb outside ambient heat energy to heat water. The input electrical energy to drive the process is usually only 0.5kW so the maximum peak of households using heat pump system is 80% lower than traditional systems.

Currently the unsubsidised cost of heat pump hot water systems is around $3,500 per household. This compares with around $2,000 for a gas or electric storage system. The additional costs would pay for themselves via savings on the electricity bill. A bulk purchase could reduce the initial costs if a large number of residents purchased new water heating systems simultaneously.

3.2.3 Direct Load Control

It is possible to install simple devices to allow the network operator to directly control the loads on an appliance. In this situation an electricity supplier might turn off, cycle, or adjust the electricity draw on an appliance. This could be introduced through an opt-in scenario and would not require many households and businesses to sign up in order to impact peak demand. The adoption of direct load control has been successful in Magnetic Island as part of their Solar Cities project, which has installed devices onto electric hot water systems.

In addition the installation of new controllers onto solar hot water systems can better schedule the timing of boosting. Generally hot water systems are configured to supply hot water to 60 degrees, this is a requirement for minimising legionella poisoning, however are then mixed with cold water to 45 degrees supply to basin/showers.

3.2.4 Energy Efficiency

A range of measures to improve energy efficiency could be implemented in respect to space heating, water heating, lighting and cooling.

Encouraging homeowners to fit insulation in rooftops where non-existent, or to increase the level of insulation where some insulation exists, could help to reduce electric heating loads. In a similar way to installing heat pumps for cutting the electric resistive hot water peak, the installation of small and appropriately sized reverse cycle air-conditioners could cut winter electricity peaks. Improvements in air-conditioner technology have seen significant increases in the efficiency of new products especially for the smaller capacity systems.

All of the above measures could be adopted in a 'bulk buy' approach whereby residents and businesses group together to obtain lower prices while still retaining high quality. Funding support may be available from State Government sources, and many of the required products are already subsidised through the Victorian Energy Efficiency Target scheme.

On the commercial and industrial side, the local businesses are responsible for around 15% of total consumption. A range of efficiency improvements are likely to be available to most of these businesses through a range of lighting, cooling and heating improvements.

East Gippsland Water has replaced drives at Mallacoota with variable speed drives, (VSDs) as part of renewals and made a few other efficiency savings over the past few years. Mallacoota is not on the top 10 electricity consumption sites for the organisation so hasn't been prioritised for efficiency improvements. There are therefore potential further efficiency improvements available.

3.2.5 Street Lighting

As noted above, street Lighting information was provided by East Gippsland Shire Council, from information prepared to support recent grant applications.

Enhar estimated the existing Mallacoota street lighting usage based on the number of street lights in Mallacoota (109) and total existing street lighting usage from the EGSC data. Based on 12 hours of usage per night, the existing street lights use around 10.6kW overnight.

Savings on the night time demand will be made when the roll out of higher efficiency street lights is completed, scheduled by mid 2016.

One option is for Twin 14 watt T5s to replace the existing 80 watt mercury vapour lamps, these offer a 68% saving over the mercury vapour lamps. This would realise a saving of 7.2kW reducing the street lighting load to 3.3kW.

This saving of 7.2kW might reduce the night time peak by up to 0.5% and therefore does not have a large impact energy system design for the purposes of this report.

3.3 Demand Management

For the design and costing of the system, the total power demand which must be supplied is a key driver of cost.

Demand-management is a cost effective means of reducing the peak generation requirement and we have assessed the quantity of local loads which can be readily scheduled. It is important to provide estimates of the local load quantity in kW which could be controlled as part of demand-management initiatives.

Demand management is an umbrella term for methods to reduce demand during controlled periods of time.

Attributes required for successful demand management include:

- The load owner must have a suitable backup generator in place permanently at the site, or be able to switch off loads for extended periods, up to several days duration.
- Grid outages at Mallacoota can last several days therefore loads which can only be managed for a few hours are less helpful but could still contribute towards reducing the capacity of the required generation/storage system.
- The load must be able to be switched off at very short notice, therefore it is preferable if communications and control systems are either be in place, or can be installed at the load. Manually operated load switching can also be of value however.
- If a control system is not currently installed, the cost of installing any control system, per kW of controllable load must be reasonably low.
- Industrial loads are preferable for the above reasons. They are larger, more likely to have backup on site, and more readily controllable than any other loads.
- Commercial premises may be able to be demand-managed, however these are less likely to have control systems in place as manual intervention on diesel generators is generally used due to the sites being occupied continuously by staff, compared to industrial sites which are generally unmanned at different times during the day.
- Domestic residential loads would only be automatically controllable if suitable electronic systems were installed inside the residence. Residential UPS and battery management systems for private properties are increasingly available off the shelf, however are not generally designed to be controlled remotely. Remote control could be retrofitted if required.
- Behaviour-change type demand management could be considered with a system of text message alerts to residents or LED displays inside residences to prompt residents to avoid switching on larger loads. However, the impact of behaviour change is not readily predictable and the cost and acceptability of such measures is complex to evaluate.

In order to reduce the demand during times of grid line outage, industrial demand management would be the most feasible solution.

3.3.1.1 Demand Management in the Water Supply Infrastructure

The pumping load is mostly during the day as customers use water with demand peaking over the summer.

There are numerous pumps sited around Mallacoota, mostly of small capacity. These include: Betka, bores, backwash (runs infrequently), High level pumps, Main sewer stations.

Table 3-1: Pumping load and generator capacities at East Gippsland Water sites in Mallacoota

Site name	Pumping peak load kW	Annual hours of use	Estimated average load kW	Diesel generator capacity kVA
Water Treatment Plant	33.4	7,560	21.6	110
Sewer Pump stations (8 pumps)	233	120	3.2	268.5
Betka Raw Water station	64			
Karbeethong high level boost pumps	6			
Irrigation site	8			
Total	344.4		24.8	378.5

All of the diesel generators listed above are backup systems located at grid-connected sites.

Although EGW does not consume a significant portion of Mallacoota's energy on an average instantaneous basis, the capacity of the existing diesel backup generators, at close to 400kW is significant in comparison to the average town demand of less than 1MW and peak demand around 1.6MW.

The existing diesel generator backup fleet includes a 110 kVA generator located at the water treatment plant:

Figure 3-2 Diesel Generator at Water Treatment Plant, rated at 110kVA [photo: Enhar]

It is considered feasible that demand management of up to approximately 200kW could be achieved by East Gippsland Water (EGW), utilising diesel generators already set up to respond quickly to outage situations. Communications and islanding ability would need to be installed however this could be cost effective in comparison to sizing a central generator to meet the whole peak demand.

This could enable the renewable energy solution to be down-sized by 100-200kW in a very easy step. This would enable the system size to be reduced and still meet the whole town's demand during periods when the main grid line is unavailable.

Compensation would normally be paid to the operator for the demand being managed, for example EGW would be compensated for reverting to diesel generators (for example, the price of diesel plus a management fee), however the net saving to the town would still be substantial since the capital cost of the energy generation system would be dramatically reduced.

3.3.1.2 Other Demand Management

Other sites which could participate in industrial and commercial load management include:

- Abalone processing industry
- Hotel and Foodworks
    - Commercial refrigeration for example is a local load which could be managed through incentives and rewards at times of peak demand.

3.3.1.3 Total firm available demand-management

For the purposes of this feasibility analysis, a 200kW demand management capacity is assumed to be feasible and therefore included in the system sizing calculations.

3.3.1.4 Impact of Demand management

The impact of demand management is illustrated in regards to a solar PV-only and wind-only scenario, both with storage.

In this scenario, a central solar PV plant with battery storage is required to satisfy all of the town's demand at all times of year.

Table 3-2: Impact of Demand management on central solar PV-battery sizing

Scenario	Solar PV capacity required (MW)	Storage Required (MWh)[1]	Approx saving in capital cost of system
Without Demand Management	9	17	-
200 kW Demand managed	7	13.5	~$6M

In the next scenario, a central wind with battery storage is required to satisfy all of the town's demand at all times of year.

Table 3-3: Impact of Demand management on central wind-storage sizing

Scenario	Wind capacity required (MW)	Storage Required (MWh)	Approx Capital Cost	Approx saving in capital cost of system
No Demand Management	6.1	7.5	~$24M	-
200 kW Demand managed	5.4	7.5	~$22M	~$2M

3.4 System Sizing After Improvements and Demand management

From the sections above it has been noted that there is a likely improvement in the demand in the Mallacoota area during outages if consideration is given to modifying the timing of the hot water heating peak and demand management.

[1] MWh are quoted in usable nominal capacity, not nameplate capacity

To understand the impact of the reprogramming of electric hot water heating we have flattened the demand during this time by using the average demand over the hours of 11 pm and 3 am. To be conservative, the demand during this time over the twelve months of 2012 was utilised. It should be noted that although solar hot water systems may reduce this requirement, it will still be present as hot water boosting still occurs during this time. Once Smart Meters are installed, more detailed analysis can be performed to develop the changeover process.

Demand management can also be applied during outages which leads to the system design to supply power during outages being reduced. From Section 3.3 this reduction has been estimate to be approximately 200kW. This reduces the daily January demand (during outages) from 24MWh/day to 19.2MWh/day.

As noted in Section 2.1.2, the peak demand for 2012 is between 1.8MW and 1.9 MW. With the addition of the reduction in hot water peak and demand management for the afternoon peak this is now reduced to 1.6MW.

If we take these changes into account for the average demand profile graph previously shown in Figure 2-14, the new average demand profile during outages is shown in Figure 3-3 below.

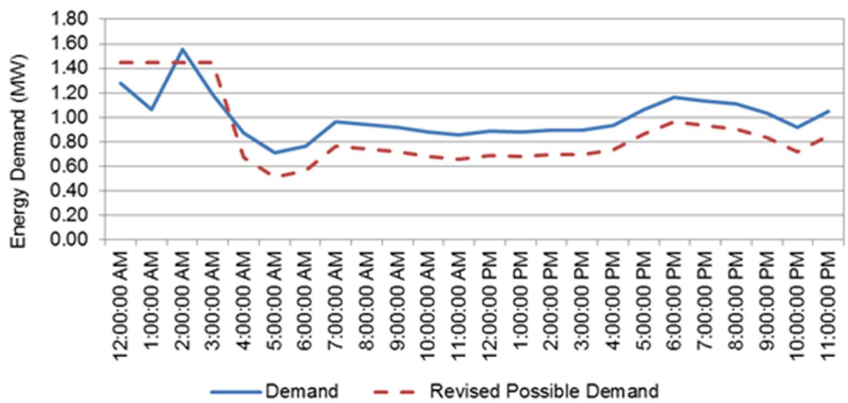


Figure 3-3 Daily energy profile during outages after demand management, recommendation for future system sizing

As can be seen from this graph there is a reduction in both the expected overnight peak demand and the daily demand in any half hour period has been reduced by 200 kW. It is important to note that this is an average demand and peak requirements still need to be included in the design of the system.

3.5 Historical Outages and Minimum Duration of Required Backup Generation

Local records have been kept by the community of outage times and durations.

It is important that the design solution at Mallacoota is able to provide reliable power during the outages which frequently occur at the town. These are both sustained outages and momentary outages.

The sustained outages pose the largest challenge in terms of generation capacity and resource availability.

It is assumed that for the system to offer reliability, it must be capable of producing power through outages of up to at least 3 days sustained duration, possibly up to 5 days. Capital costs are influenced by the duration of outage which must be handled. The longest outage in recent years has been used as a guideline.

3.6 Timing of required island generation due to natural events

The outages recorded in recent years occur at various times of year including notable sustained events in a February 2011 due to bushfire, and a June 2012 due to a storm and flood.

On this basis, there is no specific season when grid outages occur and therefore the system design must be able to increase the reliability of supply in the context of sustained outages at any time of year.

The system must be able to cope with the grid supply cutting off at any time during any season including:

- Summer
- Winter
- Night time
- Day time

If the design solution to resolve intermittent supply issues at Mallacoota is to rely on renewable energy resources which are seasonally fluctuating, it is therefore prudent to design for the worst case scenario when both the demand is highest and the renewable resource is lowest. This approach has been adopted in this study.

4 Community Engagement

4.1 Engagement Project Overview

4.1.1 Background

It is crucial to the success of the project to understand the community to be served by the electricity generating systems considered and prioritised during the feasibility study.

Engaging the community and testing the community's response to options as they develop is therefore an equal consideration with the technical and financial assessment of options.

The project team recognises that a successful solution must be technically feasible, cost-effective, and accepted by the community.

Interviews with EGSC staff and MSEG representatives in mid September 2013 informed the design of the engagement process. As active community participants MSEG members also contributed to the consultation not only with their own opinions but also their understanding of wider community view.

4.1.2 Purpose

Community engagement during the feasibility study sought to:

- understand the values that the community needs protected when considering options, and
- obtain input from the community about ideas, options, and issues which need to be considered.

4.1.3 Engagement Goal

The goal has been to understand community views in order to gauge the acceptability of different options.

4.1.4 Engagement Processes

The Mallacoota community were informed of the feasibility project by:

- five articles published in the 'Mallacoota Mouth' between October 17 and November 21
- five articles posted on the East Gippsland Shire Council website http://www.eastgippsland.vic.gov.au/Plans_and_Projects/Mallacoota_Sustainable_Energy
- five articles posted on the 'Mallacoota Community Directory' between October 17 and November 21 http://mallacootacommunitydirectory.info/

This set of articles informed the Mallacoota community about the project, invited them to attend information sessions in Mallacoota on 12 and 13 November 2013, and provided project updates and links to further information.

Ratepayers from Mallacoota were informed of the project by a letter from East Gippsland Shire Council on October 21. The letter provided background to the project and an invitation to attend the November information sessions.

Posters were distributed in shop windows in the town and an interview with MSEG members was broadcast on 3MGB Community Radio on November 8 inviting attendance at the information sessions. http://home.vicnet.net.au/~cootafm/soundarchive.html

All these communications provided email and phone details to enable contact with the project team at any time.

Three information sessions were conducted by the project team at the Mallacoota Golf Club on the afternoon and evening of November 12 and morning of November 13.

These sessions were designed to provide an opportunity for community members to meet the project team. Ideas and information were welcomed by the team, and there was opportunity to ask questions about different aspects of the project.

More than 60 community members attended the information sessions and an additional three people made written comments to the project team.

An interview of MSEG members and the Enhar project manager was broadcast on the regional television channel, WIN TV, on 14th November.

4.1.5 Engagement Project Stakeholders

Stakeholders are any individuals, group of individuals, organisations, or political entities with an interest or stake in the outcome of a decision. The following identification and analysis of stakeholders, their influence on the project and anticipated expectation was conducted during the inception phase of the project to guide the engagement process.

Stakeholder	Level of impact*	Level of influence ^	Anticipated Expectations/Issues
SP AusNet	High	High	- Would like a commercially responsible solution to improve electricity supply to Mallacoota
East Gippsland Shire Council	Medium	Low	- Would like a solution that improves social and economic wellbeing for the Mallacoota community - Would like a solution or process that may offer possibilities for other isolated communities to improve supply reliability
MSEG	High	High	- Would like an environmentally sustainable solution that improves social and economic wellbeing for the Mallacoota community
Owners of possible sites	High	High	- Would like a solution that does not negatively impact on their primary purpose but adds value to their site or income
Mallacoota residents and businesses	Medium	High	- Would like improved reliability of supply
Mallacoota residents with existing PV systems	Medium	High	- Would like improved reliability of supply and improved returns from their systems
Mallacoota visitors	Medium	Low	- Would like a good experience as a visitor

*Level of Impact – level to which this stakeholder will be impacted by the project decisions
^Level of Influence – level to which this stakeholder can impact the project decisions

4.1.6 Negotiable and Non-Negociables

As part of establishing a fair process for this study, the following aspects were agreed to be negotiable or non-negotiable.

Negotiable	***Non-Negotiable***
The appropriate weighting of the different assessment criteria	All options will be considered by the same criteria in multi-criteria analysis
Technologies for electricity generation	
Sites to be considered for the location of generation	
The size of the 'island' to be served by the possible solution	

4.1.7 Option Selection Criteria

During the inception stage of the project, conversations with MSEG, EGSC and SP AusNet led to the establishment of a set of agreed criteria to assess the options being considered during the research and assessment phase of the project.

These assessment criteria were made available on the East Gippsland Shire Council and Mallacoota Community Directory websites from October 24. See Table 4-1 below.

4.1.8 Applying the Option Selection Criteria to Specific Technology Options

In Section 6 a range of technology options that may provide a solution to Mallacoota's energy issues are examined.

The Characteristics of each option were considered against the agreed selection criteria.

Where an option scores poorly against vital criteria, a comment is made around the unmet vital criteria for that technology. This explains why a technology is not among the final recommended options.

Where an option scores well against all criteria including vital and important, a comment is made against all criteria. This explains why a technology is included in the final recommended options.

4.1.9 Electricity Demand

A summary of information about the electricity demand in Mallacoota was made available on the East Gippsland Shire Council and Mallacoota Community Directory websites from October 31.

4.1.10 Information Session Feedback

At the information sessions attendees were invited to provide written answers to a number of questions to inform the project about key aspects of the feasibility study. The questions posed and a summary of the feedback is provided below.

Wind power for Mallacoota would require 2 or 3 large turbines.
What would be your thoughts about this?

28 responses were provided indicating generally strong, but not universal, support for the concept of wind turbines. There were numerous comments indicating that the location of wind turbines would be critical to avoid visual impact. Two responses particularly indicated concerns with noise impact.

How do you describe to your friends the disruption caused by outages?

15 responses were provided indicating that outages were inconvenient, sometimes dangerous (for the elderly), and caused losses to refrigerated and frozen food. Several responses indicated that people had privately invested in either generators or batteries to address the issue. One response indicated a concern in emergency situations.

A number of responses indicated acceptance of the situation given the remote location.

What is your biggest concern about power outages?

- **Short outages (up to 5 mins)**
- **Longer outages (hours/days)**

19 responses were provided, with the majority indicating that long outages were the main concern due to loss of refrigeration. The main issue expressed with short outages was the damage to appliances or computers with power surges associated with the stopping and starting.

Would you change energy retailer to one supporting power generation in Mallacoota?

22 responses were provided, all indicating they would be prepared to change retailer.

Would you be prepared to pay extra? (say 5% more?)

21 responses were provided, all indicating that they would be prepared to pay extra. There was some need expressed for the increase to be justified.

In addition to this written feedback, the project team were informed of community opinions during conversations conducted during the information sessions. This informal feedback has been incorporated into the ongoing assessment of options by the project team.

The questions posed to the attendees were to test underlying values and to invite comment. It was not the intent of these sessions to obtain a preference for one option over another.

4.1.11 Written submissions

Three people provided written submissions to the project.

One submission provided a drawing of a concept for generating energy from wave action. Discussion on the practicalities of wave generation is contained in Section 6.12.

One submission provided a concept for a community-owned solar farm. Discussion on centralised photovoltaic generation is contained in Section 6.5. Discussion on community ownership models is contained in Section 9.1.4.

One submission indicated that the project appeared to be taking a realistic approach and indicated that it was a pity the natural gas pipeline was not located closer to Mallacoota. A Natural gas pipeline has not been considered by the feasibility study.

4.1.12 Final project update

To inform the community of the emerging assessments of different options, the following information was provided in the November 21 articles.

We are starting to feel that potentially feasible options will emerge. A number of things are becoming clearer including:

- *We have not identified a site suitable for wind turbines.*
- *We are exploring the possibility of a solar photovoltaic panel farm at the wastewater treatment plant.*
- *We are also exploring the possibility of a biogas generating system at the wastewater treatment plant. This would produce fuel from sewage and other organic wastes from the town.*
- *We expect that existing individual solar systems connected to the grid will be able to provide power during outages.*

- *If we are successful in developing a more reliable system, it is most likely that there will continue to be interruptions. We would expect that they would be no longer than 5 minutes while the outage is confirmed, the Mallacoota system is separated from the main grid, and local supply is established. Safety is the key consideration.*
- *Investigations into using large-scale battery storage for coverage of long outages have shown it to be quite an expensive option. Other options for long term outages are being considered with the possibility of diesel and/or bio gas generation in parallel with PV panels a possibility.*
- *We are exploring the possibility of making an application for ARENA funding to support the project.*

This information was provided to allow community feedback on key aspects of the feasibility study as they emerged to ensure the project team were aware of any concerns.

At the time of writing (end of December), there have been no responses provided to the project team on these emerging outcomes.

4.2 Community engagement conclusion

The community engagement activities conducted during the feasibility study have provided valuable information and insight into the community of Mallacoota. The community has shown a willingness to embrace a solution to improving energy reliability if it does not negatively impact on visual and general amenity.

The issues addressed in the selection criteria are relevant to community needs. Options ranking well against the selection criteria are likely to be embraced by the community.

The engagement process indicates that there is a strong level of community goodwill towards a local power generation solution to improve reliability of supply.

This consultation was conducted as part of a feasibility study. The questions put to the community were necessarily open and full of possibility. If a proposal is further developed as a concept and then detailed proposal further consultations would be required to test more specific details and potential impacts.

Table 4-1 Option Assessment Criteria

Criteria / Goals	Description
Emergency proofing	The ability of the option to minimize the risk or length of a supply shutdown during an emergency. Emergencies might include bush fires or floods which cause the incoming grid line to cease supplying power to Mallacoota. The weather conditions during these emergencies may affect certain options differently to others. Range: 1 = no change to current situation / 5 = minimal risk Ranking - vital
Community acceptance	The ability of the option to have broad community support as an important improvement in the economic and social wellbeing of Mallacoota. Range: 1 = significant risk of community division / 5 = strong support Ranking - vital
Ability to supply electricity for extended periods	The ability of the option to provide electricity for extended periods when operating as an 'island'. Island mode may be instigated by emergencies or other causes of grid failure. The duration of the islanding mode, both in individual events and aggregated over a year is the consideration here, as to how well the option could minimise the length of time residents are without power. Range: 1 = low capacity for extended operation / 5 = capacity for operation in 'island' mode for up to five days. Ranking – very important
Equity	The ability of the option to be available to all current customers without a financial or technical barrier. Range: 1 = significant barriers to entry / 5 = no barriers to entry Ranking - very important
Proven robust technology	The ability of the option to operate reliably without risk of failure for technical reasons at critical times. Range: 1 = unproven technology / 5= well understood technology Ranking - very important
Operation and maintenance	The ability of the option to be operated and maintained with local expertise. Range: 1 = external expertise frequently required / 5 = locally (or reliably remotely) maintained and operated. Ranking - very important
Planning permission	The ability of the option to be approved by local, state and Commonwealth planning processes. Range: 1 = significant challenges in planning permission / 5 = no anticipated challenges Ranking – very important
Economics	The ability of the option to generate an income and pay back capital investment. Although a commercial entity may incur the majority of capital cost, the cost of the option will ultimately flow on to the customers. An option that is not financially viable will be difficult to realise. Range: 1 = prohibitive financial cost / 5 = profitable in medium term Ranking - important
Construction - technically feasible	The ability of the option to be constructed in Mallacoota without technical or excessive cost barriers. Range: 1 = significant difficulty / 5 = no barriers to construction Ranking - important
Resource abundance	The ability of the option to use a reliable resource and be capable of rapid recharge of storage after extended use. Range: 1 = long recharge time / 5 = rapid recharge time Ranking – important
Intermittency protection	The ability of the option to minimize disruption from brief outages. Range: 1 = brief interruptions continue in moving from standard to 'island' mode / 5 = brief interruptions significantly reduced Ranking - important

5 Network Requirements

5.1 Methodology

This section of the report is split into two distinct sections:

1. Review of the technical requirements for the connection of generation to existing and future grids
2. Possible requirements for establishment of an entity to operate localised generation and possible mini-grid.

In reviewing the technical requirements the following steps were completed.

- Review of publically available and SP AusNet supplied documents on the local network
- Discussion with SP AusNet planning personnel on the possible future works in the area
- Review of the current and future state of the network in the area
- Review of the publically available documents concerning the closest network in NSW, Essential Energy
- Initial discussion with Essential Energy on their ability and appetite for providing a connection to Mallacoota.
- Provision of technical guidance on the requirements for connection of a mini-grid to the broader Victorian and NSW grid.
- Review of the National Electricity Rules (NER) and Australian Energy Regulator (AER) requirements for establishing an entity to operate a generation system or a mini grid.

5.2 Current Network

As discussed previously Mallacoota is fed by a single 22 kV line that originates at the Cann River Zone Substation (CNR), a distance of approximately 70 kilometres. The Cann River Zone substation is then connected to the greater SP AusNet network through a single 66 kV line from Bairnsdale through Newmerella, a distance of approximately 165 kilometres. A single 22 kV backup also runs between Newmeralla and Cann River for situations where the 66kV line may fail. The majority of this system works its way through forested areas where a number of issues can and do occur including animals climbing onto the overhead lines, bark falling onto the overhead lines and weather induced faults. This also makes it difficult for the network provider to get into the area and rectify any faults created by these issues.

One item that was considered during the investigation was that the Mallacoota township has a radial only feed around the town. This leaves the township vulnerable to sustained outages caused by issues within the town itself.

As discussed in section 2 above there have been historically a number of outages in the Mallacoota area caused by a number of different issues. It can be seen that if any line in the Mallacoota supply is impacted by a fault there is a minimum time for the line to be re-energised to supply power. Some of this time is driven by the need for the crew that are needed to fix the fault needing to come from Lakes Entrance as this is the closest depot.

Review of the SP AusNet Distribution Planning Reports show that historically the demand in the Cann River area is stable and is planned to continue to be stable for the coming period.

5.3 Network Improvements

SP AusNet has been implementing and plans to continue to implement projects that improve the reliability of the power supply to Mallacoota. Some of these improvements include:

- Trialing bark catchers on 15 spans of the 66 kV system which has reduced the incidents of bark induced faults in the system. These bark catchers are to be rolled out over the coming years at appropriate locations on the route to Mallacoota.
- The backup 22 kV system for the 66kV connection between Newmerella and Cann River has been automated to reduce the time incurred for outages in the Cann River area.
- Increased spacing of the conductors on the power lines around Mallacoota to reduce impact of bats flying through the power lines.

From our review of the available documentation, including the SP AusNet Distribution Planning Report 2013-2017, and through our discussions with SP AusNet personnel there are no capacity upgrades planned for the Mallacoota supply area.

To improve the local township network it may be advantageous to add a loop to the structure of the network in the area. This could be completed by adding a new overhead line from the industrial area to Mattson St in the area shown below in Figure 5-1. This would have the advantage of giving flexibility to SP AusNet when network issues are caused within the Mallacoota Township.

Commented [DN2]: Comment from Terry Jones:

Please delete picture and provide schematic only

Commented [DN3]: Respond from Mark Lampard:

I think this gives the best indication of what is required. Can we please request more information from Terry on why this needs to be removed?

Figure 5-1 Potential Grid Loop

Given the clear area that could be used on the roadway in the area and the short distance involved we would anticipate that the cost of this upgrade would be approximately $300,000.

5.4 Future Network State

Given the improvements currently being implemented by SP AusNet and the likely flat demand in the Mallacoota area, an improvement in the outages from the network is anticipated. However the larger outages experienced by the Mallacoota community are a function of natural causes, the type, length and terrain traversed by the network currently supplying the area and no improvement to this is anticipated.

5.5 Connection to NSW

Given the location of Mallacoota and its proximity to the New South Wales (NSW) border the concept of connection to a network in NSW was considered. The network service provider that covers the rural area of NSW is Essential Energy.

Essential Energy is a NSW Government-owned corporation. It has responsibility for building, operating and maintaining Australia's largest electricity network covering 95 per cent of NSW by area. It delivers network services to more than 800,000 homes and businesses. It also has sections of its network currently servicing parts of southern Queensland and northern Victoria.

The parts of Queensland and Victoria that Essential Energy services are quite small and are a legacy of the way in which the networks developed over many years. The regulatory requirements for these networks are quite complex along with the requirements to understand not only the NSW regulations but also those of Queensland and Victoria.

The first step in understanding if a connection into Essential Energy was possible was to have a discussion with them concerning this option. To this end, the head of the network connections group within Essential Energy was contacted. During this discussion we found that Essential Energy did not want to be involved in any new cross border connections. In fact they were in discussions with the other network service providers in Victoria and Queensland to give back the existing cross border networks to the appropriate network service providers in those states.

Given this discussion, connecting to the NSW network is not considered further.

5.6 Mini Grids

The previous discussion paper [1] noted on Minigrids:

"Mini-grids or micro-grids comprise a localised group of energy sources, storage devices and loads that are interconnected by the traditional distribution network, but are able to operate autonomously from the network when required

Mini-grids also utilise intelligent systems to manage and improve quality of supply, and facilitate the connection of various renewable or low-emissions energy sources. They can operate in 'islanded' mode by disconnecting from the wider network in the event of a network failure, thereby improving reliability of supply."

Mallacoota's options for a mini grid would involve utilising readily-available sources of renewable energy, as well as some conventional back-up generation." [1]

A mini-grid could be a suitable option for the Mallacoota area given it is remote from the main network and has an easily controllable grid integration point.

5.6.1 Benefits of a mini-grid

As initially noted in [1]; a mini-grid in Mallacoota could provide a number of benefits to the community. Some of these benefits are:

- Greater reliability of supply, particularly during peak demand periods,
- Provide islanding capability in the event of line outages,
- Improved power quality- e.g. reduced flickers, intermittency and voltage sags,
- Reduced emissions intensity- by substituting coal-fired power with renewable or lower emitting sources,
- Provide the backbone for future electric vehicle integration- for charging and as storage devices for the mini-grid,
- Help facilitate the connection of cogeneration units at locations requiring heating and/or cooling,
- Centralisation of heating and/or cooling systems through district wide solutions,
- Allow the community to actively participate in the energy market,
- Can potentially allow installed residential PV to operate during outages.

5.6.2 Mini-grids in Australia

Mini-grids are not common in the Australian National Electricity Grid context. In some cases they have been developed as part of district heating and cooling systems where electricity and hot or cold water are sold to houses and/or commercial/industrial premises. One early example of these systems was developed by GRIDX in 2007 and more information can be found at http://mail.airah.org.au/downloads/2007-02-F03.pdf. There has been a large amount of work in this area by various Councils in Melbourne, Sydney, Brisbane and Adelaide over the last few years however in all cases they have struggled to move past the feasibility stage to date.

Commented [TEJ4]: Suggest reference to the GRIDX miniGrid as one example

http://mail.airah.org.au/downloads/2007-02-F03.pdf

Commented [DN5R4]: AECOM have added reference to GRidex.

Mini-grids are however quite common in areas outside the main Australian grids, in outback and mining locations. These are generally operated using diesel or gas generation with an increased penetration of hybrid systems using solar PV, solar thermal and wind technologies alongside these fossil fuel generators.

The National Electricity Rules (NER) do not envisage a requirement for islanded mini-grids in a national grid context and as such there will be regulatory requirements to be worked through during the implementation of this project. The majority of these requirements will depend on who owns the network as this is the main concern for the current regulations. If the network continues to be owned and operated by SP AusNet, as anticipated, the regulatory requirements will be negligible. The main regulatory requirement will be with the generator being able to operate in the National Electricity Market which is further developed in Section 5.8 below.

5.7 Ability to Operate in Island Mode

It is essential to this success of this project that the town can operate in a mode where it is disconnected from the SP AusNet network (island mode), with power being supplied by a new generator to the town during periods when the town would otherwise be without power.

A system which operates in both grid connect and island mode is a first of its kind in Australia, so there are no precedents and this brings some risk, as well as great value, to the project. There will be some challenges from both a technical and regulatory aspect, as outlined above, to work through to ensure that this can occur.

One regulatory item not covered above is the consideration of the responsibility for grid safety during outage periods when the generator provides power in island mode. From a regulatory perspective, the responsibility for local grid safety may lie on the generator company responsible for running in island mode rather than SP AusNet. This would need to be further investigated as this is a new area for the NER and does not have a precedent.

The technical aspects are associated with the need to provide adequate fault current to safely operate the existing distribution system. Distribution systems are designed in such a way that the fault current required to operate the protective devices is sourced from the network which is considerable. To ensure that the local system continues to operate safely while in island mode the generation system will need to be able to produce this fault current. This usually involves the addition of 'inertia' or 'spinning reserve' to the system which is done using either fossil fuel generation or fly wheels (see Section 7.2.3.2). The proposed solution is understood to be feasible for this type of operation although more detailed engineering is required to prove this.

Although there are challenges as outlined here, at this stage of the process the solution looks feasible for implementation and should have the ability to supply the town during outages. With an appropriate solution the local household solar PV systems should also be able to operate.

5.8 Connection Requirements

The process for connection of any generation in Victoria needs to be completed in accordance with the Essential Services Commission (ESC) Guideline 15 and the National Electricity Rules (NER). The technical performance of the installation will also need to comply with Section 7 of the Distribution Code, and as such the Service and Installation Rules.

The connection process for this project will involve the following stages:

1. ***Connection Enquiry*** – An approach to SP AusNet will need to be made with a formal document outlining the basic information about the project, they will already have the majority of this information.
2. ***Response to connection enquiry*** – SP AusNet responds with details about the information required for a connection application, and the application fee.
3. ***Connection Application*** – The project team will complete and submit the connection application as per SP AusNets requirements, and there will be an application fee to be paid. Connection studies will need to be completed as part of the connection application. These connection studies will include load flow, fault level, dynamic and protection studies for the proposed system.
4. ***Negotiation*** – A negotiation as to the details of the connection will be required. This will involve negotiation of technical design, as well as commercial details. Confirmation of the connection studies will be completed by SP AusNet at this stage.
5. ***Offer to connect*** – SP AusNet makes an offer to connect once all of the technical parameters and commercial details have been agreed to.
6. ***Connection agreement*** – The project team will need to accept the offer to connect by signing it and this offer then becomes the connection agreement.
7. ***Registration and licencing*** – The project will need to register with the Australian Energy Market Operator and the Essential Services commission.
8. ***Commissioning and Testing*** – Following construction the required testing will be completed and the plant will be commissioned and connected to the network.

This is a lengthy process that can take up to 18 months to 2 years to complete.

5.8.1 Registration and Licencing

In general, generators connecting in the National Electricity Market must register (or obtain a registration exemption) with the Australian Energy Market Operator (AEMO) as per the requirements of the NER. AEMO provides forms and guidelines for registering on their website. However, AEMO has specified that small generating facilities (with a nameplate rating of less than 5 MW) are automatically exempt from the requirement to register as a generator. This project may be able to utilise this exemption.

Exemption means that you are not required to pay participant fees and do not have to participate in the energy market. Exemption from registration also exempts the generation project from involvement by AEMO in assessing detailed technical matters, thereby limiting the technical assessment of the generator to SP AusNet. Notwithstanding the above, if any generator wishes to participate in the energy market, registration is compulsory.

The need to apply for AEMO registration will depend on requirements of the business model for the generator. If the model involves sales of the energy to a single offtaker in another location, then registration into the market will be required, however if a retailer was able to purchase the entire output of the energy from the generator then registration may not be required.

The other form of registration required is with the Essential Service Commission (ESC) in Victoria. The ESC has a requirement that all generators in Victoria are registered to be able to export power into the Victorian network. It is anticipated that this project will need to register as a generator.

5.8.2 Distribution and Marginal Loss Factors

One important part of the output associated with any generator is the requirement for Marginal Loss and Distribution Loss Factors. These factors are part of the calculation of the recognised output from a generator. These factors take into account the losses, or otherwise, in the network for the energy being exported to reach the users of that energy.

If a project has a loss factor that is greater than one, it is able to claim from the market a greater amount of energy sales than it actually generated. If the loss factor for the site is less than one then it is only able to claim energy sales from the market less than the actual generation. The basic calculation is as follows:

Market Energy = Loss Factor x Actual Energy Produced

In SP AusNet's area, these factors are calculated on a case by case basis and as such we are unable to give a definite answer on the loss factor for this generator. It is noted that the current loss factor for generators in Bairnsdale is 1.08 meaning that these generators are able to sell 8% more energy into the market. Due to the size of the generator proposed and it being larger than the local load it is likely that some reduction in this loss factor would occur. Given this it is anticipated that the loss factor for a 4.5 MW generator would be approximately unity however to obtain a high accuracy on the marginal loss factor, detailed analysis would need to be conducted.

Commented [JH6]: Would it not be at least 1.08 at Mallacoota if Bairnsdale is 1.08?

Commented [I7]: See additional comments concerning size of the generator versus the load

6 Future Renewable Energy Assessment

6.1 Methodology

A range of future local generation options have been identified in the SP AusNet pre-feasibility study [1].

The full range of technology options included at the outset of this project are:

- Decentralised solar photovoltaic plant
- Centralised solar thermal plant
- Centralised solar photovoltaic
- Centralised concentrated solar photovoltaic
- Centralised wind turbine in the 0.5 – 2MW scale.
- Centralised Biogas generator
- Wave generation
- Tidal power

In addition after commencement of the study, East Gippsland Shire requested that Biomass (woody wastes) be included for consideration in the study.

The preferred solution must be reliable, proven and cost-effective and have high community acceptance. A full set of evaluation criteria were developed through the project in consultation with the client group, as noted in the section 4 above 'Community Engagement' and detailed in Table 4-1. The agreed evaluation criteria are:

- Emergency proofing
- Community acceptance
- Ability to supply electricity for extended periods
- Equity
- Proven robust technology
- Operation and maintenance
- Planning permission
- Economics
- Construction - technically feasible
- Resource abundance
- Intermittency protection (momentary outages)

We anticipated that generation from sewage-biogas, solar photovoltaic and wind energy would be the most cost-effective and proven options however the other technologies were also given due consideration.

Financial and technical considerations include:

- Current Levelised Cost of Energy (LCOE) from Australian data, applicable to 1-2MW generation range
- Availability of local experienced technology suppliers and maintenance services
- Dispatchability of the generation, whether fuel can be stored, and what size of energy storage would be required to satisfy local medium term load profile
- Modularity: how easily additional generators can be cost-effectively added to meet future increases in energy demand.

As part of the evaluation of options, a high level economic comparison was performed. Where it was clear that a certain technology option would incur very significantly higher costs than the cheapest options, the most expensive options were ruled out and not included in further detailed analysis.

6.2 Current Levelised Cost of Energy

An important criteria for the solution at Mallacoota is that the energy be provided at a cost which is affordable. The range of renewable generation sources being considered in this study could deliver energy at a wide range of costs depending on the maturity of technology and availability of the resource. A widely accepted method of comparing the cost of energy from different energy sources is the 'Levelised Cost of Energy', abbreviated to LCOE. This is the real cost per unit of power produced based on real equipment, labour, fuel and financing costs. It is equal to a long term price the power generation company would need to receive, in order for the project to break even. At this rate of income per unit of power, the project has a net present value of zero; any profit the project can make is from payments made in excess of the LCOE. The income side of the equation does not impact the LCOE, the LCOE remains tied to the capital and operational cost of equipment, labour capital and fuel, however the total income including price paid per kWh, renewable energy credits income etc, must equal the LCOE for the project to break even.

There is a large body of existing publications tackling LCOE or various renewable energy technologies including those under consideration for Mallactoota. Using these references, a first pass assessment can be made of which options are likely to lead to an affordable solution for Mallacoota.

A number of references are available for effective cost of electricity from renewables, but there does exist significant variation amongst the available sources. To give a reasonable picture of the current cost of renewable energy technologies three sources were consulted. These are:

- IEA Medium Term Renewable Energy Market Report 2013[2]
- The Australian Bureau of Resource and Energy Economics, Australian Energy Technology Assessment 2012. [3]
- The World Energy Council (WEC) and Bloomberg New Energy Finance "Cost of Energy Technologies Report", 2013.[4]

The AETA study was scheduled to be refreshed before the end 2013 and updated in 2014, however at time of publication this report the 2012 figure were the most up to date. Whilst the consensus view of energy consultants is that AETA provides reasonable estimates of future prices, there have been some criticism of its relatively high current estimates. Bloomberg New Energy Finance provides a range of services on clean energy and carbon markets and their publication referred to here [4], for the World Energy Council is very up-to-date and detailed. Table 6-1 below shows the international current cost comparisons across a range of technologies, in Australian dollars.

Table 6-1: Levelised Cost of Energy comparisons, Australian Dollars

Technology	IEA Medium Term Report 2013	BREE AETA 2012	WEC BNEF 2013
Rooftop Solar PV	16.7 –39.3 c/kWh	21 – 26 c/kWh	N/A (>1MW only)
Utility scale Solar PV	12.3 –24.5 c/kWh	22 – 27 c/kWh	13.8–20.2 c/kWh
CST Trough w storage	12.8 –29.4 c/kWh	32 – 39 c/kWh	17 – 50 c/kWh
CST Tower w storage		29.5 –35 c/kWh	10.6 – 34 c/kWh
CST Trough w/out storage		29 – 34 c/kWh	21.3 – 52.1 c/kWh
Wind	4.9 -16.7 c/kWh	11 – 12 c/kWh	7.4 – 10.6 c/kWh
Biogas generator (digestion)	10.8 –15.2 c/kWh		13.8 c/kWh

Technology	IEA Medium Term Report 2013	BREE AETA 2012	WEC BNEF 2013
Biomass generator (wood fuels)	7.9 – 23.6 c/kWh	7.5 – 16 c/kWh	12.8 c/kWh
Tidal	NA	38 c/kWh (2020)	47.9 c/kWh
Wave	NA		53.2 c/kWh

These LCOE values are for projects constructed now i.e. 2013 and are not reliant on future cost reductions through increased technology maturity or uptake.

The AETA report does not provide LCOE for Tidal or Wave for 2012 as ocean energies are not deemed to be commercial at the current time by that study, however the figure of 38c/kWh is provided as a 2020 projection. All other figures are for 2012/13.

The biomass LCOE values are for a variety of wastes, not specifically forestry residues, and are for scales at which the technology is most economic, for example 20MW and above. The biomass and biogas LCOE values are from project data generally at a larger scale than considered here for Mallacoota. The LCOE for both biomass and biogas at the <1MW scale are expected to be significantly higher than shown in Table 6-1 above.

Recent auctions in Australian Capital Territory for solar PV projects have awarded long term Feed In Tariffs of 18.6c/kWh and 17.8c/kWh to the winning bidders, an indication of the levelised cost of energy from solar PV in the scale relevant to this study.[5] There is some debate over to what degree these solar projects in ACT are profitable, since there was considerable competition for them as showcase projects. However since the definition of levelised cost is the income required for the project to break even (net present value of zero) the figures presented by BNEF may in fact be a good indication of LCOE of solar PV.

This analysis provides a basis of comparison for the technologies considered, based on constructing in 2013.

While the IEA and WEC reports use US dollars and BREE uses Australian dollars, the close matching of those two currencies in recent years makes the c/kWh data broadly comparable. To increase the accuracy of comparison further, Enhar has used exchange rates at the time each reference was published, to convert USD into AUD. Costs in [2] and [4] have been converted to Australian Dollars at exchange rates of 0. 98142 and 1.06345 respectively[6]. In regards to applicability to Australia, both the IEA and WEC reports uses data from Australia for their analysis therefore the BNEF report is considered to be suitable for Australian purposes. Enhar has inserted the Australia-specific values from the BNEF report into the above Table 6-1.

The deduction of government grant subsidy from the capital cost of a plant can reduce the amount of income required to break even. The LCOE figure above provide a comparison of unsubsidised cost, whereas in the later analysis for Mallacoota, grant subsidy is also considered.

A graphical comparison between the considered technologies extracted from [4] is shown below:

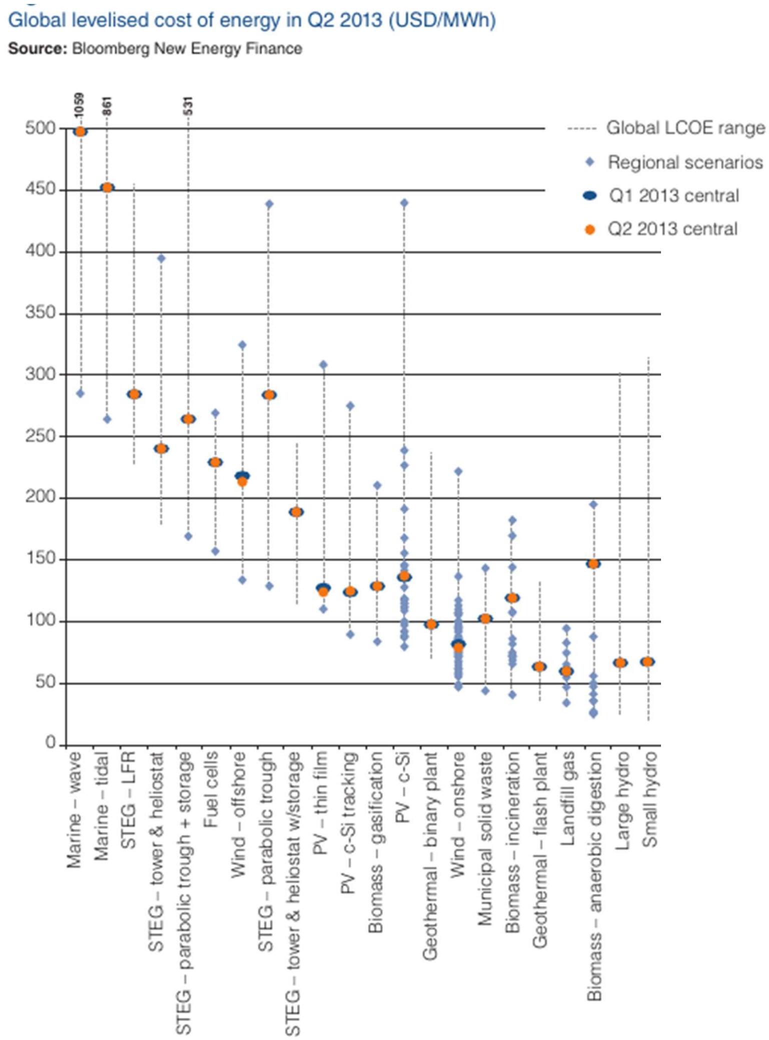


Figure 6-1 LCOE from WEC BNEF Cost of Energy Technologies Comparison 2013

Scale of Deployment

Important to note is that the studies assume technology is deployed at a scale which is economic. In the case of Mallacoota, the system size required is likely to be smaller than many projects referenced in the LCOE studies, which may impact the economics of systems sized for Mallacoota. The sensitivity of LCOE to project scale is different between the various technologies considered. The relative economics portrayed in the LCEO comparison above are only inferred to be broadly applicable to Mallacoota context. The analysis for each technology below examines the LCOE at the scale applicable to Mallacoota in more detail.

6.3 Renewable Resource Analysis

A summary of the renewable resources available at Mallacoota is provided below:

Table 6-2 Summary of Renewable Resources available at Mallacoota

Resource Type	Quantity and comments
Solar resource	Annual average daily solar radiation on a horizontal surface is 4.3 kWh/m²/day. Seasonal variations and validation against locally recorded solar data is provided below.
Wind Resource	Long term annual average wind speed is 3.9m/s at 8m at Mallacoota Airport. With shear extrapolation an estimated range is 6.0-6.5m/s at 50m and 6.8-7.9m/s at 100m. Diurnal and seasonal variations are described below, along with comparison to other wind data sources.
Digestable organic wastes suitable for biogas production.	At least 700,000 tonnes per year of sewage waste plus 350 tonnes per year of other digestable wastes including Kitchen Compost Waste, Abalone Waste, Meat Trimmings and Green Waste.
Biomass	Sawdust waste at Cann River is estimated around 2,000 tonnes per year and sawmill waste (chipped) is up to 6,000 tonnes per year.
Wave	The annual average wave resource is around 20kW/m at nearshore locations.
Tidal stream	The annual average tidal stream resource is up to 130W/m^2 at nearshore locations.

A full analysis of each type of renewable resource is provided below, considering various data regarding the locally available renewable energy resources including the quantity and variability of the resources.

6.3.1 Solar and Wind Resource at Mallacoota

The solar and wind resource at Mallacoota are readily available from the Bureau of Meteorology based on satellite observations, and wind measurements at the airport weather station:

Table 6-3: Temperature, Solar and Wind resource at Mallacoota Airport

Commented [TH8]: Site Matrices Figure 6-18 and 6-20 in sections 6.4.1 and 6.4.2 give the airport a 5 (No) in terms of Planning Zones. Robin believes the area beside the airport to the SW is much larger than the area marked on the map. He questions the justification for giving this area a 5 based on the information the Council gave us which he considers was speculative.

Commented [DN9]: Since we no longer focus on the airport site as a recommended site for solar we do not propose to look further at the ranking for that site.

Month	Air temperature	Daily solar radiation - horizontal	Wind speed
	°C	kWh/m²/d	m/s
January	19.1	6.07	4.4
February	19.2	5.41	4.2
March	17.5	4.44	4.0
April	15.0	3.28	3.8
May	12.8	2.39	3.6
June	10.9	1.99	3.6
July	10.1	2.22	3.6
August	10.6	3.02	3.7
September	12.4	3.96	3.9

October		13.7	5.06	4.3
November		15.4	5.78	4.6
December		17.1	6.15	4.6
Annual		14.5	4.14 [2]	4.0
Measured at	m			8.0

The above weather data is derived from the Mallacoota weather station, visited during this study and described in 6.9.2 below. The data table above was obtained from RETSCREEN software and has been verified through purchase of detailed hourly records from the Bureau of Meteorology. Detailed discussion of the individual types of resource are given below.

6.3.2 Solar Resource Assessment

Coastal locations experience a higher incidence of clouds than inland sites, which is reflected in the solar resource map of Victoria shown below:

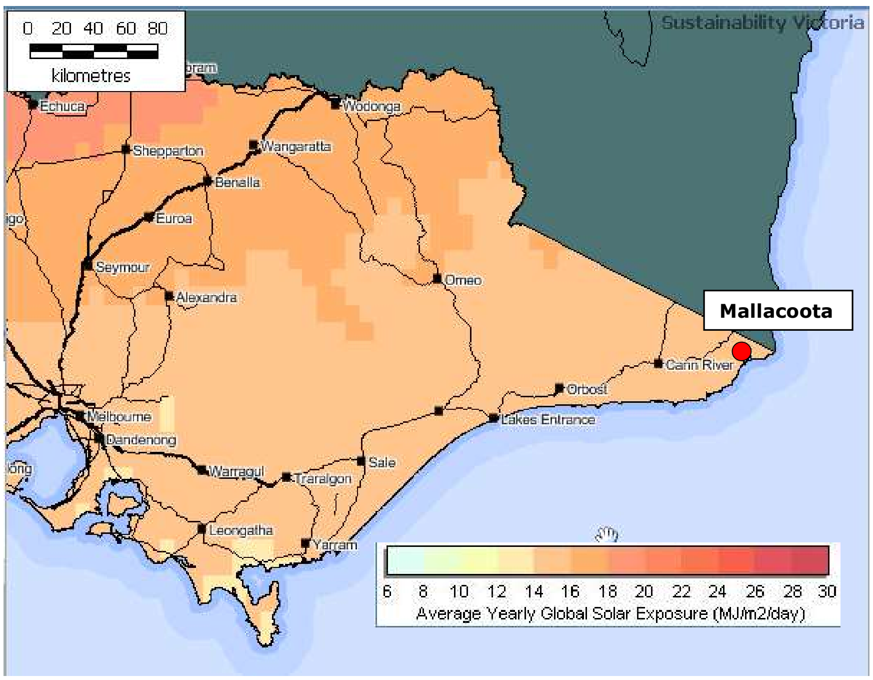


Figure 6-2: Solar Resource in Victoria. Source: Sustainability Victoria Ref [8]

Commented [TH10]: Change this Figure to remove white block that obscures Mallacoota's location. Also, check that this doesn't occur in any other Figure. I believe it happens almost every time you do this. Maybe make the box colour transparent.

Commented [DN11]: Tricia the formatting is OK on our screens, perhaps try viewing from a different computer? Refer to PDF copy which gives the true formatting which I trust will show you that it looks OK.

[2] The raw solar data from Mallacoota has been analysed by Enhar and found to be 4.3 kWh/m2/day, which is considered to be a more accurate estimate.

The Horizontal Solar Exposure data displayed in the map above is recorded by the Bureau of Meteorology. The Bureau of meteorology provides detailed solar data for specific sites including Mallacoota, based on satellite measurement.

A timeseries of global horizontal irradiation (GHI) has been obtained from the Bureau of Meteorology for the Mallacoota location. Although there is no ground based solar measurement instrument at the local weather station (visited by Enhar), the use of Satellite data enables ground level estimates of solar resource to be made. The BoM methodology for this is described on their website[7]:

> *"This process involves calculation of instantaneous downward irradiance (radiative fluxes) at the ground every hour in real time over Australia using the hourly MTSAT-2 visible data, as well as hourly cloud albedos. The hourly irradiances are then integrated during each evening to give daily insolation totals in megajoules per square metre, i.e. "daily global solar exposure"."*

Enhar analysis of the daily GHI values for Mallacoota is presented below:

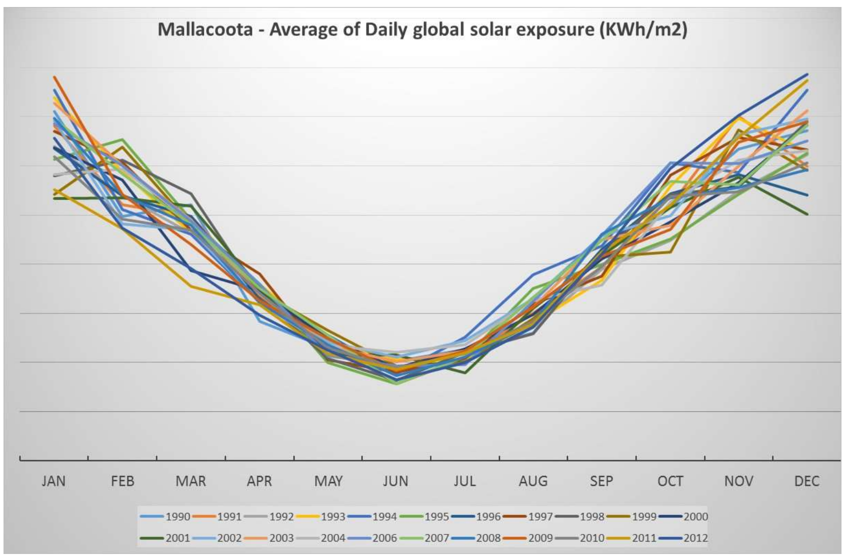


Figure 6-3: Mallacoota Solar resource annual and seasonal variation [source: BoM]

The long term average is of most relevance to energy yield calculations. This is presented below, along with a comparison to a widely recognised data source for Melbourne:

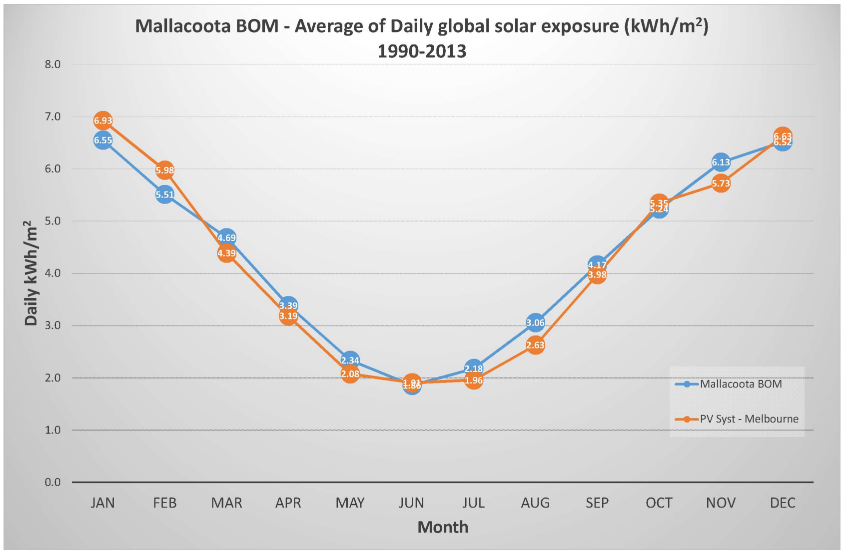


Figure 6-4: Mallacoota long term average solar resource

6.3.2.1 Impact of angle of inclination

Solar irradiation (energy) falling on a surface can vary considerably depending on the slope of the surface [8].

In summer the amount of solar irradiation is similar for a sloped surface and a horizontal surface. However, in winter a surface on a 30° slope will receive up to 60% more irradiation than a horizontal surface [8].

6.3.2.2 Validation against local solar measurements

The locally installed solar PV systems in Mallacoota provide a source of local ground-based measurement of solar energy. In particular, this measurement would take account of local cloud conditions and the relative performance variations of solar PV arising from local weather conditions.

As part of this feasibility study and community consultation, a request was made to the community for any data recorded by residents of their solar PV performance. The request was for data recorded at sites with minimal shading.

A number of local residents responded with data in various formats. The residents at 64 Mirrabooka Rd provided the most useful data set.

This site has series of panels facing approximately 5 degrees east of north, at approximately 30 degree slope. A photo of the roof with the panels is shown below, taken looking east from the road to the west of the house.

Figure 6-5: Residential solar PV system in Mallacoota from which data was analysed

There are trees to the north-east, and a building in the northerly direction however the hours of shading at this site are relatively few compared to some other solar properties in Mallacoota with significantly more shading from trees.

The data was supplied in daily values which can be directly compared to the BoM daily solar radiation records.

For days where outages were known to have occurred, data was removed before analysis. It was noted that in June 2012, there were several consecutive days where the recorded output from the solar inverter at this site was zero or near zero. This was during a period of low sunshine (also during a flooding event). Low generation could be attributed to low solar input and two days of zero output attributed to the outages during that period.

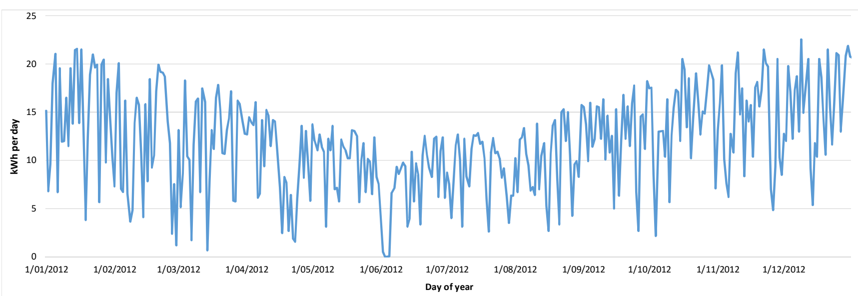


Figure 6-6 Daily Solar yield from PV system at Mirrabooka Road

When compared against the BoM daily solar data, it was found that a 2 day offset existed, with clear peaks in the BoM data occurring 2 days 'after' the Mirrabooka data. Whether this was due to a date stamp error with the BoM data or with the Mirrabooka Road data is not clear, however when a -2 day shift was applied to the BoM data, the match between the data was extremely good. It is concluded that the data do match and the error was in one of the date columns only.

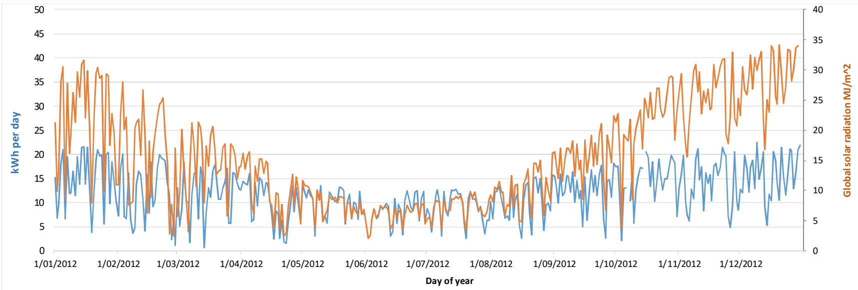


Figure 6-7: Daily solar radiation and solar production at Mallacoota

The close agreement of the data demonstrates that the weather events at Mallacoota which influence solar yield are well captured by the satellite derived BoM values. The peaks and troughs of solar production are closely aligned with the daily solar exposure as would be expected if the solar radiation measurements are accurate.

This result gives additional confidence in the use of BoM solar data at this location and addresses any concern that certain local cloud events might not have been captured in the BoM data. Despite the absence of a ground mounted solar radiation monitoring system, the BoM data is considered to be a reliable source of resource data.

The shape of the graphs in Figure 6-7 above are typical of a 30 degree fixed tilt solar system. The solar production does not follow the proportional change in solar energy through all seasons, as the solar system is properly designed to optimise output though the whole year rather than one season only.

Solar systems which move the panels to track the sun are normally implemented only at larger scale. Tracking systems would follow the solar radiation changes much more closely, though at an additional cost due to increased complexity of motors, actuators and control.

6.3.3 Wind Resource Assessment

Wind data from the Bureau of Meteorology (BOM) met mast located (Latitude: -37.5976 Longitude: 149.7289) near Mallacoota airport was purchased from 2000-2012. Half hourly wind speed and direction data from the 8m standard meteorological measuring mast was provided to Enhar for analysis purposes. While anemometers at BoM station are normally 10m above ground, the detailed records of this station indicate an 8m mast has been used.

Figure 6.8 below shows the met mast setup and location of instrumentation.

Figure 6-8 Mallacoota Airport BOM Mast [source: Enhar photo, September 2013]

Figure 6.9 below shows the latest update (17/04/2010) instrument location and local surrounding features. It is clear from the figure and the site visit undertaken that there is significant vegetation in the vicinity of the measuring equipment. It should be noted that the wind speeds derived from any data recorded at this mast is expected to be heavily influenced by wind-shading from the nearby vegetation. This, coupled with the relatively low height of the anemometer, creates uncertainties around the shear profile and extrapolated wind speeds at higher elevations.

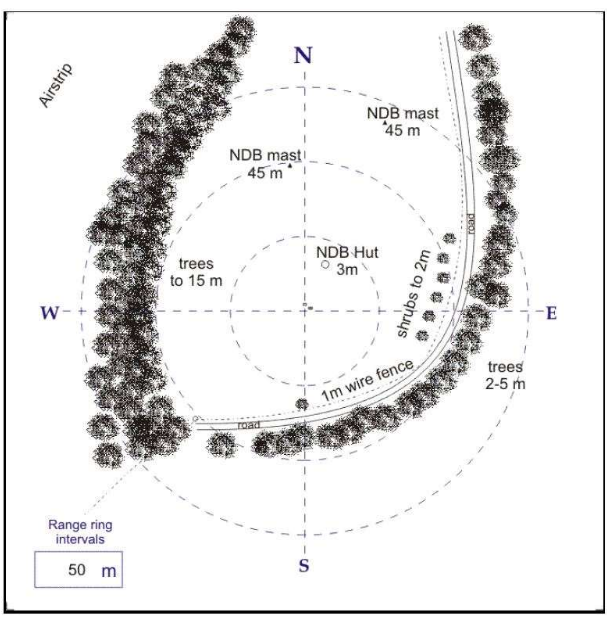


Figure 6-9 Mallacoota BOM Instrument Location and Surrounding Features

6.3.3.1 Summary of Local Wind Data

Local wind data from 2000-2012 (13 years) was analysed using specialist wind analysis software. The data recovery was more than 91% for the period examined. Due to having a single measuring height it is difficult to calculate the shear profile (increase in height with speed)precisely, the data shown below was extrapolated to 50m and 99m to cover the range of turbine hub heights which might be considered, using a logarithmic function and uniform surface roughness shear of 0.5 (standard for forested areas).

Figure 6-10 below shows the resulting wind rose, wind speed profiles and the distribution of the wind graphs.

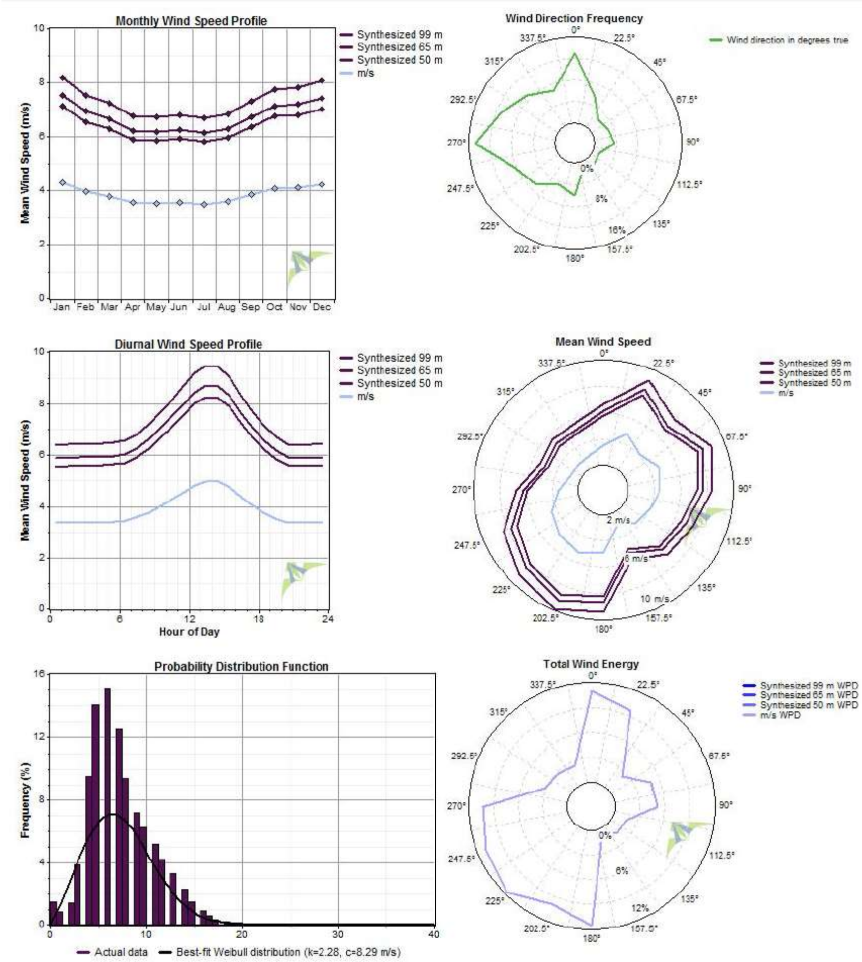


Figure 6-10 Summary of Local Wind Data, Mallacoota Airport

The average wind speed calculated for this site is 3.9m/s at 8m, for a site near the coast this appears to be unusually low. The low wind speed may be partly due to the heavy influence given the proximity, height and density of the vegetation surrounding this mast.

Utilising the shear function for a surface roughness of 0.5 the average wind speed calculated at a turbine hub height of 99m from the measured data is **7.3m/s**. There is likely to be a +/- 10% uncertainty on this estimate due to shear profile uncertainties.

6.3.3.2 Alternative Sources of Wind Data

The Victorian Wind Atlas for the BOM airport mast location shows that the wind speeds have been assessed on a Macro scale and are predicted to be **7.1-7.2m/s at 65m**. Figure 6-11 below shows the area calculated to be 7.1-7.2m/s.

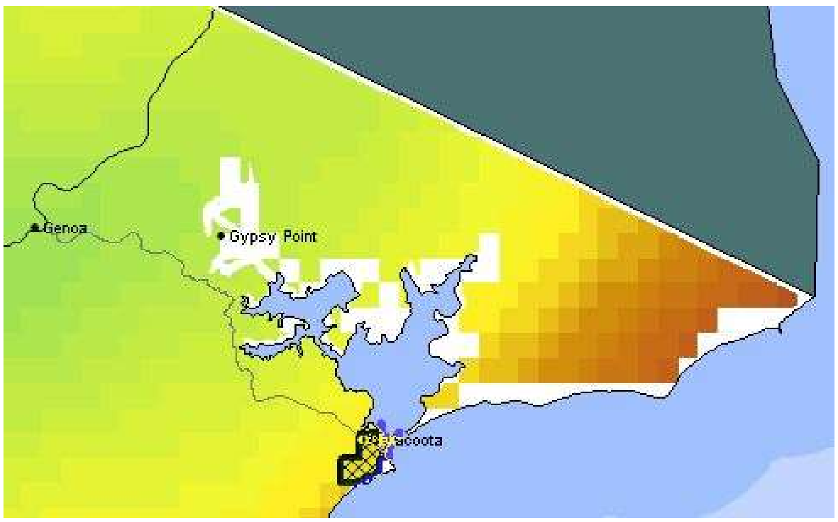


Figure 6-11 Victorian Wind Atlas Wind Speeds

Gabo Lighthouse

The nearby Gabo lighthouse wind direction and wind speed data (6 years – 2007-2013) was also purchased from the BOM met mast (8m also) to confirm the validity of the Mallacoota airport data. Gabo lighthouse met mast is located on an island approximately 17km to the west of the airport met mast.

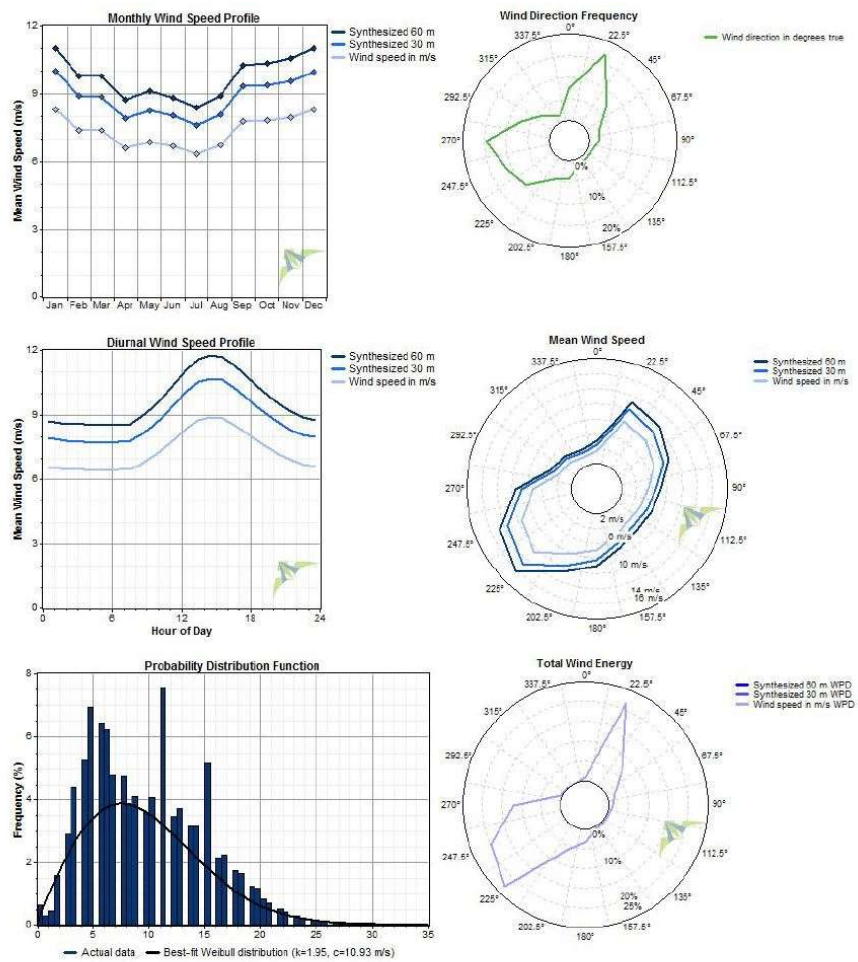
It should be noted that Gabo lighthouse mast location is also not an ideal reference location as it is shielded by nearby lighthouse buildings to the south east.

Figure 6-12 Gabo Light Location (R) relative to Mallacoota Airport (T)

The Gabo mast is located on an island and would generally be expected to be a higher wind speed due to being surrounded by water which does not slow down the wind.

Figure 6-13 shows the results of the wind analysis for the lighthouse mast.

Figure 6-13 Gabo Lighthouse Wind Data



The wind data shows an average wind speed of 7.3m/s at 8m and this is substantially higher than the met mast at Mallacoota. The wind speeds at this location are superb in terms of utilising a wind turbine output, the wind speeds are very rarely outside the turbine generation design speeds.

6.3.4 Biogas Resource Assessment

The formation of biogas through AD (anaerobic digestion) is flexible in terms of the varieties of feedstock that can be co-digested within the one digester tank. The feedstock types and estimated annually available quantities considered for Mallacoota are listed in Table 6-4.

Available abalone waste volumes were supplied by Mallacoota Abalone Cooperative and meat trimming volumes were supplied by Mallacoota Butchers. The available waste water sludge volume was estimated by East Gippsland Water based on past sludge accumulation rates which was an annual available volume of 933 m³. [9] There were a wide range of estimates of annual wet sludge volumes from different pieces of correspondence, Enhar has used the data most recently supplied [9].

Given that the density of the sludge would just be below 1000 kg per m³ we conservatively anticipate 700,000 kg of sludge would be available annually for digestion.

Kitchen compost and green waste volumes were supplied by the Kitchen to Compost funding application which was sent to by East Gippsland Shire Council[10]. The funding application was comprehensive in terms of the methods and measures that were adopted for their projected available volumes. Further details regarding the Kitchen to Compost project can be viewed in Appendix B.

Table 6-4 Digester Feedstock Type & Volume

Feedstock Type	Volume (kg) per year	Source
Waste Water Sludge	700,000	East Gippsland Water
Kitchen Compost Waste	70,000	East Gippsland Shire Council
Abalone Waste	75,000	Mallacoota Abalone Co-Operative
Meat Trimmings	5,000	Mallacoota Butcher Shop
Green Waste	200,000	East Gippsland Shire Council

Enhar has simulated the annual feedstock profile based on estimates of seasonal fluctuations:

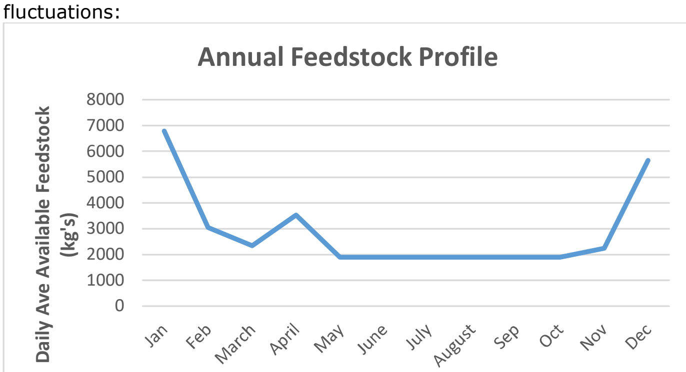


Figure 6-14 Seasonal Digester Feedstock Availability Curve (simulated)

The locally accessible materials considered for a co-digestion process include sewage sludge from the Mallacoota Waste Treatment Plant, abalone waste, kitchen to compost, meat trimmings and green waste. As the materials are all waste products, the volumes available dramatically varies with the seasonal fluctuations of the town's population. Mallacoota's population increases from 972 to 8,000 during peak holiday season according to the Australian census.

Figure 6-14 above is a projected representation of the altering available feedstock quantities throughout the year. Fluctuating quantities makes it difficult to plan and manage feedstock ratios and combinations which if not precise can have an adverse effect on digester output efficiencies.

6.3.5 Biomass resource Assessment

A reliable and low cost feedstock is required for any bioenergy project to proceed. CSIRO conducted a study to identify potential sources of biomass across Victoria.[11]

Forest residues and sawmill waste are the most obvious feedstock in East Gippsland. Mallacoota may find additional volumes of woody biomass available on an intermittent basis from vegetation management operations relating to fire safety (treatment of roadside vegetation and the product of fire prevention works), aerodrome management and general arboriculture works.

It is assumed that for the purposes of this study, any relevant feedstocks are those within a fairly short distance, say approx. 50-100km, from Mallacoota. Feedstocks further afield in the Shire may be considered in separate research underway by East Gippsland Shire but may not be appropriate to a generator at Mallacoota if distances, transport or community concerns are an issue.

Forest residue comprises non-merchantable woody material left on the forest floor after timber harvesting operations. In low elevation mixed species forest, typical of Far East Gippsland, this material is traditionally burnt. These regeneration burns are part of a regeneration program to re-establish native forest on previously harvested coupes.

To enable efficient transport, forest residue is chipped (terrain chipping), milled or mulched prior to loading on bulk transport as it is unsuitable for standard log truck transport.

Further forest residues may be available from silvicultural operations such as thinning.

Sawmill waste in the form of chips and sawdust is available at Cann River. Approximate quantities are presented in the Table below:

Table 6-5 Biomass Resource quantities available to Mallacoota[12]

Biomass Resource Type	Moisture Content (approx)	Approximate Tonnes available from Cann River (per annum)
Sawdust	40-42%	Up to 2,000
Sawmill waste (chipped)	25-35%	Up to 6,000

A high energy content biomass material is compressed sawdust pellets. The closest supplier to Mallacoota that could manufacture pellets is South East Fibre Exports (SEFE), over the border in NSW. Indications from initial correspondence with SEFE is that the site has previously produced pellets and while it does not currently produce them it could potentially recommence production if a demand arose. The moisture content of the pellets is around 8% and initial correspondence with SEFE indicated that a volume of up to 1,000 tonnes/year of pellets could be supplied based on Eucalypt chipping waste.

6.3.6 Wave Resource Assessment

A wave's capacity to generate electricity is dependent on its height and speed. The higher and faster the wave, the more energy it contains. The wave's size and speed are influenced by wind speed and the presence of land nearby. The wave resource displayed below is from the Sustainability Victoria interactive online map developed in partnership with Water Technology Pty Ltd [13].

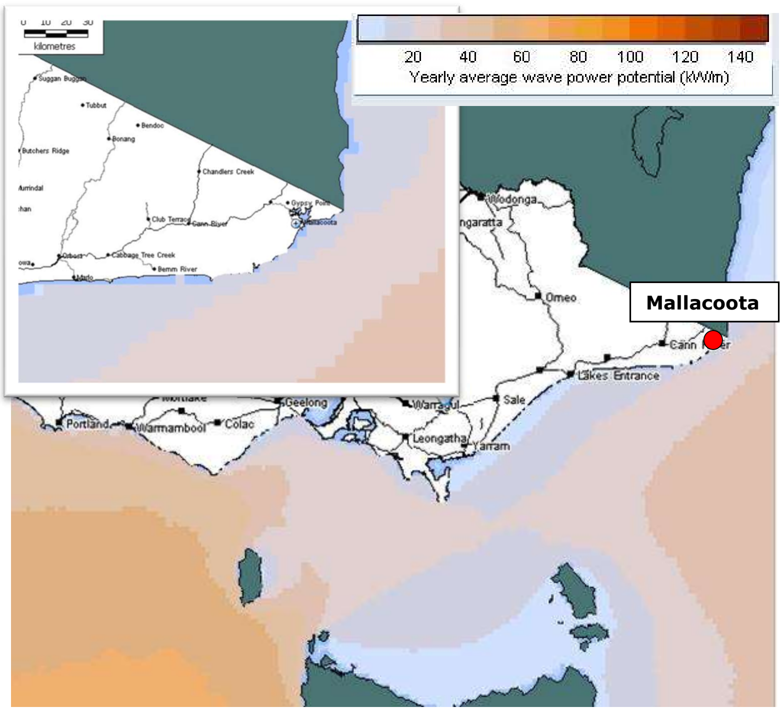


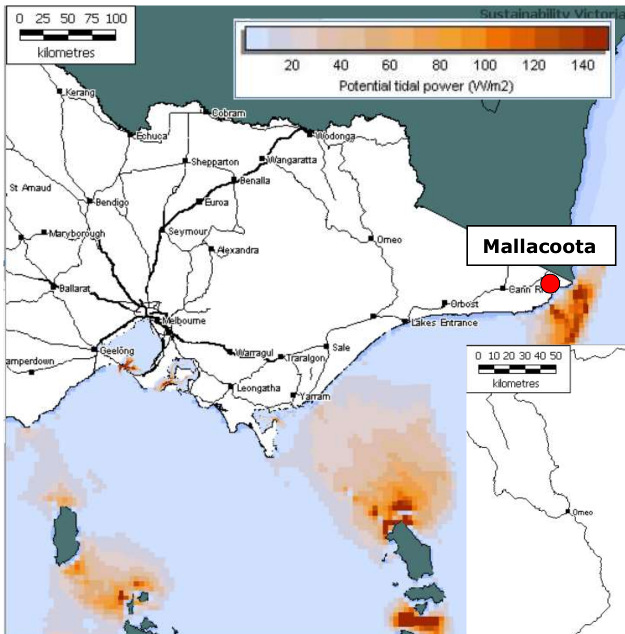
Figure 6-15: Wave Resource [Sustainability Victoria]

The predominant wave direction in Victoria is south-westerly. Wave projects under development in Victoria are generally in the Port Fairy to Portland section of the coast, where resource strengths are up to 40 kW/m at nearshore locations.

Mallacoota has a lower wave resource than those locations, around 20kW/m at nearshore locations.

6.3.7 Tidal Resource Assessment

A tidal energy resource map for Victoria was developed by Sustainability Victoria in partnership with Water Technology[14]. This notes that '*the potential for tidal power generation depends upon the tidal range, and the tidal current velocity. The map does not take into account shipping lanes, water depth and other factors involved in assessing the commercial viability of this resource.* '



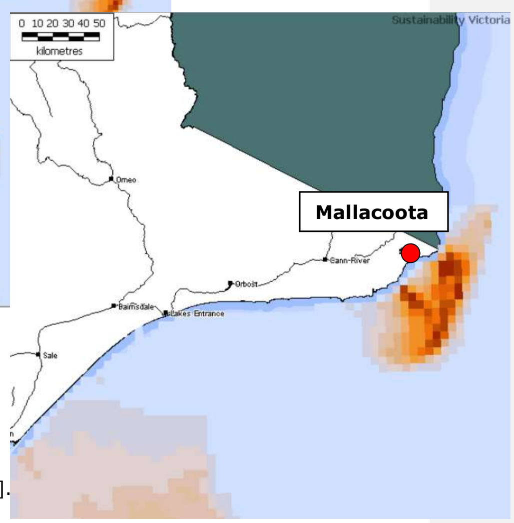


Figure 6-16: Tidal Resource map [14]

The presence of an above average tidal stream resource is notable off the coast at Mallacoota, up to 130W/m^2. according to [14].

6.4 Site Selection

A series of sites were analysed through desktop researched then a series of selected sites were visited by the project team on the 9th and 10th September 2013.

Sites were subsequently analysed in more depth as each technology was studied.

Figure 6-17: Site visits on 9th and 10th of September

From these visits and desktop analysis, a site selection evaluation matrix was developed.

6.4.1 Solar Site Evaluation

Below is a list of each site visited and also an additional site not visited at Mangans Lake Farm located inland of Mallacoota. Evaluation criteria were considered for each site.

Commented [TH12]: The fourth column I think should be Sewage Treatment Plant not Water TP. Correct?

Commented [DN13R12]: Yes, amended

MALLACOOTA SOLAR SITE MATRIX

Criteria / Goals	Mangans Lake Farm	Airport	Golf Course	Sewage TP	Bucklands Jetty	Gravel Pit
Resource	1	1	1	1	3	5
Grid	3	3	1	2	4	3
Available Area	1	1	4	1	3	5
Visual Amenity	1	1	4	1	4	1
Solves outages beyond Mangans towards Cann River	1	1	1	1	1	1
Solves outages btwn Mangans and Mallacoota town	5	1	1	1	1	1
Planning Zones	2	5	5	2	3	4
Suitable Topography	1	1	3	1	4	5
	15	14	20	10	23	25

KEY		Resource
Yes	1	High
Adequate	2	
Marginal	3	
Questionable	4	
No	5	Low

Several further sites were included in the desk based investigation for large scale solar, a map of all sites considered for large scale solar is shown below:

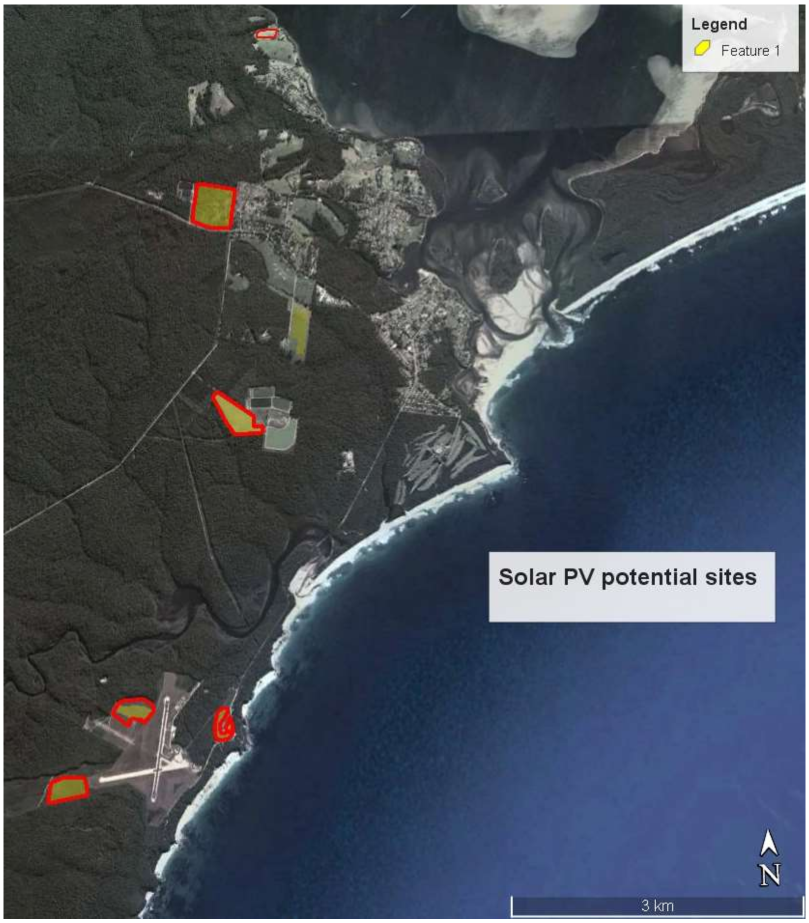


Figure 6-18: Sites investigated for Solar

6.4.2 Wind Site Evaluation

Figure 6-19 Wind Site Evaluation Matrix

MALLACOOTA WIND SITE MATRIX

Criteria / Goals	Mangans Lake Farm	Airport	Golf Course	Sewage TP	Bucklands Jetty	Gravel Pit
Resource	4	3	3	3	5	2
Grid	3	3	1	2	4	3
Available Area	1	2	1	1	3	4
Visual Amenity	1	2	5	2	5	1
Solves outages beyond Mangans	1	5	5	5	5	5
Solves outages Mangans -Mallacoota	5	1	1	1	1	1
Planning Zones	2	5	5	2	5	4
Suitable Topography	3	1	1	1	4	4
	20	**22**	**22**	**17**	**32**	**24**

KEY		Resource
Suitable	1	**High**
Adequate	2	
Marginal	3	
Questionable	4	
Possible Showstopper	5	**Low**

A map of potential wind sites is given in **Error! Reference source not found.** below.

6.4.3 Sewage Treatment Plant Site

The Sewage Treatment Plant was among the sites visited. Through various considerations, it appears to be the most feasible site for a community energy project to be constructed and operated.

Figure 6-20: Sewage Treatment Plant site [image source: East Gippsland Water]

The site is leased by East Gippsland Water (EGW), on a long term lease from the Victorian Department of Environment and Primary Industries (DEPI).

No residential properties have a view of the site therefore amenity impacts of a development here are negligible.

Distances to dwellings are significant, through forest, therefore noise impact issues of construction of a development here are minimal.

Bush fire protection is in place through an irrigator system in place operated by EGW. As this site is surrounded by a tree lot, this level of bush fire protection is already a requirement and operated by EGW.

The large open paddock is currently only used for grazing of a few horses and very small income. The installation of a solar farm on this area is expected to be acceptable to EGW indeed it may be preferable to its current usage.

A renewable energy project developer might expect to pay modest rental costs for this site under a sub-lease arrangement to EGW. The current income generated by this area of land is small. Due process to seek approval from DEPI for such a commercial sub-lease arrangement would be required.

In production of this study, discussions with the EGW Executive Operations manager were favourable and it is expected that EGW will have no objection to the use of this site for renewable energy generation.

6.5 Technology Options Review

A high level economic comparison was performed to determine which technologies could potentially be economically viable and which were likely to be economically unviable. For this process, the levelised cost of energy from recently published studies plus the ball park cost of storage can be considered. Some options and combination of options are quickly seen to be significantly more expensive than others. While all options are considered against the vital criteria, those which are known to be prohibitively expensive are ruled out from further detailed analysis.

Table 6-6: Technology Options Review summary

Technology	Project potentially economically viable at scale suited to Mallacoota, using resource available at Mallacoota?	Reasons
Decentralised Solar Photovoltaic with decentralised storage	Possibly	With LCOE relatively low, rooftop solar PV with battery storage could be economically viable, depending on the cost of battery systems, see Section 6.6.
Centralised Solar Thermal Plant with storage	No	At greater than 50c/kWh, the LCOE for this option is prohibitive, see Section 6.7 below.
Centralised Solar Photovoltaic with centralised battery storage	No	Sufficient battery storage costing $5-$6.5M would make this option unviable, see Section 6.8.8
Centralised Solar Photovoltaic with backup generator	Possibly	With estimated LCOE of less than 20c/kWh, solar PV if coupled with a diesel generator would be one of the lowest cost options.
Centralised Wind turbine with centralised battery storage	No	Although wind has a low LCOE, sufficient battery storage would add around $3-4M to the project cost,

Technology	Project potentially economically viable at scale suited to Mallacoota, using resource available at Mallacoota?	Reasons
		making this economically unattractive. See section 6.9.3 below.
Centralised Wind turbine with backup generator	Possibly	The low LCOE of wind plus the cheaper option of a backup generator make this likely to be the lowest cost of all options. See Section 6.9 below.
Centralised Biogas generator	Possibly	A biogas system could store energy in the form of biogas for use during outages therefore could be an economic option, though would depend on sufficient revenue for sales of electricity, see Section 6.10 below.
Centralised Biomass generator	Possibly	A biomass combustion system could be economically viable, see Section 6.11 below.
Wave generation	No	With LCOEs above 50c/kWh this is not currently an economically viable system. See section 6.12
Tidal generation	No	With LCOEs above 45c/kWh, this is not currently an economically viable system. See section 6.13
Concentrating solar photovoltaic	No	With LCOE estimated over 60c/kWh this is not currently an economic option.

Each option was also assessed against the 'vital' criteria of emergency-proofing and community acceptance. The assessment involved assigning a score between 1 and 5 and is presented below in Table 6-7.

Table 6-7: First Evaluation matrix

Options / Evaluation	Potentially economically viable?	Vital Criteria		
		Emergency Proof	Community Acceptance	Total Score: Vital criteria
Decentralised solar photovoltaic, with decentralised storage	Possibly	5	4	**9**
Centralised solar thermal, with storage	No	4	3	7
Centralised solar photovoltaic with centralised battery storage	No	4	5	**9**
Centralised solar photovoltaic with backup generator	Possibly	4	5	**9**
Centralised wind turbine with centralised battery storage	No	4	1	5

Centralised wind turbine with backup generator	Possibly	4	1	5
Centralised biogas generator	Possibly	4	5	**9**
Biomass	Possibly	4	1	5
Wave generation (with storage or backup generator)	No	4	3	7
Tidal power (with storage or backup generator)	No	4	3	7
Concentrating solar photovoltaic (with storage or backup generator)	No	4	3	7

KEY		**Merit**
Suitable	5	**High / Best**
Adequate	4	
Marginal	3	
Questionable	2	
Possible Showstopper	1	**Low / Worst**

Some comments on Table 6-7: All options could be technically designed to provide generation during emergencies i.e. some degree of emergency proofing. The emergency proofing scored highest where protection against momentary outages as well as against sustained outages is provided, (e.g. decentralised solar with decentralised storage).

In relation to community acceptance, the highest score is where the structures would cause minimal impact on amenity (noise, visual) and where the resource is accepted locally as environmentally sustainable. The lowest scores for community acceptance are where the structures would incur a potentially significant impact on amenity or where the resource is not accepted locally as environmentally sustainable. The community consultation exercise invited feedback on certain options at information sessions as reported in section 4 above.

From this analysis, five options are potentially economic however two of these score very low on community acceptance: Wind energy was found to be potentially divisive due to the likely visual impact of any site, as discussed in section 6.9.5 below. Community feedback on wind energy is discussed in section 4.1.10 above. Community concerns around the environmental sustainability of combusting Biomass (wood from forests) for energy are discussed in section 6.11.6 below and led to the option of Biomass scoring low against the vital criteria of community acceptance.

The remaining three options warranted more in-depth analysis: 1) decentralised solar photovoltaic with decentralised storage, 2) centralised soar photovoltaic with backup generator and 3) biogas digester with backup generator. A summary of the assessment of these three options against all criteria is provided in

Table 6-8 below.

Table 6-8: Second evaluation matrix

Criteria / Option		Decentralised solar photovoltaic, with decentralised storage	Centralised solar photovoltaic with backup generator	Centralised biogas generator
Vital Criteria	Emergency Proof	5	4	4
	Community Acceptance	4	5	5
	Total Score: Vital criteria	**9**	**9**	**9**
Very Important Criteria	Ability to supply electicity for extended periods	3	5	5
	Equity	2	5	4
	Proven robust technology	4	5	4
	Operation and maintenance	2	3	4
	Planning permission	5	4	5
Important criteria	Economics	2	4	3
	Construction - technically feasible	3	5	5
	Resource abundance	4	4	3
	Intermittency protection	5	3	3
	Total Score (all criteria)	**39**	**47**	**45**

KEY		Merit
Suitable	5	**High / Best**
Adequate	4	
Marginal	3	
Questionable	2	
Possible Showstopper	1	**Low / Worst**

Further information on each option is provided in the sections below. The extent of the analysis of each option is generally proportional to the merit of score against the criteria: options scoring highly against the most criteria are given the most extensive analysis. An exception is perhaps the case of wind energy: many of the scores for wind energy would be very site specific. Extensive analysis of various sites and wind resource was therefore undertaken in an attempt to locate a site for wind turbines(s) which would score highly against most criteria. Although no site was found which would score highly against all criteria, the wind energy option analysis is nonetheless presented to illustrate the process which may be helpful to other communities.

Enhar

6.6 Decentralised solar photovoltaic plant

Decentralised house-hold scale solar systems with battery storage offer significant advantages including provision of energy at the point of consumption, mitigation of both momentary and sustained outage, avoidance of planning permission restrictions, and avoided transmission losses.

An illustration of the system components is shown below.

Figure 6-21: Home energy storage system with PV [source: Clean Energy Council[15]]

The earlier discussion paper [1] makes the following observations:

Mallacoota has already demonstrated a high level of uptake of renewable/sustainable energy, indicated by the community's investment in solar PV power generation.
Over the last 4 years:

- *~ 20% of Mallacoota residential households have installed Solar PV*
- *~ 150kW (Kilowatts) solar generation capacity is installed*
- *~ 100 of 470 [occupied] houses[3] have solar PV*
- *~ $500,000 has been invested in solar PV*

(Figures derived courtesy of Energy Matters and the Australian Bureau of Statistics 2011 Census, [1]).

These roof top solar panels are connected to the local electricity network and eligible for feed in tariff income. The financial arrangements for this are between the home owner and their retailer. These units are permanently connected to the electricity network with the inverter controlling their output and a protection device ensuring that they disconnect when network voltage goes below a certain value (anti islanding protection) for safety reasons.

Network disconnections mean power is not available to the household through solar PV generation, feed-in tariffs are not realised and potential generation is lost unless individual household battery storage is available.

Commented [TH14]: Here you quote an earlier document that says there are 470 households and later use the figure 440. Robin says there are actually 750 houses of which some 250 are unoccupied. The point he makes is that there are quite a number of unoccupied houses that have PV, I think with (at least) the inference but that their electricity usage is much less than the averages used in the report.

Commented [DN15R14]: Inserted a footnote mentioning the figure from 2011 census which is 751 here.
Of the occupied houses, 8 are attached to a shop etc, 10 are in the 'caravan/cabin/houseboat' category. In terms of properties serviced by SP Ausnet we assume that at least the 10 caravan/cabin/houseboats are not.

3 Using 2011 census data, there are 468 occupied houses and flats in Mallacoota plus 283 unoccupied houses, totalling 751 houses. Word in [brackets] inserted by Enhar.

If for any reason the Mallacoota network is not functional for longer periods of time it is possible, with additional protection, smart inverters and storage that the solar output can be used to supply consumers connected to the "islanded network" at Mallacoota. Whilst technically feasible further studies would be needed to test the practicality from an ownership, energy retailing, protection and switching and safety point of view. [1]

6.6.1 Enabling existing solar PV to be utilised during outages

Residents with solar PV installed already have many of the components of a full independent power supply. The primary additional components which would be required to be installed at properties with solar PV are:

- Battery storage system
- Control system delivering Uninterruptible Power Supply (UPS) functionality
- Islanding functionality in times when external grid is unavailable

Collectively, these components are called an Energy Storage System (ESS).

ESS systems such as this have been installed at Mallacoota, but are rare.

With these components, properties with solar PV would be able to supply their own power during both transient and sustained outages. This would improve both the power quality and reliability of supply issues experienced by the resident.

Challenges of this scenario include:

- High cost of battery systems required to meet several days of demand during outages.
- One system per property must be installed therefore for equity, all properties would require to be provided with a system.

Existing solar PV customers may be enjoying premium feed in tariffs and might be concerned about the impact on their financial position in regards to feed in tariff earnings, if an ESS system were to be installed.

For existing solar customers on a feed in tariff, Enhar's experience is that it is possible to install a new solar PV system isolated to the new battery system, allowing the existing solar array to continue exporting to the grid and continue earning the feed in tariff. The battery system is charged by the new solar array and ensures that every day some solar power is input to the storage, available for consumption.

The SP Pro manufactured in Australia by Selectronic is a battery control and inverter system enabling battery storage, UPS, solar PV and residential appliances to be integrated and controlled. It is programmable and can for example limit battery energy consumption during outages, to preserve battery energy. It could potentially be configured to be remotely instructed in times of grid outage to cooperate with the town minigrid.

6.6.2 Adding battery storage and solar PV to properties currently without solar

For customers currently without solar PV, the configuration of an ESS and PV system is different and can be more easily integrated.

The number of market-ready ESS products has increased dramatically in recent times and includes Nedap power Router, SolarGrid ESS from Solar Inceptioin, Freedom Power Bank from Zen Energy, Sunverge, Sunsink, Voltlogic, Positronic and more.

6.6.3 Cost of residential battery storage solution

A recent market review by Enhar has identified the typical current cost of energy storage in the residential scale at AUD$1,500 per kWh-e where kWh-e = effective capacity. Effective capacity means when discharged to the recommended discharge depth, not fully discharged. $1,500/kWh-e is the typical price when adding ESS to a residential solar system already being installed, i.e. the marginal cost of installation of the ESS is lower due to solar installers being present on site already.

A typical installed cost for a 20kWh ESS system might be in the order of $20-$30,000 excluding the solar PV.

In discussions at the community consultation event, one resident who already has solar PV expressed that if an ESS solution could be provided for around $5,000 it might be acceptable, however the resident felt it was a risky option due to the complexities of the technology and potential unexpected costs. Wider community opinion regarding affordability will need to be tested if this or other options requiring personal investment are to be developed further.

6.6.4 Charging distributed batteries from the grid

Customers without solar premium feed in tariffs, including those with no PV at all, would be able to charge battery systems from grid e.g. in off peak times.

Customers operating premium feed in tariffs may be prevented from charging batteries from the grid due to difficulties in discerning whether exported power has legitimately come from the solar PV system, or from the battery system which had been charged from the grid.

For the distributed storage to offer supply security during outages, it may need to be a requirement that all owners of ESS systems keep their batteries mostly charged as a security measure in the event of an unexpected grid outage.

Customers with both ESS and solar PV would fare better during grid outages. This is due to the fact that once ESS was depleted overnight, the solar PV system would recharge the batteries during any periods of surplus solar generation.

6.6.5 System Design

Typical Victorian residential load profiles indicate around 17kWh per day usage [16]. Mallacoota residences have been analysed including power bills and it was found that a residence using electric hot water uses around 18kWh/day and a residence which has moved to solar hot water uses around 7kWh. The detail of the size and occupancy of these residences has not been assessed, and while these figures are a small sample of data, they are useful for the purposes of estimating daily usage at Mallacoota.

During outages, it could be feasible to expect residents at Mallacoota to economise on power usage. Especially if completely reliant on their own battery system, a different electricity consuming behaviour would be inevitable.

In terms of system design for output requirements per day, residents might be expected to be able to use half of their usual demand during times of outage.

For design, we will consider a winter scenario (typical June solar conditions) which is when residential electricity demand is high and solar radiation is lowest.

Due to water heating requirements, mostly met through electrical systems in Mallacoota, the minimum reasonable electrical demand during outages might be around 8.5- 10 kWh/day for a residence with electric hot water.

Commented [RC16]: Changes made in response to EGSC suggestions.

Commented [TH17]: On the surface this doesn't compute. In 3.2.2 you say avg use of electricity for electric hot water heating is 2-3kw. So, it seems important to me to explain why a residence that switches to solar hot water reduces on avg by 11kwh/day. This is important. As is the number of solar hot water units in Mallacoota because you go on to use 8.5-10kwh in calculations for demand management when that is more than the total you say solar hot water users use. Surely we would also reduce our use as much as electric hot water heater users. Thinking about it now I guess we would go up because we'd have to use electric boost if we had it.

Commented [DN18]: We are not including analysis of the residence size or occupancy rate, just reporting on data which have been given to us from 2 local residents. It was known that one residence (Brian's, data given for purposes of this report) has solar water heating and the other has electric hot water. This is one comparison of 2 properties, and does not include consideration of property size and occupancy. In Brian's case he advised that he used 13kWh/day before the solar hot water system was installed and 7kWh/day after i.e. a saving of 6kWh/day. If MSEG can obtain a larger number of bills from a wider sample of individual local residences, or S Ausnet can supply anonymous data, we would be willing to include analysis of extra data however we feel the data we have collected thus far is sufficient for the purposes of this section. In terms of design, the 8.5kWh is a figure which we use for the mid-way case i.e. allowing for some residences which use larger amounts of energy and some residences which use smaller amounts of energy.

Commented [TH19]: This is strictly an assumption or inference and should be noted as such. A careful read to locate these sorts of assumptions and name them would be very worthwhile.

Commented [DN20]: Tricia we do have to make some assumptions to produce this report, I am a little uncertain about locating all the assumptions, we feel it is legitimate and valid to include assumptions within the relevant sections as we have done here.

Commented [TH21]: As above.

To deliver 8.5kWh per residence (operating in 'energy efficient' mode), a 4.5kW solar PV array with a 7kWh battery storage system would provide sufficient energy for the residence over a period of several days. This is based on modelling by Enhar which seeks the optimum balance of PV and ESS sizes to deliver a required amount of energy per day.

Indeed a residence with such a system could continue supply its own power for longer than a few days, providing they consumed less than 8.5kWh per day as the solar input each day would consistently recharge the batteries during the day. Extended periods of cloudy weather would reduce this, for example the June 2012 weather event combined flooding with cloudy weather and outages.

During spring, summer and autumn, such a system would export to the grid, as shown in Figure 6-22 below. If the local grid were operated as a minigrid at these times, then this solar export could support the local system.

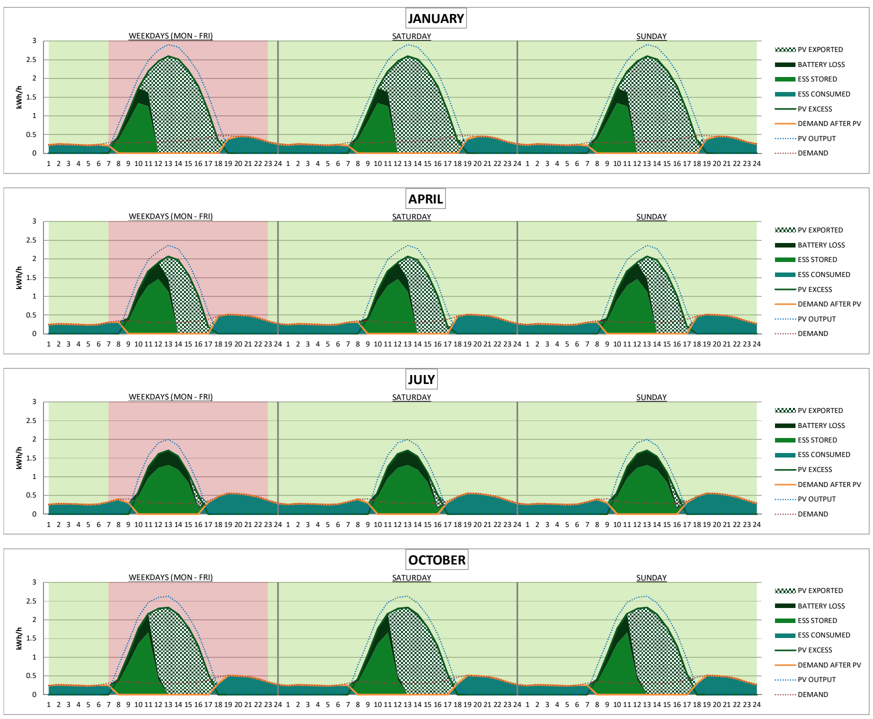


Figure 6-22: Behaviour of 4.5kW solar and 7kWh battery storage system in Mallacoota

During periods of extended cloudy weather, the residence would generate less power than it requires and experience some shortfall. There would however always be some power available every day regardless of the weather, a substantial improvement on the status quo.

In addition, the presence of battery and UPS system in every residence would give continuous power during momentary outages, another benefit of this approach.

As noted above, typical installed cost for a 20kWh ESS system might be in the order of $20-$30,000 excluding the solar PV. If energy-saving behaviour during outages is taken into account, the system size required at Mallacoota residences could be reduced and total price might be significantly lower. For example, a 7kWh-e ESS might be expected to cost around $11.5k unsubsidised.

Roof area required

In the residential case, for 4.5kW of solar PV, around 29 square meters of unshaded roof is required. North facing slope between 20 and 30 degrees is optimal, however other orientations generate worthwhile amounts of energy also.

Businesses: For 15kW, around 100 square meters of roof area is required.

6.6.5.1 System design for businesses

Analysis of energy bills would be required to establish accurate figures on business energy consumption. As an initial estimate, we take 15 businesses each consuming an average of 100kWh per day.
With energy savings activity this is reduced to 50kWh during times of grid outage. Some businesses would not be able to curtail essential loads, however might be able to fill any shortfall with diesel generators already owned on site.

6.6.6 Business Model

With approximately 100 solar residents at present, a scheme of subsidised supply of ESS systems could be considered for Mallacoota.

To ensure equity, all other residents and businesses in Mallacoota would require to be offered an ESS also. The capacity of ESS provided to each residence could be based on the average daily demand evidenced through the latest year of power bills.

Exported power during times of solar surplus might attract a special tariff if the retailer agreed, this could be arranged to incentivise residents to further increase the size of their solar PV array at their own expense. This may be more likely to occur via a retailer involved in the project.

6.6.6.1 Battery ESS Only

One model could be to provide the ESS only, which would provide approximately 1 day of frugal energy supply for all residences and businesses in the town. Solar PV would be optional and at the expense of the residence or business owner. Bulk-buy could be expected to deliver low cost options for private purchase of PV. The disadvantage of this model is that the batteries are not recharged by solar during outages. Also the system might not be perceived by the customer to create value on a daily or weekly basis, the customer might only be aware of it adding value on an annual basis during the occasional sustained outages. On that basis it might be harder to charge an ongoing fee to the customer, whereas if it is a solar PV and ESS system, the savings on the power bills would be justification for a regular service payment to be recouped if required to support the business model for investment.

If mini-grid operation is established, solar excess provided by those sites with solar PV installed could be offered to those without solar to use and recharge battery systems. This would be contingent on establishment of a mini grid and associated technical and regulatory issues discussed in section 5 of this report.

6.6.6.2 Solar PV plus ESS

If it is essential that the supplied systems supply power for more than 1 day in the event of sustained outages, then some solar PV should also be provided with the ESS. The equity issue might require all residences to be 'topped up' to a common level of solar PV capacity, though those who have already invested in solar may perceive less benefit than those who have not yet invested in solar PV who would receive both a solar PV and ESS system.

The value to the end customer is high under this scenario, as the avoided cost of energy during other times of year (when grid is available) is the full retail price including all charges. The 'generator' is located inside the customer property, 'behind the meter'.

On this basis, an ongoing payment from the customer could potentially be charged to cover battery maintenance and recoup some of the initial investment incurred by the provider of the ESS and Solar PV systems.

6.6.6.3 Distributed vs Centralised value of energy

Under a centralised generator scenario, by contrast, the value of the energy to the end customer is lower as network charges must be borne by the generator. The generator is behind the managed network therefore the retailer must pass on all costs associated with use of network to the customer as well as the price of the power generated.

6.6.7 Costs of decentralised solar PV and storage

Estimates have been made of the total costs involved in providing energy during momentary and sustained outages up to 1 day (ESS only) or several days (ESS with PV), these are summarised in the Table below.

Table 6-9: Estimated Costs for Distributed solar and energy storage

	Quantity	Daily demand during outages	solar PV required kW	Cost of PV inc GST per unit	Total cost for solar PV	ESS capacity kWh	Cost of ESS inc GST	Total ESS cost
Occupied residences with solar, assume 1.5kW	100	8.5	3	$4,667	$ 466,700	7	$ 11,550	$ 1,155,000
Occupied residences without solar	370	8.5	4.5	$7,967	$ 2,947,790	7	$11,550	$4,273,500
Total for occupied residences					$ 3,414,490			$5,428,500
Businesses (all currently without solar)	15	50	15	$26,458	$ 396,870	30	$ 49,500	$ 742,500
Grand Totals					$ 3,811,360			$ 6,171,000

All properties could be provided with solar PV under this scenario for between $3.5 and $4M and battery storage and UPS functionality could be added for around $6M. Total costs if both solar PV and ESS are provided would be of the order of $10M.

If the systems were sized larger to enable residents and businesses to consume the normal amount of energy, rather than a reduced energy consumption, during any outage then the total capital costs for this scenario might be of the order of $15-20M, largely driven by the current cost of battery technology.

The above analysis considers the occupied residences only, totalling 468 in the 2011 census. If the unoccupied residences, numbering 283 in the 2011 census, were also included, the total capital costs would increase by the corresponding fraction, namely 38%.

6.6.8 Evaluation against Option Selection Criteria

Criteria / Goals	Description
Emergency proofing.	Range: 1 = no change to current situation / 5 = minimal risk **Score: 5** A well designed ESS system would enable the resident to operate in island

Criteria / Goals	Description
	mode despite any outage on the lines. Ranking - vital
Community acceptance	Range: 1 = significant risk of community division / 5 = strong support **Score: 3-4** The feedback of community members who participated in the open days is that a central solution which benefits all residents equally is preferred. While significant opposition is not considered likely with the distributed solar and ESS scenario, full community consensus may not be available. Ranking - vital
Ability to supply electricity for extended periods	Range: 1 = low capacity for extended operation / 5 = capacity for operation in 'island' mode for up to five days. **Score: 3** Due to the high cost of battery technology, it is costly to install a large enough solar and battery system to deliver power at the usual consumption rates for long periods. Ranking – very important
Equity	Range: 1 = significant barriers to entry / 5 = no barriers to entry **Score: 2** Due to some properties being unsuitable for solar PV, either through shading or asbestos roofing, it is not possible to install the same amount of PV and ESS at each property. Ranking - very important
Proven robust technology	Range: 1 = unproven technology / 5= well understood technology **Score: 4** The technology, though not cheap, is reasonably well proven, though warranties on ESS systems are not typically longer than 2 -3 years. Ranking - very important
Operation and maintenance	Range: 1 = external expertise frequently required / 5 = locally (or reliably remotely) maintained and operated. **Score: 2**: Due to the maintenance requirements of batteries, external expertise would be required to visit all properties. Ranking - very important
Planning permission	Range: 1 = significant challenges in planning permission / 5 = no anticipated challenges **Score: 5** No permit issues are required. Some negotiations may be required by existing solar premium tariff customers to protect the income stream. Ranking – very important
Economics	Range: 1 = continuing financial cost / 5 = profitable in medium term **Score: 2** The battery solution is not cheap for individual residences, it would probably require a greater than 75% subsidy to achieve a significant uptake. The commercial returns on a subsidised ESS system are restricted to annual maintenance fees therefore obtaining any significant investment towards capital costs from a commercial company would be challenging. Finding >75% subsidy from public funds is also expected to be challenging. Ranking – important
Construction - technically feasible	Range: 1 = significant difficulty / 5 = no barriers to construction **Score: 3** All residences would be expected to have suitable location for ESS however not all residences are suitable for solar PV.

Criteria / Goals	Description
	Ranking – important
Resource abundance	Range: 1 = long recharge time / 5 = rapid recharge time **Score: 4** The solar resource during winter is significantly lower than other times of year so if the outages occurred during winter, it would be challenging to provide for normally energy behaviour. Ranking – important
Intermittency protection	Range: 1 = brief interruptions continue in moving from standard to 'island' mode / 5 = brief interruptions significantly reduced **Score: 5** ESS with UPS functionality would work well for reducing brief interruptions. Ranking - important

Distributed solar with ESS is an option which would deal with the current energy issues, and is recommended for residences in Mallacoota who are financially able to invest in a system.

However overall it is not a recommended town-wide solution. This is due to the fact that not all residences are suitable for solar PV, ESS costs are currently high and as a commercial model it would be difficult to generate ongoing revenue from a roll out of PV and ESS, therefore making it difficult to attract enough investors to the scheme. The private investment appetite is not considered high enough, or wide enough, for all properties (residential and commercial) at Mallacoota to pay the current market price for PV and ESS and even if it was, some residences are not suitable for PV so would miss out.

While grant funding, and network support payments, might be able to meet some of the funding gap, it is considered less viable than a central system discussed below.

6.7 Centralised solar thermal plant

Concentrated Solar Thermal (CST) technology comprises of reflecting mirrors concentrating solar heat energy onto a receiver. The receiver collects the heat energy and delivers it to a standard steam power generator. The technology is maturing rapidly with 2 GW of installed capacity internationally driven by Spain and US. In particular two large CST systems are under construction in America in the 100 – 150 MW scale at Tonopah and Ivanpah. Ivanpah has officially started producing energy and has a final capacity of 392 MW. Inland areas of Australia have some of the best solar resources in the world for CSP technology, however it remains only a small fraction of total energy projects in Australia.

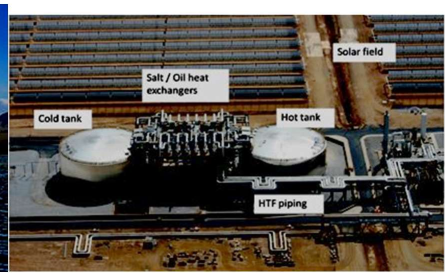


Figure 6-23 [Left] Ivanpah CST Power Station (Source: Ivanpahsolar.com) [Right] Molten Salt Thermal Storage System (Source IT Power 2012)

CST can be combined with thermal energy storage using molten salt. This provides dispatchability capacity and can even offer full 24 hour a day energy supply. This system is shown to the right of the Figure above.

The three main types of CST are trough, linear Fresnel, and central receiver (tower) systems. Trough and Tower systems are preferred because of their ability to generate temperatures required for a standard steam generator. Central receiver systems are intended for large scale systems as they require a large mirrorfield focussing heat on a central tower. Trough systems are more mature technology and offer flexibility in size and application.

A report by IT Power and Australia Solar Institute in 2012[17] assessed the practicalities of a small CST system. In general it concluded that whilst systems down to 1MW capacity are viable, they have *"the greatest uncertainty in both the cost and value estimates".* It indicates that *"CST systems have not been seriously proposed commercially on such a small scale."* So whilst it's technically feasible to design a system at the 1 – 2MW scale it would be a novel exercise and likely to be much higher cost than those expected for > 50 MW systems.

IT Power put the LCOE for off-grid/mini grid systems in Australia at:

- No Storage – 40c/kWh to 50 c/kWh
- With storage – 50 c/kWh to 60 c/kWh

This is double the LCOE experienced with large CST generators.

6.7.1 Evaluation against Option Selection Criteria

Criteria / Goals	Description
Economics	The ability of the CST option to generate an income and pay back capital investment is difficult due to the higher capital costs compared to other technologies considered. Range: 1 = prohibitive financial cost / 5 = profitable in medium term **Score: 1** Ranking – important
Community acceptance	Range: 1 = significant risk of community division / 5 = strong support **Score: 3** CST can require tall structures (receiver tower) which could be taller than surrounding trees therefore visible from the surrounding area. This amenity impact could be expected to raise some concerns in the community. Ranking - vital

Due to the economics of this technology, the installation of CST system for Mallacoota is not a recommended option.

6.8 Centralised solar photovoltaic

A centralised solar farm with centralised storage has been evaluated using solar radiation satellite data by BOM Climate data online specific for Mallacoota. Estimated solar system electrical outputs have been calculated based on typical solar panel technical properties, typical inverter efficiencies and losses due to temperature. The average system outputs per hour of each month, the daily average per months and average annual outputs have been calculated.

The solar data and system outputs were used to determine the minimum size of land coverage that would be required to meet the energy demands for the town, for different solar systems including:

- Fixed tilt solar arrays at 30˚ (optimum orientation) and 60˚ (to maximize solar generation in winter months
- Single axis tracking arrays that follow the sun from east to west over the course of the day
- Dual axis tracking arrays

In parallel with the desktop study, site visits to potential solar farm locations were completed to determine suitable locations.

The solar modeling conducted comprised of providing a solar PV system with battery storage that will meet the electrical demand of the town at any time of the year during an outage.

Inputs to the solar modelling included the annual electrical demand data for the town as well as the solar radiation profile.

In the case of emergency relief, during a sustained power outage a well-designed solar farm coupled with an energy storage system has the potential to provide the community with a reliable power supply. However the ability and rate at which it could deliver the electricity would depend upon the energy storage capacity and the charge rate of available storage is determined by the solar radiation under variable weather and seasonal conditions. Although not difficult to forecast solar radiation accurately on a monthly average timescale, the available solar radiation has the added uncertainty of unpredictable cloud cover which influences output and hence the rate of charging has uncertainties. This incurs a need to add contingency to the amount of storage in order to cope with a situation when an extended power outage occurs during unusually cloudy weather.

In regards to designing a solar PV solution to be capable of providing reliability to the town if a grid outage occurred in any season, the most challenging scenario is during winter months when solar radiation is at its lowest levels, whilst the site average demand is similar to summer months.

Coupling a solar PV system with a diesel backup generator is also considered, as it removes the need for large scale battery storage during outages.

6.8.1.1 Site Selection

An analysis of potential sites for large scale solar farms within Mallacoota was conducted. A solar farm requires significant areas of flat land with limited shading obstacles, in addition to land areas which have access to suitable grid connection points and land owners who would be willing to host a system.

Enhar calculations and industry publications [18] evaluate solar farm generation capacity per hectare at around 0.4MW per hectare for fixed angle systems (non-tracking) and for tracking systems it is XXMW per hectare. A range of potential land areas for solar systems have been analysed as shown in the Table below.

Commented [TH22]: Add relevant equivalence figure.

Table 6-10: Centralised Solar PV site summaries

Site Name	Size of potentially suitable area	Potential PV Generation Capacity (fixed axis), DC rating	Comments
Sewage Treatment Plant western area	8.7 Hectares	2.5 – 3.5 MW	Favoured site
Sewage Treatment Plant eastern area	4.8 Hectares	1.5 – 2 MW	Favoured site
Airport East	10 – 15 Ha	4 – 6.1 MW	

Site Name	Size of potentially suitable area	Potential PV Generation Capacity (fixed axis), DC rating	Comments
Airport North-West	7 – 8 Ha	2.8 – 3 MW	Impact on aviation may be a problem
Airport South-West	7 - 8 Ha	2.8 – 3.2 MW	Impact on aviation and gun club may be a problem
Lakeside Drive	1.5 Ha	0.6 MW	Construction on sloped land would be more complex
Genoa Road	15-18 Ha	6.1 - 7.3 MW	Sparse vegetation would require to be cleared.
Watertrust Road	5-6 ha	2 – 2.4 MW	Closest additional site to the sewage treatment plant

It emerged that the sewage treatments works is the most viable site from several perspectives including grid infrastructure, ease of planning and the support of East Gippsland Water.

Potential locations for solar at the sewage treatment plant are shown below.

Figure 6-24: Areas potentially suitable for solar PV generation at the sewage treatment plant

6.8.2 System Design

There are various solar PV system designs possible including fixed tilt arrays, single axis tracking arrays and dual axis tracking arrays.

With the cost of solar PV panels decreasing dramatically over recent years, the additional capital and maintenance costs required to install tracking arrays means that fixed tilt solar PV arrays are becoming more prominent.

Fixed solar PV systems tilt the frame at an optimum tilt angle to maximise annual generation. The optimum tilt angle is generally at or close to the latitude of the site.

Some images of photovoltaic plants are shown below:

Figure 6-25 Examples of Solar PV arrays

6.8.2.1 Solar PV outputs – Fixed array

Fixed array panels can be tilted at various angles. The optimum tilt angle is facing true north at an angle approximately equal to slightly less than the latitude of the site, typically approximately 30˚ for sites at Mallacoota latitude (38˚). Winter performance can be increased by increasing the panel tilt to latitude +15˚ and summer performance can be increased by decreasing the panel tilt to latitude -15˚.

For this analysis we have analysed two fixed tilt arrays:

- A solar system at 30° facing true North to maximise total annual solar PV generation.
- A solar system at 60° facing true North to increase solar performance in winter months.

The modelling below considers a 1MW system, for ease of comparison between the technologies and tilt angles.

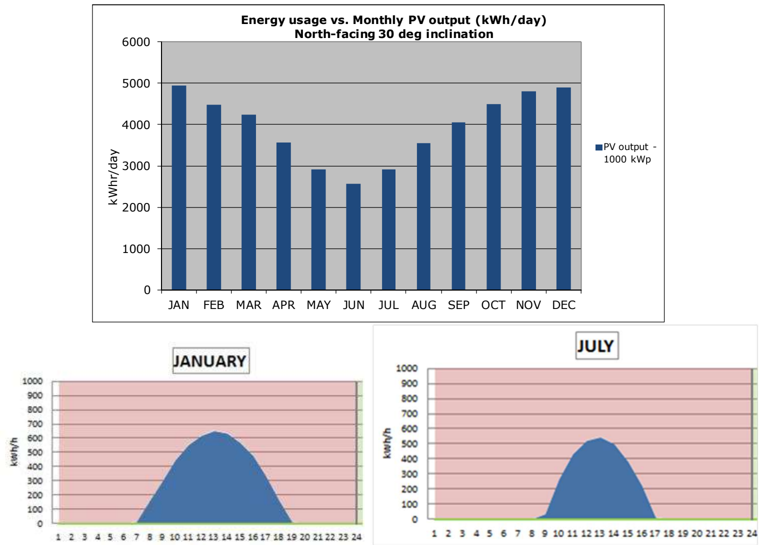


Figure 6-26: Average Daily PV outputs for 1000kWrated array for 30⁰ tilt, and average hourly outputs for January and July.

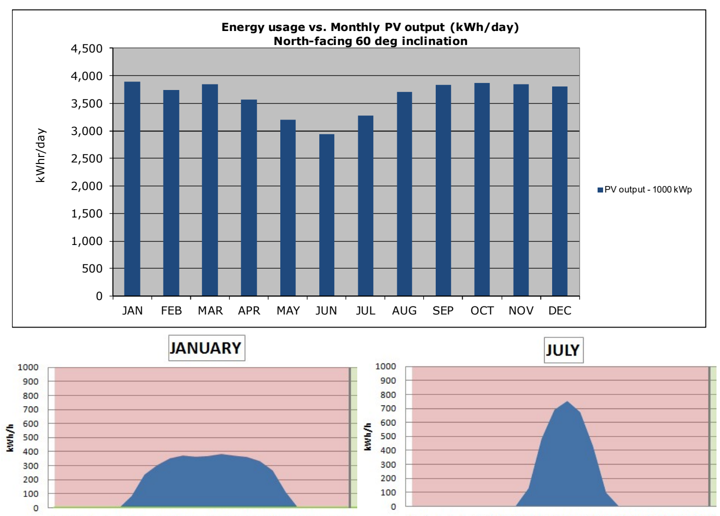


Figure 6-27: Average hourly PV outputs for 1000kW rated array for 60⁰ tilt

The calculated outputs will vary dependent in PV panel types and quality, and the electrical design of the system.

6.8.3 Tracking Arrays

The two most common tracking systems are:

- A north-south axis tracking system with a fixed tilt i.e. the system tracks the sun from east to west during the day
- A dual axis tracking system i.e. the system tracks the sun over the course of the day from east to west and north to south

Tracking PV systems are more expensive to install and also maintain, however do provide additional output compared to a fixed tilt panel array. They require a greater land area due to increased shading lengths between arrays.

Commented [TH23]: More expensive by how much? From your charts it seems they increase generation by about 1/3. Does this cover increased costs?

6.8.4 Single Axis North- South axis tracking array

Single axis tracking arrays are relatively common for large solar farms and track the sun from east to west over the course of the day, with a north-south tracking axis.

The fixed tilt angle of single axis trackers can have varying pitch from horizontal to the site's latitude angle. The higher the fixed tilt angle the greater the land area required due to additional shading required between array rows.

The optimum angle for the fixed tilt is approximately 30-35^0 for Mallacoota to maximise energy generation over the year. Land area of around 3.5 Hectares/MW is optimum.

Maintenance and installation costs are higher for tracking systems compared to fixed tilt arrays; however the output is increased over the course of the day.

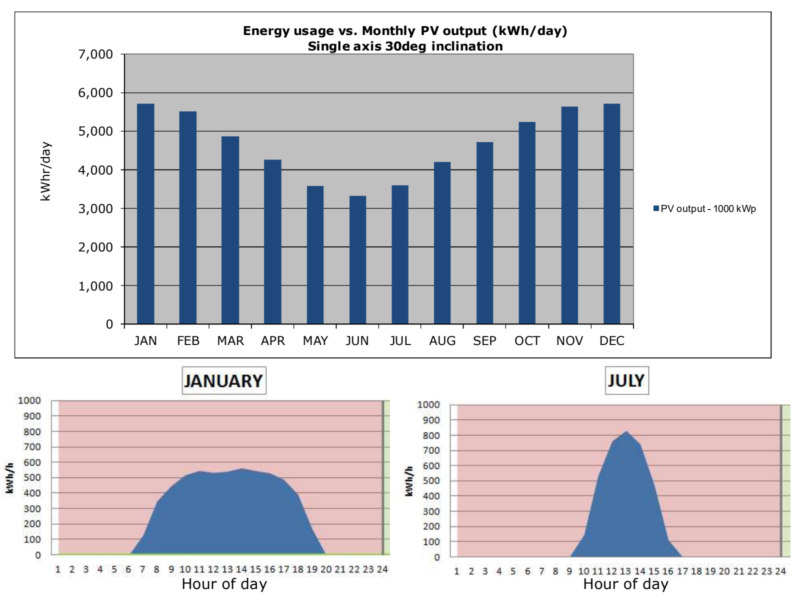


Figure 6-28: Average Daily PV output for north-south tracking array at different tilt angle 30^0 and average hourly outputs.

Commented [TH24]: The Y axis label is unreadable in the Bar Chart above.

Figure 6-29 Example tracking array

6.8.5 Solar PV output – dual axis tracking array

Dual axis tracking arrays always face the sun. There are various commercial designs to provide the tracking mechanisms. These systems require the highest maintenance and capital cost of any of the solar PV systems. Land area of around 5.3 Hectares/MW is optimum.

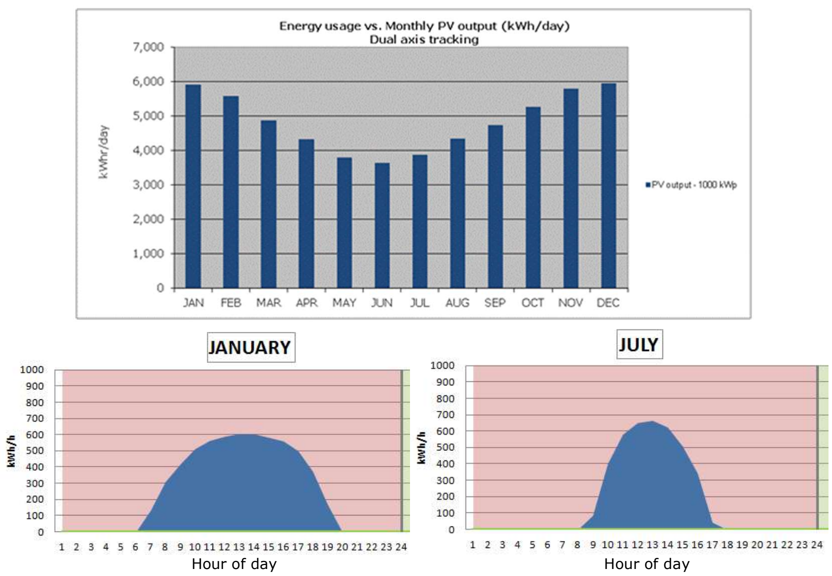


Figure 6-30: Average Daily PV output for dual tracking array and average hourly outputs for a 1000kW (DC) PV system.

6.8.6 System Optimisation

The table below analyses different system sizes to meet total net annual electrical demand of the Mallacoota township, which is around 8 GWh/year. Around 15% losses occur from the DC side to the AC side (inverter losses etc).

Solar PV design	MWhr/yr per MW(AC)	System size to meet net total annual demand (MW AC)	Approx. Total land area required (hectares)	Available land at sewage treatment plant
Fixed tilt array (30^0)	1,425	4.80	13.5	Yes
Single axis array at 30^0 (tracking east to west)	1,690	3.80	13.4	Yes
Dual Axis tracking array	1,740	3.65	19.2	No

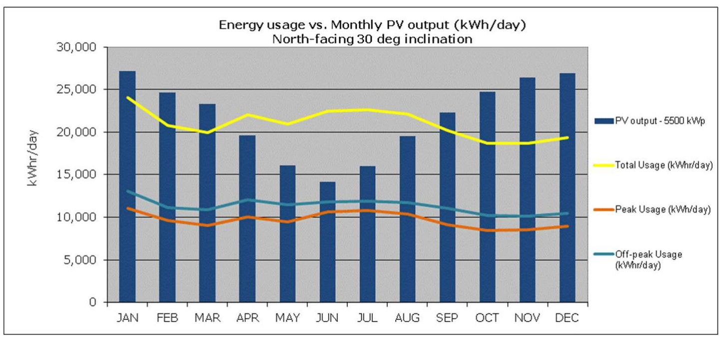


Figure 6-31: Average Daily PV output 4.8MW (AC) to generate equivalent of total 8GWh/year electrical demand.

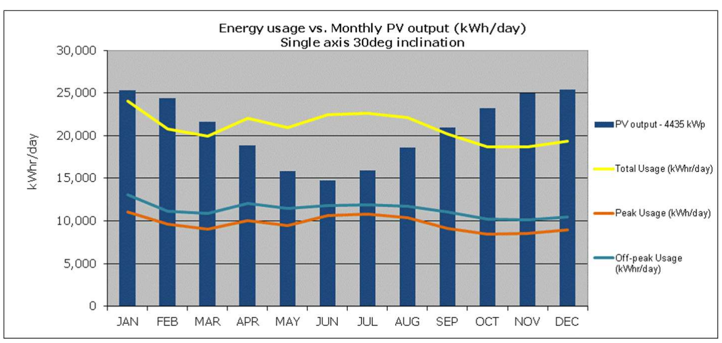


Figure 6-32: Average Daily PV output 3.8MW (AC) single axis tracking system to generate equivalent of total 8GWh/year electrical demand.

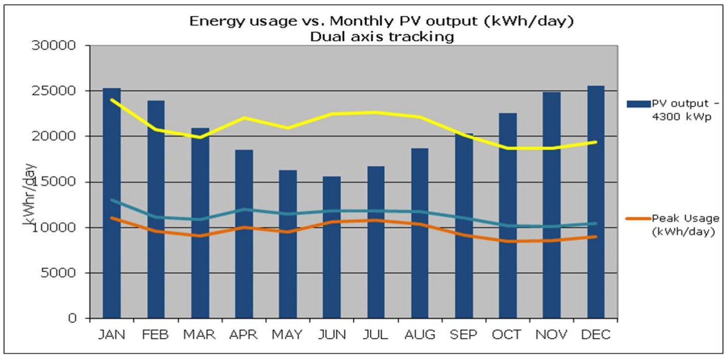


Figure 6-33: Average Daily PV output 3.65MW (DC) dual axis tracking system to generate equivalent of total 8GWh/year electrical demand.

6.8.7 Costs of centralized Solar Photovoltaic

The capital cost of solar photovoltaic systems continues to decrease dramatically due to accelerating global uptake, economies of scale and competition.

Recent industry data indicates that capital cost for solar PV fixed tilt system in the 5-20 MW scale is around $2.2-$2.5M/MW [19].

Due to the rapidly decreasing price of solar PV panels of recent years, the increased infrastructure and maintenance costs of installing single and dual axis tracking arrays is normally not justified. An approximate increase of 15%-30% in total installed price is expected for tracking arrays dependent on the tracking system; operation and maintenance costs will be approximately double for tracking arrays. The increased energy production per MW of solar capacity installed with a tracking array is offset by the increased installation, operation and maintenance costs.

Commented [TH25]: What are these costs? Need actual $$s or equivalence with respect to fixed.

With reference to Australian Energy Technology Assessment report, 2012, published by the Bureau of Resources and Energy Economics, the following information on LOCE for the various solar PV systems is provided.

Table 6-11: Relative economics of solar arrays with and without tracking

Solar PV design	**LOCE (2012) $/MWH**	**LOCE (2020) $/MWH**
Fixed tilt array (non tracking	$155 – 260	$60 – 180
Single axis array (tracking east to west)	$160 – 270	$80 - 220
Dual axis tracking array	$210 - 350	$120 -$280

Table 6-11 illustrates that fixed tilt arrays (non tracking) provide the lowest range cost of energy both now and forecast in the future. If land area is in short supply, single axis tracking can be a sensible approach as it will produce energy at the same or slightly higher cost but using less land overall. At the sewage treatment works there appears to be sufficient area available to use fixed tilt arrays.

6.8.8 Solar with Large Scale Battery system

This section considers a large scale solar photovoltaic array coupled with a large scale battery storage system.

6.8.8.1 Yield of Fixed Tilt Solar PV and Storage requirements

Outages in recent years include storm events in winter, when solar radiation is at its lowest.

Modelling has been performed to derive a solar PV-battery system size which is capable of delivering the whole power demand of the town at all times of year including winter. During this event, it is assumed that demand management of 200kW is operating, which reduces demand by 200kW compared to average load conditions.

Some results are shown below:

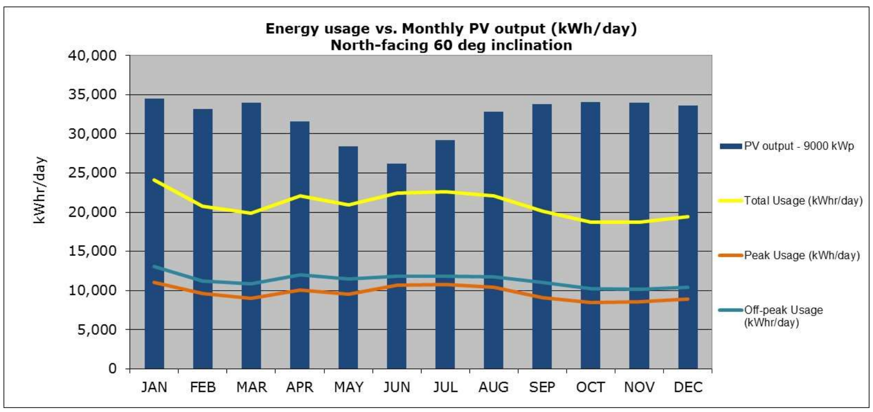


Figure 6-34: Yield for a 6MW (AC) solar PV system capable of supplying the whole town year-round, if coupled with large scale battery storage

This demonstrates that in winter, with 200kW demand management, a 6MW(AC) solar array would generate sufficient power to power the town if coupled with a large storage system. Significant storage would be required to time-shift the daytime generation. Since some energy is lost in the losses of the storage circuit, an excess of solar power is required at all times of year including winter.

Initial modelling indicates that 13.5MWh of battery storage would be required. The behavior of the storage and PV system in different seasons is shown below:

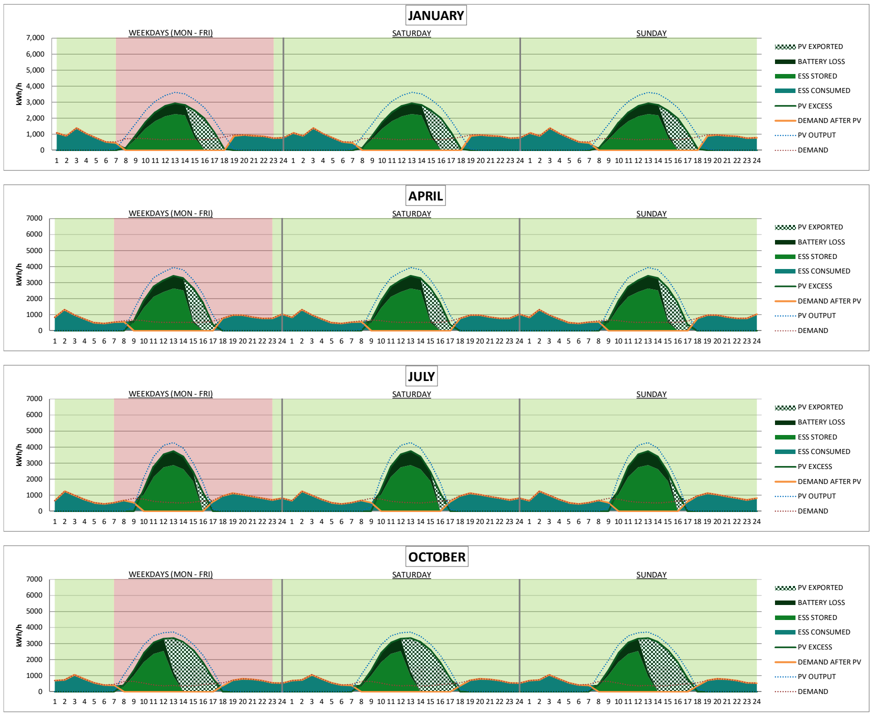


Figure 6-35: Simulation of 6MW (AC) PV with 13.5MWh of battery storage, panels at 30 degree tilt

This scenario was selected as one capable of powering the whole town all year round i.e. being capable of providing reliability at all times of year. Highly cloudy conditions would still lead to shortfalls when successive days have low solar radiation, these events have not been modelled.

The battery cost for 13.5MWh would be in in the range of $6.5M-$8.5M using lead acid technology (see section 7.2.2.3 below for more information about batteries).

As with all centralised energy storage systems, the system may not have the ability to always provide power to all residents during periods of an internal fault within the town. Decentralised storage could be considered in tandem with this solution for minimising short term outages arising due to local faults.

6.8.9 Solar Photovoltaic array with diesel/gas backup

This section considers a solar array designed for year round generation, with diesel backup operated for night time generation during outages. Although consuming some fossil fuel, this scenario removes the need for large battery array which would provide a very significant cost saving. Adding a diesel generator is very helpful for the network islanding as a spinning generator provides system stability.

During outages, the solar array would in this scenario enable the system to meet peak demand during daytime, with the diesel generator running at low load to provide network stability. At night time, the diesel generator would be required to meet the full demand.

The solar array sizing is flexible in this scenario and is driven by the need for the solar system to create sufficient revenue to fund the diesel generator and other equipment for islanding. The size of the solar array is limited through factors such as land area and line export capacity.

As illustrated above, a system could be designed which generates the same output on an annual basis as the town consumes on an annual basis, around 8GWh/year. This would create the outcome where the whole town, at a future time, could choose to purchase power from a retailer associated with the Mallacoota generating plant.

Also it creates the situation that the town becomes 'carbon neutral'.

A 4.5-4.8MW (AC) rated solar array with fixed tilt at 30 degrees would generate approximately 8 GWh/year, matching the town annual consumption.

The sizing of the central diesel generator is around 1.6MW, this is elaborated further in sections below. Other existing local diesel generators could also contribute during islanding mode which might reduce the capacity of the central diesel generator however a system design is considered which does not rely on the existing local diesel generators.

Commented [TH26]: It would make sense to comment on solar array with small battery backup and diesel generator here somewhere.

6.8.10 Other matters relating to solar generation

Utility scale solar PV systems are rated as one of the more established alternative energy sources on the market and it is feasible that a viable commercial enterprise could be envisaged.

A major challenge with a large solar system scenario could be the capacity of the grid line to handle export of solar during summer months when up to several MW of solar capacity would need to be exported away from the town. Initial enquiries with SP Ausnet have indicated that export of the capacity required would be technically viable, subject to suitable studies to verify safety issues.

Centralised solar with an diesel generation system has the advantages of being a developed technology, extensively supported in terms of investment opportunities and is likely to be publically acceptable due to the fact that the project is in one location and not likely to be visible to local residents. Additional advantages are that this type of system is relatively rapid to install and has low operating and maintenance costs.

One disadvantage of centralised solar systems compared to wind turbines is that they take up a large amount of physical space and require a consistent flat topography with little or no shading. The available site at the sewage treatment plant however offers sufficient flat land to accommodate at least 4.5MW (AC) of solar photovoltaic generation.

A solar system with a diesel generator is a significantly more cost-effective scenario than solar coupled with battery storage.

6.8.11 Evaluation against Option Selection Criteria

This considers the option of a large solar system, potentially combined with other generation/storage.

Criteria / Goals	Description
Emergency proofing	Range: 1 = no change to current situation / 5 = minimal risk **Score: 4** During high fire risk periods, solar radiation is likely to be high. A solar system could generate well in those conditions, however the effect of temperature on solar cell efficiency would have to be considered. Ranking – vital
Community acceptance	Range: 1 = significant risk of community division / 5 = strong support **Score: 5** During community consultation sessions, solar was the most widely accepted of all the solutions discussed. This was particularly as local residents have solar

	systems and understand and trust the technology. A central solar system was favoured over decentralised solar as not all residences are suitable for solar. Ranking – vital
Ability to supply electricity for extended periods	Range: 1 = low capacity for extended operation / 5 = capacity for operation in 'island' mode for up to five days. **Score: 5** If coupled with a diesel generator or storage, solar could provide power during extended periods. If weather was cloudy, the extended periods would be achieved by the diesel or storage. Ranking – very important
Equity	Range: 1 = significant barriers to entry / 5 = no barriers to entry **Score: 5** The central solar PV option offers equal benefit to all local customers and as an established technology has a low risk profile both technically and financially. Ranking - very important
Proven robust technology	Range: 1 = unproven technology / 5= well understood technology **Score: 5** Solar PV has been deployed globally at a rate fast approaching that of large scale wind. With hundreds of Gigawatts of capacity now installed globally, solar PV is a well understood technology. Ranking - very important
Operation and maintenance	Range: 1 = external expertise frequently required / 5 = locally (or reliably remotely) maintained and operated. **Score: 3** Maintenance in terms of cleaning can be done locally. Specialist planned maintenance can be provided remotely and unplanned maintenance would also be remote, with potential for local solar electricians to be employed. Ranking - very important
Planning permission	Range: 1 = significant challenges in planning permission / 5 = no anticipated challenges **Score: 4** Permits are expected to be relatively straight forward. Some assessment may be required of fire risk, impact on birds and on grazing. Ranking – very important
Economics	Range: 1 = prohibitive financial cost / 5 = profitable in medium term **Score: 4** Solar PV is a relatively inexpensive and well understood technology. The capital cost would require government subsidy in order to offer power at a market competitive rate, however specific government funding has been identified which could be suitable for closing this gap. Ranking – important
Construction - technically feasible	Range: 1 = significant difficulty / 5 = no barriers to construction **Score: 5** The site identified is highly suitable as it is both flat and extensive. Ranking – important
Resource abundance	Range: 1 = long recharge time / 5 = rapid recharge time **Score: 4** The Mallacoota solar resource is at a level suitable for year-round generation. During outages, night time generation is required from an alternative source such as diesel or battery storage. Ranking – important

Intermittency protection	1 = brief interruptions continue in moving from standard to 'island' mode / 5 = brief interruptions significantly reduced **Score: 3** a solar-diesel system does not provide protection against momentary outages, however could be coupled with equipment which does provide some degree of intermittency protection. Ranking – important

Due to its high score on both vital and important criteria, a large central solar array is a recommended option for Mallacoota. The solar recommendations are discussed in more detail in section 8 'Potential Solution' below.

6.9 Centralised wind turbine in the 0.5 – 3MW scale.

Wind energy is a highly established form of large scale renewable generation and was included in the scope of this study.

6.9.1 Site Selection

Following an initial site selection process that looked at available suitable areas of land in the Mallacoota region, proximity to coastline (free wind stream) and proximity to local nearby residences the highest ranked sites were selected to undergo further investigation. A site visit was undertaken by Enhar employees on 9th September 2013 to further investigate the sites identified as having potential to accommodate a turbine. This was both from a technical viewpoint and considering impact on views and community acceptance.

In terms of site selection, the size of turbine being considered has important implications. Research into suitably sized wind turbines was completed by Enhar. A number of criteria were considered including availability of turbine supply, economics, brand reputation, suitability for the Australian market, and readiness to offer long term operations and maintenance agreements and performance guarantees.

Enercon are among the few turbine suppliers who have a track record of supplying individual turbines. A turbine model considered in the feasibility analysis is the German designed Enercon E101 3MW wind turbine, which is a horizontal axis turbine with a rotor diameter of 101m. The calculations in the analysis assume installation on a concrete monopile, steel tubular tower at a hub height of 99m. Additionally an Enercon E48 wind turbine on a 50m tower has also been included in the yield calculations for mixed energy generation system comparison purposes. Other turbines which could potentially be considered include Goldwind and Repower.

The four optimum locations identified in the selection process were the Golf Course, the Airport, the wastewater treatment facility and the a hilltop area adjacent to the replanted gravel pit area beside the incoming grid lines approximately 5.5km to the west of Mallacoota. These sites are shown below.

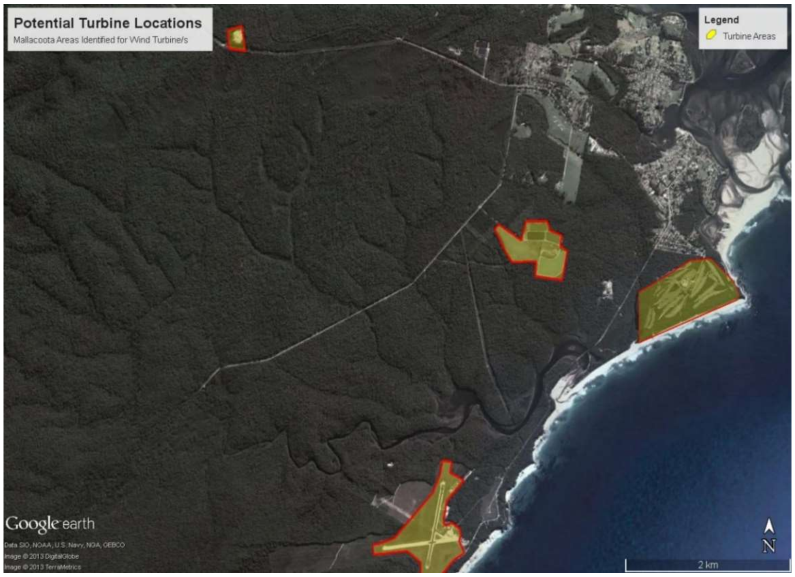


Figure 6-36 Potential Wind Turbine Locations

Each site was further assessed against a number of site specific criteria including, aviation, landscape values, planning requirements and designations, determination of obstacles affecting wind flow and turbulence, site constraints (access and infrastructure), noise, shadow flicker and grid connection.

Victorian Planning Provision Clause 52.32 gives guidance on 'Wind Energy Facility' developments within the Planning Scheme. This includes 2km setbacks to residential properties, unless written permission is obtained from local residents, and exclusion zones.

2km setbacks to residential properties

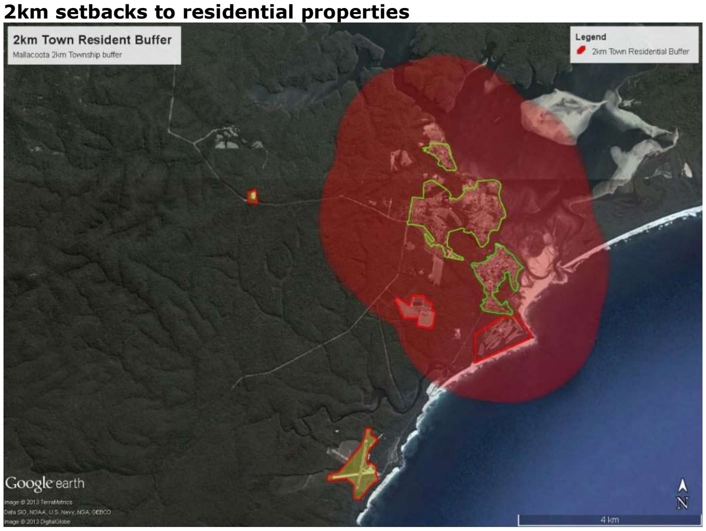


Figure 6-37 2km Mallacoota Township Buffer

Figure 6-38 above shows a 2km buffer from the main township areas. The waste water treatment facility and golf course is within this 2km red zone.

Golf Course
The golf course is an ideal location in terms of resource due to maximising exposure to the coastal winds, potential grid connection possibilities, and the footprint of a wind turbine lends itself to being particularly compatible with the current land use (so long as sited such that it cannot interfere with golfing activity).

The major disadvantage for this location is the proximity to nearby residences (possible noise and shadow flicker). More importantly, this area has been identified as an area with noteworthy landscape amenity values.

The E48 is considered to be a medium scale turbine but is still very large and will make a considerable impact on the landscape views when looking out to the coastal seas from the golf course and town. The E101 is a much larger turbine and would have significantly greater visual impacts.

Mallacoota Airport
The airport location has the advantage of greater distance from local residences causing fewer potential problems relating to noise and shadow flicker. The airport is located adjacent to the coast which in terms of wind resource is ideal (wind speeds are high over water). Although grid connection is more difficult than the golf course, there is a nearby possible HV connection point approximately 400m to the east of the site boundary.

The principal concern with the airport location is the proximity to the runway. Any object that stands above the 'obstacle restriction area' becomes an obstacle for aviation purposes. The obstacle restriction areas include the runway end safety areas and a specified boundary region around each runway. Only equipment and installations required for navigation purposes sited in such a manner as to reduce the hazard may be approved.

Enhar contacted the Civil Aviation Safety Authority (CASA) and the advice was in the first instance to contact the operator of the airport to discuss specific requirements, no mitigation circumstances were suggested. The operator will require specific location and obstacle information so they can make an assessment and determination for the applicant's proposed installation.

In consultation with Council members involved in the preparation of this study, it was felt that a strong case would need to be presented as to why the airport should be used for wind generation given the aviation safety priority at this site.

Wastewater Treatment Facility
Enhar identified the wastewater treatment facility as having a good potential to host a wind turbine due to the site's relative remoteness and the current land use (grazing) of the potential turbine location. The wind resource is unlikely to be as good as the coastal sites of the golf course and the airport however the altitude of the site (40m asl) is likely to positively affect the speed of the wind.

There are a number of trees at the boundary of the sites which will negatively impact the wind speeds of any proposed turbines. The biggest difficulty with the proposed location is from the planning perspective. The site falls within 2km of a number of township residential houses (and closer near town houses). The planning requirements for a turbine such as that proposed is expected to be problematic. It will more than likely require the permission from all householders who are less than 2km from the turbine. Any permit application must be accompanied by evidence of the written consent of the owners of all the dwellings. Approval of a wind generation facility is prohibited by the planning scheme where evidence of written consent from residents within 2km is not provided.

Commented [TH27]: I don't understand.

Gabo Island

The Gabo Island is a potential site with a fantastic wind resource. However landscape impacts, community acceptance and cabling costs make this a very challenging site to develop.

Hilltop Land, former Gravel Pit

A small cleared parcel of land to the West of the Mallacoota township was identified by Enhar from aerial photos. A site visit was undertaken to determine if there was merit in locating a wind turbine here. The location is excellent in terms of remoteness. The elevation is approximately 130m asl and has relatively free access to the coastal breezes so is likely to have the highest wind resource of any of the available sites. It is located next to the main incoming power network lines to Mallacoota. At the site visit it was explained by the community that recent efforts had been made to re-vegetate the exposed land which is a former gravel extraction quarry or 'pit'. Further development of the site with a wind turbine would impact the revegetation intentions at this site but could be worth considering due to the other advantages of this site for wind energy.

The main technical disadvantage of this location is the turbulence in the wind arising from the surrounding forested area. The existing trees are relatively tall and likely to heavily influence the wind regime at this site. Additionally the access to the site will require major upgrade works to enable turbine component deliveries. Access would be via the road that runs along the base of the power line poles holding the incoming electricity supply, currently a 4x4 track.

For any larger wind turbine development however this site could achieve the best economic return due to higher yield.

Environmental impact issues at this location would include native vegetation, national park protections, and impacts on rare birds which use the forests.

Commented [TH28]: One of the reasons that a centralised wind turbine was not a recommended solution was that it scored very low on the Community Acceptance criteria. Martyn needs to confirm this but he believes the issue is that the land is part of the National Park and managed by Parks Victoria making it unavailable to the project. Community acceptance was also low but not the primary driver. Martyn will talk with Parks as soon as he can.

Commented [DN29]: Our senior wind consultant Aaron Donoghue identified this site as relatively the best site for wind among the sites considered. If there were to be an effort to include a wind turbine then this would probably have been the site to use, and the environmental hurdles attempted. We agree that the National Park status is a major factor as noted in the following paragraph.

Figure 6-38 Hilltop former Gravel Pit Location Photograph

6.9.2 Local Wind Data Analysis

6.9.2.1 Estimate of Long Term Average Annual Wind Speeds

Due to the above average uncertainty with the wind data sourced from the Mallacoota BOM met mast, as discussed in section 6.3.3 above, it is particularly difficult to provide an estimate of any real certainty of the long term annual average wind speeds at the sites identified at turbine hub heights. The wind speeds range from 3.9m at 8m height (Mallacoota) to 7.3m/s at 8m (Gabo), a difference of 187%.

In reality the estimated wind speeds will be somewhere in between, however without accurate information it is impracticable to make anything other than a large error range best estimate (**6.8-7.9m/s at 99m** – best estimate at the airport BOM station location).

The two datasets were correlated for a 5 year period (2008-2012) and whilst the direction showed an r^2 value of 0.902 (reasonable correlation) the wind speed data showed little correlation with each other (r^2 value of 0.484). The poor correlation makes the uncertainty of any worthwhile wind speed predictions exceptionally high, and points towards further wind monitoring.

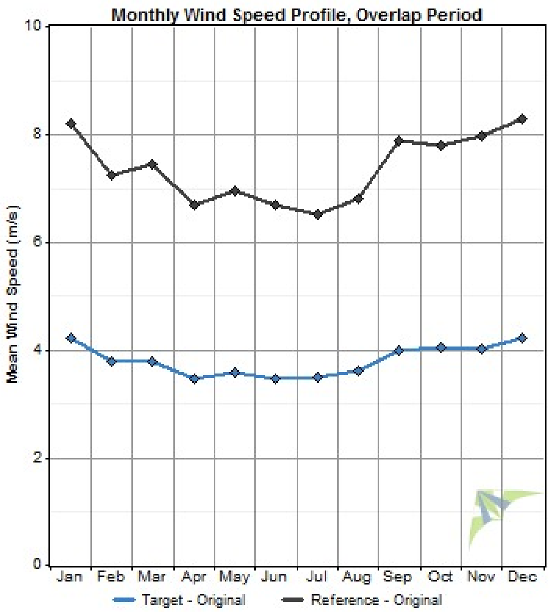


Figure 6-39 Monthly Wind speeds at Mallacoota (Target) and Gabo (Reference)

It is clear from the data that there is substantial discrepancies between the nearest BOM (Gabo), the Victorian Wind Atlas and the airport site recorded speeds. The wind speed is highly likely to be greater than the Airport recorded data due to the fact that the mast is only at 8m and some of the surrounding vegetation is at 15m. There is no easy way to quantify exactly what the wind speeds on the site are at the intended wind turbine hub height without further wind monitoring.

Enhar recommends that to increase the certainty of the wind speed and direction estimates at the potential wind turbine hub height, a new mast with measuring equipment could be erected at any proposed turbine position with monitoring equipment at a number of heights to accurately determine the wind speeds and shear at the site.

Alternatively to save on costs and better understand any shielding influence at the Mallacoota BOM station one option could be to install measuring equipment on the already in place 40-45m masts at either the airport or the waste water treatment plants. There appears to be a suitable mast at both of these locations so if wind is to be further investigated then this could be a cheaper alternative to providing accurate information on which to base any business case.

Once data from these masts is available, a correlation could be made to understand the long term level of shielding and uncertainty at the local BOM location.
Wind Energy Yield Calculation

Table 6-12 below shows the energy yield output for a large and small Enercon wind turbine with the respective hub heights in brackets. Assumed losses of 10% have been included in the calculation.

Table 6-12 Energy Yield Estimate - Mallacoota Airport Location

	Hub Height	Percentage Of Time At		Energy Statistics		
	Wind Speed (m/s)	Zero Power	Rated Power	Net Power (kW)	Net Annual Energy Production MWh	Capacity Factor (%)
Enercon E-101 / 3,050 kW (99m)	7.33	2.3%	6.0%	1,002	8,781	32.9
Enercon E-48 / 800 kW (50m)	6.38	3.7%	1.4%	180	1,584	22.3

6.9.3 Wind-Battery System Design

The design case where a wind-battery storage system provides full power for the town during any grid outage is similar to the case where the system provides full power to the town for the whole year. This is because if a system can provide power during any sustained outage, it has to be able to cope with worst case weather conditions and if it can do this, it can provide full supply during the whole year anyway.

Some simulation has been conducted in the HOMER software:

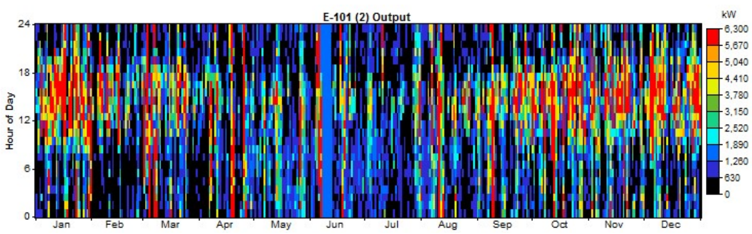


Figure 6-40 Simulated yield 2 x 3.1MW wind turbine during 2012

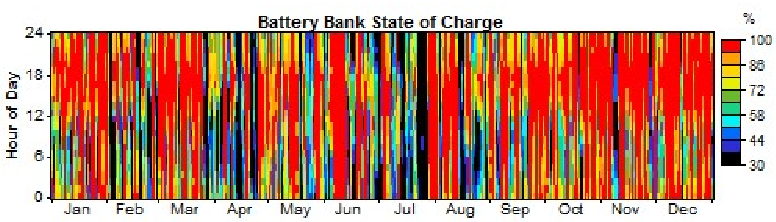


Figure 6-41: Simulated Battery Bank charge during 2012

This indicates that with 200kW of demand management, a 6.1MW wind system may suffice, and would require 7.5MWh of storage to ensure all demand was met at all times of the year. Approximate costs for a 7.5MWh battery system are between $4M and $4.7M using lead acid battery technology.

A significant amount of wind energy is exported down the grid line in this scenario, over 5MW in some instances.

As with solar PV, one constraint is the capacity of the incoming grid line. It is expected that the line may be able to export approximately 4.5MW away from Mallacoota, therefore there may be a requirement for a dump load connected to the wind turbines to deal with high wind events.

Dump loads may not be a problem for the project economics, if the cost of the overall system is still optimised.

6.9.4 Wind – Diesel system

A wind turbine could be used to generate revenue to support a permanent 1-2MW diesel generator at Mallacoota. This would enable backup supply security during outages, similar to the equivalent scenario considered with solar-diesel system.

6.9.5 Environmental and Social Impacts

Several major issues have been identified with the establishment of any wind turbine at any sites in Mallacoota.

Airport Safety is a concern with the airport site and would likely be an issue with any of the sites considered.

Delivery of turbine blades down the narrow access roads to Mallacoota would be an issue especially for the larger turbines whose blades are in excess of 50m long.

The impact on the landscape could be significant and would be potentially a source of division in the community. The iconic views of Mallacoota are a social asset, and the establishment of a major structure which impacts those views could be considered a threat to tourism income.

Rare birds populate the area such as ground parrots in the airport area and a Mutton bird flight path in the region. Impacts on bird populations, especially any species protected by law, would be a major environmental consideration.

Residential neighbours to any project, if located within 2km of the turbine location, would have to provide written approval.

Community acceptance is a key concern. At the consultation event in November 2013 in Mallacoota, no site could be identified for a wind turbine which would not cause concern to at least some of the participants.

The length of time to obtain approvals and permits would be significant and therefore delay the commissioning of a solution by several years compared to other technologies which do not face the scale of planning issues noted in this section.

6.9.6 Evaluation against Option Selection Criteria

Criteria / Goals	Description
Emergency proofing	The ability of a wind-diesel or wind-battery to minimize the risk or length of a supply shutdown during an emergency. Range: 1 = no change to current situation / 5 = minimal risk **Score: 5** Ranking - vital
Community acceptance	The ability of the option to have broad community support as an important improvement in the economic and social wellbeing of Mallacoota. Range: 1 = significant risk of community division / 5 = strong support

	Score: 1 During community consultation, while some participants accepted the concept, all potential sites caused concern to at least some of the particpants. Ranking - vital
Ability to supply electricity for extended periods	The ability of the option to provide electricity for extended periods when operating as an 'island'. Range: 1 = low capacity for extended operation / 5 = capacity for operation in 'island' mode for up to five days. **Score: 5** Wind has been used in island grids successfully in many locations, especially when coupled with diesel generators. Ranking – very important
Proven robust technology	The ability of the option to operate reliably without risk of failure for technical reasons at critical times. Range: 1 = unproven technology / 5= well understood technology **Score: 5** Ranking - very important
Planning permission	The ability of the option to be approved by local, state and Commonwealth planning processes. Range: 1 = significant challenges in planning permission / 5 = no anticipated challenges **Score: 2** Ranking – very important
Economics	The ability of the option to generate an income and pay back capital investment. Range: 1 = continuing financial cost / 5 = profitable in medium term **Score: 5** A wind diesel system would be the cheapest of the options considered. Ranking - important
Construction - technically feasible	The ability of the option to be constructed in Mallacoota without technical or excessive cost barriers. Range: 1 = significant difficulty / 5 = no barriers to construction **Score: 2** The difficulty of transporting long turbine blades to the town along the narrow roads may be considerable. Ranking - important

A wind turbine is not a recommended option for Mallacoota due to scoring very low on one of the vital selection criteria.

6.10 Centralised Biogas generator

A biogas fuelled turbine generating an emergency power supply during outages could provide electricity for extended periods of time providing there was an ample supply of stored biogas on site. Biogas is created naturally through anaerobic digestion of biodegradable materials. With the use of a digester and storage vessel it can be harvested and refined to a standard which can be used for direct combustion to generate electricity. Biogas fuelled generation is a well-established technology and similar to any combustion engine the reliability of continuous operation is determined by maintenance, fuel quality and fuel availability.

Fuel quality and consistency is paramount for reliable operation and electrical output in a biogas system. Biogas traits can vary significantly with each harvest thus making it difficult to combust effectively. Typically biogas in its natural state has deficient methane content for energy production and refinement of the gas is required. The raw biogas is produced at a low cost however the cost of refinement can increase these costs. Fuel availability is dictated by availability of biodegradable feedstock for the digestion process along with the efficiency of the harvested yields. In regards to biogas offering a viable emergency power supply throughout the year, the most significant constraint is the consistent availability of feedstock.

The schematic below is useful in highlighting the various stages that are incorporated within the biogas to energy cycle.

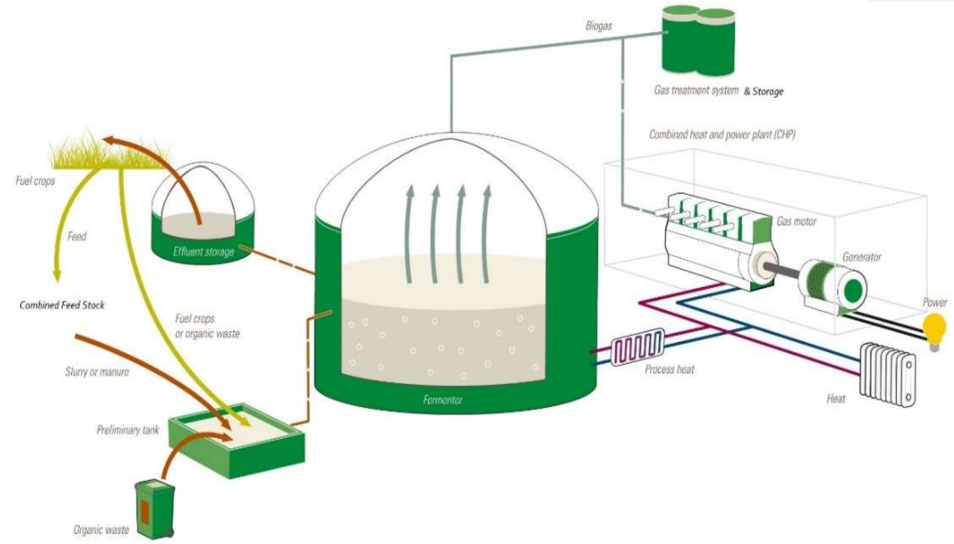


Figure 6-424: Illustration of a biogas to energy system

Source: http://www.easyenergy.gr/en/Biomass-Biogas-plants/

6.10.1 Site Selection

The Mallacoota Waste Treatment Plant is the most suitable site for a potential biogas system. There is an abundance of sewage sludge piped to the site which can be used as feedstock. Biogas digestion, if installed, would be inserted up stream of the existing settlement lagoons, and the lagoons would still be used.

Figure 6-435 Mallacoota Waste Water Treatment Plant site considered for potential biogas plant.

The site has other advantages such as being surrounded by dense bushlands which acts as a natural barrier for noise and possible odours that may be exuded during the digestion process.

A kitchen to compost scheme is already underway in Mallacoota and the compost process will be sited at the sewage treatment works. The site map and layout of the Kitchen to Compost project can be viewed in Appendix B. This project has commenced construction. A photo of the area which has been prepared for this purpose is below:

Figure 6-44: Foundation for kitchen to compost area adjacent to sewage treatment works [photo by Enhar, November 2013]

Figure 6-45: Kitchen to compost area [source: East Gippsland Shire]

6.10.2 Methodology

Varieties and quantities of harvestable feedstock resources for the town were researched to estimate available volumes annually. Based on the estimated available resources, calculations were conducted in order to approximate potential biogas yields and thus resulting power generation outputs. The analysis of feedstock quantities and potential output was then used to size biogas storage options and generation systems for the calculated biogas yields.

6.10.3 Digester Technology

The existing kitchen to compost system will create a volume of biogas which could be harvested through the addition of gas collection systems.

Alternatively a new digester could be installed which would process all compost wastes along with sewage wastes. Given the significantly greater amounts of biogas which could be generated from sewage wastes compared to compost and food wastes (see Table 6-13 below), a new digester compatible with sewage wastes would be expected to be more attractive from an energy generation perspective.

The Indian floating cover biogas digester shown in Figure 6-29 is a representation of a potential anaerobic digester design that would be suitable for Mallacoota. The feedstock is prepared and fed down the inlet pipe where it undergoes digestion in the first digestion chamber. As the feedstock levels and anaerobic digestion rates increase, the digestion residues also referred to as slurry will rise to the top of the partition where it will then begin to fall into the second digestion chamber. At this stage the digested slurry has already undergone the complete anaerobic digestion cycle with all potential biogas being emitted into the airtight chamber. The digested slurry can then be dewatered and dried, resulting in a nutrient-rich digestate that can be used as fertilizer. Meanwhile the harvested biogas inside the system is being kept at a constant pressure as the floating cover will move relative to the volume of biogas that is being emitted from the digested feedstock. The biogas will then exit the vessel via the gas outlet pipe where it will undergo refinement to enhance the methane content and remove harmful residues. The refined biogas will then be contained under compressed storage where it can be used for emergency standby operations.

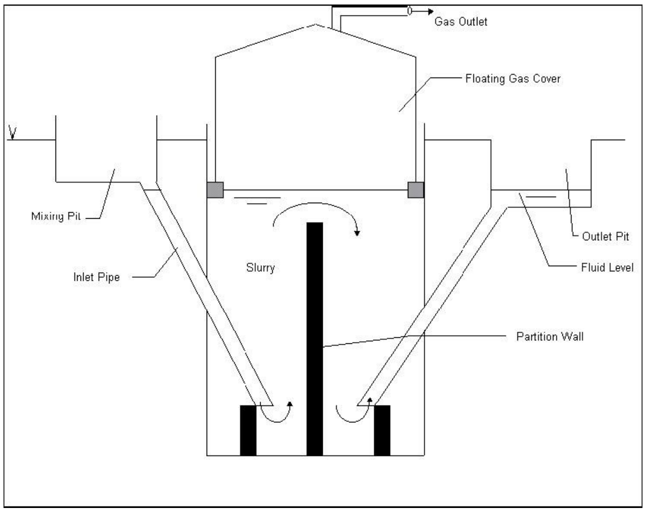


Figure 6-46 Digester design option. Indian floating cover biogas digester [20]

6.10.4 Biogas Yield

Potential biogas yield volumes from the available feedstock inputs listed in Table 3-1 were calculated using RETScreen. RETScreen is a clean energy project analysis software tool that is designed to assist in defining technically and financially viable solutions for potential renewable energy developments. The Biogas tool in the software was used to determine the overall annual biogas output potential from our given inputs which can be seen in Table 6-13 below.

Table 6-13 Annual biogas yields from available feedstock

Feedstock Type	Volume (kg) per year	Biogas production factor (m³/kg)	Biogas annual production (m³)	Methane Content (%)
Waste Water Sludge	700,000	0.33	517,409	66
Kitchen Compost Waste	70,000	0.5	3,719	63
Abalone Waste	75,000	0.7	14,931	66
Meat Trimmings	5,000	0.7	995	60
Green Waste	270,000	0.62	12,915	60
Total	1,050,000	-	549,969	60%

Table 6-13 illustrates the potential annual biogas yields from the available biodegradable feedstock within the town of Mallacoota. As previously discussed, there are dramatic fluctuations in feedstock availability which will directly affect the output consistency of produced biogas. The figure below highlights available feedstock trends and estimated biogas yields throughout the course of a year.

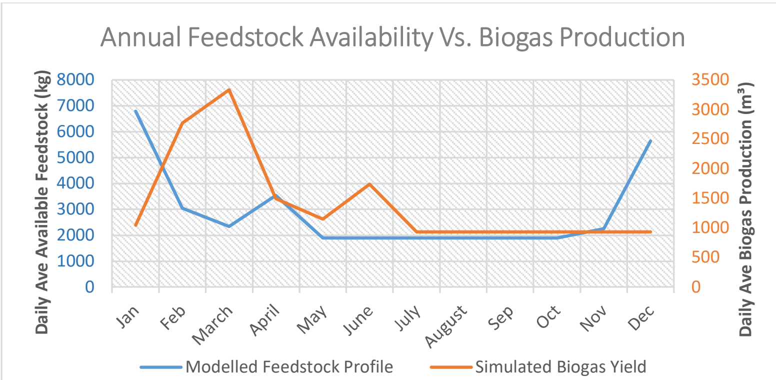


Figure 6-47 Biogas Yields relative to Feedstock Availability throughout a typical year

Commented [TH30]: Where does the base data for this come from?

Commented [DN31]: See additional text by Jack Bruce inserted below about the derivation of the seasonal profile. Jack has used his local knowledge and has communicated with local contacts throughout this study to verify inputs and estimates.

Estimated projection of fluctuation of biogas yields relative to available feedstock can be viewed in the above Figure 6-47. The daily available feedstock profile was modelled based on Mallacoota's fluctuating seasonal population. Population values were established using the 2011 census data supplied by Australian Bureau of Statistics [21].For the modelling it was assumed that the availability of abalone waste and green waste volumes were linear throughout the year as they are not affected by seasonal population fluctuations. However it was assumed that kitchen, sewerage and meat trimming waste volumes were directly impacted by seasonal population numbers. Seasonal population fluctuations were estimated including the December and January peaks, with monthly population numbers estimated for the modelling. No measured monthly population trend data for Mallacoota was available, hence a modelled approach is required. Using Microsoft Excel and the population data, the profile of daily average available feedstock relative to daily average biogas production was estimated as shown in Figure 6-47.
It can be seen that the biogas yield curve traces the movement of the feedstock curve with a time delay of 2-3 months, this is due to the anaerobic digestion period. Depending on the temperature of the digester and feedstock volumes, the average hydraulic retention time taken for the digestion process cycle ranges from 40-60 days.

An essential characteristic which is also outlined in Table 6-13 above is the methane content of the produced biogas. Biogas traits can vary significantly with each harvest thus making it difficult to combust effectively. In its raw state biogas generally contains 50-75 % methane, 25-45% carbon dioxide, 2-8% water vapour and traces of hydrogen sulphide. In comparison natural gas contains 80-90 % methane. The calculated harvested methane from Table 6-13 only contains 60% methane which is deficient and would not be suitable for a gas fired turbine, but may be suitable for other types of generator. If hydrogen sulphide (H2S) is not effectively removed, it can cause engine wear and failure in a matter of hours. Biogas predominantly has a high residual moisture content which can cause starting problems and efficiency losses. However these issues could be overcome through refinement methods which would increase the methane ratios while also removing hydrogen sulphide and water vapours.

6.10.5 Biogas Power Generation

The gas fired generator selected for the biogas power generation analysis was the Lean-Burn 1540 kW Cummins generator set. This model of generator was chosen as it is capable of running on natural gas and alternative gaseous fuels such as biogas.

Figure 6-48 Cummins 1540 kW Lean-Burn Generator, (Lean-Burn Gas Fueled Generator Sets, Cummins Power Generation, 2012)

A measurement called the Methane Number (MN) is used to determine fuel gas suitability as an engine fuel. Cummins specifies in their specifications and data document (Lean-Burn Gas Fueled Generator Sets, Cummins, 2012) [4] that the gas engine generator will operate with an MN number of anything above 50. The calculated produced biogas has a MN of 63 where in comparison natural gas typically has a MN of 70-95, therefore the Lean-Burn is capable of combusting the produced biogas or in times of deficient supply the option of also combusting stored natural gas.

An additional advantage of gas fired generators is the significant reduction of emissions in the exhaust. In their specifications and data document Cummins affirms that the gas engine generators have NOx emissions as low as 0.85 grams/BHP-hr, and produce low amounts of hydrocarbons (HC), carbon monoxide (CO) and particulate matter (PM). Thus the generator is capable of meeting the most stringent air quality regulations even without after-treatment devices in the exhaust stream.

Cummins identify in their Generator Set data sheet (Cummins Power Generation, 2010) [5] that although the generator can operate on lower MN number there will be a compromise with power output and engine wear with poorer gas quality. For these reasons and to assist with the accuracy of the modelling based on the rated loads and fuel consumption rates, it is recommended the potential biogas is refined to a state where the MN is optimal.

Table 6-14 below exhibits how altering methane properties in the biogas fuel source effects the overall power output and efficiency of the Cummins 1540 kW Lean-Burn. To ensure we can gain potential maximum power output, the biogas will need to be refined to an MN of 73% or above.

Table 6-14 Rated power output with various methane content.

Percent of Rated Load	100%	90%	90%	50%
Methane Number Capability	73%	68%	61%	52%

Table 6-15 below illustrates the variations in the biogas characteristics as it is refined; decreased volume, higher MN of 95 and increased energy density by 8,281.9 Btu per m³. Note for the purpose of this study, refinement calculations were strictly theoretical and

[4] Lean-Burn Gas Fueled Generator Sets, Cummins Power Generation, 2012
[5] Generator Set data sheet 1540 kW continuous, Cummins Power Generation, 2010

therefore assumed an ideal state with 100% efficiency in the refinement methods. Realistically in practice refining is never 100% efficient therefore to compensate for losses a methane number as high as 95 was chosen for the modelling as it reduces the risk for margin of error and established properties very similar to natural gas thus also improving reliability.

Table 6-15 Variations in volume, methane content and energy density due to refining.

	Total Volume (m^3)	Methane Content	Energy per m^3 (Btu)	Total Energy (MMBtu)
Raw Biogas	549,969	60%	22,945	12,619
Refined Biogas	357,480	95%	35,300	12,619

The total electrical output from our modelled biogas stocks was calculated using the refined biogas qualities from Table 6-15 and the known fuel consumption rates at various applied loads for the 1540 kW Lean-Burn generator set which was supplied by Cummins in the Generator set data sheet. The results are shown in Table 6-16 below.

Table 6-16 Fuel consumption and output for various applied loads.

Rated Load Applied (%)	100%	90%	75%	50%
Fuel Consumption of refined biogas (MMBtu/hr)	13.73	12.35	10.56	7.63
Electrical Efficiency (%)	38.30	38.30	37.40	34.40
Electrical Output (MW)	1.54	1.39	1.16	0.77
Potential operating time (hours/year)	919.08	1021.78	1195	1653.87
Total output from given renewable fuel stocks (MWh/year)	1415.39	1420.27	1386.18	1273.48
No. days generation for town @ 19.2MWh/day	73.72	73.9	72.2	66.33

It can be seen in Table 6-16 that the Lean-Burn generator set operates most efficiently on an applied load of 90-100%. At this load rating there is the potential to create 1,420 MWh of total electrical output per year from the calculated harvested biogas resource.

It is known that Mallacoota's average daily demand in January (2012) is 24 MWh, see section 2.1.2.3 above. After demand management of 200kW during outages, this drops to 19.2MWh/day.

Therefore biogas has the potential to supply the town with an emergency power supply for approximately 73 days per year. Note this is presuming a years' worth of digested and stored biogas is available onsite for continuous operation of the Lean-Burn generator; in practice to limit the cost of the storage vessel the vessel might be limited to around 5 days of usage and the surplus gas would need to be utilised at the rate it was generated.

Biogas is therefore a potential solution for backup generation during grid outages, with biogas stored for times of emergency usage.

With sufficient bio gas for around 73 days of generation, there would be sufficient power for all outages according to recent years of records. If multiple long outages occur in quick succession however, this could be more challenging, as the biogas accumulation is a slow process. Outside of peak biogas production season (Jan-Feb), it would take on average 16 days to generate enough biogas to generate power for the whole town for a 3 day outage.

Therefore for full security a natural gas or diesel supplementary tank may be required and using a generator able to be fired from both biogas and natural gas or diesel. Alternatively the biogas storage vessel could be increased in size but the capital cost of the vessel is likely to be a limiting factor.

6.10.6 Capital Cost of System

A tender process would be a suitable method to obtain accurate pricing of the overall biogas equipment and auxiliary components for the complete system. Biogas digestor systems are not 'off the shelf' as they must be designed to suit the specific feedstock types and flow rates at the specific site. The following sections discuss what equipment is essential for the effective operation of a biogas plant and further action for estimated system costs.

- **Feedstock preparation equipment:** Prior to the feedstock entering the anaerobic digestion vessel it will need to be shredded to a suitable size and pre-heated to an optimal temperature of 30-38°C. This process will require a shredder and heat exchanger; specific size and costs will involve further research into the available feedstock characteristics.

- **Anaerobic Digester (AD):** An insulated airtight vat is needed to house the feedstock and reliably maintain a temperature range of 30-38°C. Continuously stirred tank reactors (CSTR) are most effective at providing rapid feedstock digestion rates, thus stirring equipment in the form of an agitator will also be necessary. Exact volume of the digester and cost will depend on ideal feedstock ratio's and volume flow rates at which the feedstock will enter the digester. Prime feedstock ratios will entail chemical analysis of the available resources.

- **Stirring equipment:** Agitators or submersible mixers are critical for the AD process as regular stirring ensures there is a consistent moisture content and feedstock ratio throughout the vat. Consistent viscosity is also crucial for the effective operations of the pumping equipment, generally pumps used for biogas systems cannot pump any matter with moisture content greater than 15%. As stated previously, sizing and cost of an agitator will also be dictated by further investigation into feedstock ratios and characteristics.

- **Pumping Equipment:** Pumping equipment will be needed to extract the digested slurry. Specific size and cost will be dictated by the scale of the anaerobic digestion vat and the volume flow rate of feedstock entering the vat.

- **Biogas Refinery Equipment:** As previously discussed and outlined in table 6-8 the produced biogas has deficient methane content, therefore refinery equipment will be needed to purify and increase methane content to favourable levels. Also referred to as "scrubbing", biogas refinement can be obtained through a variety of technical methods. A customized scrubbing tank and supporting equipment could be assembled at a feasible scale for this project at an estimated cost of around $100,000.

- **Biogas Compressor:** Following the refinement process the biogas will need to be compressed for storage purposes. Suitable compressor size would be approximately 380V which is capable of compressing the average daily yield of 2000 m^3, estimated prices range from $3,000 - $3,250 plus shipping and installation according Shanghai Rich Manufacturing Co. [22]. Note for compressing gas for sale as bottled gas, additional equipment would be required not costed here.

- **Gas Storage:** The harvested biogas will need to be effectively stored on site for standby use during emergency outages. From the RETScreen biogas modelling it is estimated that the annually produced volume of refined biogas is 357,480 m³ at atmospheric pressure. Taking into account the depletion of biogas throughout the year due to usage, slight leakages, fluctuating yields and by also utilizing compressed storage procedures it is recommended a storage vessel of 20,000 m³ will be of adequate size. Double membrane expandable gas storage vessels are the most frequently used and cheapest storage option in the biogas field. Biogas equipment manufactures Sichuan Motet Energy Technology Co. Ltd. [23] in China advertise a 20,000 m³ double membrane for approximately $300,000 excluding delivery and installation. A price estimate from an Italian supplier called Ecomembrane was obtained for this study and a 15,000 m^3 membrane would cost €204,000 excluding delivery and installation which at current exchange rates is around AUD$320,000. Inclusive of delivery and installation around $500,000 could therefore be allowed for the vessel item.

- **Dewatering Equipment:** The digested sludge that is pumped out of the digester will need to be dewatered and heated into a dry cake which will make it suitable for use as a fertilizer. Appropriate cost of dewatering equipment will depend directly upon the size which is required to extract the digested feedstock. This will entail further investigation into hydraulic retention rates and feedstock volume flow rates.

- **Gas Generator:** As discussed in section 6.10.6 the biogas generator recommended for this system is the Cummins 1540 kW Lean-Burn with a cost of $815,000 Plus GST excluding installation and connection or approximately $1,500,000 per MW including installation and connection. If heat recovery equipment was also installed it would cost approximately $2,300,000 per MW. Estimated basic operation and maintenance costs are $16.00 per MWh per year.

6.10.7 Summary of biogas potential

Two main technical concerns arise when considering biogas power generation as a standby energy supply during emergency outages.

- **Reliability of supply:** Analysis of Mallacoota's historic power outage records illustrates that they are inconsistent in both duration and frequency. Reliability of supply is the core issue with using biogas for emergency standby. Production of bio-gas through co-digesting is time consuming, generally a minimum of 30 days to harvest biogas, thus if consecutive outages occurred of substantial durations then biogas would not be capable of supplying emergency relief unless stored in substantial quantities. In addition the dramatic fluctuations in population directly impact the volumes of waste which will be available to use as feedstock for the co-digester. Altering quantities makes it difficult to plan and manage feedstock ratios and combinations which if not precise can have an adverse effect on output efficiencies.

- **Quality of Supply:** If the harvested biogas is not refined to a standard that is specified e.g. for the chosen Cummins 1540 kW Lean-Burn, it can have detrimental effects on engine wear and power output. As outlined in Table 6-14, if the MN (methane number) drops by 21, the power output will decrease 50%. Required maintenance will also increase in frequency and cost as the lower quality fuel source causes increased wear and contamination build up inside the engine. Therefore quality of fuel supply is paramount and directly impacts the supply quality of electricity generation during emergency outages.

Although these issues are significant in terms of the impact they impose on the successful operation of biogas power generation, they can be overcome through preventative measures which are listed below.

- **Combined Storage:** To ensure there is ample supply of gas at the site at any one time, during emergency situations if there are deficient volumes of stored biogas the expandable membrane could be restocked with natural gas. The addition of the natural gas would also increase the energy content of the biogas resulting in a higher quality and more reliable fuel source. Alternatively the natural gas could be stored in a compressed form in a separate tank, and mixed at the inlet to the generator.

- **Quality Testing:** Consistent quality testing of the refined biogas would be required to ensure the methane, carbon and hydrogen levels meet the specified standards. If the produced biogas was not meeting standards then it would be mandatory to pass the biogas back through the refinery process again or for it to be enriched with higher quality natural gas.

These preventative actions would significantly increase the potential for biogas to operate reliably as an emergency power source during a sustained outage.

6.10.8 Evaluation against Option Selection Criteria

Criteria / Goals	Description
Emergency proofing	Range: 1 = no change to current situation / 5 = minimal risk **Score: 4** A generator fired with biogas could be switched on within a matter of minutes in the event of an emergency. A biogas system would require additional equipment in order to provide uninterrupted supply, therefore scores 4 rather than 5. Ranking – vital
Community acceptance	Range: 1 = significant risk of community division / 5 = strong support **Score: 5** At the community consultation event, support was indicated for a biogas solution. The MSEG group also indicate strong support for this option due to its sustainability advantages over diesel. The establishment of the kitchen to compost scheme already underway in Mallacoota is evidence of community support for use of organic waste streams. Ranking – vital
Ability to supply electricity for extended periods	Range: 1 = low capacity for extended operation / 5 = capacity for operation in 'island' mode for up to five days. **Score: 5** As shown above, the quantity of biogas which could be produced on an annual basis would be sufficient for generation for the whole town during outages, up to 6 days per year. If combined with another generation system such as solar PV, the islanding duration ability would be even greater, as less biogas would be required during daylight hours while the PV is generating. Ranking – very important
Equity	Range: 1 = significant barriers to entry / 5 = no barriers to entry **Score: 4** The system would be centrally located and provide equal benefit to all Mallacoota customers. See below under 'Economics' for comments about financial challenges. Ranking - very important
Proven robust technology	Range: 1 = unproven technology / 5= well understood technology **Score: 4** . East Gippsland Water has operated an anaerobic digester in Bairnsdale for many years. Issues with filtration as customer sanitary habits change are important, as is evident at the Bairnsdale plant, hence design of the system is important, however these issues are well understood. The scale of a digester suited to Mallacoota is smaller than most case studies in Australia, and this aspect may impact on costs.

	Ranking - very important
Operation and maintenance	Range: 1 = external expertise frequently required / 5 = locally (or reliably remotely) maintained and operated. **Score: 4** Local expertise from Mallacoota could be well suited to feedstock collection and delivery. Maintenance of the digester, refiner, compressor and generator would require expertise from further afield, this is available in Bairnsdale where East Gippsland Water have suitably qualified staff. Ranking - very important
Planning permission	Range: 1 = significant challenges in planning permission / 5 = no anticipated challenges **Score: 5** No anticipated challenges with permissions for infrastructure on a site already allocated for similar uses. Ranking – very important
Economics	Range: 1 = continuing financial cost / 5 = profitable in medium term Score: **3** The financial challenge is that on its own, a biogas generator would generate limited income due to the quantity of gas available therefore might require a high price for its occasional power generation. In isolation it is considered unlikely that a biogas system could generate sufficient revenue to fund the installation of a large enough generator to provide the town with backup power. However, if linked to another generator system which provided much of the required infrastructure (such as a larger wind or solar project), and when other value of digestion is taken into account, it could be expected that the cost of this option would be competitive and not cause a price increase to current customers. Ranking - important
Construction - technically feasible	The ability of the option to be constructed in Mallacoota without technical or excessive cost barriers. Range: 1 = significant difficulty / 5 = no barriers to construction **Score: 5** Ranking - important
Resource abundance	The ability of the option to use a reliable resource and be capable of rapid recharge of storage after extended use, or to minimise the requirement for diesel consumption during outages. Range: 1 = long recharge time / 5 = rapid recharge time **Score: 3** The rate of biogas accumulation is not rapid, however by using a storage tank, a satisfactory amount of storage for outages would be readily achievable. Ranking – important
Intermittency protection	The ability of the option to minimize disruption from brief outages. Range: 1 = brief interruptions continue in moving from standard to 'island' mode / 5 = brief interruptions significantly reduced **Score: 2** On its own a biogas generator cannot prevent momentary interruptions however could be combined with other technology to address momentary outages. Ranking – important

Due to its many advantages, biogas digester system is a recommended solution for Mallacoota.

For financial viability, it may require an addition project, such as a wind or solar plant, to create revenue to fund a permanent generator at the site sized to supply the whole town and with islanding capability. One of the cross-benefits could be that the other larger plant would purchase the gas from the biogas plant.

6.11 Biomass

Bioenergy is stationary energy or heat produced from biomass. Many types of biomass can be used to produce bioenergy, including biomass from primary sources (agricultural crops and forestry) and biomass from secondary or waste sources (agricultural and forestry residues, by-products from industrial processes and municipal wastes disposed of in landfill).[24]

Biomass energy schemes are most commonly attached to industry sites where there is a demand for heat as well as power and a need to dispose of biomass wastes.

6.11.1 Technology Options

Technologies to produce energy from biomass include:

- Conventional combustion
- Gasification
- Pyrolysis

Conventional, (direct) combustion is the simplest and most widely used bioenergy technology for converting biomass to heat which can then be used for space heating or cooling, to heat water, for use in industrial processes, or to produce electricity via a steam engine or turbine. Combustion typically has an electrical efficiency of only 20-35%.

Gasification is a thermo-chemical process that involves heating a solid biomass to temperatures of around 800-1000°C in a gasifier with a limited supply of oxygen. Under these conditions, fuel is only partly burnt and is largely converted to 'syngas' which contains a mixture of methane, hydrogen, carbon monoxide, carbon dioxide and nitrogen. Smaller amounts of char are produced through gasification. Syngas can be used directly for heat or power applications, for example to run gas engines, gas turbines or combined cycle power systems. It can also be upgraded for biofuel production via a number of existing and emerging technologies. Gasification is generally more efficient than combustion-based routes in terms of electricity generation. However, it is more demanding in terms of biomass specifications like moisture content and particle size. The need to scrub gases and dispose of tars can be an issue if the syngas is to be run through a gas engine to generate power.

Gas produced from a biomass gasifier could compliment a biogas digestor system at Mallacoota. The additional gas produced could potentially be run through the same generator, subject to gas quality issues.

Pyrolysis is similar to gasification, in that it involves thermal degradation of biomass heated in the absence of air, or with very limited air or oxygen. It produces solid, liquid and/or gaseous products at ratios dependent on the speed and temperature of the pyrolysis process. The gases and compounds in the liquids can be used to generate bioenergy and generate electricity.

6.11.2 Biomass Generation at Mallacoota

The efficiency of the given technology determines the total volume of wood waste required.

As noted above, the highest energy content material for biomass would be compressed sawdust pellets. As noted in the resource section 6.3.5 above, the closest supplier to Mallacoota that could manufacture these pellets is South East Fibre Exports (SEFE) across the border in NSW. While not currently producing these pellets this facility has previously produced them and when contacted advised that production could recommence if a demand arose. The moisture content of their pellets is 4-6%. For electricity generation, volume flow rate of these pellets is approximately 1-1.5 tonne per MWh of output [[25]].

The capital cost of a biomass system of this scale is approximately $4-5 million per MW (single fuel type technology, steam turbine with heat recovery). The lack of a major heat customer at Mallacoota is a down side for a heat recovery technical option and availability of water for cooling the turbine would have to be considered.

If a fuel source with higher moisture content such as forestry residue were to be considered (upwards of 70% moisture content), or sawdust/sawmill chips (25-40% moisture content) the volume flow rate will increase dramatically. There are systems capable of burning materials with a range of moisture contents and energy output is more challenging to predict under these circumstances, therefore a single fuel type can be more straightforward.

From the resource assessment reported above in Section 6.3.5, and using an industry estimate of 0.88 MWh electrical output generated per tonne of sawdust[26] , it can be estimated that the volumes of sawdust and sawmill waste stated from Cann River could supply 50-60% of the town's annual 8GWh annual demand. The addition of 1,000 tonnes/year of wood pellets from SEFE, if available, could supply a further 20-30% of the town's annual demand.

If feedstocks with a wide range of moisture contents and sizes were used at one facility, the complexity of drying and processing could be expected to increase but would be technically feasible.

6.11.3 Costs of transportation

The cost of transportation is a challenge for the economics of biomass power generation.
Transport to Mallacoota adds significantly to the cost, sawdust is not straightforward to transport.

A bioenergy generation project based in Cann River may be more economic in terms of transport cost, where an energy generation system could be established at the source of the fuel.

6.11.4 Levelised Cost of Energy

A study by Bioenergy Australia called 'Bioenergy in Australia'[27] written in 2012 costed a 500kW biomass gasification plant for Australian conditions.

The scenario was a plant turning around 9,100 tonnes of biomass per year into electricity which is similar to the sawdust and sawmill waste quantity available from Cann River.

The calculated LCOE of a 500kW biomass in this study was found to be 31c/kWh.

The impact of scale of deployment was illustrated in the same report. It considered three hypothetical bioenergy plants of different scale and configuration. These were a 500 kW gasification plant fuelling a reciprocating gas engine that drives a generator, and 5 and 20 MW plants with conventional boilers and steam turbines producing electricity.

The resulting analysis in [27] found that the Levelised costs for the 3 scenarios were:

500 kW : $310/MWh
5 MW : $230/MWh
20 MW : $160/MWh

6.11.5 Eligibility for Large Generation Certificates

The Renewable Energy Act enables generators from eligible renewable sources to earn Large Generation Certificates (LGCs). The value of electricity is generally higher than the value of LGCs. Therefore LGC price and eligibility is a secondary consideration to the price of electricity, however is still an important factor.

The eligibility of biomass feedstocks for LGCs must be demonstrated by any generator using biomass, in order to claim LGC earnings. This audit trail is probably more onerous than other types of renewable energy due to the need to prove that no native forest was used.

Wood waste from native forests was originally eligible under the Mandatory Renewable Energy Target (MRET), and was removed from the Renewable Energy Target (RET) in 2011 following agreement of the Multi-Party Climate Change Committee as part of the Clean Energy Future plan [Australian Government RET Report, Chapter 7]. [28]

The Renewable Energy (Electricity) Amendment Regulations 2011 specifically excludes the eligibility of electricity generated using biomass derived from a native forest to create LGCs.[29]

Wood waste from plantation forests is however eligible to generate certificates under the LRET, and this includes non-endemic native species, but must be taken from land that is cleared of native vegetation before 1 January 1990 to establish the plantation [28].

If biomass used is ineligible for Large Generation Certificates (LGCs), the economics of the scheme would be impacted.

The Clean Energy Regulator publishes volume weighted average market prices for LGCs[30]. The 2013 weighted average is currently $38.69 per certificate, with one certificate earned per MWh generated. The 2014 forecast is $35.24 or 3.5 c/kWh. This equates to 3.5 c/kWh impact on the economics in the first year of the project.

The RET scheme increases year on year to reach the national target of 20% renewable energy in 2020 and the market for LGCs lasts until 2030, this scheme is the key driver which has underpinned most commercial renewable energy generators in Australia since its inception in 2002.

The eligibility of sawdust from Cann River for earning LGCs has not been assessed as part of this study.

6.11.6 Community Acceptance

MSEG members canvassed the view of their own networks during the preparation of this study and found that 100% of those questioned would oppose the use of biomass in the town due to concerns around the environmental sustainability of using forestry and its residues as an energy source.

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The establishment of a biomass system relying on forestry residues at Mallacoota may be opposed by a sector of the community.

6.11.7 Evaluation against Option Selection Criteria

Criteria / Goals	Description and scoring
Community acceptance	This is about the ability of the option to have broad community support as an important improvement in the economic and social wellbeing of Mallacoota. Martyn Hiley, a member of Mallacoota Sustainable Energy Group (MSEG), asked each of the members of the MSEG team to give him their views on how they think Biomass would be accepted by the Mallacoota community at large. The unanimous response was that if biomass is included in any part of the Mallacoota Sustainable Energy solution, that solution would be unacceptable to many community members. In addition, individually, the MSEG members felt strongly that a solution that includes biomass could jeopardize the project. While a survey of local opinion throughout the town was not conducted on biomass specifically, as biomass was not one of the technologies included in the original project scope, community members were invited to feedback any ideas and opinions through various channels including at open day sessions. There was no special support for biomass expressed through these channels and it does not appear likely that there is significant support for the use of

	forestry residue for energy in Mallacoota. Scoring: 1 = significant risk of community division Ranking – vital

Early indications are that use of biomass for energy may cause significant community concerns at Mallacoota.

Although it is technically feasible to use Biomass for energy purposes at Mallacoota, this option fails to meet the vital criteria of community acceptance.

It is therefore not a recommended solution at Mallacoota.

To minimise transport costs and optimise the economics of any biomass scheme, it may be preferable to consider development locations at the source of biomass fuels such as communities with existing sawmills.

Biomass is a widespread resource in Gippsland. In terms of applicability to other communities around East Gippsland Shire. If biomass resource is available locally and community acceptance is high, it could present opportunities for power generation at those locations. It could also present opportunities for combined heat and power.

6.12 Wave generation

Wave technology is an evolving field and currently deployment is currently dominated by demonstration projects and testing centres. Commercial wave farms are a very rare thing and will remain so while costs remain significantly higher than wind and solar alternatives.

An example of a wave project in Australia is the recent CETO project in Western Australia. Enhar attended a seminar by CETO in Melbourne on 26th September 2013 at which their recent developments were presented.

CETO's next major projects include demonstrating 3 x 240kW units called 'CETO 5' at a site 3.2km offshore near Perth.

The depth of the water is 24m and the project will produce desalinated water as well as power.

The total costs for this project are $30M, of which the government is funding $22M. This includes the total capital costs and the cost of the company activity over 3 years.

The total generation capacity of this project is 720kW. Annual yield estimates were not presented.

The LCOE estimates for wave energy in the published references are around 38 – 50 c/kWh (refer to section 6.2 above). CETO indicated during their presentation that they expect that under full production, the company could deliver systems which generate power at costs competitive with diesel generation i.e. 30 – 40 c/kWh.

A simplistic comparison of wave energy costs to the current costs of wind at around $2M per MW installed, or solar PV plant at around $3M per MW installed, with LCOEs of around 10c/kWh and 20c/kWh respectively, illustrates the magnitude of the current gap in the technology maturity and commercial viability.

For wave technology to reduce from $30M for 720kW to less than $1.5M/MW for pricing to match other mature renewable energy technologies will take many years and there are many unknowns.

6.12.1 Evaluation against Option Selection Criteria

Criteria / Goals	Description
Proven robust technology	The ability of the option to operate reliably without risk of failure for technical reasons at critical times. Range: 1 = unproven technology / 5= well understood technology **Score: 1** While demonstration R&D projects have been successful in developing the technology, to date in Australia no wave generation system has operated for any extended period of time providing power on a commercial basis. Ranking - very important
Economics	The ability of the option to generate an income and pay back capital investment. Range: 1 = continuing financial cost / 5 = profitable in medium term **Score: 1** The high cost of wave energy compared to all other sources considered makes it extremely challenging economically. Ranking – important

Wave energy is not a recommended solution for Mallacoota as it scores poorly against very important criteria.

6.13 Tidal power

Construction of a tidal barrage at the entrance of Mallacoota Inlet is considered in the earlier discussion paper by SP Ausnet [1].

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The high environmental impact and high costs of this relative to other renewable options are a barrier to this option.

As noted above for wave technology, a driver to pursue tidal technology at Mallacoota would be to demonstrate cutting edge technology. We believe this is not the primary purpose of this project.

6.13.1 Tidal Barrage

A recent presentation at All Energy on the Derby tidal barrage project in Western Australia discussed a 40MW tidal basin project. A tidal barrage project at Mallacoota is not feasible for the following reasons:

- The tidal range at Mallacoota is insufficient for a barrage to be effective
- The size of demand is relatively small and tidal barrage technology is only viable in the ~40MW scale and above (as per the Derby project in WA)
- The environmental impacts of constructing a barrage are likely to be unacceptable.

Criteria / Goals	Description and scoring
Community acceptance	This is about the ability of the option to have broad community support as an important improvement in the economic and social wellbeing of Mallacoota. Range: 1 = significant risk of community division / 5 = strong support Score: 1 The community would be likely to have grave concerns regarding construction of a large barrage across the inlet. Ranking – vital

Tidal barrage is not a recommended technology at Mallacoota as it scores poorly against vital criteria.

6.13.2 Tidal Stream

There is a significant tidal stream resource off the coast at Mallacoota. This is demonstrated in the Victorian Tidal resource map published by Sustainability Victoria, presented in section 6.3.7 above.

A large number of tidal stream energy technologies are under development globally with some at full scale demonstration phase in Europe and elsewhere.

The following issues would be faced with a tidal stream project at Mallacoota:

- High capital cost and unknown maintenance costs leading to a very high cost of energy.
- High environmental impact assessment requirements including detailed studies into impacts on marine mammals, fish, birds
- Long development and construction timeframe leading to an uncertain schedule for the town.
- In the absence of tariffs or incentives or a banded RET to ensure bankability, a very long term Power purchase agreement at a rate of around 40-50c/kWh would need to be provided to the project to achieve financial close and delivery.

For these reasons, a tidal stream energy project is not considered a feasible option for the near to medium term for the town. Since other lower cost and easier to deploy technologies already exist there is no significant advantage in waiting for tidal technology to become more commercially ready for this project.

6.13.3 Evaluation of tidal stream against Option Selection Criteria

Criteria / Goals	Description
Proven robust technology	The ability of the option to operate reliably without risk of failure for technical reasons at critical times. Range: 1 = unproven technology / 5= well understood technology **Score: 2** Tidal stream has been demonstrated internationally at pilot scale with at least one Australian company developing technology, however this is not yet commercially deployed at full scale. Tidal lagoon has been demonstrated globally at full scale but never in Australia. Ranking - very important
Operation and maintenance	The ability of the option to be operated and maintained with local expertise. Range: 1 = external expertise frequently required / 5 = locally (or reliably remotely) maintained and operated. **Score: 1** With no Australian based commercially operating tidal generation systems in place to date, external expertise would be essential. While technology developers are active in Australia, their focus is pilot schemes and no fleet of operating commercial tidal energy plants and maintenance staff have been established in Australia. Ranking - very important
Economics	The ability of the option to generate an income and pay back capital investment. Although a commercial entity may incur the majority of capital cost, the cost of the option will ultimately flow on to the customers. An option that is not financially viable will be difficult to realise. Range: 1 = continuing financial cost / 5 = profitable in medium term **Score: 1** The high cost of tidal power compared to other sources makes this option prohibitive. Ranking - important
Resource abundance	The ability of the option to use a reliable resource and be capable of rapid recharge of storage after extended use.

Criteria / Goals	Description
	Range: 1 = long recharge time / 5 = rapid recharge time **Score: 4** The high anticipated resource and predictability of tidal stream is helpful in scheduling power generation. Tidal stream resource maps indicate high resource quantity off the coast at Mallacoota. Ranking – important

Tidal scores poorly on several very important criteria therefore is not included in the recommended solutions for Mallacoota.

6.14 Diesel & Natural gas fuelled electrical generation

This project priority is to focus on renewable energy options. In the event that renewable energy is unable to meet the whole town demand through an outage period in a cost-effective manner, the option of including a conventional fossil fuelled generator is also considered.

Diesel fuelled engines are an established, robust and reliable technology utilised for electrical generation. In comparison to diesel, gas fired electrical generating technology is less widespread in Australia and considered less reliable due to common issues with quality of supply regarding gas main pressures. Nonetheless, opinions are changing and natural gas fuelled generators are becoming more popular with the expansion and abundance of natural gas extraction. Natural gas currently has a dramatic cost advantage over diesel fuel.

6.14.1 Sizing requirements

Table 6-12 below outlines the various models of Cummins diesel and gas fuelled generators that are considered suitable to supply the town with an emergency power supply during outages. Analysis of the town's demand profile established that a generator with a capacity of 1.6 MW would be required to meet the highest night time demand during peak holiday season. It is expected that this night time peak can be smoothed with demand management techniques and the gradual migration away from electric hot water to solar hot water or heat pump systems. Therefore a 1.6MW system would be comfortably sized for the load at Mallacoota.

Table 6-12 Generator sizes and capital costs

Model	C1400 D5	C2000 D5	C2750 D5	C1540 N5C
Standby Rating	1120 kW	1650 kW	2200 kW	1540 kW
Capital Cost	$304,000	$609,000	$910,000	$815,000

These prices are for the generator hardware only and exclude installation and grid connection costs.

6.14.2 Diesel & Natural Gas

Table 6-13 is a comparison between two similar sized diesel and gas generators. The table explores the differences between the two technologies and how the different fuel sources impact on critical aspects relative to electrical generation.

Table 6-13 Comparison of diesel & natural gas electrical generation

	Diesel	Natural Gas

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Capital Cost	-Cummins C2000 D5 (Standby 1.65 MW) is priced $609,000 Plus GST (excludes installation and connection, total cost estimate $1.5M)	-Cummins C1540N5C (1.54 MW) Gas Generator is priced at $815,000 Plus GST -It is estimated at $1.5 million per MW for basic site installation. Heat recovery included is estimated at $2.3 million per MW
Efficiency & Operation Costs	-The recommended diesel generator for this project is the Cummins C2000 D5. At 100% load rating it consumes 393 L/hr. Australian Institute of Petroleum [31] listed diesel prices on the 17th of November at $1.58 per litre. At this market price it would equate to a running cost of 38 ¢/kWh.	-The recommended gas fired generator for this project is the Cummins C1540N5C. At 100% load rating it consumes 13.73 MMBtu/hr which is the equivalent of 14,485.85 MJ/hr. Given a Victorian market gas price [32] of 1.5¢ equates to a running cost of 14.1 ¢/kWh.
Maintenance Costs	-Cummins recommend preventative maintenance is to be carried out every 3 months when in standby operation, costing approximately $484.00. -Cummins recommend a service every 300 hours or an oil sample at 12 months costing $2,933.00 Plus GST. -Services can be carried out by local diesel mechanics or if Cummins supplied the services they charge an additional $1.45 per Km (Return trip from Melbourne costing $1,490.6)	-Cummins recommend preventative maintenance is to be carried out every 3 months when in standby operation, costing approximately $484.00. -Cummins recommend a service every 300 hours or an oil sample at 12 months costing $2,933.00 Plus GST. -Services can be carried out by local diesel mechanics or if Cummins supplied the services they charge an additional $1.45 per Km (Return trip from Melbourne costing $1,490.6)
Engine Lifecycle	-When in standby use the Cummins 1.65 MW diesel generator has an estimated operating lifecycle 24,000 hours. -Estimated lifecycle would more than double in length if it was used for continuous operation.	-Gas fuelled generators operate at a very high temperature relative to diesel generators. An elevated operating temperature causes unwanted strain and wear on the engine if the system is being stopped and started frequently. The substantial variations in engine temperature dramatically shortens the predicted lifecycle, due to this factor Cummins would not estimate lifecycle for the 1540 kW system when used for standby operations. However it can be presumed it would be significantly shorter than the diesel.
Ramp-Up Time	-Once combusting and in operating diesel powered generators are capable of apply 100% load to the engine. Cummins estimate the start up time at approximately 15 seconds.	-Before applying 100% load, gas powered generators need to be sufficiently warmed up to optimal operating temperature. The time this takes is directly impacted by the surrounding ambient temperature, in South East Victoria, start-up time is around 5-10 minutes.
Reliability	-Proven, robust and reliable technology. -Ability to reliably operate and adjust output under varying load. -Reliability could be impacted if fuel quality is not ideal.	-Gas generators often have issues regarding reliability if they are operating directly off a gas main. Gas mains generally cannot deliver the pressure and flow rate required thus the generator cut out. However this is not an issue if the supply is from an onsite high pressure storage vessel.
Fuel Source Storage Issues	-According to (ADF1403.doc, BP Australia Ltd, 2002) [No33] Diesel will remain in a useable state for 12 months at an ambient temperature	-Natural gas can be stored for an unlimited amount of time with little degradation of quality if the vessel is well insulated and retained at a

	of 20°C and for 6-12 months at an ambient temperature of 30°C. -As diesel deteriorates with age, sediment and gum begins to form which blocks filters and causes carbon and soot deposits on injectors which will lead to engine failure. -Storage length can be improved with the use of metal deactivators.	temperature below 10°C. However if the ambient temperature fluctuates regularly and is often above 20°C then the gas will form impurities such as increased moisture content, this can have adverse effects on engine operation.

Summarizing the comparisons in this table it is recognised that gas is regarded as a cheap, effective and reliable energy source when used for a continuous supply. However the key issue of frequent heating and cooling that arises when in standby use does not make natural gas an ideal backup generating option. Based on these fundamental concerns it is recommended that diesel fuelled electrical generation is the most suitable for this project as it is reliant and effective when used for standby operations. Conversion of a diesel generator to dual fuel usage is however an option considered below.

6.14.3 Fuel Storage and Emergency Supply

During extreme situations such as bush fire or flood, the local police declare an emergency situation and the town diesel supply is then restricted to only those uses deemed to be essential in emergency situations. This includes the Hotel (emergency assembly location) and local doctor's office, amongst others.

The central generator should not be designed to be reliant on diesel supply from the fuel station in town. A separate dedicated fuel store is recommended for the generator location, and this site will be designated as a critical store so the fuel cannot be taken by emergency services for other use during outages.

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The size of storage tank would be influenced by the amount of generation required (number of days backup) and type of fuel as discussed in the table above.

6.14.3.1 Fuel and Storage Costs

An outage was simulated using the renewable energy modelling software HOMER in order to help determine what sized diesel storage vessel and fuel costs would be needed for a 1, 2 & 3 day outage.

A solar generation scenario was considered for this simulation; solar generation reduces the amount of diesel required during daytimes. A 4.5MW solar system was modelled, as discussed in section 6.8 above.

The real demand data for the town on an hourly basis was used in the simulation. Potential demand management reductions were not included into the calculations as the objective of the model was to accurately determine what volume of diesel fuel supply would be required to have on site given the most unfavourable conditions. Therefore the exclusion of further possible demand reductions ensures that the recommended storage sizing and required diesel back up supply is on the conservative side and reinforced by a margin of safety.

The particular days of August the 1st 2nd & 3rd for 2012 were chosen for the modelling scenario as these days had the lowest solar radiation. This gave rise to the largest deficit between potential PV power output (4.5MW solar PV system) and the primary power load demand which in turn would give rise to the highest diesel consumption requirements within the 2012 period.

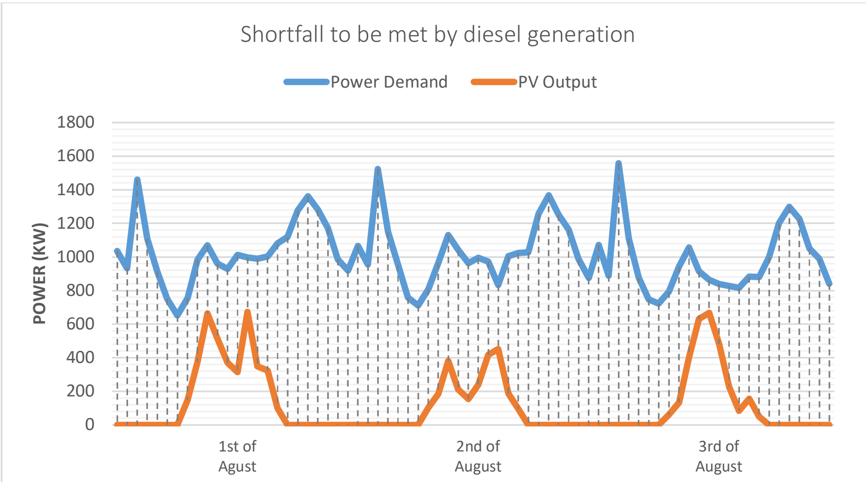

Figure 6-49 Solar deficit needed to be met by diesel generation, August 2012

Figure 6-49 above is the graphed results from HOMER modelling which display the power demand profile for the town and volume of potential PV output to the grid for August 1st, 2nd & 3rd 2012. As the graph illustrates, there is insufficient PV output to meet the town's power demands for these consecutive days. Therefore if an outage occurred in this period the backup diesel generation source would consume significant amounts of diesel. The capacity of the diesel generation required in kW is simply the difference between the power demand and PV output profiles, thus it fluctuates relative to the strength of the solar resource at that time.

Figure 6-41 below demonstrates the diesel generation output relative to the potential PV output required to meet the town's electricity demands for August 1st, 2nd and 3rd 2012. It is apparent that the maximum output required from the diesel generator is during the night time peaks at a value of approximately 1.55 MW when there is no input from the solar resource. The maximum output from the PV resource is 0.7 MW which occurs around 12.00 p.m. on the 1st and 3rd of August. The addition of the two output profiles constructs the power demand profile.

Commented [TH39]: What about the 200kw Demand Management Capacity? Is it included in the considerations here?

Commented [DN40]: See paragraph added above, clarifying that demand management is conservatively excluded.

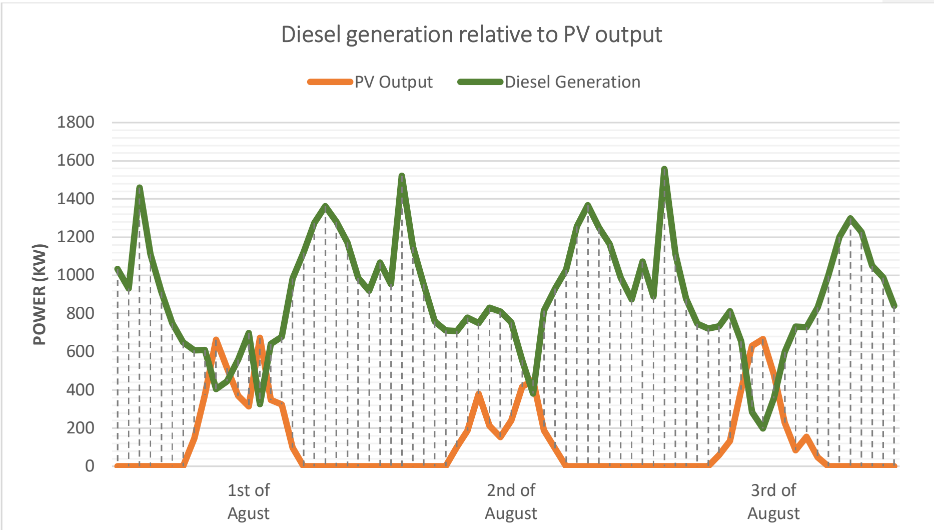

Figure 6-50 Required diesel generation relative to PV output

The required volume of diesel and corresponding costs for a 1 day, 2 day and 3 day outage were calculated based on the required diesel generation input to the grid as seen in Figure 6-50 above. The results can be seen in Table 6-14 below. Note that the storage required and operating costs are not linear, this is due to the fact that we modelled an outage based on actual demand data for these days therefore the fluctuating fuel requirements relates to the simulated interaction between the town's demand and solar generation.

Table 6-14 Required volume of stored diesel and costs for a 1-3 day outage.

	1 Day Outage	2 Day Outage	3 Day Outage
Storage Required (L)	5,148	10,650	15,696
Fuel Costs for event ($)	8,134	16,827	24,800
Approximate capital Cost of required storage Tank ($)	5,832	11,547	18,014

Figure 6-51 Example of a 10,000 Litre above-ground diesel storage tank.

As seen in the Table above, an outage with a duration of 24 hours would require 5,148 litres of stored diesel onsite to supply fuel continuously to the Cummins C2000 D5. Given the current diesel price of $1.58 a litre taken from AIP [31] this would correspond to a daily cost of $5,832. Longer outages incur higher costs for fuel and tanks. A large enough tank for a long outage would be preferable for energy security. Capital cost of required diesel storage tanks were taken from Tank Management Services [34] who are an Australian supplier of diesel storage and pumping equipment.

In the case of diesel, it may be possible to store sufficient diesel supply to provide the whole town for multiple days however if not used for 6 months the fuel would have to be purged and replaced at a cost. The 6-month old diesel could potentially be sold to the local fuel station.

In the case of gas it would be easier to store large enough volumes for longer periods.

The fire safety of fuel tanks would have to be assessed and appropriate preventative measures taken to minimise the risk of damage in bush fire events.

6.14.4 Dual fuel

Dual fuel (also referred to as bi fuel) engine technology has the capability to effectively operate off both diesel and gas simultaneously or just the one fuel type individually. The two individual fuels are stored in separate tanks with the electric fuel injectors delivering both fuels in unison to the combustion chamber at the optimal ratio. Dual fuel is a rapidly expanding and developing technology that has been widely adopted in the transportation, power generation and manufacturing industries due to its wide range of benefits. Many of the disadvantages regarding gas fuelled electrical generation discussed in table 6.13 are overcome through the application of co-combusting diesel and gas simultaneously, performance improvements include; cleaner burning combustion cycle, improved efficiencies, extended run time and lowered costs. An additional benefit of dual fuel technology is that it can be added on to an existing diesel or gas engine to function in dual fuel mode.

Efficiency is vastly improved by the introduction of natural gas to the combustion chamber due to the extensively increased HHV (higher heating value) and BTU (British Thermal Units) content. The increased combustion temperature results in all the remaining potential energy from the diesel emissions to also be combusted, which previously would not have ignited at the lower temperature and would have simply been extracted through the exhaust chamber. Consequently this creates a much cleaner and more efficient cycle.

A Melbourne based company called GasTech Engine Equipment Pty Ltd supplies and installs engine conversion systems for diesel engines. They term this technology as 'Diesel ignition Technology" which is a dual fuel multi-port electronic sequential injection technology that operates on a small amount of diesel for combustion ignition followed by natural gas in the form of either CNG or LNG. (GasTech Engine & Equipment Pty Ltd) [35]. GasTech advise the main advantages of their technology are that there is no de-rating of engine horsepower, seamless change back to 100% diesel without loss of power and improved efficiency.

GasTech quoted the conversion of the Cummins C2000 D5 (1.65 MW) to operate on natural gas will cost of the order of $188,000. This is for the conversion and excludes installation on site or commissioning. To operate on natural gas it will have a substitution rate of 30% diesel and 70% gas minimum with no loss of power. GasTech also advised the conversion would take approximately 2 months to complete.

6.14.5 Biogas Generator

This dual fuel conversion process would also enable a diesel generator to run from biogas as well as natural gas. It could therefore be compatible with increasing the renewable fraction of generation by the system, if a supply of biogas can be provided e.g. through an anaerobic digestion system at Mallacoota.

The process of claiming renewable energy credits (RECs) might be made more complex by the need to verify what portion of the fuel energy value was provided from renewable sources (biogas), vs which portion was from fossil fuel (diesel or natural gas). The financial advantage of the RECs may however be worth the administrative cost of this process.

6.15 Concentrated Photovoltaic

Concentrated photovoltaic (CPV) is a developing technology that uses a parabolic dish or mirror to concentrate sunlight to a solar photovoltaic cell. The large area of the reflective surface allows an amplified volume of sunlight onto a small area of PV cell which is situated in the focal point of the dish. The benefit of this arrangement is that the small PV cell is exposed to an immense concentration of radiation that is provided by low-cost large-area material, thus the utilization of the cheap material is able to vastly improve the systems overall output.

The centrally mounted PV converter cells are generally water cooled using closed-loop circulation, it is paramount that cooling is effective otherwise output efficiency and cell life will be critically reduced. CPV has the highest efficiency of all concentrated solar power technologies, reportedly up to 43%, however it is still an emerging technology with only a few MW of capacity currently installed in Australia and many projects still undergoing research and development.

A 1.5 MW peak rating pilot demonstration facility was commissioned by Solar Systems in 2013 in the city of Mildura, North Western Victoria. As can be viewed in Figure 1.1 below, the site has an array of 40 CPV dishes. These are feeding output into the national power grid supplying power to about 500 homes under a power purchase agreement with Diamond Energy. The 40 dishes take up an area of 4 hectares which is the equivalent of approximately 2.66 hectares per MW. The project has received $15 million funding to cover a proportion of the costs for the 1.5 MW system. The project is intended to expand to a 100 MW facility with additional government funding if the technology can be proven to be reliable and robust [36].

Inland locations such as Mildura are best suited for CPV sites as they are predominantly less cloudy than coastal regions and therefore have less diffuse light. Diffuse light occurs in cloudy overcast conditions as the light refracts through the clouds, scatters and is too diffuse to be concentrated by the parabolic dishes. A measurement called Direct Normal Irradiance (DNI) measures the quantity of solar energy arriving at the earth’s surface from the suns direct beam. According to the Australian Energy Resource Assessment report [37] Mildura has a DNI of 6.66 kWh/m²/day where in comparison Mallacoota DNI averages 4.44 kWh/m²/day. A DNI value of 33% less means that a potential CPV plant at Mallacoota would have approximately one third less potential operating hours when compared to the Mildura site which would have a substantial impact on the total output.

Figure 6-14-1, 1.5 MW Concentrated Photovoltaic demonstration facility in Mildura.

Figure 6-14-2 CPV parabolic dish and receiver.

Other common issues regarding CPV are the capital costs of the tracking technology and the challenges that arise with accurate design of photovoltaic concentrators. The angle that the light meets the direct centre of the parabolic dish should be held constantly at 90°. This requires sensitive tracking technology capable of moving constantly in order to follow the path of the sun throughout all times of the year which can be technically challenging. Maintenance of tracking systems can be costly.

A report by IT Power and Australia Solar Institute in 2012 [38], compared concentrating solar power technologies including concentrating solar PV (CPV) and concentrating solar thermal (CST). It gave an estimate levelised cost of electricity for a large scale CST plant in an optimal geographic location such as Longreach at ~25 c/kWh. A sensitivity analysis was undertaken on this for location and size. The same large scale plant located in Mildura would have a LCOE of around 35 c/kWh. In spite of limited real world data on CPV project costs an attempt was made to provide an LCOE of CPV and variation of LCOE with system size. A CPV system below 5MW is projected to be 1.7 to 2 more expensive than the above provided cost. Therefore a CPV of 5MW in Mildura would have a LCOE of approximately 61 c/kWh. A system in Mallacoota would have an even greater cost of electricity supply due to the poorer resource. This is a prohibitively high electricity cost and would rule out CPV as a technology for consideration in Mallacoota at this point in time.

It should be noted that Silex Systems, the company behind the CPV system in Mildura, have set a target LCOE for their technology of 10c/kWh within the next few years, which is consistent with targets set by CPV companies in the USA. However there is little data regarding progress towards these targets and the current LCOE on the Mildura plant is not publicly published.

By comparison wind is approximately $0.10/kWh and a solar PV plant is around $0.20/kWh, highlighting that CPV is currently a less economic solution for Mallacoota than other viable alternatives.

6.15.1 Evaluation against Option Selection Criteria

Criteria / Goals	**Description**
Proven robust technology	Range: 1 = unproven technology / 5= well understood technology **Score: 1** Concentrated photovoltaic is an emerging technology still undergoing research and development. Technical challenges include reliability of the tracking devices and overheating of the receivers. Ranking - very important
Economics	Range: 1 = prohibitive financial cost / 5 = profitable in medium term **Score: 1** Concentrated photovoltaic at the scale required for Mallacoota would currently be economically unfeasible. Ranking - important

6.16 References for Section 6

Commented [TH41]: Where is reference 'i'?

1 Sustainable Energy for Mallacoota Discussion Paper, May 2013 by Terry Jones and Siriwaan Sao, SP Ausnet. Published in 2013 on the MSEG website

2 IEA Medium Term Renewable Energy Market Report 2013

3 'The Australian Energy Technology Assessment 2012' by the Australian Government Bureau of Resources and Energy Economics Available from www.bree.gov.au
Available from www.bree.gov.au

4 The World Energy Council and Bloomberg New Energy Finance "Cost of Energy Technologies Report", 2013.

5 ACT Government Environment and Sustainable Development Directorate, http://www.environment.act.gov.au/energy/solar_auction

[6] The WEC report was published on 3rd October 2013 and states 'All local currency values have been translated to USD at current foreign exchange rates.' According to www.xe.com the exchange rate on 3rd October 2013 from USD to AUD was 1.06345. IEA report was published on 21st June 2013 when the exchange rate from USD to AUD was 0.98142, these rates have been applied to the LCOE figures in Table 6-1.

[7] Bureau of Meteorology Website: http://www.bom.gov.au/climate/austmaps/about-solar-maps.shtml

[8] Sustainability Victoria solar resource map http://www.sustainability.vic.gov.au/Publications-and-Research/Research/Renewable-energy-resources/Interactive-maps/Solar-map

[9] Correspondence from East Gippsland Water operations team to Enhar in November 2013 including sludge statistics from measurements in 2010.

[10] Building Victoria's Organics Recovery Fund Application Form completed by East Gippsland Shire Director of Operations in October 2012, forwarded to Enhar by the Manager of Waste and Assets on 28th November 2013.

[11] Regional estimates of Victorian biomass resources, Taylor et al, 2011

[12] The Quantities of sawdust and sawmill waste at Cann River were researched and reported by Lester Wharfe of East Gippsland Shire Council.

[13] Sustainability Victoria wave resource map http://www.sustainability.vic.gov.au/Publications-and-Research/Research/Renewable-energy-resources/Interactive-maps/Wave-map

[14] Sustainability Victoria tidal stream resource map http://www.sustainability.vic.gov.au/en/Publications-and-Research/Research/Renewable-energy-resources/Interactive-maps/Tidal-map

[15] Sandy Atkins presentation at Clean Energy Week 2013 'Applicable Standards for Different Installation Types'

[16] NEF Report by AEMO

[17] IT Power, Lovegrove et al, 2012, "Realising the Potential for Concentrating Solar Power in Australia, Australian Solar Institute

[18] Solar Farms for Mount Remarkable, IT Power, for Mount Remarkable Council, published on www.mtr.sa.gov.au

[19] Renew Economy article, 'ACT solar auction won by Elementus, Zhenfa Solar' By Giles Parkinson on 19 August 2013.

[20] http://www.cd3wd.com/cd3wd_40/ap/Category_Biogas.html

[21] http://www.censusdata.abs.gov.au/census_services/getproduct/census/2011/quickstat/SSC20832

[22] Shanghai Rich Manufacturing Co. , http://www.alibaba.com/productgs/612987559/Shanghai_biogas_compressor_11kw_CE_ISO.html?s=p

[23] Sichuan Motet New Energy Technology Co. Ltd. , http://zhangxf831.en.ec21.com/

[24] Fuelled for Growth – Investing in Victoria's biofuels and bioenergy industries. Regional Development Victoria July 2012

[25] This mass flow rate was advised to Enhar by Alternative Clean Technologies, a biomass project developer

[26] 'The Facts: timber, climate change & sustainability' www.timberqueesnland.com.au

[27] 'Bioenergy in Australia' by Colin Stucley et al, published by Bioenergy Australia 2012, accessed via http://www.bioenergyaustralia.org/

[28] http://climatechangeauthority.gov.au/ret/final-report/chapter-7

[29] http://ret.cleanenergyregulator.gov.au/Forms-and-Publications/Publications/Power-Stations/Power-Station-publications

[30] Clean Energy Regulator Volume Weighted average market prices for LGCs, published at ret.cleanenergyregulator.gov.au

[31] Australian Institute of Petroleum http://www.aip.com.au/

[32] Gas Industry Act, Dodo Power & Gas Pty Ltd, 2013

[33]Long Term Storage of Diesel, ADF1403.doc, BP Australia Ltd, 2002

[34] http://www.rapidspray.com.au/products/tanks/diesel/refuelling

[35] http://www.gastechengine.com.au/Technology.html

[36] Article in Reneweconomy Magazine http://reneweconomy.com.au/2013/australias-largest-concentrated-solar-power-plant-officially-launched-67313

[37] Australian Energy Resource Assessment, 2010 by Department of Resources, Energy and Tourism, Australian Bureau of Agricultural and Resource Economics ABARE and Geoscience Australia, www.abare.gov.au

[38] Realising the potential of Concentrating Solar Power in Australia, IT Power, 2012 for the Australian Solar Institute

7 Integration with Storage Technology

It is possible that storage could enable a much higher proportion of local demand to be met by renewable generation. Most renewable sources are variable and if cost effective storage can be included then continual power generation could be achieved even when the 22kV grid connection is lost.

The integration of storage technology may improve the availability of the grid in the Mallacoota area. Common uses for integrated storage systems are spinning reserve, automatic scheduling, support for un-scheduled load increases, generator control, Volt Amps Reactive (VAR) support and power system stabilization. This section investigates which applications are most appropriate for the location.

Ramp-up times from each storage or hybrid solution may impact on the project in light of the local load profile.

Biogas has the advantage that the fuel can be stored and the generators run to meet the load, as discussed in section 6.10.

The option development and prioritisation is to be based on the following objectives:

- Ability to reliably supply energy for extended periods of time
- Ability to address momentary power outages (intermittency protection)
- Proven and robust technology
- Community acceptance
- Economics
- Constructability and technical feasibility
- Ongoing operations and maintenance costs and ease of local technical support

The recommendations outlined in this section are based on the objectives listed above, publically available information, common industry opinion and our experience in this field.

7.1 Large Scale Energy Storage in Australia

Australia currently has over 2.2GW of pumped storage operating in the National Electricity Market and just over 4.5MW of utility scale batteries installed primarily in off-grid remote applications. As global growth in energy storage technologies evolves, it is expected that cost competitiveness of storage systems will enable greater uptake in Australia in the following applications;

- Grid Stability
- Grid augmentation and extensions
- Renewable and other distributed generation Integration
- Off-grid and fringe of grid systems

Key barriers for the uptake of large scale energy storage in Australia include:

- Economics – large upfront costs associated with installation of large scale energy storage can deem projects unviable. Viability is highly site specific and relies on the benefits associated with energy storage for the application.
- Technology maturity – Many storage technologies are commercially available however uptake has not been wide spread creating concerns by end-users on proven longevity and performance. As the industry matures, confidence will grow.
- Market – Real case studies are limited and the debate has only recently begun in respect to the role energy storage technologies can play in our energy markets.
- Technical – There are concerns regarding the technical integration of battery storage with local grid operation. This technical expertise will further develop as the market grows and the technology matures.

- Regulatory – The regulatory framework and local standards do not currently provide clear guidance for the implementation of energy storage.

7.2 Large Scale Energy Storage Technologies

This section includes a high-level description and discussion of the various large-scale energy storage technologies in the market. Table 7-1 includes a more detailed analysis of the technologies.

7.2.1 Bulk Energy Storage

7.2.1.1 Pumped Hydro

Pumped hydro-power energy storage utilises the potential energy of water as it is pumped from a low elevation to a higher elevation. Typically off-peak electric power is used to operate the pumps and the water is stored at the elevated location until periods of high energy demand. Pumped hydro-power energy storage plays a key role in load balanced large grids. Pumped hydro-power storage is the largest and most mature form of grid connected energy storage available[1].

This technology usually requires large energy outputs to be commercially viable. Using this method as a possible solution for this project is further explored in section 7.3.

7.2.1.2 Compressed Air Energy Storage - underground

Compressed air energy storage operates by storing pressurized air in underground geologic storage structures. Compressed air energy storage uses excess (or off-peak) electricity to power large air compressors, which push pressurized air into the underground location. When energy is needed, the underground stored air is released through a turbine to generator electricity. Typical underground geologic material includes salt or limestone caverns[2].

Mallacoota does not have the required underground locations for this type of energy storage.

7.2.1.1 Compressed Air Energy Storage – above ground

Isothermal compressed air energy storage has recently entered the market on grid-scale and involves a slightly different process to that outlined above. In an isothermal compressed air system, the heat produced during air compression is stored in water. The process is then reversed as the energy is extracted. In this set-up, fossil fuels are not required to reheat the air[3].

Although this technology could provide a solution to this project it is not considered to be commercial at this time.

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[1] Alstom – Hydro Pumped Storage Power Plants http://www.alstom.com/Global/Power/Resources/Documents/Brochures/hydro-pumped-storage-power-plant.pdf [viewed 23 October 2013]

[2] CleanTechnica – Compressed Air Energy Storage http://cleantechnica.com/2013/05/23/compressed-air-energy-storage-in-the-northwest-enough-wind-energy-to-power-85000-for-a-month-can-be-stored-in-porous-rocks/ [viewed 23 October 2013]

[3] Market Wired – SustainX Smarter Energy Storage http://www.marketwired.com/press-release/SustainX-Begins-Operating-Worlds-First-Grid-Scale-Isothermal-Compressed-Air-Energy-1829475.htm?pagewanted=all [viewed 8 November 2013]

7.2.2 Grid Support Energy Storage

7.2.2.1 Sodium Sulphur Batteries

A sodium sulphur battery cell is a type of molten-salt battery made up of a liquid sodium anode and sulphur cathode operating at around 350°C. Sodium sulphur batteries are utilised for various applications which require high energy density. There are safety concerns when handling this battery cell due to the operating temperatures required[4].

Given the technical requirements of this battery is not considered to be viable for this project.

7.2.2.2 Flow Batteries – e.g. Vanadium Redox, Zinc-Bromine

A flow battery is a type of instantaneous rechargeable battery that has two liquid chemical components separated by a membrane, with ion exchange between. Unlike conventional batteries where energy is stored in the electrode material (the cell), flow batteries store energy in the liquid solutions (electrolytes). The system capacity is dependent on the size of the two tanks, and can therefore be scaled and customised. As the energised chemicals are held in separate tanks, safety risks are reduced[5].

Flow batteries are not considered to be commercial at this time and as such are not considered applicable to this project.

7.2.2.3 Lead Acid Batteries

Lead acid batteries are made up of a series of identical cells that each contains positive and negative plates of lead and lead dioxide active material. Lead acid batteries are the most mature form of battery energy storage and installation costs are typically low compared to other technologies. Lead acid batteries are widely used globally. Lead acid batteries are known for having relatively short lifespans and detrimental environmental impacts upon disposal. The operation of lead acid batteries can be inflexible – as there are recommended limits on the level of charge and discharge, the rate of charge and discharge and frequency of charge and discharge[6].

In recent years, advanced lead acid battery variations have entered the market. These include lead acid batteries coupled with super-capacitors (see below)[7].

This form of storage is considered to be commercial and technically viable for this project.

Costs

Current market costs for lead acid batteries in the scale considered for this study are around $360 per kWh.

Current market costs for large scale advanced lead acid battery systems are of the order of $1.4M for the first MWh and $0.4M for each additional MWh after that.

For the large scale scenarios considered in the Solar and wind analysis sections, the range of battery storage quantities was between 7.5MWh (with 6.1MW of wind, no diesel) and 13.5MWh (with 4.5MW of solar, no diesel).

The costs of such a system using advanced lead acid batteries would be of the order of $4M (7.5MWh storage) and $6.4M (13.5MWh storage). For standard lead acid the costs would be around $2.7M and $5M respectively.

[4] VoxSolaris – The Sodium Sulphur Battery http://www.voxsolaris.com/batnas.html [viewed 23 October 2013]
[5] UNSW – The Vanadium Redox Flow Battery http://www.ceic.unsw.edu.au/centers/vrb/technology-services/vanadium-redox-flow-batteries.html [viewed 23 October 2013]
[6] Biggin Hill – Lead Acid Batteries http://www.bigginhill.co.uk/batteries.htm [viewed 23 October 2013]
[7] Ecoult – UltraBattery http://www.ecoult.com/technology/ultrabattery/ [viewed 24 October 2013]

To facilitate the ramp rates and step load changes for the Mallacoota project advanced lead acid battery would also be a useful component of an overall solar-diesel system. To facilitate this a notional 500kW battery system could be used to assist a solar-diesel scenario at Mallacoota and would cost of the order of $0.7M based on industry pricing obtained during this study. This would provide the benefit of managing the load on the diesel during any step changes in load and ensure the diesel operates reliably. It has been found in off grid projects around Australia that a small system of this proportional size is required to assist in this regard to ensure the system operates successfully.

7.2.2.4 Lithium Ion Batteries

Lithium ion batteries contain a carbon anode (such as graphite), a metal oxide cathode and an electrolyte material containing lithium salt. Lithium ion batteries are a fairly recent technology and are commonly used in electronics, such as mobile phones. They are very lightweight, have a high energy density, hold charge well and can charge and discharge with flexibility. However, lithium ion batteries have relatively short lifespans, are higher in cost than conventional batteries and have some safety concerns with respect to their chemical composition.[8]

Our market research on large scale storage indicates that the price per kWh for Lithium-Ion batteries is between $2,100 and $2,500 per kWh of storage compared to $360 per kWh for lead acid batteries at this scale. This is a factor of between 5 and 7 times more capital required for Lithiom-Ion technology when compared to standard lead acid batteries.

This form of storage is considered to be commercial and technically viable for this project. However it is unlikely to be financially viable for this project in the short to medium term. This may change in the future as this technology moves down the technology cost curve.

7.2.3 Power Quality Energy Storage

7.2.3.1 Super Capacitors

A super capacitor is an electrochemical capacitor that can store large amounts of energy and can charge and discharge in a very short time frame. Super capacitors are typically used in applications that require fast, high levels of power, such as powering the rapid acceleration of an electric vehicle. Super capacitors can be fitted alongside conventional batteries (such as lead acid) to assist with high power demands - stopping batteries from being oversized[9]. Super capacitors are relatively expensive compared with conventional longer term energy storage.

This technology, although commercial, is not considered further for this project as by themselves they will be too expensive to add value to the solution. This technology could be used for this project when coupled with a lead acid battery in the form of an advanced lead acid battery.

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[8] How Stuff Works – Lithium Ion Batteries http://electronics.howstuffworks.com/everyday-tech/lithium-ion-battery.htm [viewed 23 October 2013]

[9] CSIRO – Super capacitors: powerful mobile energy storage devices http://www.csiro.au/Organisation-Structure/Flagships/Energy-Flagship/Supercapacitors.aspx [viewed 23 October 2013]

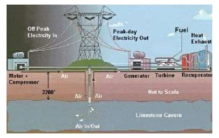
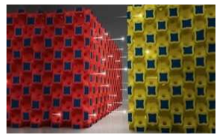
7.2.3.2 Flywheel Technologies

A flywheel is a mechanical form of energy storage which utilises rotational kinetic energy. A flywheel operates by using electricity to spin a cylindrical rotor at high speeds (maintained through inertia), which is able to discharge as required. Flywheel technologies can discharge large amounts of power in a very short timeframe. Flywheel technologies can assist in achieving grid stability in islanded locations. Flywheels are typically limited to large applications and are relatively high in cost.[10]

It is possible that flywheel technology may be required for this project to add 'inertia' to the electrical system. This would be required if the recommended solution includes an inverter only solution. However since the recommended solution presented in 8 includes a rotating generator (diesel generator) a flywheel is not an essential component.

[10] Beacon Power http://www.beaconpower.com/products/about-flywheels.asp [viewed 23 October 2013], ABB http://www.abbaustralia.com.au/product/us/9AAC167812.aspx [viewed 23 October 2013]

Table 7-1 - Technology Analysis [16] [17]

Typical Characteristics	Bulk Energy Storage		Grid Support and Load Shifting (can also be both Power Quality and Bulk Storage)						Power Quality	
	Pumped Hydro	Compressed Air Energy Storage	Sodium-Sulphur	Flow Batteries (Vanadium Redox)	Flow Batteries (Zn-Br)	Valve Regulated Lead Acid (VRLA)	Advanced Lead-Acid	Li-Ion	Super Capacitor	Fly Wheel
Image			 Source: NGK website		 Source: RedFlow website					
Maturity	Mature	Commercial	Commercial	Demonstration	Demonstration	Mature	Commercial	Commercial	Commercial	Commercial
Capacity Range (MWh)	50– >1,000	10 – >1,000	5 - >100	0.6 – >100	0.625 – 250	10 - 20	0.1 - 250	0.1 - 50		5
Power Range (MW)	280 – 1,400	10 - 1,000	1 - 100	0.1 – 100	0.1 – 100	0.1 - 50[18]	0.1 - 50	0.05 - 20	0.01 - 1	.001 - 1
Duration (hrs)	6 – 12	8 – 30	6 – 7.2	3.3 – 5	5	2 - 4	0.25 - 8	0.25 - 7	Milliseconds – 1hr	Milliseconds - 0.25hr
% Efficiency	80 – 82	40 - 75[19]	75	65 – 75	60 – 65	85 – 90	90 - 94	80 – 94	80 - 98[19]	85 – 87
Total cycles			4,500	>10,000	>10,000	1500 – 5,000	4,500 – 10,000	4,500 – 10,000		>100 000
Operating life (years)	Up to 60	20 - 30[19]	15	15 – 25	20	3 - 15	5-15	N/A	8 – 20+	20
Applications										
Advantages	Commercial, large scale, efficient	Cost, flexible sizing, large scale	Efficient, density (power & energy), cycling (vs. other battery)	Independent energy & power sizing, scalable		Mature, power density	Efficient, density (energy & power)	Efficient, density (energy & power), mature for mobility	High power density, efficient and responsive	Power density, efficient, scalable
Drawbacks	Low energy density, availability of sites, depends on availability of water	Lack of suitable geology, low energy density, need to heat the air with gas	Safety, discharge rate (vs. other battery), must be kept hot	Cost (more complex balance of system)		Environmental impact. Lifespan.	Cost, case studies in alternative applications	Cost, safety	Low energy density, cost ($/kWh), voltage changes	Cost, low energy density
Identified Suppliers *(N)AP: (Non) Australian Presence, List is not exhaustive*	AP: Snowy Hydro, Hydro Tasmania, CS Energy.	SustainX	AP: NGK Stanger Pty. Ltd. GE (Sodium/Nickel/ Chloride)	NAP: Prudent Energy	AP: ZBB, RedFlow	AP: Sonnenschein	AP: Alcobatt, Ecoult (Australian developed technology)	AP: Eltek, ABB NAP: EPPSI Energy, Mitsubishi, Toshiba	AP: Glyn (Maxwell products)	AP: ABB
Case Study	1,500MW Tumut 3 power station – first pumped storage hydroelectric power station in Australia[20]	290MW system operating in Huntorf, Germany. The Air is stored in two caverns of 150,000m³ for production over 4 hours.	The 51MW Rokkasho-Futamata Wind Farm uses a NGK 34MW Rated sodium-sulphur battery for load levelling and spinning reserve	Prudent Energy 5kW/30kWh system installed at Kitangi, Kenya as part of a hybrid power system at an off-grid site	40 5kW/10kWh energy storage systems installed for the Smart Grid, Smart City project in Australia[21]	1MW for rapid spinning reserve, frequency control and better power quality at Metlakatla, US.	Ecoult 1MW/1MWh system for the Hampton Wind Smoothing Project in NSW[22]	12MW frequency regulation and spinning reserve project at AES Gener's Los Andes substation in Chile	Maxwell Technologies installed a system in California capable of providing 450kW in 30s of uninterrupted power supply to a water treatment plant[19]	1MW/15min Beacon Power flywheel for ISO ancillary service applications

Legend

	Large scale renewables integration		Uninterrupted power supply		Power quality & frequency regulation		Wholesale markets		Ancillary services	

[16] EPRI, "Electrical Energy Storage Technology Options," EPRI, Palo Alto, 2010.
[17] Schlumberger SBC Energy Institute, "Leading the Energy Transition, Electricity Storage," 2013.
[18] European Commission - Directorate-General for Energy, *The Future Role and Challenges of Energy Storage*, 3013.
[19] SBC Energy Institute, Leading the Energy Transition - Electricity Storage, Gravenhage, 2013.
[20] Snowyhydro, "Hydro - The Engineering," Available: http://www.snowyhydro.com.au/energy/hydro/the-engineering [viewed 11 October 2013].
[21] CSIRO, "Smart Grid Smart City," 2010.
[22] Ecoult, "Wind Smoothing and Ramp Rate Control," Available: http://www.ecoult.com/case-studies/hampton-wind-farm-australia-wind-smoothing/ [viewed 4 October 2013].

7.3 Pumped Hydro option

Pumped Hydro is the most highly deployed large scale energy storage technology. It is generally deployed at significantly larger scales than the Mallacoota demand would require and it is not certain whether a cost effective solution could be constructed at the scale required at Mallacoota.

Hills to the west or east of Gypsy Point might offer sufficient head in close enough proximity to water resource to consider a pumped hydro scheme. Given the topography, a head of 60 metres looks to be available for a pumped hydro system.

Using a 60 metre head assumption with a requirement to produce continual power of 1.5 MW during an outage a calculation on the required volume of storage required for the Mallacoota project was completed. The results of this can be seen in Table 7-2 below.

Table 7-2 - Pumped Hydro Volume

Hours of storage	Volume of water (cubic metres)	Area of storage (square metres)	How many MCGs
12	130,000	32,000	1.6
24	260,000	65,000	3.25
48	520,000	130,000	6.5
72	780,000	194,000	9.7

To give a real life comparison the number of Melbourne Cricket Grounds (MCGs) that this would compare to if a 4 metre depth was used has been included in the table. As can be seen this is a large area that would need to be found in the heavily forested national park area around the township. This could possibly be completed using tanks however this would still require an area to cater for the tank farm.

This solution would be quite heavy with environmental approvals and as such is not considered appropriate for this project.

7.4 Battery options

Lead acid batteries have been proven on a large scale, are comparatively low in cost and have high energy and power density. If they are rarely used, ongoing maintenance costs are low. As discussed above, there are environmental concerns with this technology and they are fairly inflexible to operate. Alternative battery technologies that offer improved operational flexibility are currently not commercialised and/or not price competitive.

Given the need for this project to have the ability to cope with both small fluctuations and long term storage it is likely that the battery type most appropriate to the application in Mallacoota would be *advanced* lead acid technologies. These technologies have been used for network support at a commercial scale in the USA. The other benefit of this technology is that it can be used to assist with sudden reductions or increased in demand if operating in an island operation under diesel backup generation.

Lithium ion batteries are lightweight, have a high energy density, hold charge well and can charge and discharge with flexibility. As discussed above, this technology is not anticipated to be price competitive at the moment for this type of application at large scale.

7.4.1 Value Earned from making battery available for dispatch

Batteries can be a valuable asset in the network and can earn revenue through participating in the wholesale market and the ancillary services market. The battery would be identified by a network operator and could be controlled at certain times to support the network. Such participation could earn a 1MW battery system approximately $40,000 per year for example, as extra revenue to the project. Reposit power is an Australian company specialising in battery sizing and economic optimization who provide services in relation to obtaining value for batteries in the network.

7.5 Large Scale Energy Storage Recommendations

The Mallacoota community is looking for an energy system that reliably supplies energy for extended periods of time, is proven and robust, is economically viable, technically feasible and has low ongoing maintenance. Momentary outages are also of concern; however recent long term outages have had the largest impact on the community.

Based on the objectives discussed, if the project was to commence in the next 1-2 years it is our recommendation to incorporate advanced lead acid battery types. If the project was to commence in the next 2-5 years, our recommendation would be to further investigate and monitor pricing trends of lithium ion battery technologies.

During the process of this feasibility study it became clear that a large scale battery storage would be prohibitively expensive if required to be large enough to smooth an intermittent renewable supply (including wind or solar) during an outage of several days. A backup generator using diesel or biogas or both could provide for the shortfall in a significantly more cost-effective manner and therefore the option of large scale battery storage is not persued.

In a solar-diesel scenario, a small battery component is highly beneficial and recommended. Advanced lead acid is the recommended technology type for this application.

8 Potential Solutions

Having investigated the current and future demand, renewable energy options, storage technology and community consultation feedback, we now turn to the potentially viable solutions which could be recommended for Mallacoota.

Three scenarios were considered:

- Scenario 1: Solar project supporting the diesel-battery on its own including grid connection and islanding.
- Scenario 2: biogas system established to provide gas to the diesel genset in Scenario 1 (this option is reliant on Scenario 1 also being implemented).
- Scenario 3: biogas only (no solar) supporting a dual fuel diesel genset and grid connection and islanding.

This chapter also considers economic viability through financial modelling of costs and income. For the financial modelling, we will also refer to these as 'business' 1, 2 and 3.

Table 8-1: Description of solutions considered

Scenario (business)	Items included in scenario/business
1	1.6MW peak diesel genset and 15,000L diesel tank, 4.5MW solar PV array, 500kW/100kWh advanced lead acid battery, controller, grid upgrades, 4 transformers, circuit breakers and protection systems
2	Biogas digester, refinery equipment, storage tank, dewatering equipment, pipework
3	1.6MW peak diesel genset and 15,000L diesel tank, dual fuel conversion, Biogas digester, refinery equipment, storage tank, gas compression equipment for bottling, dewatering equipment, pipework, grid upgrades, circuit breakers and protection system

The sections below provide an investigation into each option including financial viability and business model options.

8.1 Scenario 1: Solar – Battery - Diesel system

The first solution is a solar park of several MW capacity at the sewage treatment plant. This would be integrated with a large diesel generator up to 1.6MW capacity which would provide permanent backup in the event of outages in the grid line feeding the town.

Also integrated would be a battery system which provides power quality benefits and reduces the short term loading on the diesel when sudden cloud cover occurs for example, or outages occur during night time.

Solar PV appears to be the most viable renewable electricity-generation solution to create sufficient revenue to support the costs of the required permanent backup generator and islanding capability. It is recommended because:

- Centralised solar PV & diesel meets the criteria of emergency proofing and community acceptability, and also scores highly on all the other criteria.
- The levelised cost of solar PV at the scale of a few MW has reduced significantly and is competitive with most other renewable sources. Wind at this scale would be cheaper but does not score well enough on community acceptance to be a recommended solution. While the levelised cost of large scale biomass and biogas may be competitive with solar PV (as presented in Table 6-1 above), at the smaller scale of up to a few MW required for Mallacoota biogas does not produce cheaper power than solar PV as shown below.
- A highly suitable site is available for solar PV with several technical advantages as well as environmental advantages and low amenity impact
- Solar PV is a proven technology with a many highly competent companies operating in Australia. A solar PV installation could generate income on an ongoing basis to create revenue to subsidise the substantial costs of the islanding and backup components (diesel generator and electrical connection costs).

- Solar PV is already in widespread use within the Mallacoota community and is therefore understood well in the community.
- Federal and State government bodies such as ARENA and others have awarded significant numbers of grant for solar PV projects and therefore this technology has a track record among funders and lenders.
- The site is large enough to accommodate any range of solar system size up to at least 4.5MW(AC) which means a staged development is feasible
- Solar PV with diesel and a small battery is also a well proven combination especially in mini grids and off grid communities and industrial sites around Australia which successfully use it.

A conceptual schematic of the major recommended system components is shown below:

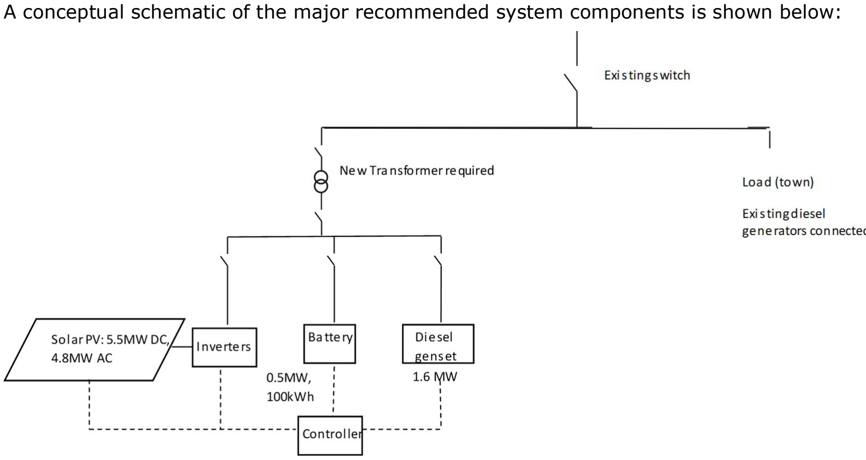


Figure 8-1: Schematic of Solar-diesel-battery system

From an electrical perspective, a single line diagram has been prepared, presented below:

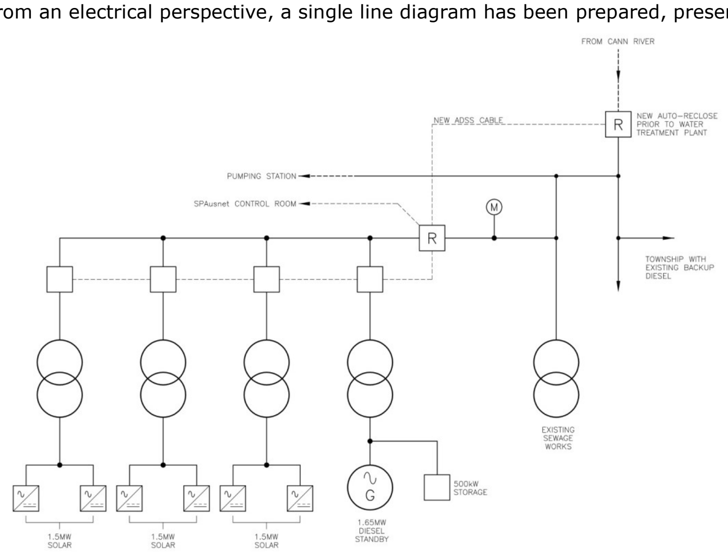


Figure 8-2 Single line diagram of recommended solution

8.1.1 Cost items

An initial estimate of capital and operational costs is presented below.

Design and Development Costs:

- Engineering design labour
- Permitting and applications

Capital Costs:

The major capital cost items to establish this system include:

- Solar photovoltaic panels and inverters, between 1.5MW – 4.5MW depending on factors such as grid export capacity, Power Purchase Agreement (PPA) size of customer etc.
- Steel support structure and foundations, civil works
- Diesel generator and diesel tank
- Battery system
- Power Controller
- Grid upgrades including two Automatic Circuit Reclosers (ACR's), an upgrade to the existing line into the sewage ponds and a dedicated fibre optic cable between the two ACR's for communication and protection requirements.
- Four (4) new transformers
- Circuit breakers and protection systems
- Onsite electrical interconnection between transformers

We have reviewed the required capital for this project and the total requirement is around $13M if the maximum of 4.5MW solar is developed.

This is broken down into:

Table 8-1 Estimated capital cost of solar-diesel-battery system

Cost item	Approximate Capital Cost ($)
Electrical Connection Requirements	$ 1.7M
Diesel Generator, 1.6MW peak	$ 1.28M
Solar Generator (4.5MW)	$ 9.1M
Battery (0.5MW)	$ 0.7M
Total	**$12.78M**

The size of the solar array is a key variable. If 1.5MW of solar were included at the outset rather than 4.5MW, the total capital costs would reduce to around $7M. Additional solar could be developed at later stages as PPA arrangements allow.

The islanding ability and backup generator infrastructure for the town require some revenue stream to justify their installation and maintenance. A solar PV system would be potentially capable of generating sufficient revenue to achieve this, hence it is a recommended option.

Operating Costs items:

- Maintenance of panels
- Diesel generator maintenance
- Diesel fuel costs

- Battery maintenance
- Administration

Solar PV plant operational costs are $27.33/kW/year according to the World Energy Council Cost of Technologies report [4] already referenced in Chapter 6.

At this rates, a 4.5MW solar PV plant would have operational costs around $88,000/year inclusive of all O&M costs.

The diesel generator requires maintenance and we have included costs from commercial quotations which amount to around $7,000 per year inclusive of 4 quarterly services and 1 annual service.

Diesel fuel costs if assumed enough fuel for 1 x 3 day outage per year would amount to around $24,800 per year, as derived in section 6.13.3 of the report.

Income

The following sources of income could be earned by the project:
- Sale of Electricity
- Large Generation Certificates
- Network Support Payments

Network Support payments are a potential means for SP Ausnet to value the backup generation capability reducing the number of unplanned outages at Mallacoota. A discussion of network support payments is provided in Appendix D, developing potential value ranges for this item.

8.1.2 Financial Model

A 20 year cashflow analysis has been performed and is provided in full in Appendix E and is summarised in section 8.4 below.

This shows that the solar PV project to achieve a 7 year payback or better requires
- 50% capital grant
- PPA of 7c/kWh in year 1, rising with CPI
  - To underwrite project finance, the PPA should be with a creditworthy entity who is willing to enter into a long term (10+ year) PPA at a fixed price
  - Residential customers or small local businesses while important, are not expected to enter into long term PPAs and contracts with them would not be bankable in terms of under-writing project financing.
  - A large energy consumer with a large number of smaller sites could be a candidate for a suitable PPA, although price-competitiveness will be a key consideration.

Sensitivity Analysis

4.5MW is a size suitable for balancing the entire consumption of Mallacoota with solar generation, on an annual aggregate basis. In order to reduce the amount of capital required, the size of the plant could be reduced. Using 1.5MW modules, alternatives of 3MW and 1.5MW can be considered.

The impact of reducing the solar capacity on the minimum required power purchase price is presented below:

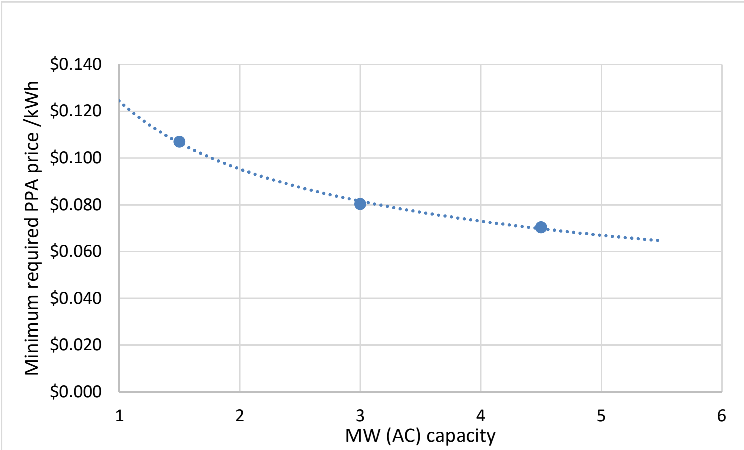


Figure 8-3: Solar-diesel-battery: Sensitivity of PPA price to solar capacity

The impact of reducing the capacity of the solar array is to increase the price per kWh required to achieve the same payback. A key reason for this is that the cost of the 1.6MW diesel component and battery do not reduce.

The sensitivity of PPA price to network support payments is discussed below in Appendix D. The figure below illustrates the reduction in required PPA price if network support payments are increased.

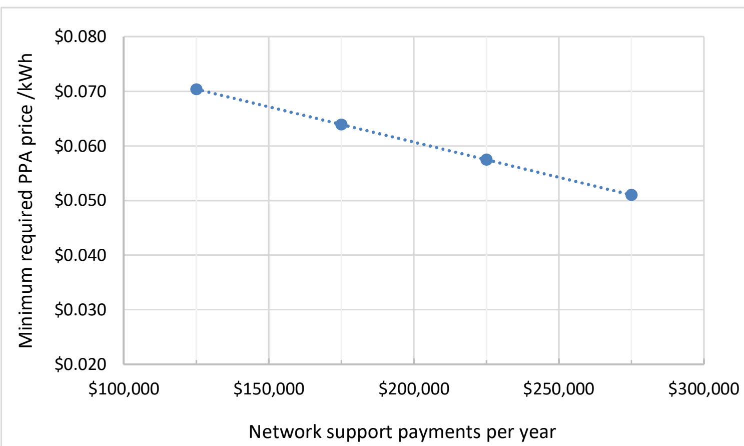


Figure 8-4 Sensitivity of PPA for a 4.5MW Solar-diesel-battery scenario to network support payments

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8.1.3 Business Model

The recommended business model is a special purpose vehicle (SPV)[23] to be established which develops and owns the solar park. Major shareholders of the SPV will include a developer and equity partner. Community residents and businesses can also invest at the outset, or invest after commissioning at a lower risk. While local community members may be able to raise only a modest amount of capital at the outset, the opportunity for participation in the early stages would be received favourably by a number of supportive community members.

The revenue from the solar park must be sufficient to fund the establishment and maintenance of a large diesel generator which is permanently located at the sewage treatment plant adjacent to the solar park. This diesel generator would be essential during grid outages, i.e. around 1% of the year.

The diesel generator component of the SPV would also be partially funded through an annual retention fee paid by SP AusNet and dispatch payments in lieu of the security of supply granted by the existence of the diesel generator. The avoided costs of temporary supply of diesel generator, diesel fuel and payment of compensation to customers for extended outages could be factored into a ‘network support payment’ paid annually by SP AusNet to the SPV.

During grid outages, to ensure steady load matching during times of sudden cloud, or outage occurring during the night, a battery system is recommended to be integrated into the solar-diesel arrangement. This would be rated at 0.5MW capacity and around 100kWh for a few minutes of supply for the whole town.

Ultracapacitor type advanced lead acid batteries would be suitable. These would also provide the added benefit of grid quality improvements.

Advantages

The above project could be financially viable in its own right with appropriate grant funding and sufficient PPA levels. Based on feedback received from specific government funding sources, it is expected that sufficient government funding could viably be obtained.

With initial government capital funding, this project could be commercially viable on an ongoing basis, provide ongoing revenue, provide energy security during grid outages, significantly increase the proportion of renewable energy supply in Mallacoota, assist the town to reach carbon neutral status and provide a community ownership opportunity.

8.1.4 Planning and Environmental Issues

Planning and environmental issues including action plan for obtaining permits are discussed below in section 8.3.

The open fields at the site and adjacent forest are home to certain bird populations. It has been reported by locals who are bird-watchers that most of the birds that use the area prefer grasslands or the transition zone between the forest and the fields. A solar farm is likely to affect bird populations only slightly as there would be grasses growing around and under the solar farm panels. The abundance of birds at the sewage ponds might require some operational phase ecological monitoring. Also soiling of panels via birdlife may have a minor impact on cleaning and maintenance costs for the solar PV system.

[23] An SPV is an entity whose operations are limited to the acquisition and financing of specific assets.[ref http://www.investopedia.com/]

8.1.5 Grid Connection

The solar park generates power throughout the year, exporting any surplus away from Mallacoota up to the capacity of the grid. SP AusNet initial discussions indicate that an export of 4.5MW may be feasible. Detailed system engineering will be required to confirm this.

Commented [TH42]: More 'further'

Commented [DN43R42]: Grid connection studies and applications are major exercises and not within the scope of this study.

There will be a requirement to upgrade the existing power line that feeds the sewage plant to ensure the required capacity is available for this project. Other upgrades to the grid include installation of two new ACR's to control the system and an optic fibre interface between these two devices to ensure co-ordination between them. Protection upgrades will be included to ensure that the system operates safely.

8.1.6 Government Funding

Solar-diesel-battery systems are a proven, repeatable solution offering low risk to investors and funders. The addition of the battery component gives assurance of continued supply through step change events such as sudden cloud cover which the diesel may otherwise be unsuited to.

Federal ARENA funding could be sought for this scheme under the I-RAR program.

8.2 Scenario 2: Biogas – storage – generator system

Another renewable resource available in Mallactooa is the biogas which could be harvested from a digester, as described in section 6.10 above.

As a separate but complimentary project to Scenario 1, a biogas system could also be established at the sewage treatment works. This would supply biogas to the generator in scenario 1 for backup power generation which will be combusted in combination with diesel in dual fuel mode as discussed in Section 6.14.4. This would greatly increase the renewable fraction of the energy used to supply Mallacoota during outages.

Scenario 2 could be initially developed and owned by an entity which is separate to the entity developing scenario 1. East Gippsland Water may be well placed to consider involvement in development and ownership of the digester, for example.

The digester would create an ongoing supply of biogas which would be scrubbed to improve methane content. Any available gas would firstly be input to a biogas storage tank, sized to store enough biogas to generate power for approximately 3-5 days of usage for the town. During outages, with the solar park generating power every daytime, the amount of biogas required to match the load is significantly reduced as it is primarily required during night time hours.

A schematic of the system is provided below:

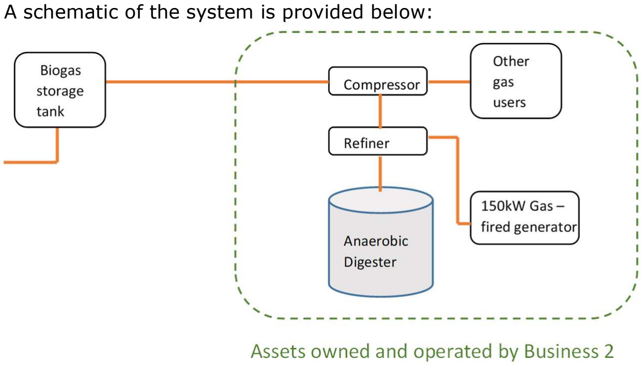

Figure 8-5: Mallacoota Biogas system schematic

8.2.1 Possible Business Models

Commented [DN44]: Moved here from section 6, in response to MSEG (Tricia) comment

A biogas generator sized to supply the whole town's needs would be under-utilised most of the year due to limited production rate of biogas.

Business 2 would sell biogas to business 1 however there may be years when only a small number of outages occur. Therefore to utilise the gas which is produced ongoingly, the business model for scenario 2 could benefit from inclusion of a 160kW generator in addition to the 1.6MW generator for the town (business 1). Whenever the storage tank is full, business 1 does not buy further biogas and the 160kW generator would be used to continuously convert biogas to electricity as biogas was generated.
During outages, business 1 would generate night time power from the biogas in preference to diesel.

The components of the solution which would ensure reliability of supply would be:

- A co-fired generator sized to be capable of meeting the whole town's requirements. Dual fuel conversion of the diesel generator already included in scenario 1 would be added to the capital costs of scenario 1.
- A tank capable of storing sufficient biogas to generate power for at least 3-5 days for the whole town, and this tank being refilled as quickly as possible i.e. biogas first preference is to fill the 'security' tank when the tank is less than full. A case could be made that business 1 in scenario 1, which is responsible for generating backup power for the town during outages, should be responsible for the procurement and maintenance of a biogas storage tank. For this analysis however it is assumed that the business in scenario 2 pays for the storage membrane tank. An example illustration of a storage membrane is provided below:

Figure 8-6: Example of a biogas storage membrane (source: Biogas Australia)

8.2.2 Cost of a Biogas plant

The following sub headings examine the breakdown of the costs involved with the design, equipment, installation and operating costs of a co-digesting biogas plant. Estimated capital costs are provided however the final costs of each individual item and task requires comprehensive research into the system's optimal design and operating conditions, and a tender process.

The total capital cost of an installed biogas plant of the scale required for Mallacoota can be estimated in the range $1M - $2M. Typical biogas plants burn the biogas in generators immediately as the biogas is created, such a system at the scale suited to the feedstock at Mallacoota would be expected to cost around $1.5M. The long term storage element of the current scenario is unusual and adds around $0.5M to the cost. Costs considered include the estimated capital cost involved with system design, capital equipment and installation costs. A closer look at major cost areas is provided below.

Design Costs:
Estimate Total $125,000 for:

- Analysis of the available feedstock and research into optimal feedstock ratios
- Modelling of potential biogas yields
- Sizing of biogas system and supporting infrastructure

- Overall engineering design of the system
- Documentation for planning application

Equipment Costs:

Table 8-1 Estimated capital cost of required biogas system equipment

Equipment item	**Approximate Capital Cost ($)** excluding installation
Anaerobic Digester	$300,000
Biogas Generator 160kW	$200,000
Refinery equipment (Scrubber)	$100,000
Pumping equipment	$50,000
Dewatering Equipment	$80,000
Stirring equipment (Agitator)	$5,000
Preparation equipment (Shredder)	$10,000
Storage tank (membrane)	$300,000
Total	**$1,045,000**

Construction Costs:
Estimated construction and installation cost: $850,000 including:

- Foundation and concrete pad installation
- Labour input and wages
- Equipment and plant operating costs
- Materials
- Delivery of materials and equipment

Grid connection costs
Estimate $100,000 including

- Grid connection for 160kW generator

The costs of the 1.6MW generator and its grid connection are included in business 1 above.

Gas Piping
Gas would require to be transported from the digester location to the 1.6MW generator location. Figure 8-10 below illustrates possible locations for the infrastructure and illustrates that a distance of a few hundred metres would probably separate the optimum digester location (next to the incoming sewage pipeline) from the optimum generator location (next to the existing transformer). Either a gas pipeline or an underground electrical cable would be required between the two. A budget of $20,000 has been allowed for these requirements.

Total Capital Cost
The total capital cost of the biogas project including planning, design, equipment, installation, grid and gas transport is of the order of $2.1M.

Operating Costs items:
Operating cost items can be estimated as a function of capital costs, for mixed digesters at farm sites this is typically 3% of capital (turnkey) costs per year[24].

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[24] USDA report, 'An analysis of Energy Production Costs from Anaerobic Digestion', 2007, accessed via http://directives.sc.egov.usda.gov/, page 6

Considering the additional procedure of interfacing with the kitchen to compost scheme and administering any gate fees, we have used a figure of 7% of capital costs for this context. Final site-specific operational costs will be a function of whether suitably skilled expertise is available locally and specific characteristics of the available feedstock.

Estimated annual operational cost $160,000 including:

- Collection and transportation of the substrate
- Water supply for cleaning the stable and mixing the substrate
- Preparation and feeding of the substrate
- Supervision, maintenance and repair of the plant
- Storage and disposal of the slurry/fertiliser
- Administration

8.2.3 Sale of Bio Gas

Once the biogas project establishes a stable supply of fuel, the business in scenario 1 would invest in either a biogas conversion for the 1.6MW diesel generator or an additional gas fuelled generator. Refined biogas would be purchased from the operator of the biogas plant. The biogas might be supplied to business 1 at a cost lower than the diesel alternative depending on the arrangement between the two businesses and to what extent the biogas business was publicly funded. During outages, business 1 would generate night time power from the biogas in preference to diesel.

Once the gas storage tank is full, and the emergency night time supply is assured for outages, business 1 could decide whether to generate additional renewable power through the purchase of surplus biogas, or allow the operator of the digester to use gas for other purposes.

Surplus biogas, not required for emergency reserve, could be utilised by business 2 for a range of purposes such as:

- Power generation to be utilised at the sewage treatment works.
- Power generation to be exported to the grid under a power purchase agreement.
- Cooking gas to be bottled and sold to the town in 45kg canisters for local heating & cooking, and/or use at the local Abalone business for refrigeration. See section 8.3 below which considers heating and cooking gas markets.

8.2.4 Potential Income and Financial Model

The potential income for biogas in this scenario is assumed to be through electricity generation which is the most common approach for biogas projects. In this scenario, the refined biogas, not required for outages, could be combusted through the 160kW electrical generator as the gas is produced. The electricity produced through the 160kW generator would be sold under a power purchase arrangement and would earn LGCs.

A financial model has been developed for this scenario and is provided in detail in Appendix F. To achieve a 7 year payback through the sale of electricity requires:

- 50% capital grant
- PPA of 17.9c/kWh in year 1, rising with CPI
  - A bankable long term PPA contract as high as 17.9c/kWh is not generally viable other than through government feed in tariffs such the Australian Capital Territory large scale solar tariff/auction, which are not currently available in Victoria for biogas. Additional grant funding (above 50%) may be required for business 2 if it were to be developed commercially.

The sale of gas as a heating and cooking fuel would potentially offer a significantly higher revenue and improve commercial viability. This alternative is considered below in Scenario 3.

There are also substantial cost benefits of the avoided waste disposal for Mallacoota residents and commercial business if they were to choose to deposit their biodegradable waste to the biogas site rather than the local landfill. It could be necessary to charge a gate fee for all acceptable feedstock waste to cover costs of sorting and preparation prior to entering the digester, however the cost would be competitive with the fees that are currently being charged for the town. Cheaper fees could possibly result in an influx of additional available feedstock that would have previously been left to decompose in resident's backyards as they were not willing to pay for waste deposit. The kitchen to compost scheme, detailed in Appendix B, is already being established to gather compostable materials at the sewage treatment plant site. While this is expected to divert the majority of compostable materials from landfill, there may be additional digestable materials which could be obtained through gate fee incentives or other incentives.

Commented [TH45]: My understanding is that green waste can be left at the landfill site for free.

Commented [DN46R45]: To be conservative, we have not included income from gate fees in the financial model as the gate fees would be modest or for some feedstocks not charged at all.

East Gippsland Shire Council is planning to change Mallacoota's landfill site to a waste transfer station, i.e. exporting all waste materials other than compost from Mallacoota to Bairnsdale for processing.

Income from sale of Fertiliser

The remaining digestate from the anaerobic digestion cycle has potential to be dewatered to a desired moisture content of approximately 60% and then sold as organic fertilizer suitable for garden fill. Figure 8.6 and 8.7 and demonstrate the difference in characteristics of the digested sludge before and after dewatering.

Figure 8-7 Digested Sludge residues

Figure 8-8 Dewatered sludge suitable for fertilizer

The table below illustrates the volume of remaining sludge following the digestion process.

Table 8-2: Estimation of annual fertiliser mass

Total mass of feedstock in (kg)	Total mass of biogas out (kg)	Remaining mass of sludge digestate (kg)	Remaining mass at 60% moisture content (kg)
1,120,000	658,068	461,931.27	81,114

Based on local prices of composted organic residues the fertilizer could be sold for around \$75 per m³. Approximating the density of the compost at 891 kg/m³ [25] results in a volume of 93.28 m³ and a potential income of \$7,000/year.

8.2.5 Interaction between the two projects

During normal grid availability when the gas storage tank is full, and the emergency night time supply is assured for outages, business 1 could decide whether to generate additional renewable power through the purchase of surplus biogas, or allow the operator of the digester to use gas for other purposes.

The operational costs of business 1 may be slightly decreased by the establishment of business 2, as the price for biogas could be lower than diesel (for the same energy content) and LGCs could be earned by business 1 for the power generated from biogas through the 1.6MW generator during outages. If the cost of the biogas storage membrane were to be shared between business 1 and 2, the capital cost and overall payback period for business 1 could slightly increase.

8.2.6 Conversion of Diesel Generator to Natural gas / Biogas

As noted above in section 6.14.4, the 1.6MW diesel generator could be converted to duel fuel to enable it to run from biogas as well as diesel.

The project could then earn Renewable Energy Credits when combusting biogas in place of diesel. The audit trail required by the Renewable Energy Regulator may require that careful monitoring of fuel types input is conducted, in order to avoid inadvertently claiming RECs for generation arising from diesel fuel. This would be a challenge to optimising income in a scenario where a single generator is fuelled both from a fossil fuel and renewable biogas.

An advantage of this scenario is that surplus biogas when available, could be used to run the generator at periodic times, e.g. monthly intervals, to ensure the generator is maintained in good working order.

[25] On Farm Composting Handbook, 1992 by NRAES (Natural Resource, Agriculture, and Engineering Service), http://compost.css.cornell.edu/OnFarmHandbook/apa.taba1.html

8.2.7 Description of Combined Scenario 1 and 2

The combined system is shown below including scenario 1 and 2:

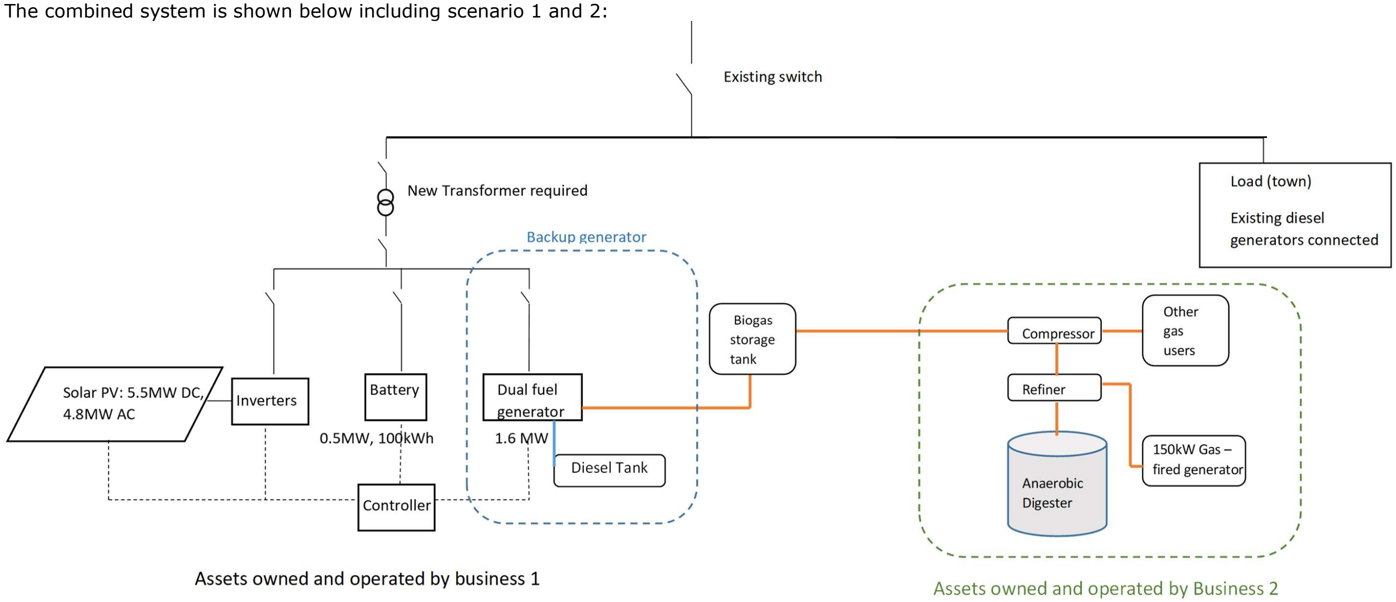


Figure 8-9: Combined Solar-Diesel and Biogas Solution

8.2.8 Site Layout

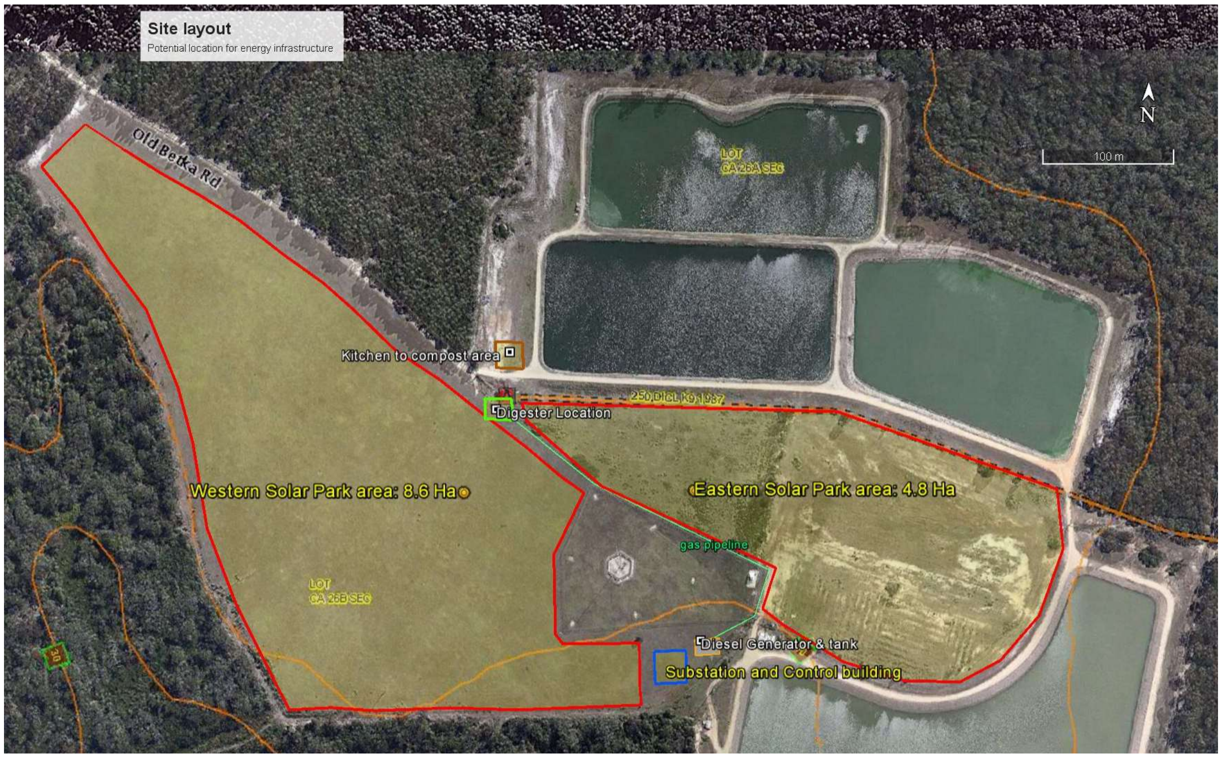


Figure 8-10: Possible site layout for potential scheme design including solar PV, diesel and biogas systems

8.3 Scenario 3: Biogas digester selling bottled gas

If the biogas system were developed without the solar-diesel project taking place, the biogas project would have to create sufficient revenue to support the establishment of the full scale 1.6MW generator capability and islanding mode infrastructure by itself.

This section examines a scenario where a biogas project sells gas for heating and cooking purposes to create sufficient revenue to fund these items.

Commented [TH47]: Again, where is the 'sweet spot'? If we include both biogas and solar now as our preferred option, how does this change the numbers? This may be our first preference or best solution but not pursued because of Arena funding. Doesn't mean we shouldn't say it's our ideal option if it can be possible.

Commented [DN48]: The new financial modelling compares several scenarios including the scenario with both biogas and solar.

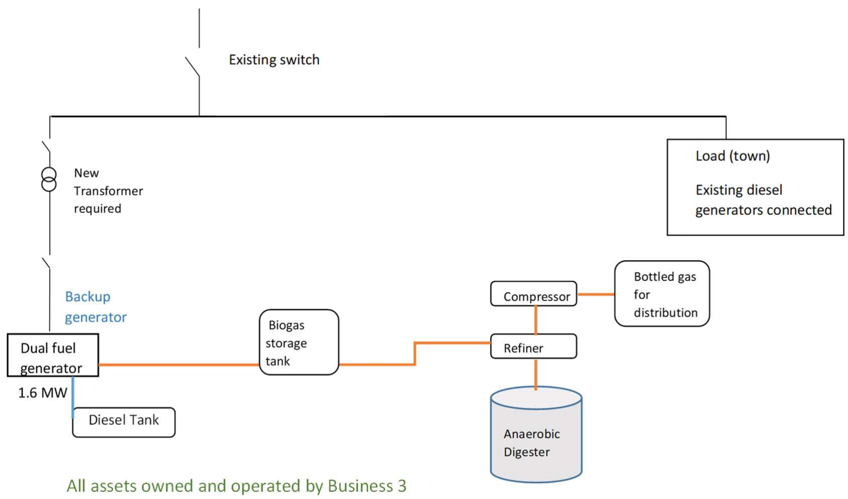


Figure 8-11: Schematic for Scenario 3

8.3.1 Capital Costs

Table 8-3: Capital Cost estimate for Scenario 3

item	Approximate Capital Cost, $M
Electrical Connection Requirements	1.20
Diesel storage tank, 5,500L	0.02
1.6MW Diesel Generator	1.28
Dual Fuel conversion	0.19
Design and planning	0.13
Digester Equipment and construction	1.35
Biogas storage vessel, 15,000m^3 including construction	0.50
Gas pipeline	0.02
Refinement and compression	0.20
Contingency	0.20
Total	**5.08**

Estimated total capital costs are around $5M.

Operational Costs are calculated for the digester at 7% of turnkey cost for the digester, refiner membrane tank and compressor. Diesel genset operational costs are the same as under scenario 1 except that fuel costs are lower since around 75% of the fuel for generation during outages comes from biogas rather than diesel.

Total operation costs in year 1 are estimated at $172k, see Appendix G for further detail.

8.3.2 Potential Income

As Mallacoota does not have a mains gas supply, the surplus of refined biogas that is not required for electricity generation during outages could also be compressed and supplied in bottles to residents and businesses for cooking, heating and industrial purposes. Numerous precedents of use of biogas for cooking exist internationally, and precedents of using biogas for heating exist in Australia.

Speaking to local residents it has been assessed that households that rely on gas for strictly gas stove cooking purposes consume 2 bottles of Liquefied Petroleum Gas (LPG) weighing 45 kg each year. 1 kg of LPG contains 47,000 Btu, therefore a 45kg bottle contains 2.115 MMBtu of energy. At a current retail price of $145 per 45kg bottle, the retail price is currently around $66/MMBtu.

Knowing that there are around 468 households occupied year round and also taking into account additional residents during the peak holiday seasons, gas used for barbeques and gas fired hot water it is projected that the Mallacoota's residential gas market consumes at least 1,200 bottles of natural gas annually. This equates to 54,000 kg or 73,972 m³ of natural gas at atmospheric pressure a year. Commercial gas usage for cooking at restaurants, heating and cooking at businesses and industrial processes is not included in this estimate.

As there is a potential annual yield of around 357,500 m³ of refined biogas which has equivalent methane content to natural gas, the potential usage of gas could consist of 12,900 m³ combusted for electrical generation during outages and the remaining 344,500 m³ bottled and sold locally. This exceeds the Mallacoota market for bottled gas therefore an opportunity for sales of bottled gas to nearby towns arises. Towns in the surrounding area also lacking mains gas, currently paying similar prices for bottled gas would be candidate markets. Based on population figures, Eden would potentially be a large enough market to purchase all remaining gas.

In terms of market uptake for biogas, a number of factors need to be considered. Hygiene and health issues would be important as well as pricing. The refinement of the gas would need to be accompanied by appropriate marketing regarding use of biogas for cooking and heating. Usage of biogas for cooking would require satisfactory assurances to consumers regarding gas quality and hygiene.

We have assumed that the gas distribution company is separate to the biogas production company. In terms of price obtained for the biogas, for the financial modelling we have assumed that the price paid to the biogas plant operator would be 35% below the retail price. This allows for distribution costs and bottle refill processes. At a biogas wholesale price of $43/MMBtu the project payback is relatively attractive at 5 years.

Table 8-4 below illustrates potential income streams.

Table 8-4 Potential income streams for biogas

	Potential Income	Number of units per year	Estimated Income per year
Bottled Gas sold to Mallacoota (excluding commercial)	$91 per 45 kg bottle ($43/MMBtu)	1,200 bottles	$109,000
Bottled gas sold to local region	$91 per 45 kg bottle ($43/MMBtu)	4,550 bottles	$414,000
		TOTAL	$523,000

Appendix G contains a financial model cashflow for this scenario.

8.3.3 Financing and Risks

Prior experience with financing biogas plants has highlighted the impact that uncertainties on feed stock volumes and flow rates can create barriers to raising finance. For biogas-to electricity schemes, investors normally require that the fuel supply is under-written to cover the risk that fuel might be unavailable in the anticipated quantities. This can add cost and complexity to biogas project developments.

Solar by contrast does not have the risk of fuel supply and on that front is therefore easier to finance.

8.4 Financial comparison of scenarios

A target was set for the businesses to achieve a simple payback of 5-7 years, preferably as close to 5 years as possible. Paybacks of less than 7 years are considered by Diamond Energy a suitable indicator of financial viability for a project. The management of equity, debt and dividends was also considered, however the core issue of commercial viability must first be addressed in terms of an acceptable simple payback.

Table 8-5: Comparison of Economic Indicators for 3 scenarios

		Business 1	Business 2	Business 3
Total Capital Cost		$12.78M	$2.14M	$5.08
Grant % and grant total		50%, $6.39M	50%, $1.07M	50%, $2.54M
Annual costs, 1st year of operation	Annual operational costs, Year 1	$123,000	$160,000	$154,000
	Annual diesel fuel costs	$32,000	n/a (covered by business 1)	$13,000
	Total annual costs	$155,000	$160,000	$172,000
Annual Income, 1st year of operation	Minimum power purchase price required, rising annually with CPI	7c/kWh	17.9c/kWh	4.5c/kWh (but still works at 0c/kWh)
	Power purchase volume required	8 GWh/yr	1.3 GWh/yr	n/a
	Annual income, sale of electricity	$560,000	$237,000	$3,400*
	Annual Large Generation Certificate income	$272,000	$45,000	$2,000*
	Biogas purchase price required	n/a	$33/MMBtu	$43.03/MMBtu
	Income from sale of biogas	n/a	$12,000	$523,357
	Income from sale of fertiliser	n/a/	$7,000	$7,000
	Network support payment / year	$125,000	$125,000	$125,000
	Total annual income	$997,000	$301,000	$661,000
Simple payback, after grant		7 years	7 years	5 years
Net present value, over 10 years, 6.5% discount rate		$337,000	$90,000	$1,261,000

* The income from sale of electricity and LGCs by business 3 is minor and could be excluded without impacting the payback, indeed may be more likely to be excluded to reduce administration costs.

The analysis in the Table above does not include the cost of debt and equity.

Key observations from Table above:

- If seeking to base the financial viability of the solution on the ongoing sale of renewable electricity, a long term power purchase price of between 7c and 17.9c/kWh could be required, after a 50% capital grant.
- A bankable PPA contract at 7c/kWh could suit a purchaser with a large portfolio of sites with small to medium electricity consumption.
- Current forecasts for wholesale electricity prices over the next 4 years are around 4.2c/kWh[26].
- A bankable long term PPA contract as high as 17.9c/kWh is not generally viable other than through government feed in tariffs such the Australian Capital Territory large scale solar tariff/auction, which are not currently available in Victoria. Additional grant funding (above 50%) may be required for business 2 if it is to be developed commercially.
- The 3rd Business scenario considers the sale of biogas for cooking. Biogas if refined then sold in bottles for cooking could fetch a price similar to the current price of bottled LPG in Mallacoota. This could create over 4 times as much income from the biogas as through converting to electricity.
- The future increase in natural gas prices forecast in the medium and long term could further strengthen the investment case for business 3 (sale of biogas).
- Sale of biogas for heating is undertaken in Australia, sale of biogas cooking is unusual in Australia (though is commonplace in China and India). If the income from sale of gas for heating & cooking is ignored, the required PPA price for an electricity-only biogas system is substantially higher than could be commercially secured in the current electricity market. For example, a biogas to electricity system if developed with the 1.6MW generator and without solar PV, would require a long term PPA price around 22c/kWh, (rising with CPI) to achieve a 7 year payback.

8.5 Environmental Permits

Initial correspondence with the Council was made regarding permitting requirements for an electricity generation facility at the sewage treatment plant site.

The general advice is that under the East Gippsland Planning Scheme, the property at Old Betka Road, Mallacoota is within Public Use Zone (PUZ1) with Wildfire Management Overlay (BMO or WMO) applied. See Appendix C for further information and maps of the planning overlays.

A planning permit is expected to be required under the zone. Consent from DEPI would be required given the property is Crown Land.

Victorian Planning Provision 52.42 addresses Renewable Energy Facilities (other than wind energy facility and geothermal energy extraction) and details the application requirements including consideration of a number of environmental components including:

- the extent of vegetation removal and a rehabilitation plan for the site
- whether a Works Approval or Licence is required from EPA
- an assessment of the impact upon Aboriginal or non-Aboriginal cultural heritage
- an assessment of the impact of the proposal on any species listed under the Flora and Fauna Guarantee Act 1988 or Environment Protection and Biodiversity Conservation Act 1999
- an environmental management plan including, a construction management plan, any rehabilitation and monitoring.

[26] Base Future Prices for Victoria forecast 2014-2017, obtained from asxenergy.com.au

The site should be checked in respect to any species listed under the Flora and Fauna Guarantee Act 1988 or Environment Protection and Biodiversity Conservation Act 1999.

The flat area considered for development is grassland already cleared of native vegetation. Avoidance of the need to clear any native vegetation should be prioritised by keeping all development within areas already cleared of native vegetation. The Biodiversity interactive map consulted for this study indicates that native tree cover extends close to the site and initial advice from East Gippsland Shire Council is that a native vegetation permit woud be required if any native vegetation is impacted.

It is also recommended that within an action plan for obtaining permits that discussions with the Country Fire Association (CFA) are included.

8.6 Ability to Operate in Island Mode

It is essential to the success of this project that the town can operate in island mode, with power being supplied by the new generator to the town during periods when the town would otherwise be without power. The proposed solution is understood to be feasible for this type of operation and more detailed engineering will be required as the project moves to subsequent phases.

Chapter 5 discusses Islanding and Mini Grids in further detail.

A system which operates in both grid connect and island mode is a first of its kind in Australia, so there are no precedents and this brings some risk, as well as great value, to the project. There will be some challenges from both a technical and regulatory aspect to work through to ensure that this can occur.

The responsibility for grid safety during outage periods when the generator provides power in island mode is a key consideration. From a regulatory perspective, the responsibility for local grid safety may lie on the generator company responsible for running in island mode rather than SP AusNet and this would need to be fully investigated.

Although there are challenges as outlined here, at this stage the solution looks to be able to be implemented and have the ability to supply the town during outages.

9 Business Models

This section discusses possible business models for the proposed solutions. The client group expressed an interest in a discussion of legal entities, partnerships, structures, estimated costs, operation and maintenance costs, etc.

9.1 Scenarios

The business model will be dependent on the scale and location of the technology deployed.

9.1.1 Centralised Generator Scenario

In this scenario, a large generator is located in a central location requiring the use of a piece of land large enough for the long term operation of the plant.

Discussions have been held with commercial companies in the technology, development and operation and retail spaces regarding this project, especially the central solar generator plant option.

It is important to clarify responsibilities and roles. Responsibilities in a typical development process can be outlined as follows:

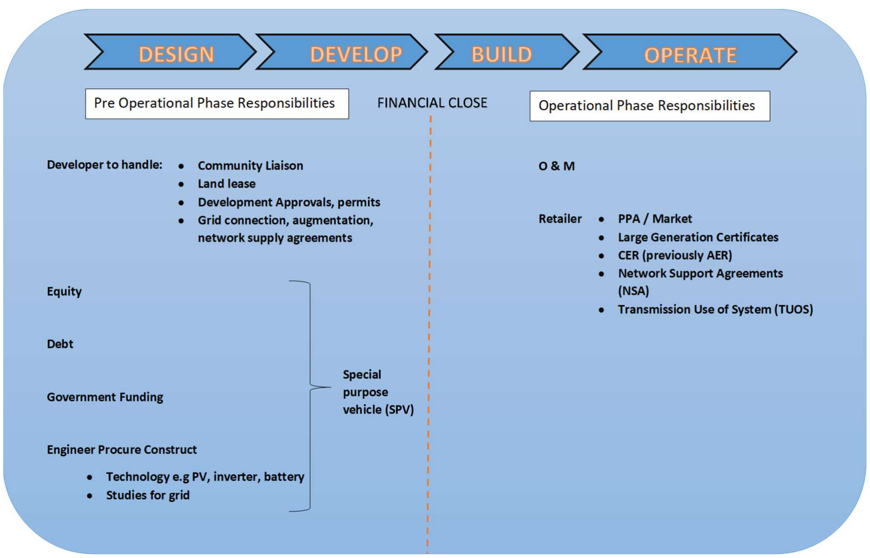


Figure 9-1: Business model responsibilities for a centralised generating plant

Each component of this chart must be handled by a competent responsible company or organisation to ensure success. The various agreements and contracts required should be negotiated and structured well before the project gets to financial close.

A 'special purpose vehicle' or SPV is an entity which is commonly established to be responsible for a project development. Share-holders in the SPV can include those who put in 'sweat equity' instead of cash, plus those who put in cash. A community share raising could be conducted to raise some equity and a community share, discussed in more detail below.

In terms of the ownership structure over time, prior to financial close, the SPV is owned by the developer. After financial close, a share-holding is issued to various parties.

The SPV entity would be the party named in the agreements for land, permits, funding etc. It would also be the named entity in the power purchase agreement and any network support agreements.

The ownership of the SPV in its early phases begins with a developer or developer consortium. As equity and risk finance is introduced, the equity and risk investors may come to own a share of the entity, or rights over the entity. Upon completion of construction, the ownership may transfer to an operator or the SPV may continue to own the asset and contract a competent organisation to operate the plant.

In a scenario with a commercial party leading the development, there is a step in the project where the rights to the intellectual property (IP) of the project and its associated reports would be assigned to a selected developer on an exclusive basis. This could be for a specified period of time, sufficient to allow development to proceed.

9.1.2 Government Funding: business structure requirements

In regards to government funding, discussions have been held with staff of the Australian Renewable Energy Agency (ARENA). Discussions have been held in relation to ARENA's Industrial and Remote Australian Renewables (IRAR) program. The Expressions of Interest (EOI) has a deadline of 31st December 2013. ARENA advisers communicated to the project team and highlighted the following factors which a successful ARENA funding applicant would be required to have in place. These factors are provided here as an illustration of what most public funders (not only ARENA) would need to see in place in order to commit funding to a project:

1. Definition of the technical solution (e.g. XMW PV + XMWh storage etc)

2. Initial high level EPC costing estimate for technical solution (i.e. ideally multiple quotes)

3. Business model to supply the technical solution (e.g. retailer PPA with end users + network support agreement can underwrite the financing of the Capex, which consequently sizes the ARENA grant requirement to subsidise the Capex to turn the project IRR positive to a level required to attract investment)

4. Revenue line confirmation i.e. Memorandum of Understanding (MOU) of off take agreement (i.e. PPA from local retailer to the project SPV) + any network support revenue from network operator / owner

5. Financing confirmation i.e. letters of interest from equity / debt funders for the non-government contribution to the project SPV

6. Demonstrated Capability: Initial feasibility assessment and capable project partners: developers, engineers and vendors. It is also likely that a retailer should be on board the team at this stage.

Some of these items could be established after an EOI stage however the majority would need to be established at EOI stage.

9.1.3 Distributed generation model

If the generation and storage is completely distributed, as in the rooftop solar PV and ESS scenario, the business model is simplified due to the avoidance of land lease, environmental permitting etc. Also fewer charges are between the generator and the customer since use of network charges are not applicable to a system operating in a property 'behind the meter.

The number of parties to a town-wide development could increase dramatically however, as each location (e.g. each property to host solar PV or storage) would need to be formally contracted.

The business model for a distributed solar model would involve a particular entity taking on a group purchasing role, consolidating buying power of the community, accepting external funds if available and running the roll out as a centralised business model.

9.1.4 Community-owned development or commercial development

To achieve maximum community ownership a cooperative could be formed to develop, construct and own the asset. This would involve a major process of community fundraising which may significantly be more lengthy and complex than using a SPV model with a commercial investor.

In discussions with the MSEG group, concerns have been raised that fundraising within the community may be a slow process and a fully community owned model would be unlikely to deliver a solution. The MSEG group favoured a model with commercial developer and government funding as the scenario most likely to result in an installed solution within an acceptable timeframe.

As part of the community involvement under this scenario, some percentage of profit or earning from the project could be committed back into the community as a dividend or goodwill gesture, to community supported project.

9.1.5 Community Capital Raising

The community has expressed a view that community share sales are unlikely to raise significant capital in the early stages of a project.

Potential investors amongst the community would be looking for well substantiated revenue, cash flow and profitability projections prior to investment. The community has already invested substantially in solar, approximately $500k has been invested in private solar PV systems. Those residents would be looking to see a return from investment in a central solar system via a) continued feed-in tariffs through minimal outages and b) a return on their investment in renewable generation through an appropriate retailer and retail pricing incl feed in tariff.

A certain number of shares could be offered to the community. Provided the community took up a certain level of shares in aggregate, it could be entitled to elect a representative from the community to be on the board of Directors.

Another option would be if the community share-holding is at a lower level, the community have shares but no member on the board.

These community-related ownership proposals would have to be discussed and agreed both with community members and potential major financiers for the project.

9.1.6 Community Representation on the SPV

Views expressed by the community during the preparation of this study included the opinion that over and above the benefit to Mallacoota for security of supply, some other identifiable benefits should come back to the community especially if public funds are awarded to the project.

An example might be funds for financial support of a retirement village in the community, or other projects providing public benefit.

Commented [TH49]: Very good idea

Some clear feedback from the community consultation event is that the community would expect to have some say in the running of the operation. In this context the community would likely find it uncomfortable not to have a member on the board of directors of the SPV.

Commented [TH50]: It doesn't necessarily follow that ownership equals a place on the board. There are all kinds of examples where that is not the case, where people of worth and with something to contribute are invited onto boards.

One of the founding members of MSEG made the following suggestion:

..A single board position on the SPV should be available to the Mallacoota community, possibly via an election, voting being from each residential and commercial subscriber in the supply/generator network area. Such a position would primarily act as a conduit between the Community and the Board, … as one voice[the community board member] would not control the board but would be able to ensure the communities "reasonable" voice is heard and that the Boards statutory obligations as a commercial entity are understood by the community.

A piece of feedback received from another community member on this point is as follows:

"If cash input determines membership [of the board] perhaps the community could find a way to collectively pool their shares into an entity that would qualify."

The risk perceived by some community members is that those in the community that see no financial gain via shares could perceive the project as benefiting only a select few. This could develop into a negative view of the whole project.

Share holdings can be offered to community members after the project is installed and the SPV is successfully earning profit. Investment levels to suit a wide range of incomes could be offered at this stage, to make the opportunity accessible to a wider cross section of the community. In the early stages of a commercial development, only large investments are sought. Therefore in the longer term, a share of community ownership may be easier to achieve after commissioning than in the development phase of the project.

9.1.7 Financial Close

This is the point in time when any major loan required for construction is executed.

Share issuing around financial close will introduce the equity partner to the project. The developer will retain some share in the project. Around this time, (financial close), shares are also made available to the community, as noted above.

9.2 Power Purchase Agreements

To recoup investment and make profit, the SPV generator entity will require customers for the power. For a strong business case to be established, this component of the business case should be established as early on as possible. In a National Electricity Market where overall demand is now reducing, many renewable energy generation projects encounter challenges with identifying and negotiating a power purchase agreement (PPA) and therefore this is considered to be a key risk item.

A system could be established generating 8 GWh/year which would nominally equal the amount of annual consumption in Mallacoota. In this instance, 8GWh/year of power purchase agreements would need to be established.

In reality, it is possible that if less than 8 GWh/year of PPA is available in the initial phase, the project could be developed in stages with the first stage matched in scale with the volume of PPA secured. Later on, extensions of the development could be considered if further PPAs are secured.

9.2.1 Residents and local businesses

All retail customers of electricity in eastern Australia can select from any electricity retailer on the National Electricity Market (NEM). Preliminary research indicates that Mallacoota residents currently use retailers such as Neighbourhood Energy, Tru Energy, Red Energy, Diamond Energy, and more. The largest business customer surveyed uses AGL. The community is not thought to be heavily biased towards one retailer.

Supply agreements are generally up to a few years in length, with 'churn' occurring when selecting new deals. At the customer end in Mallacoota, support could be generated for this project by a 'show of hands' of which customers would be willing to switch retailers to support the new generator and the community consultation posed this question to community members. To create an investment case in the development phase, this would have to be backed up with formal commitments.

To establish a formal commitment for example, a survey of local electricity customers in Mallacoota could ask "if the cost was within +/- 10% of your current deal, would you be willing to sign up to a new electricity deal with your local community supplier in order to support the local generation project?" A high positive response on this question would strengthen the business case for investment. A majority of customers willing to switch would be important. At the community consultation events held during this study, community members were asked whether they would consider switching retailer and also whether they would consider paying a slightly higher rate for assurance of reliable supply, most of those questioned responded positively to both questions.

Community members would expect to be provided with a guarantee of islanding ability during outages, as part of the new retail deal. In addition the community would seek a guarantee of community representation in the generator business as discussed above.

A down side to basing an investment on commitments from residential customers is the risk that residential customers can switch away from the scheme after short contracts and are unlikely to enter into long term contracts. This could result in limited confidence for investors and equity partners.

9.2.2 Larger Power Users

This commitment to purchase the power from the Mallacoota generator(s) could extend to larger local entities such as East Gippsland Shire Council or East Gippsland Water.

Long term power purchase agreements would have the largest positive impact on the project. 10 or 20 year power purchase agreements with larger power customers would substantially assist to under-write investment.

The rates paid by these larger power users for their smaller sites are higher than the rates paid for their largest sites.

9.2.2.1 East Gippsland Water PPA

Positive discussions have been held to date with EGW, who consume over 3 GWh/year for their 8 largest sites. Data on the consumption for smaller sites was not available, however it expected to be considerable.

Power procurement processes are subject to best value and a new arrangement would need to demonstrate that no cost increases are taking place which could impact ratepayers.

9.2.2.2 Council power purchase

East Gippsland Shire Council for its major buildings purchases around 4.7 GWh/year. The grid demand for major buildings will reduce when a Cogen project is installed in Bairnsdale over the next 2 years. Funding has been secured for the Cogen project to be implemented.

Power supply contracts for the Council are due to be re-tendered in 2015.

The Local Government Act section 1.8.6-7 specifies that competitive tender processes are to be adopted. Public tender is required for procurement above $50,000 in value. 'Best Practice Guidelines for Local Government Procurement' covers this topic in some detail.

One of the few precedents known, has been set by the City of Onkaparinga in South Australia who sought to support the establishment of a renewable energy generating system in their region through offering a power purchase option.

However if Council power purchase arrangements can assist projects which enhance energy security, this may be a matter for full evaluation before any action could be taken by Council. The Council may wish to provide this benefit to multiple communities around the Shire. On this basis, the quantity of power purchase contract may be better spread across multiple projects rather than focussed on a single site or project.

The probity and procurement processes for Council would need to be fully addressed by any approach. Sufficient time would need to be allowed for this to proceed and initial indications from East Gippsland Shire Council are that a power purchase agreement for this purpose may not be possible in the short term.

9.2.3 Identifying the Funding Gap

The capital costs for installing a solution may benefit from initial government grant funding in order for the development to reach financial close and reach commissioning. The stakeholders who have been consulted during this feasibility have the view that the entity, once established, should be self-sustaining and fully commercially viable during its ongoing operation.

The entity would be expected to be fully commercial and have a sustainable business model which did not depend on ongoing subsidy.

Government grant funding typically analyses to what extent a proposed project is commercial without grant funding, then identifies any funding ‘gap’ where a once-off injection of public money may assist the project to be established.

10 Identifying Funding Sources

This section considers funding and technical support options with guidance including funding sources, potential partners, mentors, grant application assistance, etc.

10.1 ARENA funding

The Australian Renewable Energy Agency, ARENA is a government funded body with bipartisan support which is has survived the recent change of federal government. ARENA has $5Bn of funds to stimulate the increased uptake of renewable energy in Australia.

From discussions with ARENA, the Mallacoota project has a chance of receiving ARENA support by fulfilling the following requirements:

- The project is meeting a challenge which other communities are also facing.
- The project overcomes a road-block which is also standing in the way of other communities who want to increase their use of renewable generation.
- The project may use an 'enabling technology' which enables more renewable to be used e.g. storage solutions can be enabling technologies.
- The project may be repeatable and can be replicated by other communities around Australia.
- The project delivers knowledge-sharing regarding the increased deployment of renewable energy solutions in remote areas catalysing further renewable energy uptake in Australia

10.1.1 IRAR

The Regional Australian Renewables program is the first ARENA initiative which is relevant to this project.

The IRAR Fact Sheet[1] states:

> *"The Regional Australia's Renewables – Industry program (IRAR) aims to demonstrate renewable energy solutions, including hybrid and integrated systems, in off-grid and fringe of grid areas, especially where renewable energy is close to being cost competitive."*

Due to Mallacoota's location, it is classified as fringe of grid. The IRAR program has been confirmed to include community projects in fringe of grid locations, not only industrial projects. This is therefore a potential funding source for the Mallacoota project. The amount of funds allocated is decided on an as-needs basis, with other funding sources first identified the project would then identify what amount of ARENA funding would be required to create a positive internal rate of return. IRAR funding can be either capital investment or income stream.

Eligibility criteria set out in the IRAR Fact Sheet are:

> "To be eligible for funding under the I–RAR program a project must meet the following criteria:
> *A. The project must involve the demonstration and use of one or more renewable energy solutions and/or enabling technologies, including hybrid or integrated systems. In the case of bioenergy, biomass must be derived from a sustainable source, which does not compete with food or feed production.*
>
> *B. Projects must affirm a user of the renewable energy generated under the project, firstly through a Letter of Commitment in the EOI stage and secondly through submitting a document, such as an agreed Power Purchase Agreement or letter detailing the internal power use arrangements, in the full application stage.*
>
> *C. The project must produce additional or new generation capacity equal to or greater than 1MWe Of renewable energy or an equivalent measure of bioenergy or heat energy for direct use applications.*

D. The project location must be off-grid or fringe-of grid (or both), where fossil fuels are displaced, or would otherwise be, used.

E. The project must involve capital expenditure and associated implementation activities (design, procurement, construction, commissioning, capacity building etc) relating to the demonstration and use of the renewable energy or enabling technologies (or both).

F. The project schedule must lead to a final investment decision within a timeframe that would allow the project to be commissioned prior to 30 June 2018 (ARENA may vary this date at its absolute discretion).

G. The renewable energy solution must be operated for at least five years following commissioning.

2.10 If multiple projects are proposed to occur in parallel they may be able to be classified as a single project.

Merit Criteria; [ARENA IRAR Guidelines]

The merit of eligible applications will be assessed for overall value for money against the following merit criteria. The following merit criteria are considered equally:

A. Financial viability of the project and ARENA funding sought, including whether the project offers a degree of profit sharing.

B. The extent to which the project will contribute to RAR Initiative objectives, in particular its likely demonstration effect and degree of knowledge sharing.

C. Project readiness, including how soon the project can be commissioned, with projects that are timed earlier within the program window receiving favour.

D. Capability of the applicant, in particular to supply matching funds, complete construction and operate as intended.

E. Quality of project design (technical feasibility).

F. The overall risk associated with the project including, without limitation: compliance, technical, planning and financial risks.

10.1.1.1 Level of Funding

ARENA funds a demonstrated 'gap' where the matched funding is in place from conventional sources. It is understood that it is possible for ARENA to fund up to 50% of project cost subject to all other criteria being met.

The Expression of Interest (EOI) deadline for the IRAR program is 31st December 2013.
The project would have to be clearly defined in order for an EOI to be accepted, as discussed in section 9.1.2 above.

Following the EOI phase, a full application process would be undertaken. Successful applicants would expect to receive funding agreements during 2014. The IRAR program is competitive and there would be no guarantee of funding until a funding agreement was executed by the government. Several other agreements with the organisations involved would also need to be signed by this stage, allocating roles and responsibilities as described in section 9.1.2 above.

10.1.2 IRG

Another ARENA funding initiative which may be suitable for the project is the 'integrating renewables into the grid', IRG, which is expected to open to applications some time in 2014. The ARENA website states:

> *"The [IRG] initiative will focus on demonstration projects developed in consultation with network and distribution operators, with studies on grid integration to be supported through the Supporting High-value Australian Renewable Energy Knowledge initiative."*

If the project demonstrates a way in which renewable generation can stabilise a weak distribution grid and provide island operation during times of grid outages, it may meet the goals of the IRG stream.

It is possible that IRAR could fund the generation solution, and IRG could fund the integration solution. A challenge with this approach would be that to successfully obtain IRAR funding, the funding sources for all components would have to be pre-arranged, therefore adding future government funding through IRG program might not be permitted under an earlier IRAR agreement.

Alternatively, if IRAR funding is not obtained, then IRG is a second option for this project.

Information about IRG is available on the ARENA website: http://arena.gov.au/initiatives-and-programs/integrating-renewables-into-the-grid/

This scheme is expected to target all geographic areas where integration of renewables into the grid is an issue. This is not confined to off grid and fringe of grid, therefore the competition for this program may be broader.

The IRG is currently being designed and the application dates are not yet announced.

10.1.3 ARENA funding risks

The Federal Liberal government has already announced one cut to ARENA funding. There is media speculation about further cuts to the program budget.

Given it has bipartisan support, it is considered likely that ARENA will survive and it is a legal requirement that all ARENA funding agreements executed will be honoured.

Funding budget cuts normally impact unallocated funds rather than currently allocated funds. Therefore projects in the earlier programs such as IRAR are less likely to be impacted by Federal budget cuts than future programs such as IRG and beyond. The lowest risk option from a funding security perspective would therefore be to apply for the soonest available funding program, such as IRAR.

The other risks to the ARENA application include the need for confirmed business models to be in place and the difficulty in reaching these milestones in the required timeframe by 31st December 2013. The original timeframe for this feasibility project, of completion in December 2013, would normally lead to a period of consideration leading to next decisions in Q1 or Q2 of 2014. A competitive tendering process would normally be expected to take several months.

10.2 Regional Development Victoria

A number of programs are run by Regional Development Victoria (RDV)[2], some of which may be worth approaching.

Enhar issued queries to RDV which were forwarded to Manager Energy & Infrastructure. The Manager Energy & Infrastructure at RDV responded with one phone discussion with Enhar to discuss support which might be available.

Economic Infrastructure Program

An RDV program which might be able to fund energy projects is the Economic Infrastructure program; this has supported certain components of renewable energy projects in the past. This program is designed for enabling infrastructure and assisting first of a kind rollout.

Australian Tartaric has a biomass boiler project in Victoria to which RDV is contributing some funds under the Sustainable Energy program. This program aims to reduce the amount of energy used per product output. This is not available to community groups, only to industry.

Balfour Beaty have a 30MW power station in Victoria running off almond hulls, and RDV has assisted with the grid connection.

RDV assisted the Hepburn wind project with the grid connection component. This assistance contributed to alleviating issues at Hepburn Springs which suffered from blackouts and brownouts. Regional Electric Access program at the time, this program is now incorporated in the Economic Infrastructure program.

Transforming and Transitioning Local Economies program aims to develop vibrant and resilient regional economies. The types of infrastructure projects that may be supported through this sub-program include major projects in the public realm that will attract private sector investment.

The Resilient Community Program is designed to support communities across Victoria to build their capability to prepare for, withstand and recover from all types of hazards. Local councils, community groups and business associations are eligible for grants of up to $110,000 for community-led projects to increase shared responsibility between these groups for managing all hazards, from bushfires to floods and storm surges.

Putting Locals First is another RDV program which has assisted with community projects in the past.

RDV can also contribute facilitation assistance to projects.

10.3 SP AusNet

SP AusNet has indicated it intends being a partner and supporter of a solution for Mallacoota. In terms of how SP AusNet could make a financial contribution it has been advised that not just storage but any demand side measures are encouraged by regulator through the DMIS/DMIA scheme, in 5 year EDPR regulation periods. A project for Mallacoota could be included into the 2016-2021 process for funding under the innovation and demand side participation category. SP AusNet has a current program of activities in embedded generation and demand management and would look to extend that program with potentially a minigrid exercise at Mallacoota.

In terms of when SP AusNet could have funds to spend on the project implementation, currently SP AusNet is in year 3 of 5 year EDPR period which finishes in 2015.

For 2016-21 funds applications are being drafted at the end of 2013. An 18 month process would normally occur for the funds to be approved/available by the Regulator.

The earliest SP AusNet would expect to look into funding would be around mid-2014. This could be firmed up around the end of 2014 so that in 2015, SP AusNet would have a good idea of whether they can expect funding from the EDPR process.

10.4 Embedded Generation benefits

An enquiry was made to SP AusNet about what incentives or rewards are in place for consumption of locally generated power by local consumers.

Advice was provided by SP AusNet as follows:

> *"An embedded generator is eligible to receive payments from SP AusNet for any avoided Transmission Use of System (TUoS) charges.*

The payment is calculated based on the reduction in TUoS that is charged to SP AusNet, resulting from any reduction in load on the relevant transmission connection point due to the operation of the embedded generator.

The methodology for calculation of the avoided TUoS is prescribed in the rules and relates only to the locational component of the TUoS charges.

It should also be noted that the value of avoided TUoS is variable as it depends on actual network load conditions and can only be calculated on an ex-post basis.

In most cases, generator revenue from avoided TUoS is small in comparison to revenue from energy and/or REC sales.

The generator may also be eligible to receive a network support payment from SP AusNet if it has the ability to supply customers during an outage of the network."

10.4.1 Network Support Payments

These could be calculated based on the cost to SP Ausnet of the status quo, and benefits to the regulator of any proposed solution. Average diesel deployment rates, costs and historic penalty rates are relevant factors however the business case for investment would be a matter for SP Ausnet to assess before specific levels of network support payments could be confirmed.

10.5 Sustainability Victoria

A clear focus of the Victorian government is in the area of waste and resource efficiency. There is various support on offer to schemes which reduce waste to landfill. In that context, the biogas system may attract some Sustainability Victoria funding. Sustainability Victoria have already provided funding to the Kitchen to Compost scheme at Mallacoota.

The solar-diesel component is not within the funding remit of any current Sustainability Victoria scheme.

10.6 Local Government

East Gippsland Shire is a sponsor of this report. It is understood that East Gippsland Shire Council supports the establishment of reliable power supplies to Mallacoota and other communities around the Shire.

Components of the project, such as a biogas system, which assist to divert waste to landfill sites may attract support from the Council such as through feedstock collection and delivery. The kitchen to compost scheme is already a Council funded initiative, along with Sustainability Victoria funding.

Enhar has not identified any specific funding available from the Council for establishment of this project in the short term.

10.7 Community Share Raising

A community fund raising exercise could be considered. The Hepburn Wind example successfully demonstrated that several million dollars can be raised from community members where a strong promotional effort is in place. The co-operative model was adopted in that example, where all profits are shared by the cooperative members.

10.8 References for section 10

[1] ARENA website: www.arena.gov.au

[2] Regional Development Victoria http://www.rdv.vic.gov.au

11 Action Plan for the Community

This section contains a recommended action plan. These are recommendations for consideration by the Mallacoota Sustainable Energy Working Group, however as noted in the disclaimer at the beginning of this report, the group is under no obligation to proceed with any of the recommendations.

This assessment is a feasibility study. To go from the stage of completion of feasibility study through to detailed planning and implementation, a number of steps would be important. These include:

- Identifying experienced project developers with strong track records in implementing energy projects of the scale and type short-listed by this study. This may include a lead development partner with associated equity partner(s) and an energy retailer.
- Compare proposals from experienced project developers for the supply, installation, commissioning and operation of complete systems to meet the needs of Mallacoota. These should be based on detailed site information.
- Determine whether both public and private organisations are to be involved in funding and implementation and operation.
- Build links between any relevant private and public organisations who will be involved including memorandums of understanding between the parties.
- Determine whether SP Ausnet will participate through network support payments or capital equipment contributions or some other model.
- In regards to mini grid and islanding, identify suitable organisations competent to develop and manage the islanding capability.
- Maintain community consultation throughout the process and ensure community representation.

12 Applicability of the feasibility study process for other communities

Part of the scope of this report is to document the applicability or otherwise of the feasibility study process for application in other communities, this section addresses this topic.

This report provides a model for assessing the possibilities for other communities in East Gippsland Shire.

This project provides a model for the things that need to be ascertained (Chapters 1 to 5) in specific communities. Chapter 6 and 7 identify a shorter list of generation and storage technologies currently likely to be feasible, and the rest of the chapters provide the process for testing feasibility and gaining funding.

A social and technical assessment for each community particularly Chapters 1, 2, 3, 4 and 5 would be required with particular reference to the ease of "islanding" and availability of piped gas. Some sections would not need modification.

The technical assessment of generation options in Chapter 6 shows that there are potentially viable options for consideration in other communities. Dependent on the analysis flowing from each communities chapters 1,2,3,4 and 5 could follow an assessment of one or a combination of:

- 6.7 centralised photovoltaic
- 6.8 centralised wind turbine
- 6.9 Centralised biogas
- 6.10 Biomass

These could be assessed against a selection criteria similar to the one developed for this project.

In terms of storage technologies, the analysis of chapter 7 demonstrates the relative advantages of battery technology types which would be equally applicable in other communities.

Potential Solutions (Chapter 8) and Business Models (Chapter 9) would then be prepared to suit the specific community. Chapter 10 (Funding Sources) would depend on the current grant landscape. Certain grants would be available in regional areas or on the fringes of the grid; urban communities with stronger grid infrastructure may experience less energy reliability issues and be less eligible for certain grants.

In terms of opportunities for other remote towns which do not have piped gas supply and rely on bottled gas for cooking and heating, the biogas option presents certain advantages. For example, if bio-digesters could be established at each small town to process sewage and food wastes locally, the derived biogas could be refined and compressed into bottles and sold locally at a rate competitive with the market prices for bottled LPG.

In East Gippsland Shire for example, a project could be established to promote local opportunities for biogas digestion as a source of renewable gas fuel. The study component could include:

- Identification of all settlements which are remote from the piped gas supply network.
- Evaluation of market prices for bottled gas in those settlements using current and historic data
- Identifying the available digestable feedstock in each settlement
- Market research into use of biogas for heating and cooking, including gas quality requirements and any relevant consumer issues such as health and safety, odour etc.
- Business case development incorporating value of biogas for heating and cooking, the local market for gas as well as avoided costs of waste disposals

Benefits would be available to water utility companies in relation to waste water processing as well as to local councils in relation to waste management.

State funding might be available both for the feasibility and implementation phases of such a project.

Capital costs could potentially be minimised through tendering a set of projects simultaneously. While each project would need to be designed site specifically, similar technology could be used at multiple sites.

13 Conclusions and Recommendations

13.1 Conclusions

A number of scenarios have been found to offer potentially viable solutions for Mallacoota to obtain backup power generation from renewable energy.

When sized to meet the demand of a small town such as Mallacoota, certain renewable technologies are not currently economically viable. Even considering grant support and preferential power purchase arrangements, certain technologies would be significantly outside the realm of economic viability at their present stage of development. Technologies found to be currently uneconomic at this scale based on well-established research include concentrating solar thermal, concentrating solar PV, wave and tidal energy. Solutions such as solar photovoltaic (distributed and centralised), wind energy, biogas and biomass are lower cost options more able to offer an economic return.

Solutions involving large scale battery storage to smooth intermittent renewable generation are technically viable. However the current cost of battery storage makes scenarios such as wind-battery and solar-battery unviable at this scale. Battery storage at a residential level coupled with solar photovoltaic could be a more economic application of battery technology, however is not an equitable solution since not all residences in Mallacoota are suitable for rooftop solar.

A pumped hydro scheme to provide the required quantity of power during outages of several days would require a large area of land on a hillside to be converted into a reservoir. In a national park environment this is unlikely to be possible due to environmental permitting restrictions.

Options which include a reciprocating generator were found to be the most viable for this backup generation application. These options includes a solar-diesel hybrid system or a biogas-fuelled generator, or a combination of these.

Certain technologies were found to be potentially economically viable but unlikely to be acceptable to this particular community. Wind turbines for example would be relatively economic but due to their high visual impact, even in the best available sites, would be likely to be divisive for the community. Biomass (wood and timber wastes) from surrounding forests was another energy resource considered. Concerns around the environmental sustainability of using forest-derived materials to convert to energy would make biomass energy systems unlikely to be accepted at this community.

At the information sessions in Mallacoota the community expressed a positive support for a solar solution and also a biogas digester solution, if located at the sewage treatment plant site. More residents expressed support for a central solution which benefits all residents equally compared to private solutions installed at individual houses.

Solving the economics of a solution is highly dependent on creating an ongoing revenue stream from the project. Creating a revenue stream from ongoing sale of electricity is possible through use of a large solar array, or to a lesser extent from a biogas generator. Using a solar array in the scale of 4.5MW for example, which appears viable at the identified sewage treatment plant site, an electricity contract purchasing the generated power at around 7c/kWh may be required in order for the project to achieve a suitable payback. This rate is above the wholesale rate for power therefore a specific type of customer would have to be identified, for example an organisation with a large number of small sites. Finding enough customer(s) to purchase all the output may be challenging in which case the size of the solar array could be reduced, however this in turn would increase the required tariff.

The level of network support payments available to the project could reduce the required purchase rate, however this would be subject to negotiations between the distributor and the project developer. If network support payments matched the current total guaranteed service level payments made to the town, the required power contract to underwrite the development could be achieved at a rate competitive with current market prices paid by large energy customers.

In remote areas on the fringe of grid, piped gas may also be unavailable, as is the case at Mallacoota. It could be possible to increase reliability of power supply and also lower the cost of local bottled gas through establishing a biogas digester linked to both a backup generator and a gas distribution business. Figures developed in this study indicate that if gas can be sold for distributions in 45kg bottles at a price 35% below retail prices for gas (per unit of energy), that an economic return could be achieved. This may be of interest to other communities in the region and worthy of a separate study.

Sufficient biogas could be obtained from digestion of the town's sewage waste and food wastes to satisfy the town's current requirement for bottled gas (heating and cooking).

A range of options have been presented which can be taken forward from this study. Maintaining a good level of community involvement will be important for the project as it proceeds.

13.2 Recommendations

To establish a generator at Mallacoota to provide power during outages, the following additional analysis may be of value:

Operational Costs of Biogas Plant

Accurate evaluation of operational costs for a biogas plant could benefit from further investigation into local expertise and research into the characteristics of the available feedstock. If a biogas option is to be the subject of a tender process, the proponents will be responsible for operational costs and will need to ensure the income streams (sale of biogas or electricity) are sufficient.

Islanding Mode

To ensure that the local system continues to operate safely while in island mode the generation system will need to be able to produce a certain fault current. This usually involves the addition of 'inertia' or 'spinning reserve' to the system which is done using either fossil fuel generation or fly wheels (see Section 7.2.3.2). The proposed solution is understood to be feasible for this type of operation although more detailed engineering would be required to prove this.

Marginal Loss Factor

It is anticipated that the loss factor for a generator at Mallacoota would be approximately unity however further detailed analysis could be done to confirmed this. If a commercial generator is proposed to be established the proponent will be responsible for ensuring the power purchase price, accounting for Marginal Loss Factor, is sufficient.

Appendix A: Demand Management Calculations

East Gippsland Water (EGW) provided substantial data towards this study in order to assist with demand management estimation.

Pump Capacities

Water Treatment Plant

The water treatment plant has a 110kva generator and 100kva mains transformer to cope with peak demand of all the associated pumps including the production bore on site:

- The bore pump is 15kw – Variable Speed Drive (VSD) Fitted
- Backwash pump 5kw – VSD Fitted
- Reservoir return pump 5.5kw – VSD fitted
- High Level pumps 4.4kw – VSD Fitted
- Service water and chemical pumps total 1.5kW
- Wash water pumps 2 kW

Sewer Pump Stations

EGW has 6 sewer pump stations of various sizes, four of these have generators as follows:

- Pump st 1 - 2 x 55kw pumps – VSD fitted - generator 156kva
- Pump st 2 – 2 x 15kw pumps
- Pump st 3 – 2 x 13.5 kw pumps – generator 37.5kva
- Pump st 4 – 2 x 8.6 kw pumps
- Pump st 5 – 2 x 18.5 kw pumps – generator 55kva
- Pump st 6 – 2 x 5.9 kw pumps – generator 20kva

Betka raw water pump station has

- 1 x 4 kw pump - VSD fitted
- 2 x 30kw pumps

Karbeethong high level boost pumps

- 2 x 3 kw pumps

Irrigation site:

- 1 x 8kw pump

EGW ha a 63kva mobile generator that supplies power to the equipment not fitted with generators as required, which is also used for equipment in Cann River

Site name	Pumping peak load kW	Estimated average load kW	Diesel generator capacity kVA
Water Treatment Plant	33.4	21.6	100
Sewer Pump stations	233	3.2	268.5
Betka Raw Water station	64		
Karbeethong high level boost pumps	6		
Irrigation site	8		
Total	344.4	24.8	368.5

Appendix B: Kitchen to Compost Project information

This information was kindly provided by Nola Anderson, Regional Education Officer, Gippsland Regional Waste Management Group.

This material was prepared for a submission to the AWRE Innovative Council Awards.

Mallacoota – Kitchen to Compost

Mallacoota is located on the coast in the far north-east of Victoria, some 230km from East Gippsland Council's business centre of Bairnsdale. Mallacoota's landfill is on the point of closure and kerbside green waste collection is transported 230km to Bairnsdale for picking and shredding prior to composting at Dutson Downs, a further 96km away.

In 2011 Gippsland Regional Waste Management Group, in association with the East Gippsland Council, undertook a trial in Mallacoota to remove kitchen organics from the municipal waste stream by adding them to the kerbside green waste bin and having them composted on a local farm using VRM Biologic compost accelerants.

The collection of organics in the kitchen was undertaken using the MaxAir BioBin kitchen caddies and compostable BioBags to minimize odour issues and to replicate the process of householders putting 'waste' material in a bag, tying the top and depositing it in a kerbside bin.

The trial was enthusiastically supported by the Mallacoota community. Community members were intrigued to see how well the material composted, especially under the biological activity and sought to visit the on-farm composting site to see for themselves that the process was non-offensive.

The success of the trial saw the establishment of a Mallacoota Kitchen to Compost committee that lobbied the council for the collection and processing of organics to be continued on a permanent basis. The community could see it saved a resource going to landfill as well as recognizing the near capacity of the Mallacoota landfill; it saved the cost and greenhouse emissions produced in hauling green waste to Bairnsdale; composting locally created employment and the resulting compost could be used as a soil amendment either on a farm or by the council on community parks, gardens or sporting fields in place of imported fertilizer.

The Council acknowledged the community support for the process and with recognition that, through the trial, most households already had the basic infrastructure and that the farmer was prepared to continue to compost the material, the Mallacoota combined collection and composting of kitchen organics and green waste was continued while Council investigated permanent collection and processing costs and options.

Negotiations were conducted with East Gippsland Water in relation to the possibility of constructing a composting pad and associated storage infrastructure on its' land to facilitate EPA approval for putrescible composting and to reduce the distance involved in transporting the material from the township to a composting site.

An application to Sustainability Victoria for funding to facilitate composting pad construction; the purchase of a compost sieve; compost inoculants and tarps and additional MaxAir caddies and bags to extend the service to the small surrounding communities of Cann River and Genoa was successful. The Council's application received support from the following organisations: Friends of Mallacoota; Mallacoota and District Business and Tourism Association Inc; Transcoota – Mallacoota Kitchen to Compost Committee and Mallacoota Community Enterprises Limited (Mallacoota Community Bank).
The funding has enabled the Council to proceed with a contractual arrangement with the East Gippsland Water; applications for EPA approval for composting putrescible waste on the East Gippsland Water site and Council building permits for the storage shed.

Originality

The Mallacoota Kitchen to Compost activity is the only kitchen organics collection and processing undertaken in Gippsland and the only one known to be using this type of kitchen collection and composting process in Victoria. The use of the MaxAir kitchen caddies and BioBags enables the collection and processing of organic scraps not able to be composted in home composting bins, such as fish, meat and dairy and therefore has the capacity to completely eliminate food organics from the waste stream.

The VRM Biologic composting accelerants see composting undertaken without shredding the material, which means contaminants are not shredded and are therefore able to be removed at several stages during the composting process as they become obvious rather than ending up as small pieces of contaminants in the end product. The end product also meets compost standard AS4454.

Measurability of the Benefits

A November 2010 audit showed that, on average, each household in East Gippsland deposited 3.37 kg of food waste in the garbage bin per week, representing 42% of the total waste in the garbage bin by weight. Thirty Mallacoota garbage and 30 garden waste bins were audited during the Kitchen to Compost trial in May and September 2011.
The audits indicates an 18.2% and 24.9% drop in the weight of garbage in bins presented in May and September respectively compared with the baseline weight (8.02kg) presented prior to the trial in November 2010. The reduction is largely attributed to removal of food (reduction of 1.5kg and 2.3kg in May and September respectively); however there is also evidence that improved diversion of green waste and recyclables contributed to the reduction. Seven of the audited garbage bins had no food waste in May and five contained no food waste in September.

The green waste collections are fortnightly. Therefore, it is assumed that in May and September approximately 1kg and 1.55kg of food waste was diverted each week representing approximately half of the food waste contained within the garbage bin as identified in the November 2010 audit.

The trial audits showed there is more education required with householders to divert meat and bread to the green waste recycle bin, however the audits also showed residents also were more focussed on correct diversion of recyclables and green waste to the appropriate bins.

Food diverted from the municipal waste stream no longer ends up in landfill, which frees up landfill airspace, reduces methane production in landfill and creates the opportunity for what was previously a ‘waste’ to be used as a resource.

There has been a saving in transport costs and therefore greenhouse gases by processing the food and green waste locally rather than transporting green waste back to Bairnsdale and subsequently on to Dutson Downs for processing.

Impact of the innovation

The community came on board and through the Transcoota – Mallacoota Kitchen to Compost Committee drove the continuation of Kitchen to Compost from a trail to a permanent operation. The community is proud of its achievements and is keen to extend the household collection to commercial premises in the region and eventually to the caravan parks and tourist accommodation.

Local businesses including the supermarkets and Mallacoota Community Enterprises Limited (Mallacoota Community Bank) volunteered to be depots for distribution of additional BioBags (to go into the MaxAir Biobin caddies).

Mallacoota was a community that felt disenfranchised due to its remote location and distance from local government head office. Through working together with Council on this project there has been enormous cooperation and understanding has grown between all parties.

The value to our constituency – environmentally, socially and economically

Environmentally, the Kitchen to Compost project has reduced waste to landfill, subsequently freeing up air space and reducing methane production. It also has reduced transport costs and therefore greenhouse gases, through processing the food and greenwaste locally rather than transporting it back to Bairnsdale and subsequently on to Dutson Downs for processing.

The compost produced from the locally sourced/produced materials has been used on a local farm to increase pasture productivity through the introduction of organic matter. In the future, use of the compost by council could reduce its' town amenity costs by providing a source of material for maintaining gardens and sporting grounds.

Socially, the Kitchen to Compost project has brought members of the community together. Community groups such as Friends of Mallacoota and the Lions Club of Mallacoota were involved in the original roll-out of the trial infrastructure and became local advocates. They also were instrumental in approaching Council to continue the service upon completion of the trial and during the trial actively investigated alternative composting sites that would provide a site more likely to gain EPA licencing approval as a permanent site with closer access to the major collection township than the site used in the trial.

Economically:

- there is a reduction of putrescible material going to landfill, which both frees up airspace and reduces methane production;
- there has been a saving in transport by processing the food and greenwaste locally rather than transporting it 230km to Bairnsdale and subsequently another 96km on to Dutson Downs for processing;
- the reduced transportation required reduces greenhouse gas production;
- the use of the compost as a soil conditioner on a local farm has reduced financial expenditure on synthetic fertilizers and their associated transportation to the district;
- by not purchasing fertilizer, money has been retained within the community;
- EPA has approved the construction of a composting pad at East Gippsland Water and locals have been employed to construct the pad;
- The Council will employ a local person to undertake the composting and manage the site.

Kitchen to Compost site at WWTP

Appendix C: Planning Report for Sewage Treatment Site

Planning Property Report

From www.dpcd.vic.gov.au/planning on 04 September 2013 09:49 AM

Address: OLD BETKA ROAD MALLACOOTA 3892
Crown Description: Allot. 26B PARISH OF MALLACOOTA
Local Government (Council): EAST GIPPSLAND **Council Property Number:** N/A
Directory Reference: VicRoads 70 D7

Planning Zone

PUBLIC USE ZONE - SERVICE AND UTILITY (PUZ1)
SCHEDULE TO THE PUBLIC USE ZONE - SERVICE AND UTILITY

0 1000m

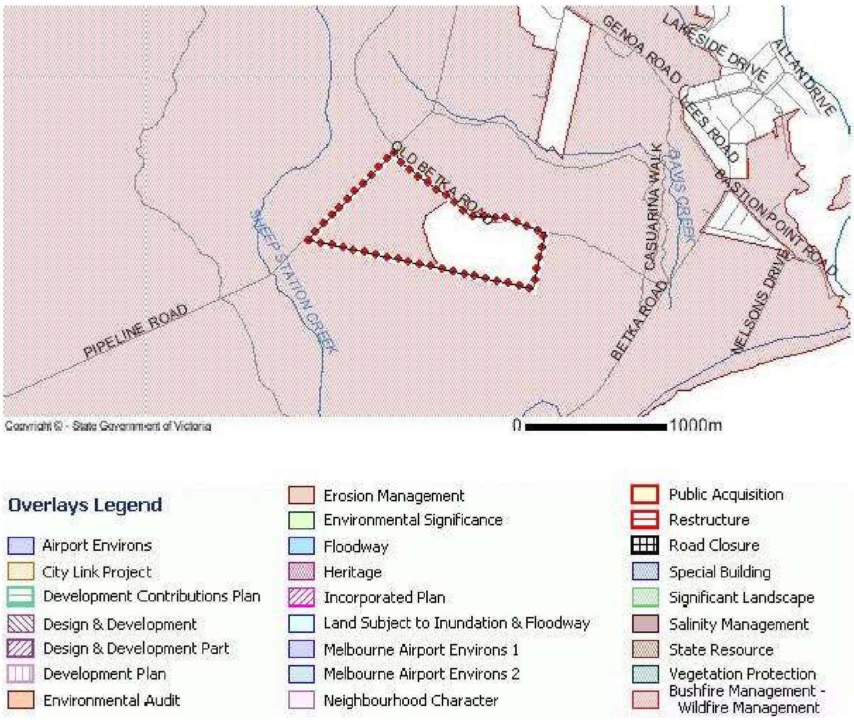
Note: labels for zones may appear outside the actual zone - please compare the labels with the legend.

Zones Legend

- ACZ - Activity Centre
- B1Z - Commercial 1
- B2Z - Commercial 1
- B3Z - Commercial 2
- B4Z - Commercial 2
- B5Z - Commercial 1
- C1Z - Commercial 1
- C2Z - Commercial 2
- CA - Commonwealth Land
- CCZ - Capital City
- CDZ - Comprehensive Development
- DZ - Dockland
- ERZ - Environmental Rural
- FZ - Farming
- GRZ - General Residential
- GWAZ - Green Wedge A
- GWZ - Green Wedge
- IN1Z - Industrial 1
- IN2Z - Industrial 2
- IN3Z - Industrial 3
- LDRZ - Low Density Residential
- MUZ - Mixed Use
- NRZ - Neighbourhood Residential
- PCRZ - Public Conservation & Resource
- PDZ - Priority Development
- PPRZ - Public Park & Recreation
- PUZ1 - Public Use - Service & Utility
- PUZ2 - Public Use - Education
- PUZ3 - Public Use - Health Community
- PUZ4 - Public Use - Transport
- PUZ5 - Public Use - Cemetery/Crematorium
- PUZ6 - Public Use - Local Government
- PUZ7 - Public Use - Other Public Use
- R1Z - Residential 1
- R2Z - Residential 2
- R3Z - Residential 3
- RAZ - Rural Activity
- RCZ - Rural Conservation
- RDZ1 - Road - Category 1
- RDZ2 - Road - Category 2
- RGZ - Residential Growth
- RLZ - Rural Living
- RUZ - Rural
- SUZ - Special Use
- TZ - Township
- UFZ - Urban Floodway
- UGZ - Urban Growth
- Urban Growth Boundary

Planning Overlay

WILDFIRE MANAGEMENT OVERLAY (BMO or WMO)



Below is a copy of initial consultation with East Gippsland Shire Council on the environmental permitting requirements of a development at this site.

Appendix D: Network Support Payments

The cost of upgrading the transmission line to Mallacoota to increase reliability of supply during extreme weather events would be significant. For example the cost of upgrading 80km of line at $200,000 per km could be of the order of $16M.

If a 1.6MW diesel generator at Mallacoota were installed as a standalone solution, a capital cost of $1.2M- $2M would be incurred, plus annual maintenance plus diesel fuel costs proportional to the frequency and duration of any sustained outages.

If a solution were installed with a renewable component which includes full backup generation capacity for the town and islanding capability, the issue of sustained outages would be largely resolved.

As a means of reimbursing a project which provides the backup generation and islanding capability, SP Ausnet could consider paying annual 'network support payments' in recognition of the avoided outages. These payments would be contingent on successful backup generation capability, performance during any outage events and the residual number of outages.

If consumers experience power outages beyond set thresholds, they are entitled to compensation from their electricity distributor. These are known as "Guaranteed Service Level" payments. Payments differ depending on the type of outage. The Victorian Department of State Development Business and Innovation[27] and SP Ausnet website[28] provide guidance on the level of payments.

Network support payments considered could be in proportion to the avoided cost of Guaranteed Service Level payments and and temporary genset hire paid in recent years.

Residents at Mallacoota receive payments in respect of certain outages, according to these regulated rules. SP Ausnet assesses claims from the community and pay the approved sum to electricity retailers, residents then make a claim to their retailers to receive the rebate payments.

Some relevant data has been provided by MSEG including a document by local resident Laurie Hamilton[29] which was produced in February 2013. This contains a description of the sums and references an approval process by SP Ausnet. It details rebate entitlements for 2012 and 2011, in respect of the momentary and sustained outages in 2011 and 2012. The majority (over 90%) of rebate payments are in respect of the sustained outages (greater than 1 minute duration).

The solutions recommended in this study may not alleviate the momentary outages (less than 1 minute) but would be designed to alleviate the sustained outages.

In considering the sustained outages only, and assuming that rebate payments were paid to 735 dwellings (2011 census data inclusive of all houses, excluding caravans and non-classified data), the annual sums were of the order of $290,000 in 2011 and $220,000 in 2012. An initial estimate for 2013 is around $160,000 based on a per-property sum of $235 (inclusive of momentary and sustained outages) although the 2013 data is a preliminary figure and has not yet been confirmed.

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[27] Victorian Department of State Development Business and Innovation http://www.energyandresources.vic.gov.au/energy/safety-and-emergencies/power-outages/customer-compensation
[28] www.sp-ausnet.com.au Customers > Electricity Customers > Our Obligations
[29] Document by Laurie Hamilton entitled 'Power Outages.docx', Feb 2013, supplied to Enhar by the Mallacoota Sustainable Energy Group in January 2014.

Automatic

SP Ausnet has advised that natural events causing extended outages (2-3 days outage) have only occurred twice in the last 6 years.

Enhar's understanding is that an annual average of Guaranteed Service Level payments for the whole town of Mallacoota over the past 3 years is in the range $200,000 - $250,000 per year. This does not include hire of diesel generators.

The technology options recommended in this study would provide reconnection of power to the local network after several minutes of outage, rather than instantaneous reconnection. Therefore not all 'sustained' outages (>1 minute) would be avoided, but most outages lasting longer than a few minutes would be avoided.

A value in the modelling of $125,000 per year was used as a base case for network support payments, recognising that momentary outages would still occur and also recognising the potential for the solution to create a lower cost outcome for SP Ausnet.

If network support payments were to increase, the other financial thresholds of the project, such as required PPA price, would decrease. A sensitivity analysis was performed on the impact of varying the network support payment, as illustrated below:

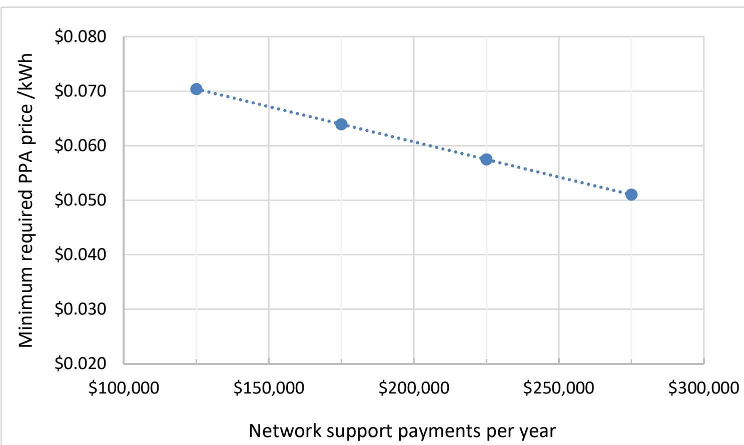

Figure D-13-1: Sensitivity of PPA for a 4.5MW Solar-diesel-battery scenario to network support payments

The figure above illustrates the impact of varying network support payments, using the Scenario 1 case.

Appendix E: Financial Model for Scenario 1

Appendix F: Financial Model for Scenario 2

Appendix G: Financial Model for Scenario 3