JUNE 2022

KNOWLEDGE-SHARING REPORT

LEARNINGS FROM A FEASIBILITY STUDY OF GREEN HYDROGEN AND METHANOL PRODUCTION AT THE BELL BAY ADVANCED MANUFACTURING ZONE IN TASMANIA, AUSTRALIA

BELL BAY POWERFUELS PROJECT

ACKNOWLEDGEMENT OF COUNTRY

ABEL Energy respectfully acknowledges the traditional custodians of the land on which the Bell Bay Powerfuels Project is proposed to be built. The Stoney Creek Nation, made up of at least three clans – Tyerenotepanner; Panninher and Lettermairrener – lived along the same riverways sustainably for several thousand generations, and today they are remembered as the traditional custodians of this land.

CONTENTS

WE WILL TAKE AUSTRALIAN SUNSHINE AND WIND AND TURN IT INTO CLEAN FUELS FOR THE WORLD.

ACKNOWLEDGEMENTS

ABEL Energy acknowledges and thanks the personnel from the following organisations who have assisted the company in the course of its development of the Bell Bay Powerfuels Project, and preparing the Feasibility Study and this Knowledge-Sharing Report. Any errors however should not be attributed to anyone other than ABEL Energy.

GOVERNMENT BODIES AND UTILITIES

Tasmanian Government

TasNetworks

epa TASMANIA ENVIRONMENT PROTECTION AUTHORITY

Hydro Tasmania

TasPorts

LOCAL GROUPS

NRM North

TIMBERLANDS Pacific

forico future fibre

George Town Council 1804

Bell Bay Advanced Manufacturing Zone

TIMBERLINK AUSTRALIA

STUDY PARTICIPANTS

pwc

thyssenkrupp

pitt&sherry

Nuffield Group

Foresion

AT+M

MEMBERSHIP ORGANISATIONS

Methanol Institute

CO_2 Value Australia

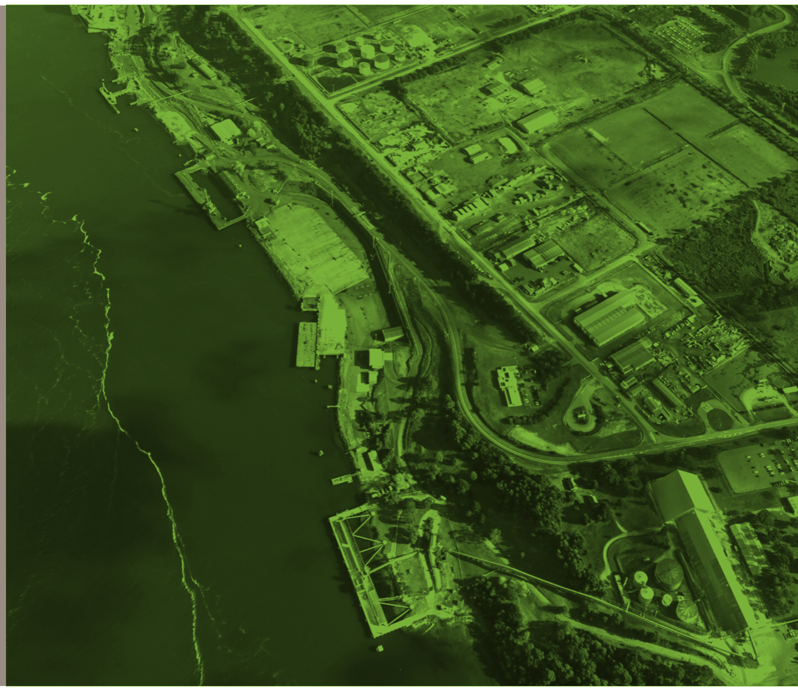
THIS PROJECT WILL ENABLE ABEL ENERGY TO BECOME A WORLD LEADER IN THE PRODUCTION OF GREEN METHANOL AND INITIATE THE DEVELOPMENT OF FURTHER PROJECTS AND TECHNOLOGY IN TASMANIA AND AUSTRALIA.

AT A GLANCE

ABEL Energy is developing a green hydrogen and methanol project in Australia at Bell Bay, Tasmania. The project will harness the renewable resources of Tasmania, including world-leading low-emissions renewable power and harvest residues from certified forestry plantations, to produce net-zero methanol. ABEL Energy undertook a feasibility study of a production process that would abate 135,000 tonnes of carbon dioxide per year.

ECONOMICS

- HARNESSING 100MW OF RENEWABLE POWER
- GROSS REGIONAL PRODUCT IMPACT MORE THAN $1.15 BILLION
- NEARLY 500 CONSTRUCTION JOBS
- PRODUCING 75,000 TONNES OF METHANOL PER ANNUM
- ABATING 135,000 TONNES OF CO_2 EMISSIONS
- OVER 150 LOCAL JOBS FOR AT LEAST 25 YEARS



The project will re-establish domestic methanol production, enhance local liquid fuel security, reduce imports of methanol, diesel and propane, reduce both greenhouse gas and pollutant emissions from mining, shipping and LPG consumption, and generate export income. It will enable ABEL Energy to become a world leader in the production of green methanol and initiate the development of further projects and technology in Tasmania and Australia.

The Tasmanian Government has supported ABEL Energy to complete the feasibility study which has shown globally-competitive green methanol production is possible in Bell Bay. The project will now proceed through Front End Engineering and Design (FEED) to reach a final investment decision (FID). The project will complete the permitting and design stages and be operational by late 2025.

EXECUTIVE SUMMARY

The ability of the Australian State of Tasmania to provide low-cost, near-100% renewable power through its mainly Government-owned electricity generators and transmission and distribution networks places it in an enviable position.

Tasmania is the only region in Australia currently supplying its residents and industries with fully renewable electricity. That same electricity can be used for the production of competitively-priced green hydrogen and derivatives through electrolysis of water. In this way, the use of fossil fuels can ultimately be displaced in all applications in Tasmania and beyond, not just in power generation.

The common feature of most similarly-advantaged regions around the world is their reliance on decades of hydropower infrastructure development. Tasmania is no exception, with the State-owned **Hydro Tasmania** providing over 80% of the electricity distributed in the Tasmanian power grid.

ABEL Energy is one of a number of Australian companies drawn to Tasmania by its renewable power infrastructure. In particular, the **Bell Bay Advanced Manufacturing Zone** is an ideal location for the development of new green hydrogen-based industries, given its status as an existing industrial zone and its access to renewable power, a sea port, and a skilled local workforce.

In November 2020, the Tasmanian Government announced that ABEL Energy was one of three applicants awarded grant funding under the **Tasmanian Renewable Hydrogen Industry Development Funding Program**. The grant of A$555,000 contributed to a A$1.3 million feasibility study (the **Study**) by ABEL Energy into the use of green hydrogen to make methanol at Bell Bay near George Town in northern Tasmania. Some of the learnings from the Study are summarised in this knowledge-sharing report.

The project under development by ABEL Energy at Bell Bay – the **Bell Bay Powerfuels Project** – differs from other proposed projects in the region because of the focus on net-zero methanol production. Most of the other projects are concerned with production of green ammonia.

Methanol (CH_3OH) is the simplest alcohol, is biodegradable and is found naturally, for example, in minute quantities in ripe fruit. These days it is synthesised at industrial scale, mainly from natural gas, to meet a fast-growing market. About 100 million tonnes is used annually around the world (including up to 100,000 tonnes per year in Australia), primarily for the production of other essential hydrocarbon chemicals and as a fuel additive. Like many industrial chemicals, methanol is toxic if ingested, but decades of industrial production have shown it can be produced and handled safely.

It is produced at dedicated plants where cheap natural gas is readily available, and shipped to where it is needed. But it can also be produced renewably at large scale by combining green hydrogen and biogenic carbon, thereby closing the biogenic carbon loop.

This feature of methanol, as well as its other physical properties, has seen renewable methanol proposed as playing a new and much broader role in the energy transition as follows.

First, it is the **most obvious candidate to replace fossil fuels as the future building block for the myriad of hydrocarbon chemicals and materials used by humankind today**. Many hydrocarbons – combinations of hydrogen and carbon – are produced naturally in the form of plants, and provide us with our food, timber and so on. But hydrocarbons produced synthetically such as plastics, textiles, pharmaceuticals, personal care products, paint – indeed, most things in our daily lives – are either composed of or contain materials emanating at very large scale from the petrochemical industry. If oil and gas extraction is phased out, modern societies must adopt a new cleaner source for these hydrocarbons.

Second, **green methanol is also emerging as an excellent fuel** for more than just motor sports. It can play a highly versatile role, for engines, turbines and fuel cells, wherever electricity grids and batteries are either unavailable or impractical, such as in large ships. Like crude oil and derived fuels, methanol is a liquid. Similar storage, shipping and general handling convenience results in lower costs and greater safety. In contrast to crude oil however, methanol has a far more benign environmental impact, being an ultra-clean-burning alcohol that mixes with water and biodegrades quickly in case of a spill.

The Study set out a pathway for ABEL Energy to use local renewable electricity from the Tasmanian grid to produce hydrogen and oxygen via electrolysis of water, and combine the hydrogen with carbon dioxide that resulted from combustion of local sustainable forestry harvest residues. The process is enhanced by using the oxygen from the electrolysers to generate a higher purity CO_2 from the residues via 'oxy-fuel combustion', and using the heat to generate additional power for the facility. There are also alternative processing technologies currently under consideration which do not require complete combustion.

An important feature of the Project will be the use of biogenic carbon as an input. The presence of a world-class fully-certified plantation forestry industry in close proximity to Bell Bay will enable ABEL Energy to access harvest residues – second-generation biomass – that currently have no other purpose. The residues can be collected and used to generate power and carbon oxide gas inputs for the Project. Subsequent projects will eventually rely on direct air capture of CO_2 for their carbon source, but the necessary technology is not yet commercially available.

Also included as part of the Study was an investigation of the impact and consequences of turning down the proposed 100MW alkaline water electrolyser unit to 10% of capacity for up to 4 hours each day to allow power to be diverted elsewhere during times of high demand and high prices. It is this capability that leads to a lower average cost of power to the plant, and assists the network operator when frequency control services and additional capacity are needed.

Other prospects for further consideration include the conversion of some of the green methanol output to a cylinder gas called dimethyl ether, better known as DME.

To summarise, the Study demonstrated that the Bell Bay Powerfuels Project could –

- **deploy a 100MW alkaline water electrolyser unit** capable of producing more than 43 tonnes per day (tpd) of green hydrogen from water;
- **use the resulting green hydrogen, and CO2** from the oxy-fuel combustion of forestry harvest residues, **to produce 226 tpd of green methanol;**
- **be constructed as a commercially viable plant** for the benefit of investors, employees and the communities that comprise the Tamar Valley, the State of Tasmania, and Australia.

Indeed, by displacing fossil fuel diesel and methanol in Australia and elsewhere, the Project could have a global impact by abating over 135,000 tonnes of CO_2 emissions per year. It could also provide the design template for many subsequent projects in Australia which, during the course of this decade, would result in millions of tonnes of CO_2 emissions being abated annually.

Other benefits include –

- a **new climate-tech industry** for the Tamar Valley community which is essentially future-proof, and which in its first phase will employ 50 local full-time employees and generate hundreds of indirect jobs in the region;
- providing domestic and international **maritime customers** with a safe, sustainable and ultra-clean-burning fuel to replace heavy fuel oil and petroleum diesel to run their vessels;
- providing those Australian **mining and agricultural industries** with limited access to a power grid with a **simple energy-dense liquid substitute fuel for diesel;** for use in engines, turbines and fuel cells that are either designed for methanol, or can easily be adapted;
- providing the **Australian LPG industry** with a green methanol derivative gas, renewable DME – **rDME –** which can be blended with, and ultimately replace, fossil fuel propane and butane as a sustainable cylinder gas for their customers;
- a contribution to **local fuel security**, being the only fuel produced in Tasmania from local inputs;
- providing the **Australian chemical sector** with the opportunity to access their first local source of methanol since 2016 – a source which will significantly reduce the fossil fuel intensity of their products.

ABEL Energy is currently engaged in optimising the design of the Project to reduce operational costs and capital cost, before commencing the Front End Engineering and Design **(FEED)** phase. A final investment decision is scheduled for mid-2023, to enable construction and commissioning of the plant by 2025.

Development of an industrial project at Bell Bay is not without challenges around land, power and water availability. However ABEL Energy is confident that it can work with the relevant stakeholders to find innovative solutions to any potential problems.


Bass Strait
King Island
Currie
Deal I.
Furneaux Group
Flinders Island
Prime Seal I.
Whitemark
Cape Barren I.
Clarke I.
Three Hummock I.
Hunter I.
Cape Grim
Robbins I.
Cape Portland
Ringarooma Bay
Anderson Bay
Smithton
Marrawah
Wynyard
Somerset
Burnie
Penguin
Ulverstone
Turners Beach
Devonport
Port Sorell
George Town
BELL BAY
Beaconsfield
Latrobe
Bridport
Scottsdale
Bay of Fires
St Helens
Arthur
Legana
Launceston
Sheffield
Mersey
Westbury
Deloraine
Perth
Evandale
Longford
St Marys
Sandy Cape
Lake Mackintosh
Pieman
Rosebery
Lake Rowallan
Great Lake
South Esk
Conara
TASMANIA
Zeehan
Arthurs Lake
Miena
Bicheno
Queenstown
Lake St Clair
Macquarie
Lake Burbury
Lake Sorell
Swansea
Coles Bay
Great Oyster Bay
Cape Sorell
Macquarie Harbour
Franklin
L. King William
Lake Echo
Lake Crescent
Tarraleah
Oatlands
Schouten I.
Clyde
Gordon
Hamilton
Orford
Maria I.
Derwent
Lake Gordon
Brighton
Bridgewater
Strathgordon
Sorell
New Norfolk
HOBART
Rokeby
SOUTHERN OCEAN
Lake Pedder
Kingstont
Huon
Huonville
Margate
Tasman Pen.
Storm Bay
Bruny Island
Geeveston
Port Arthur
Cape Pillar
D'Entrecasteaux Channel
Alonnah
Port Davey
Southport
South Bruny
South West Cape
South East Cape
TASMAN SEA

INTRODUCTION

ABEL Energy is an Australian company developing projects for the production of green hydrogen and green methanol. The first of such projects is known as the Bell Bay Powerfuels Project (the Project) and is to be located at the Bell Bay Advanced Manufacturing Zone near George Town in the Australian State of Tasmania.

The use of renewable electricity to generate green hydrogen by splitting water has attracted the interest of governments, corporations and other energy stakeholders around the world, especially as a means of storing, transporting and using energy in circumstances where it is not possible or practical to use electricity transmission and distribution infrastructure or batteries alone.

Indeed, the production of green hydrogen will be indispensable in the quest to phase out the emissions-intensive production of hydrogen from fossil fuels for use in ammonia production, refineries and other processes that require pure hydrogen as a feedstock.

On the other hand, the use of green hydrogen as a fuel which can be stored and transported as petroleum fuels are today is still uncertain and requires significant technical and commercial hurdles to be overcome. The physical properties of hydrogen are well-known and make it a difficult gas to handle.

In the meantime, there are opportunities to use green hydrogen as a means of reducing greenhouse gas emissions from fossil fuels, in circumstances where there is already a market and supply chain infrastructure in place. The most prominent examples are the production of green ammonia and green methanol. ABEL Energy proposes to make green methanol.

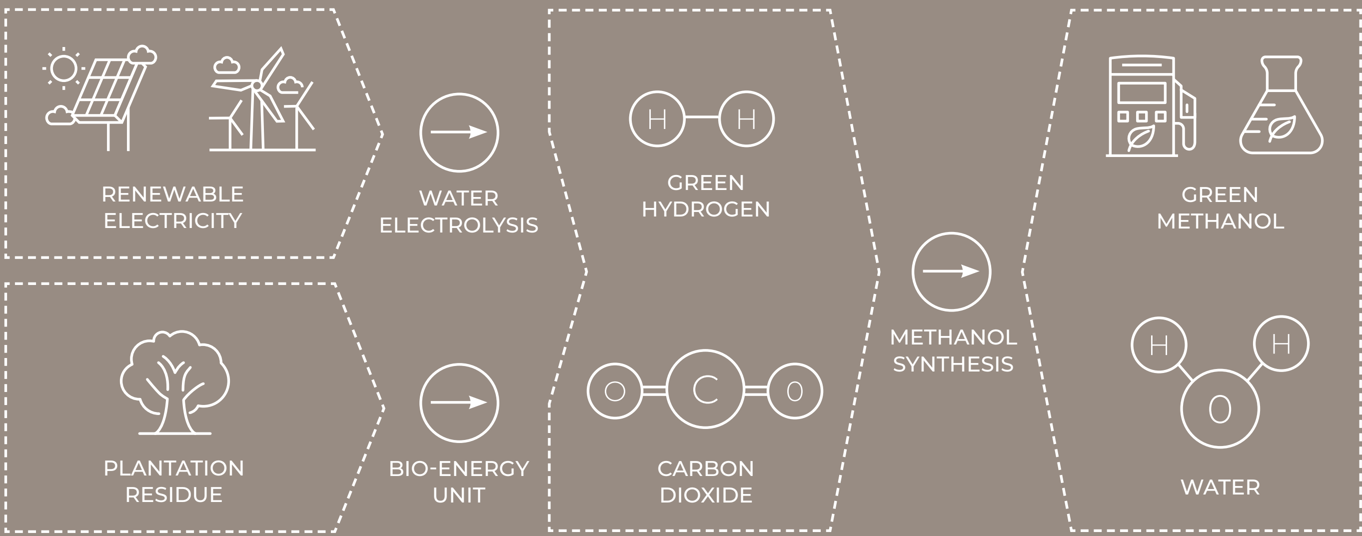
WHAT IS GREEN METHANOL?

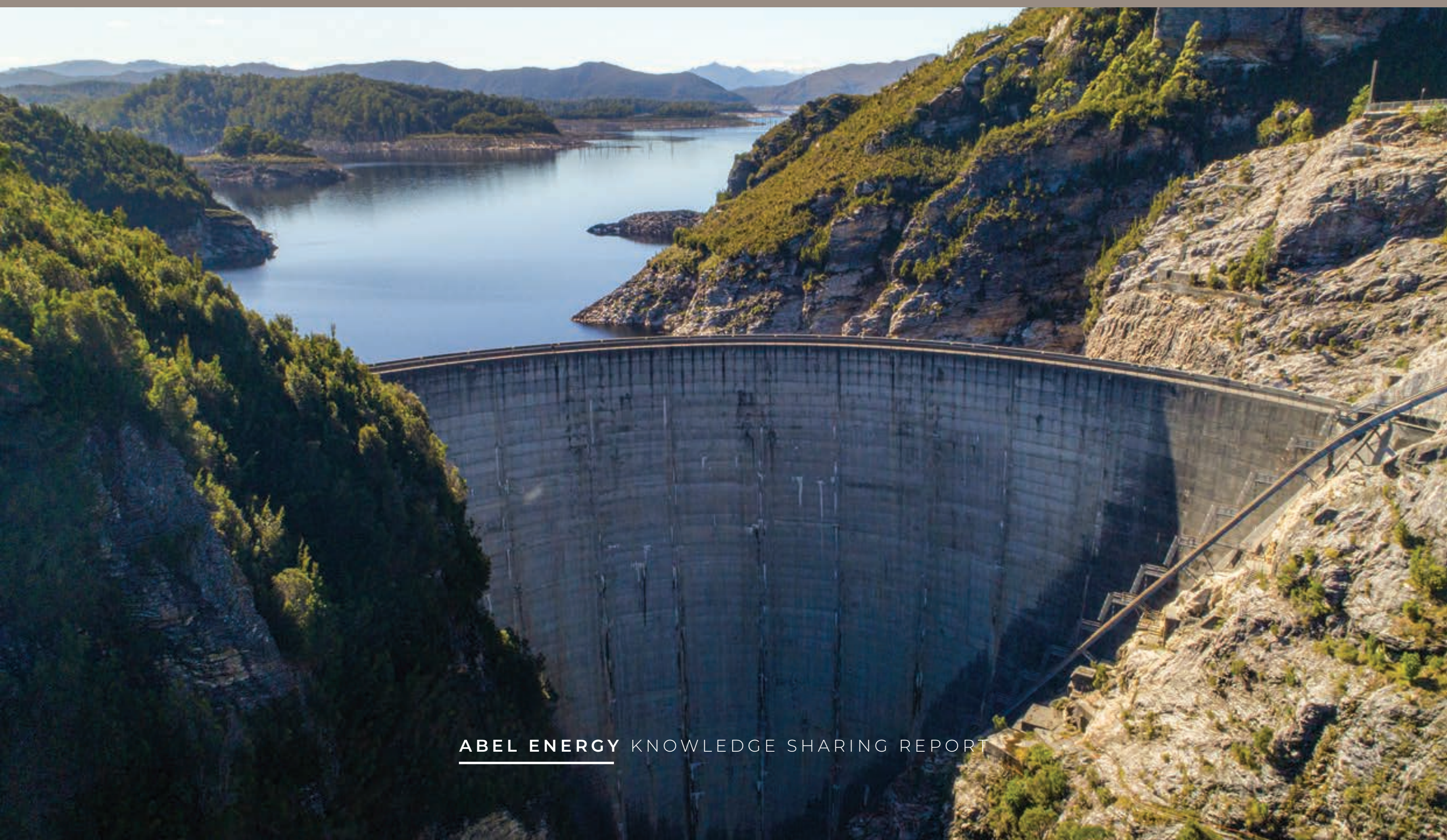
Methanol is a clear liquid chemical used in thousands of everyday products, including plastics, paints, cosmetics, and pharmaceuticals. Methanol is also an energy resource used in the marine, automotive, and electricity sectors and an emerging renewable energy resource.

Methanol is a water-soluble, readily biodegradable and ultra-clean-burning fuel. Increasingly, methanol's environmental and economic advantages make it an attractive alternative fuel for powering ships and heavy-duty machinery.

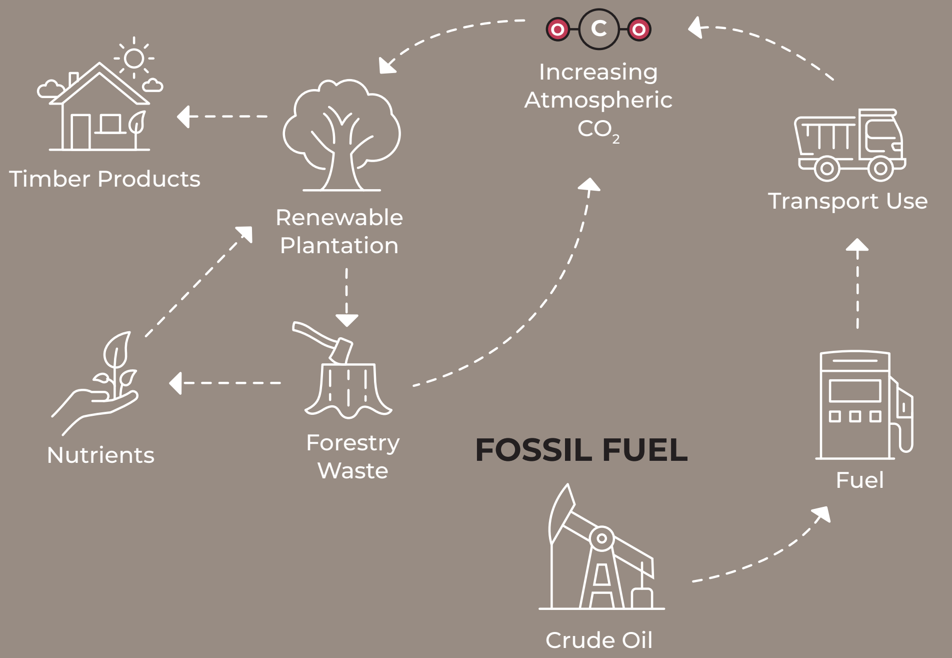
Green methanol is produced from renewable sources and is not derived from fossil fuels.

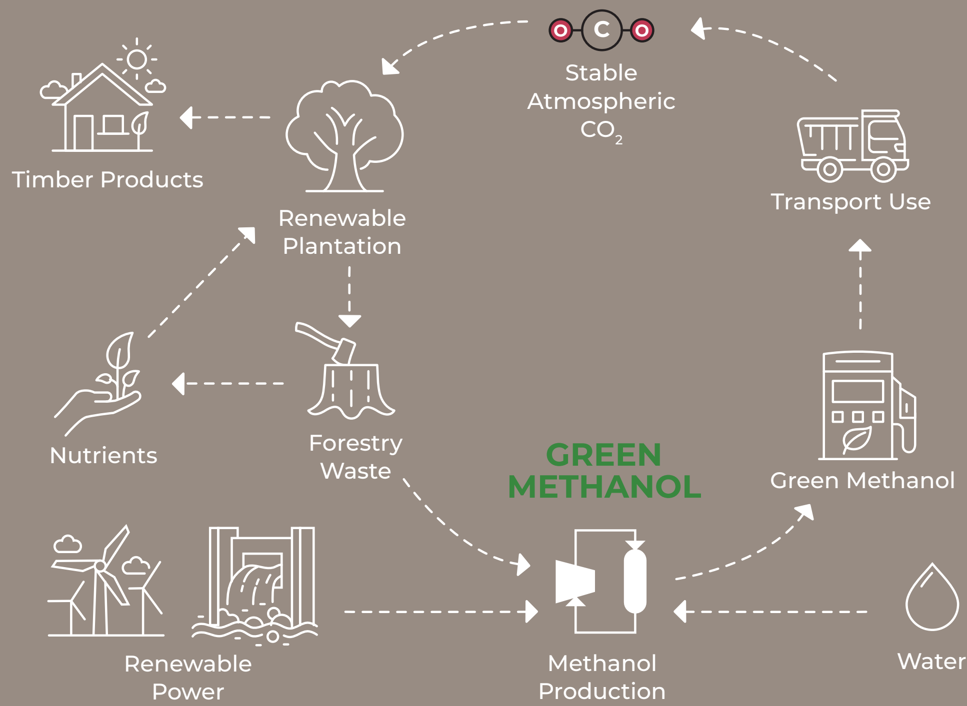
The Bell Bay Powerfuels Project will use renewable energy from wind and hydro power to split water, producing green hydrogen. The Study investigated the use of carbon dioxide from oxy-fuel combustion of forest residues as a renewable source of carbon. The produced hydrogen and carbon dioxide can be combined to produce green methanol.





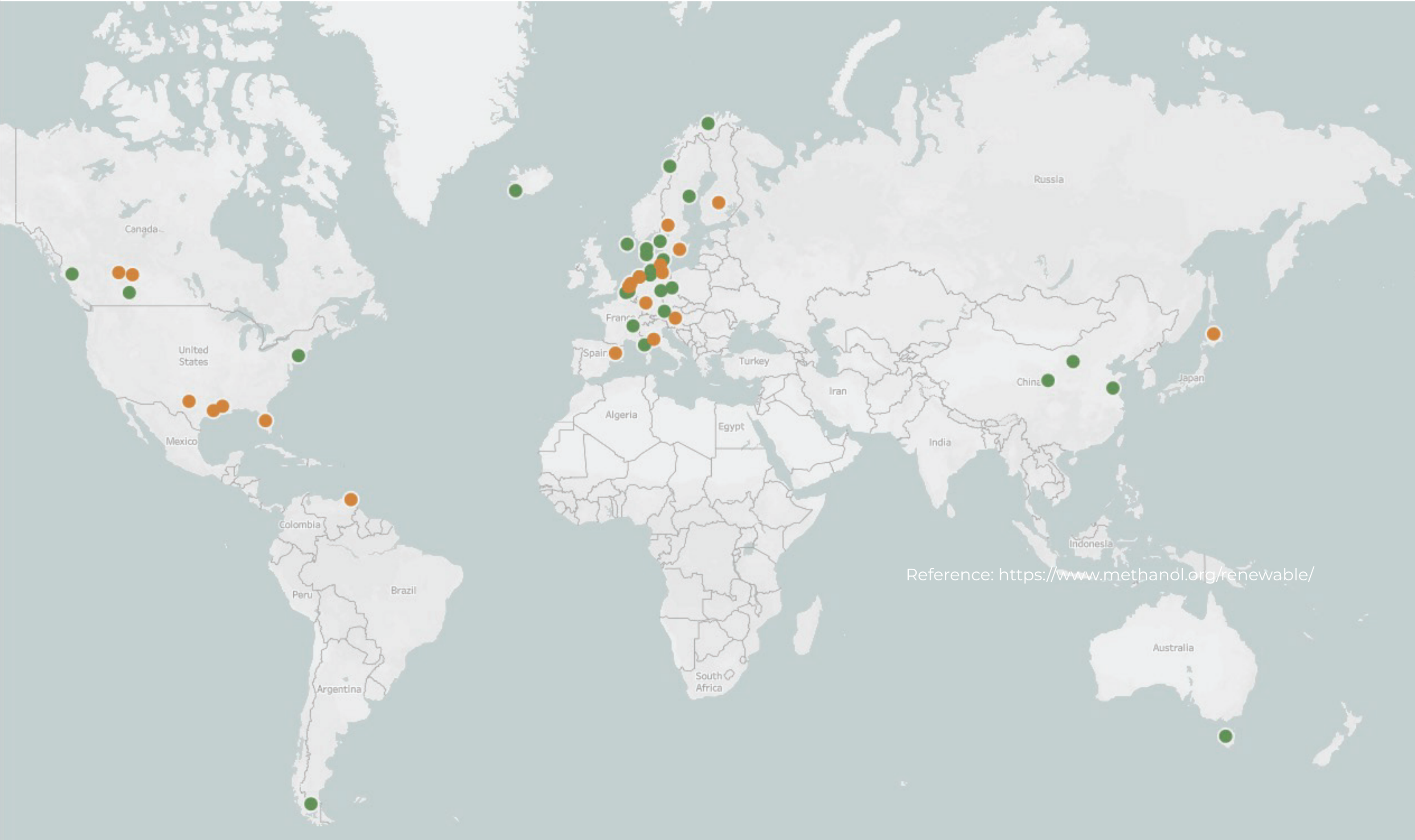
Traditionally methanol is produced from fossil fuels such as natural gas, and in the course of production as well as upon combustion, leads to increased quantities of carbon dioxide in the atmosphere. Green methanol production however involves the extraction of carbon dioxide from the atmosphere, either directly, or indirectly using plants. This approach makes green methanol a net-zero fuel as it avoids releasing into the atmosphere additional greenhouse gases from fossilised carbon formed over millions of years.





Currently, most hydrogen is still produced from fossil fuels. Hydrogen production is based on natural gas (48%), oil (30%) and Coal (18%) - IRENA, 2018. Only about 4% of hydrogen is obtained by electrolysis using either electric power from the grid or a renewable source. The quantity of green hydrogen produced will need to expand greatly in the future to cater for future green chemicals and fuels.

There are more than 45 green methanol projects proposed globally, mostly located in Europe (30 projects) and North America (9 projects). Bell Bay Powerfuels was the first Australian-based project in the public domain.



PRODUCT

Biomethanol

E-methanol[1]

[1] E-Methanol is based on water electrolysis and Biomethanol uses biomass only to produce green methanol

TO TRANSITION TOWARDS DECARBONISATION, WE NEED A SIGNIFICANT AND TIMELY ACCELERATION IN THE PRODUCTION OF GREEN FUELS. GREEN METHANOL IS THE ONLY MARKET-READY AND SCALABLE AVAILABLE SOLUTION TODAY FOR SHIPPING. PRODUCTION MUST BE INCREASED THROUGH COLLABORATION ACROSS THE ECOSYSTEM AND AROUND THE WORLD. THAT IS WHY THESE PARTNERSHIPS MARK AN IMPORTANT MILESTONE TO GET THE TRANSITION TO GREEN ENERGY UNDERWAY.

HENRIETTE HALLBERG THYGESEN
CEO OF FLEET & STRATEGIC BRANDS, A.P. MOLLER - MAERSK

METHANOL MARKET

Given the uncertainty around the timing and extent of the development of a green hydrogen market in Australia and around the world, ABEL Energy will focus initially on supplying customers with green methanol.

Methanol is the simplest alcohol, having only one carbon atom in the molecule – CH_3OH. Next in the alcohol family is the better-known ethanol with two carbon atoms – CH_3CH_2OH. Like ethanol, methanol is a clear liquid. It is also the simplest hydrocarbon – combination of hydrogen and carbon – that is a liquid at ambient temperature and pressure. This particular feature has profound implications for the role that methanol may be able to play in the energy transition currently underway. Below is a table* setting out the properties of methanol compared with some common fuels:

PROPERTIES	METHANOL	METHANE	LNG	DIESEL FUEL
MOLECULAR FORMULA	CH_3OH	CH_4	C_nH_m; 90-99% CH_4	$C_nH_{1.8n}$; C_8-C_{20}
CARBON CONTENTS (WT%)	37.49	74.84	≈75	86.88
DENSITY AT 16°C (KG/M³)	794.6	422.5[a]	431 to 464[a]	833 to 881
BOILING POINT AT 101.3KPA(°C)[B]	64.5	-161.5	-160 (-161)	163 to 399
NET HEATING VALUE (MJ/KG)	20	50	49	42.5
NET HEATING VALUE (GJ/M³)	16		22	35
AUTO-IGNITION TEMPERATURE (°C)	464	537	580	257
FLASHPOINT (°C)[C]	11		-136	52 to 96
CETANE RATING	5		0	>40
FLAMMABILITY LIMITS (VOL % IN AIR)	6.72 to 36.5	1.4 to 7.6	4.2 to 16.0	1.0 to 5.0
WATER SOLUBILITY	Complete	No		No
SULFUR CONTENT (%)	0	0	<0.06	Varies, <0.5 or <0.1

a for methane / LNG at boiling point

b to convert kpa to psi, multiply by 0.145

c the lowest temperature at which it can vaporize to form ignitable mixture in air

*ANDERSSON, Karin (2015)

THE ORIGIN OF METHANOL

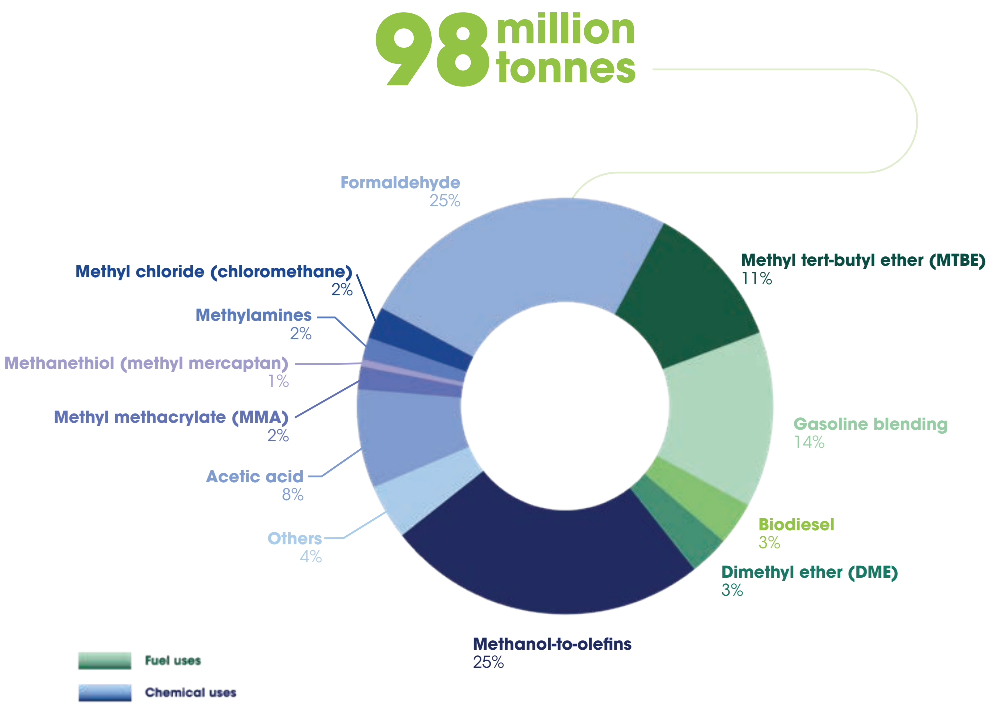
Methanol has an ancient history in human civilisation because it was a by-product of the technology that first enabled the smelting of iron, that technology being the conversion of wood to charcoal.

Heating wood in the absence of air prevented combustion but drove off the moisture and lighter hydrocarbons in the form of vapour from the wood, resulting in a light carbon-dense fuel – charcoal – which burned much hotter (and with less smoke) than raw wood. This heat allowed pure metals such as iron to be isolated from their ore.

One of the hydrocarbons in the vapours released by this process and which condensed to a liquid was methanol. For this reason, it was often called 'wood alcohol'.

Sourcing methanol from the production of charcoal could be described as the first of three phases in humankind's use of methanol for energy and materials. The ancient Egyptians used a methanol-containing liquid from wood to preserve human bodies after death. In fact, nearly all methanol continued to be produced from wood until the early 20th century. Ironically, this methanol was therefore carbon-neutral, that is, it did not involve the extraction and release of fossilised carbon from the ground into the atmosphere.

This changed with the second phase in the evolution of methanol use, which began in about the 1920s with the gasification of coal, and then the reforming of natural gas, to produce methanol at a much larger scale than was possible with wood. This in turn promoted the use of methanol for more and more chemical applications, including fuel additives. Today about 100 million tonnes of methanol is made this way each year around the world, mainly for essential chemicals and fuel additives (see diagram below).



Source: IRENA AND METHANOL INSTITUTE (2021), Innovation Outlook : Renewable Methanol International Renewable Energy Agency, Abu Dhabi.

Methanol has also been used as a high-performance fuel in its own right in motor racing, but was never a serious competitor against petrol and diesel for other fuel applications. It was more costly to produce and had only half the volumetric energy density of petroleum fuels.

We are now on the cusp of a third phase which had its genesis in a series of papers published by Nobel Laureate Professor George Olah and colleagues from the University of Southern California in the late 1990s. The proposition put in those papers was later expanded in 2006 in a landmark book titled ***Beyond Oil and Gas: The Methanol Economy.***

The book noted the finite nature and climate consequences of fossil fuel use, but also posed the question of what to do if fossil fuel extraction comes to an end. In particular, those unsung heroes of the 20th century, organic chemists, had managed to synthesize thousands of hydrocarbon compounds – combinations of hydrogen and carbon – to fulfill every industrial, medical and domestic need of human societies. Plastics, pharmaceuticals, textiles, adhesives, sealants, paints, personal care products, construction materials – all emerged at massive scale from a petrochemical industry based on fossil fuels. There was no going back to whale oil, ivory and peacock feathers, especially as the human population on earth in 2050 is projected to be more than six times what it was in 1900. There is therefore an issue about how this industry will transition away from fossil fuels.

As the title of that book suggests, methanol could play a significant role in this transition. As the simplest hydrocarbon molecule that is a liquid, methanol can be produced, stored and transported around the world in bulk carriers. With such a simple molecular structure, it is the ideal building block for more complex hydrocarbon chemicals and materials. And green methanol can ultimately be produced at massive scale simply by combining two gases that are available in inexhaustible quantities – hydrogen from water (including seawater) and CO_2 from the air.

However, this role in the energy transition is not restricted merely to that of a chemical feedstock. Methanol can be a fuel for engines, turbines and fuel cells. Based on methanol's particular properties, and trends in market demand, ABEL Energy is targeting the following market sectors for the sale of its green methanol product:

- **Maritime transport** – as a fuel for ships;
- **Heavy duty off-grid applications** – as a fuel for mining, agricultural and power generation equipment;
- **Chemical sector** – as a feedstock for various essential hydrocarbon chemicals;
- **LPG sector** – as a feedstock for the production of a cylinder gas called dimethyl ether (DME)

MARITIME TRANSPORT

The most common fuel used by the shipping industry today is heavy fuel oil **(HFO)**. About 330 million tonnes of HFO is consumed each year. However, HFO is a notoriously polluting fuel, with a typically high sulphur content. Emissions of sulphur oxides, nitrogen oxides and particulates from combustion of HFO are so bad that many ports require that ships switch to cleaner-burning fuels as they approach the port.

In addition to the pollution issues, there are now also moves by the International Maritime Organization **(IMO)** to require ships to reduce their greenhouse gas emissions.

For both problems, green methanol is an excellent solution. Although it has slightly less than half the volumetric energy density of HFO, it is significantly better in this respect than most other green alternatives such as liquid hydrogen or green ammonia. The fact that methanol is a safe and easy-to-handle liquid is also an advantage. Further, methanol spills, while undesirable, have a far lesser impact on marine environments than petroleum fuels or ammonia. Like other alcohols, methanol mixes with water and biodegrades relatively quickly.

Methanol has been used as a fuel for ships since 2016 following the development by **MAN Energy Solutions** of large dual-fuel 2-stroke engines capable of running on methanol. This concept was given a significant boost in September 2021 by an announcement from the world's largest container shipping company, **A.P. Moller – Maersk**, that they had ordered 12 large new container ships all designed to run on green methanol.

Design of recently ordered methanol fuelled container ship by A.P. Moller – Maersk

The design of the new ships gives an insight into why a liquid fuel like methanol is needed, as opposed to batteries. Once a ship leaves port, the engine operates on a 24 hour cycle for weeks at a time. The ships will have a large tank capable of holding 16,000 m^3 of methanol (12,500 tonnes). The energy content of a full tank of methanol will be about 70,000 MWh, which will feed a large modern 2-stroke engine operating at over 50% efficiency. In this way, up to 35,000 MWh of work can be delivered to the propellers from one tank. By comparison, the largest grid-scale battery currently under contemplation in Australia, covering hectares of land, has a proposed storage capacity of 2,800 MWh.

It is expected that demand for green methanol from the shipping industry will outstrip supply for the next decade at least, so the key challenge for producers like ABEL Energy will be reaching production cost targets which will allow customers access to green methanol at an affordable price.

HEAVY-DUTY OFF-GRID APPLICATIONS

Replacing fossil fuel diesel for heavy-duty off-grid applications such as mining and agricultural equipment and power generation is a significant challenge. Diesel has been a safe, energy-dense fuel for many decades. Electrification of equipment requires access to large volumes of renewable power, which is typically not possible in remote locations.

Being a liquid, green methanol provides a solution which can be adapted to existing supply chains and equipment more easily than most other green alternatives. Unlike some green alternatives, the future prospects for large scale production of green methanol are very promising, especially once direct air capture of CO_2 is commercialised.

Versatilty is another important feature of green methanol. It can be used in many different applications, with engines, turbines and fuel cells likely to be the most popular. The widespread release of methanol fuelled engines by manufacturers will be a turning point.

CHEMICAL FEEDSTOCK APPLICATIONS

As noted earlier, methanol is the ideal candidate to replace fossil fuel petroleum feedstocks for virtually all of the hydrocarbons used by humankind today. In China, large **methanol-to-olefin** plants built over the last decade demonstrate the maturity of the technology to produce ethylene and propylene – the most important petrochemicals and precursors of all plastics – from methanol. Reducing the greenhouse gas intensity of this industry is therefore constrained only by access to competitively-priced green methanol.

In the meantime, Australian chemical producers currently import all of the methanol they require. ABEL Energy will make green methanol available to this market.

DME FOR LPG INDUSTRY

LPG suppliers around the world are concerned that demand for fossil fuel propane and butane, ie. cylinder gases produced by oil refineries, will wane as carbon intensity concerns grow. A number of large LPG companies have decided to focus on introducing a renewable cylinder gas in the form of DME into their product suite. Given that all DME today is made from methanol, green methanol could play a role in defossillising the LPG industry. Renewable DME **(rDME)** is currently being blended with propane by certain LPG companies in North America, with the intention of eventually replacing propane entirely with rDME.

If there is sufficient demand from Australian LPG suppliers, ABEL Energy will consider adding a methanol-to-DME production unit at Bell Bay or elsewhere, to enable blending to commence.

Pure methanol has been used in open wheel racing since the mid-1960s. Unlike petroleum fires, methanol fires can be extinguished with plain water (while methanol is less dense than water, they are miscible, and the addition of water will cause the fire to use its heat to boil the water). In addition, a methanol-based fire burns invisibly, unlike gasoline, which burns with thick black smoke. If a fire occurs on the track, there is less smoke to obstruct the view of fast approaching drivers and first responders.

https://www.chemeurope.com/

PRICING

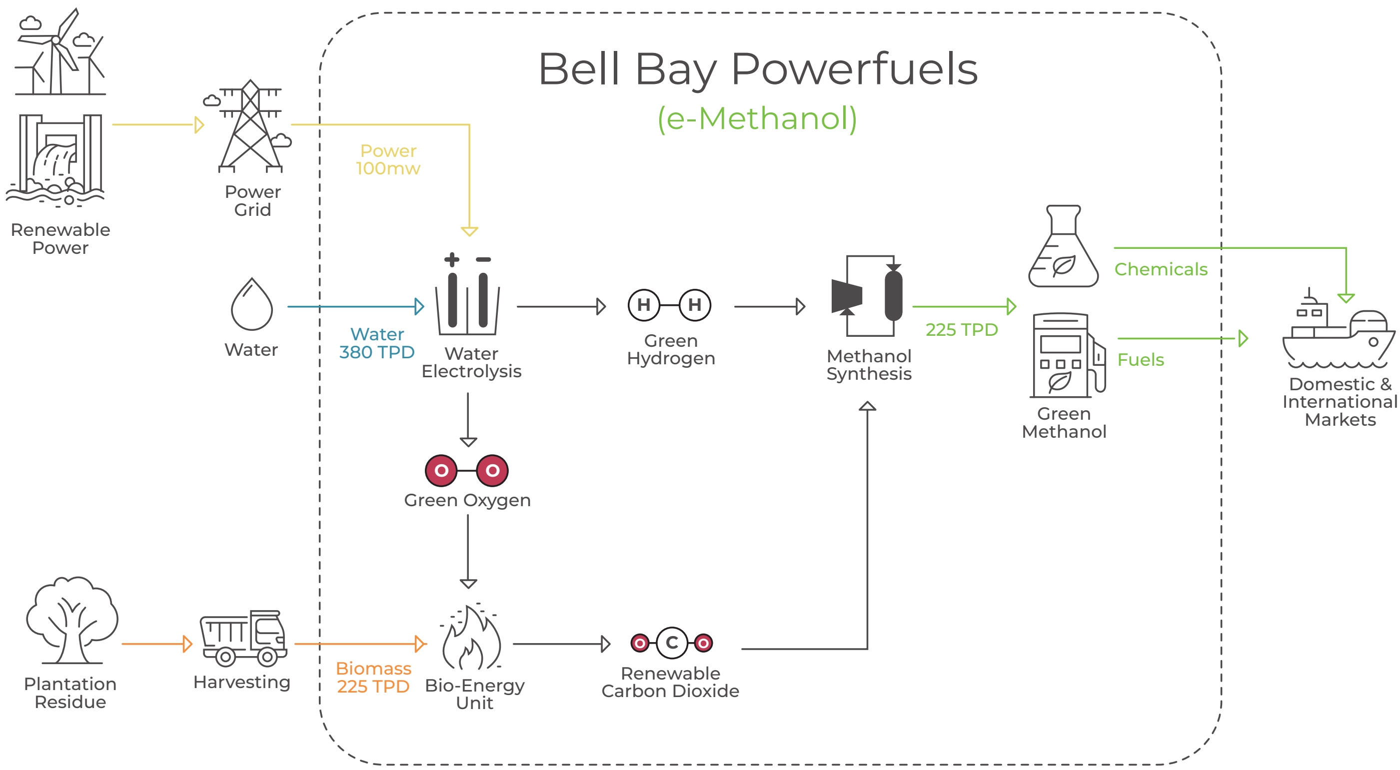
The global energy crisis being experienced at the time of writing this Report, as well as the still-unfolding myriad of carbon pricing mechanisms under development around the world, make price forecasting extremely uncertain. Current spot prices for fossil fuel methanol are unusually high at USD 25-30 per GJ. While green methanol is presently attracting some very substantial green premiums in certain markets, medium-term targets are generally in the range of USD 35-50 per GJ.

TASMANIA'S SUSTAINABLE FOREST SECTOR PRODUCES HIGH QUALITY PRODUCTS INCLUDING BEAUTIFUL TIMBERS WHICH ARE HELD IN HIGH REGARD BY ARCHITECTS, CRAFTSPEOPLE AND ARTISTS.

PROJECT OVERVIEW

The Project will bring together two of Tasmania's key strengths - an almost 100% renewable power grid and extensive FSC-certified plantation forestry to demonstrate the commercial viability of net-zero methanol production. The project will demonstrate in Australia several existing technologies and deploy them together at commercial scale.

Bell Bay has been designated as a Clean Hydrogen Industrial Hub and in May 2022 was allocated funding of $70 million by the Australian Government. ABEL Energy was one of the four supporting projects named as part of the successful Hub bid.



The Project is modestly sized fitting within the constraints of the existing power network, renewable power generation and biomass supply whilst being sufficiently sized for commercial operation producing methanol at globally competitive prices. The Study considered a facility design that could start operation in late 2025 and produce 75,000 tonnes of methanol per annum. Such a facility would abate over 100,000 tonnes of carbon dioxide per year or over 3 million tonnes over the life of the project.

The Project is estimated to generate up to 500 regional jobs during construction and at least 50 directly operating the facility at Bell Bay. Other jobs will be created locally including harvesting forestry residue and to support the project and its employees.

This is the first project of a series to be built in Australia by ABEL Energy. However, because an expansion of the project at Bell Bay or replication elsewhere will always be constrained eventually by the availability of biomass, ABEL Energy believes that Direct Air Capture **(DAC)** of carbon dioxide from the atmosphere will ultimately replace biomass as a source of biogenic carbon for future projects producing green methanol.

The project will propel ABEL Energy to being a major global green methanol supplier, with the internal knowledge and experience to develop further projects. As the only current project in Australia developing a green methanol facility, Bell Bay Powerfuels will enable some or all of the following:

- Production of a drop-in fuel to aid the nation's fuel security with a locally produced net-zero fuel with lower particulate, nitrogen oxides **(NOx)** and sulphur oxide **(SOx)** emissions. Further, using green methanol to reduce scope 1 and 2 greenhouse gas emissions from mining equipment would assist in maintaining the Australian mining industry's global competitiveness. The local forestry industry could reap similar benefits in their vehicle and harvesting fleets. Green methanol can meet the needs of large off-grid energy users, where batteries cannot store the required energy.
- Develop a green methanol export industry for use in the global shipping market, with the world's largest container shipping company Maersk recently placing an order for twelve new methanol fuelled vessels to satisfy the demand for net-zero shipping and reduction of NOx, SOx and particluates in ports
- Substitution of current methanol imports to Australia, currently nearly 100,000 tonnes per year. Green methanol for chemical use also enables longer term sequestration in manufactured goods by displacing fossil fuel-based products
- By converting a portion of the methanol to DME, produce an LPG substitute to support the local LPG industry, to provide a green fuel to consumers especially in regional areas.
- The beneficial use of forestry wastes rather than the current practice of decomposition or controlled burns.

The facility is targeting a Carbon Intensity **(CI)** of 5g CO_2e per megajoule. Carbon emissions are primarily due to collection and transport of forestry residue and methanol shipping.

EVERY YEAR, TASMANIA PRODUCES ABOUT 9000 GIGAWATT HOURS OF CLEAN ELECTRICITY FROM HYDROPOWER – ENOUGH TO POWER ABOUT 900,000 AUSTRALIAN HOMES AND SMALL BUSINESSES.

BELL BAY ADVANCED MANUFACTURING ZONE

SITE SELECTION

Bell Bay is a major port in the north of Tasmania, handling 59% of the State's manufactured exports[2]. It is located on an estuary known officially as River Tamar or by its native name kanamluka. Tasmania's largest industrial precint is situated at the port.

It hosts the Bell Bay Aluminum smelter, Liberty Bell Bay manganese alloy smelter, Timberlink sawmill, various woodchip export facilities and bulk cargo import and storage facilities handling various products including refined fuels. Bell Bay is located south of George Town and is well connected to both the Tasmanian power transmission network, and to the Basslink Interconnector to Victoria.

For the purposes of the Study, three alternative sites in Bell Bay were selected for development assessment potential. It should be noted that ABEL Energy has no rights or other interests in any of the selected sites at this stage; the sites are owned by various corporate landowners.

The first site is in proximity of the Timberlink sawmill and is located on level undeveloped land. The site is near a suitable power easement and has good road access. The site is located away from the port but access to berth 4 (Oil Products/ Petroleum) could be provided by TasPorts.

The second site is the former Bell Bay Power Station, which was initially oil and subsequently gas fired. The power station has been decommissioned but has not been demolished. The site is somewhat constrained in size, and parts of the site are significantly sloping including a hill on the eastern side. The site has existing infrastructure such as a wharf, buildings, roads that will either require repair to be reused or will need to be demolished. The buildings contain asbestos and there is a former waste dump within the site. The site has good access to the estuary, the East Tamar Highway and to an existing power easement.

The third site is adjacent to the Forico Long Reach Mill where woodchips had previously been produced and exported. The site has some former roadway and pavements and is sloped with terracing over several levels. It has road access to the East Tamar Highway, an existing wharf on the River Tamar (owned by TasPorts) and is close to a power easement.

[2] https://bbamz.com.au/

SITE	ADVANTAGES	CHALLENGES
ADJACENT TO TIMBERLINK	Greenfield / undeveloped site	Remote from wharf
	Access to power infrastructure	Access to water
	Close to TimberLink sawmill	Site availability
BELL BAY POWER STATION	Power and wharf access	Constrained site /significant sloping
	Existing infrastructure	Infrastructure demolition
	Existing visual profile	Asbestos and waste dump
		Site availability
ADJACENT TO FORICO	Power and wharf access	Unlevel site
	Existing terracing	Infrastructure demolition
	Close to Forico	Site availability

All of the sites considered in the Study are potentially viable for Bell Bay Powerfuels. ABEL Energy will continue to consider its options as developments unfold. Each site has differing external infrastructure requirements, for power, water, and product export. Selection of an available site will take into account the site feasibility ranking, timeline for site availability for development and the negociated commercial site value. ABEL Energy will continue to work with the Tasmanian Government, local utility providers and the Bell Bay Advanced Manufacturing Zone **(BBAMZ)** as part of concluding the formal site acquisition.

ALL SITES RELATIVE TO THE BELL BAY INDUSTRIAL ZONE

EVENTUALLY, METHANOL WILL BE MADE BY THE CHEMICAL CONVERSION OF ATMOSPHERIC CO_2, WITH HYDROGEN GENERATED BY THE ELECTROLYSIS OF WATER, USING ANY FORM OF AVAILABLE ENERGY. AS HUMANKIND WILL BE ABLE TO PRODUCE METHANOL BY CHEMICALLY RECYCLING CO_2 FROM AIR AND HYDROGEN FROM WATER, IT WILL BECOME AVAILABLE TO ALL AND PROVIDE AN INEXHAUSTIBLE RESOURCE FOR THE FUTURE.

NOBEL PRIZE LAUREATE GEORGE OLAH ET AL,
BEYOND OIL AND GAS: THE METHANOL ECONOMY, 2018

TECHNOLOGY

WATER ELECTROLYSIS

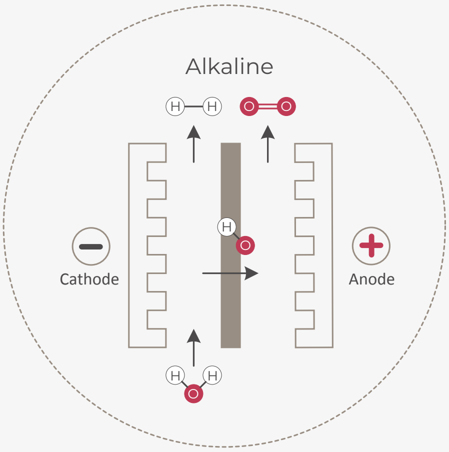
Electrolysis is used to split water into hydrogen and oxygen using electricity. The produced hydrogen is a feed for the methanol plant and the oxygen is used for biomass processing.

The Study used thyssenkrupp Nucera's Alkaline Water Electrolysis **(AWE)** technology for this application as AWE technology is the most mature commercial technology, in use since the 1920s, for hydrogen production in the fertiliser and chlorine industries.

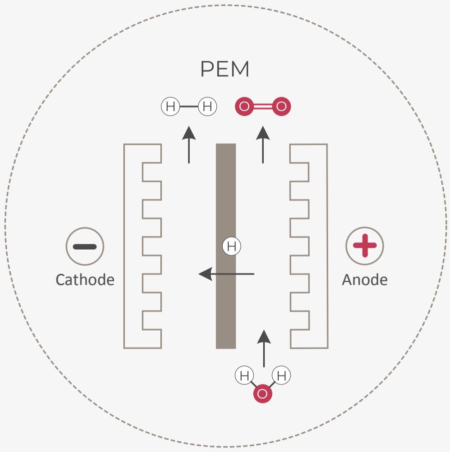
ALKALINE AND PEM ELECTROLYSIS

Water electrolysis uses electricity to split water into hydrogen and oxygen. When coupled with renewable electricity electrolysis produces what is known as green hydrogen. There are two main mature water electrolysis technologies, Alkaline Water Electrolysis (AWE) and Proton Exchange Membrane (PEM) electrolysis.

The first AWE developments started in the early 20th century growing to 100MW+ units in the mid-century based on hydropower. PEM technology was developed in the 1960s. Both technologies have continued to develop since these early days to improve energy efficiency, operating life and production cost.



ALKALINE WATER ELECTROLYSIS USES AN ALKALINE SOLUTION OF POTASSIUM HYDROXIDE/WATER AND TWO CHARGED ELECTRODES TO PRODUCE HIGH PURITY HYDROGEN AND OXYGEN.

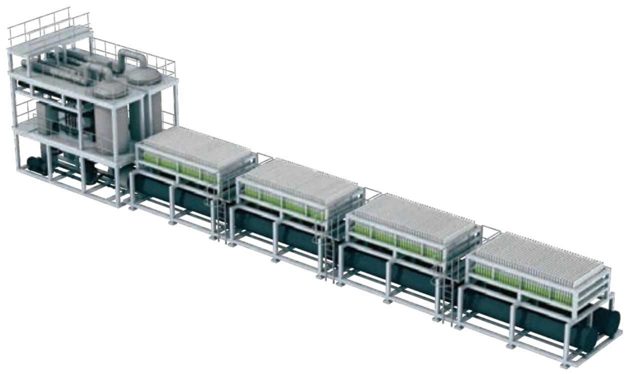


PEM ELECTROLYSIS UTILISES A SOLID ACIDIC POLYMER ELECTROLYTE TO TRANSPORT PROTONS PRODUCING HIGH PURITY HYDROGEN AND OXYGEN/WATER SOLUTION.

AWE is currently better suited to large commercial scale operation because of lower cost and a longer proven operating life. PEM electrolysis potentially offers better responsiveness to power fluctuations, which is of lower importance when grid connected. The quoted efficiencies of each technology are similar and can be optimised based on power load.

The electrolysis unit considered in the Study will have a total nominal capacity of 100MW. The electrolyser system includes a process section containing gas treatment, electrolyte circulation, cell feed and discharge. Demineralised water is added to the alkaline solution to replace the water consumed by electrolysis.

Direct Current power is provided to the AWE units by a combination of transformers and rectifiers and fed to the electrolysers by bus bars.

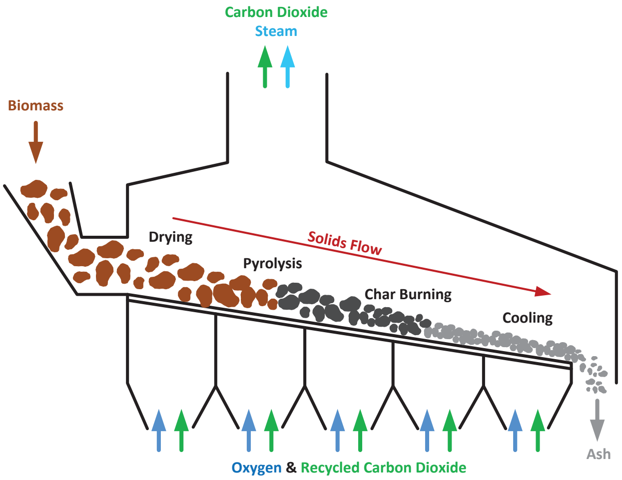


THYSSENKRUPP NUCERA 20MW MODULE

The produced hydrogen is cooled and filtered and fed to the methanol plant or hydrogen storage via compression. Oxygen produced in the electrolysers is also cooled and filtered, to be used for biomass combustion or sent to storage.

BIOMASS COMBUSTION PLANT

The Study investigated biomass combustion using oxygen, with this being the source for the renewable carbon dioxide required for methanol production. The Alkaline Water Electrolysis Plant produces the required oxygen for combustion which is also stored for periods when electrolysis is operating at reduced load or is not in operation.



Wood chips derived from plantation forest residue are the feedstock for the biomass combustion, which is carried out in a grate-fired boiler. Oxygen is used for combustion rather than air to minimise the proportion of inert components such as nitrogen, to improve the efficiency of downstream processing. Furthermore, the equipment is specifically designed to reduce undesirable air leakage into the system.

To avoid the high temperatures generated by pure oxygen combustion, recirculated product gas mainly consisting of carbon dioxide is used to reduce the temperature in the combustion zone. Waste liquids from the methanol unit are also recycled into the biomass boiler and burned to increase the carbon loop efficiency of the overall plant and to productively utilise these by-products.

Ash is continuously removed from the biomass boiler and transferred to ash handling, storage and export facilities.

The heat generated by combustion is used both for production of steam and for preheating of boiler feed water **(BFW)** and oxygen. The first step of heat recovery is the generation of superheated steam. Following this heat recovery, the produced gas is cooled in two further steps by preheating of BFW and oxygen. The cooled gas is partly recirculated to combustion, while the remainder is scrubbed with water before further gas treatment.

The raw produced gas contains components which would detrimentally affect the catalyst used in methanol production, such as sulphur or chlorine-based species. These need to be removed to avoid deactivation of the methanol synthesis catalyst. Additionally, NOx components must be removed from syngas to avoid the formation of trimethylamine **(TMA)** in the methanol synthesis. Small concentrations of TMA in the product methanol produce an undesirable characteristic smell.

The biomass combustion plant produces 94% purity carbon dioxide gas with minimal inert compounds and is designed to operate as low as 25% capacity to suit operational requirements.

METHANOL

In the Study, methanol is produced through a catalysed reaction where hydrogen and carbon dioxide are reacted to produce methanol and water.

Traditionally fossil fuel-based methanol is produced from a gas mixture commonly known as synthesis gas **(syngas)** which primarily contains hydrogen, carbon monoxide and a smaller quantity of carbon dioxide. This mixture is favoured as the methanol reaction based on carbon monoxide does not produce water and is therefore preferred to reduce subsequent water removal. However, green methanol based on renewable carbon dioxide does produce water and this is able to be removed by distillation. Therefore, the green methanol process is similar to conventional methanol plants requiring only a few modifications. All required equipment is proven and state of the art.

Hydrogen and carbon dioxide produced from biomass combustion and water electrolysis are compressed and purified before being fed to the methanol synthesis.

In the next step the compressed gases are heated by recovering heat from the synthesis products prior to entering the methanol synthesis reactor. The process uses an isothermal reactor and for the methanol synthesis a copper, zinc oxide and alumina based catalyst is used. Such types of reactors are also used in conventional methanol plants. Suitable catalysts are available from a number of catalyst suppliers. A minimum temperature is necessary to activate the reaction, however a maximum temperature should not be exceeded to prevent catalyst deactivation and side product formation. The conversion of carbon dioxide to methanol is favoured by increased pressure.

The product gas from the methanol reactor is cooled and the condensed raw methanol is separated from the unreacted syngas. The recovered syngas is compressed by a recycle gas compressor and then mixed with the feed syngas to the methanol synthesis unit.

The liquid raw methanol is depressurised and is sent to the methanol distillation section. The major impurities contained in the raw methanol are water, dissolved gases and by-products formed in the methanol synthesis reactor. The by-products are mainly light components such as dimethyl ether, methyl-formate and higher alcohols such as ethanol, propanol and butanol.

In order to produce AA-grade methanol three distillation columns are required, firstly a pre-run column followed by a high pressure then a low-pressure methanol column.

A methanol slop system is also incorporated to collect various drains in the methanol plant, for reprocessing, treatment, or disposal.

STORAGE

Hydrogen storage is used to buffer hydrogen production from the water electrolysis unit for operational stability to best avoid shutdowns. Hydrogen storage is used to cover the short fall of production verses the demand of the methanol plant.

Oxygen storage is required to ensure the biomass combustion can continue to operate when the electrolysis unit is offline or at turndown.

Methanol storage is relatively straightforward using atmospheric tanks at ambient conditions, similar to existing fuel storage. The storage is sized to allow sufficient time to build inventory until a ship arrives. Methanol storage is also used to ensure product quality specifications are met. The produced pure methanol is firstly stored in check tanks, where samples are taken to confirm the AA-grade specification. Normally it will then be transferred to AA-grade product storage of 6500 cubic meters or approximately 22 days. If the samples do not meet specification the contents are transferred to the off-spec methanol tank and recycled to the distillation plant for retreatment.

METHANOL PLANT AT SCHWARZE PUMPE IN GERMANY (WWW.THYSSENKRUPP-INDUSTRIAL-SOLUTIONS.COM)

METHANOL PRODUCTION HISTORY

The first process that could be used to produce methanol synthetically was developed by French chemist Paul Sabatier in 1905. His process used carbon dioxide and hydrogen to produce methanol. The proposed production of green methanol uses this approach.

Following this process German chemists at BASF, Alwin Mittasch and Mathias Pier, patented a process to synthesise methanol from a mixture of carbon monoxide, carbon dioxide, and hydrogen.

This process was first deployed in 1923 at Leuna, Germany. The operating conditions were extreme at about 400 °C and pressures of between 250 and 350 atm using a zinc/chromium oxide catalyst.

Modern methanol production has been made more efficient through use of catalysts commonly copper based capable of operating at lower pressures. The modern low pressure methanol process was developed by ICI in the late 1960s with the technology patent long since expired.

DESIGN BASIS

CLIMATIC DATA

The site climatic data used in the Study was based on Low Head, Tasmania as follows (unless otherwise indicated):

- Ambient temperature ranges from 0.5°C to 28.7 °C
- Relative humidity ranges from 64% to 82 % and absolute humidity range from 39% to 100 %
- Design Barometric Pressure 1013 mbara
- Daily maximum rainfall: 204.8 mm with a 1 hourly peak rainfall 31.8 mm/h (based on Launceston) and a 24-hour rainfall 91.9 mm/24h (based on Launceston)

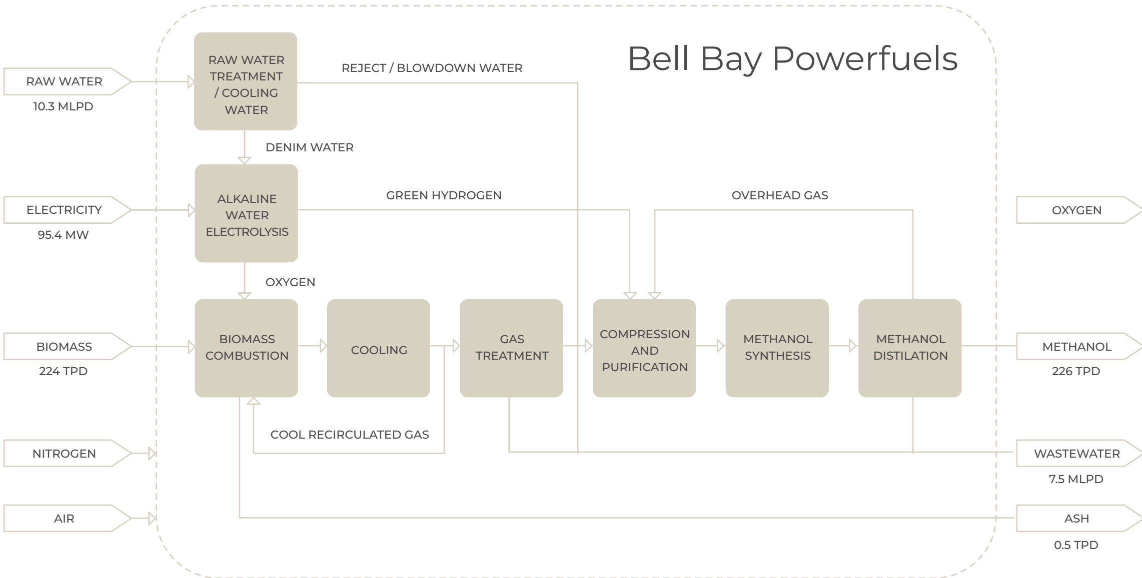
PLANT CAPACITY AND LIFE

In the Study, the overall plant capacity was set at 100MW, which fits within current system constraints. The AWE plant with a nominal capacity of 100MW produces 20,000 Nm^3/h hydrogen and 10,000 Nm^3/h oxygen. The corresponding methanol plant nameplate capacity is 226 tonnes per day and the required biomass combustion plant gas production is 6,700 Nm^3/h.

The biomass combustion plant, gas treatment plant, methanol plant and AWE plant are each designed for a lifetime of 25 years of operation provided they are operated under correct preventive maintenance. Plant life is typically longer and can also be extended.

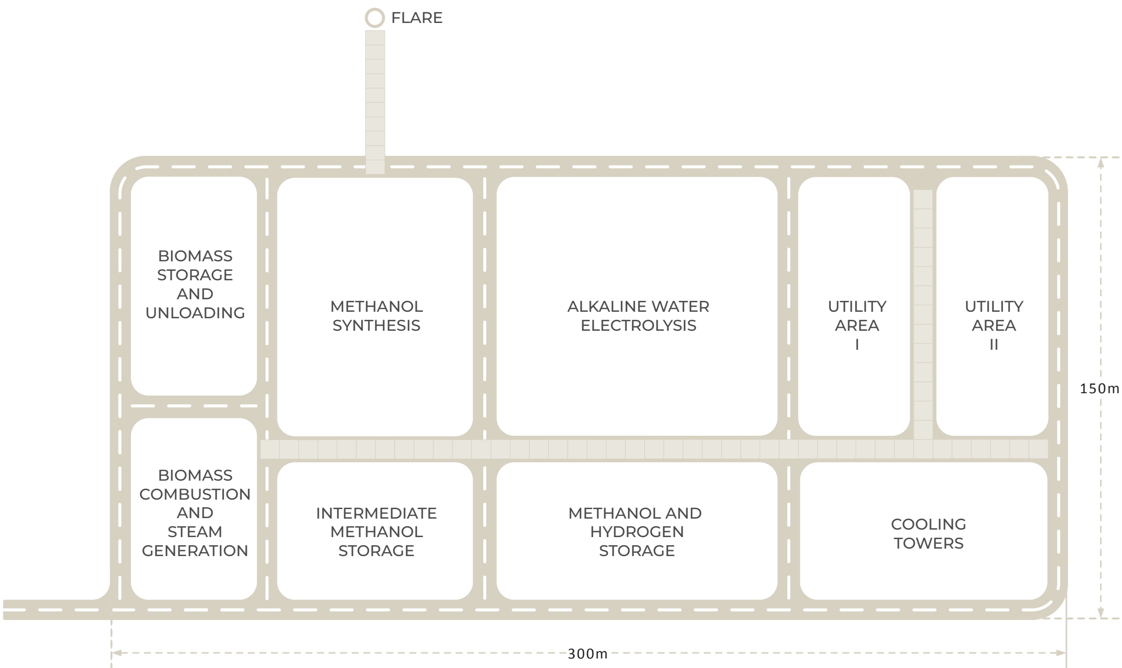
FLOW SCHEME & LAYOUT

The overall facility flow scheme including key processing units, inputs and products is outlined below:



*NOTE: SOME UTILITIES AND MINOR STREAMS NOT SHOWN

The overall facility layout is shown below:



FEEDSTOCKS

BIOMASS

Two types of plantation biomass have been considered for the Bell Bay facility, Hardwood (Eucalyptus) and softwood (pine).

HARDWOOD

Hardwood plantations are grown to produce woodchips primarily for the quality paper market. Trees are harvested and graded into the following categories,

- Pulp Logs – suitable for chipping
- Defect Logs - logs with defects (knots, hollows, branched etc)
- Fuel logs – logs of insufficient diameter for existing chippers
- Slash – nutrient rich material especially leaves and bark

Hardwood biomass for use in the production of green methanol would target defect and fuel logs. These logs are currently left in place during harvesting, due to difficulty in processing with existing equipment and to a lesser extent to recover some nutrients into the soil. Other residue left behind in a plantation after logging is referred to as slash, which is rich in nutrients and includes bark and leaves. Hardwoods are debarked at the coupe as part of the harvesting process.

The moisture content of eucalyptus is typically 40-45% when cut but can increase to 50-55% while stockpiled through water absorption. Strategies have been developed to assist natural drying of wood, primarily to increase the load capacity of logging trucks. These techniques can reduce the water content to 35% or lower. A study analysing the drying process of logs and harvesting residues from Eucalyptus plantations in Western Australia, found that in the residue piles, the initial moisture content was 45%, after one month in the field it was 23%, after three months it was 14% then after 6 months it was 10%. (2013 Ghaffariyan)

forico
future fibre

At the Long Reach Mill near Bell Bay, Forico accommodates the worlds largest woodchip vessels to export wood chips produced from hardwood and softwood plantations, and sawmill residues. In fact, the Bell Bay region exports over 2 million tonnes of woodchips per annum. Forico manages plantation estates within the region growing two hardwood species and one softwood species. As part of plantation harvesting Forico has extensively investigated beneficial use of hardwood residues. These residues would be potentially available as a biomass feedstock.

The Forico site at Long Reach has a significant landholding and unused port facilities which would ideally suit biomass-based methanol production facility.

SOFTWOOD

The softwood is grown in plantations for the production of both timber and paper, and the portions of the harvested logs not suitable for timber production are chipped for export. Example uses of pine wood chips include the production of newsprint, glossy flyers, hygiene paper and as a feedstock to manufacturing.

A greater proportion of a pine tree is harvested as logs relative to hardwood due to the relatively straight growth of the trees. The harvested logs are referred to as sawlogs. The remainder of the tree including leaves, branches and small diameter logs are left in the plantation as slash. Softwood based biomass for use in the production of green methanol would target defect logs and small diameter fuel logs.

Saw logs are transported with bark attached to protect the softwood and is removed during processing at the timber mill. Timber is cut from saw logs producing green sawdust and offcuts. The offcuts are chipped for export. The cut timber is dried to around 10-12% moisture and dressed and cut to length producing dry shavings, sawdust and further off cuts. Currently at Timberlink, the local Bell Bay timber mill, shavings sawdust and offcuts are fed to a boiler to produce heat for drying the cut timber.

TIMBER LINK
AUSTRALIA

Timberlink has a modern sawmill in the Bell Bay industrial zone processing sustainable plantation pine logs into timber products. They produce a wide range of fit-for-purpose finished timbers catering to the building industry and consumers. Innovative new products such as bio-composites and Timberlink Green Low Odour framing are being developed and produced in Tasmania. Timberlink has strong links with the local community and directly employs 200 people at Bell Bay.

The location of the Timberlink sawmill in Bell Bay is well suited to collaboration with biomass-based methanol production. Co-operation with residue harvesting, recycling of wastes, the sharing of utilities and emission reductions are potential synergistic opportunities between Timberlink and Bell Bay Powerfuels.

HARVESTING AND SUPPLY CHAINS

Harvesting occurs in coupes within dedicated plantations which have been nurtured for up to 30 years. At the coupe, trees are felled and cut in logs which are moved to landings where they are graded. Hardwood coupes also debark harvested logs. Currently suitable logs are transported to Bell Bay to produce timber and woodchips for export. Unsuitable logs (eg fuel, defect etc) are either left in place or moved into windrows. A harvested coupe is replanted to begin the next cycle of growth using the slash to provide nutrients.

The existing large equipment used in Tasmania is not well suited to the collection of fuel and defect logs. Dedicated smaller vehicles catering for the defect and fuel logs will likely be required to improve the economics of biomass residue collection. Following harvesting, strategies for natural drying of feed biomass needs to be incorporated into supply chains to optimise delivery cost and minimise feed water content.

Existing supply chains cater for pulp and saw logs. New supply chains will be required to collect the fuel logs and transport them to the Bell Bay site. There is a capacity diseconomy of scale for residue quantities greater than 200,000 tonnes per annum. Study partners Foresion assisted ABEL Energy through the development of logistic models to optimise the biomass supply chain.

FEEDSTOCK REQUIREMENTS

The Bell Bay Powerfuels Project will receive a blend of softwood and hardwood. For the basis of the Study the delivered moisture content to the Bell Bay facility was assumed to average 35% and feed to the biomass plant was 25%.

At nameplate capacity the biomass feed to Bell Bay Powerfuels is 224 tonne per day.

COST OF BIOMASS

The cost of biomass for the facility incorporates cost for harvesting, transport, road tolls, chipping, and stumpage. Stumpage is the price paid for the right to harvest plantations.

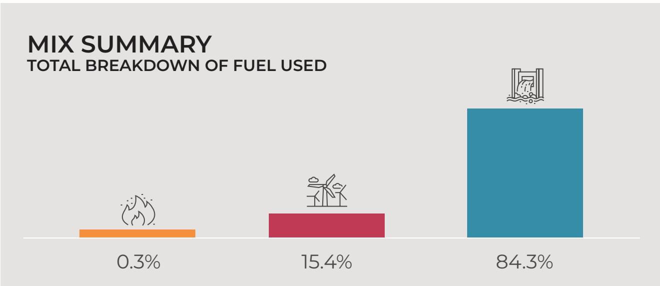
The total cost for delivered biomass based on estimates of these cost elements is between $50 to $80 per tonne. The cost of delivered chipped wood with 50% moisture to site was assumed for the purposes of the Study to average $65 per tonne. The actual price of biomass will reflect the cost of production, optimisation of transport / drying and potential savings from removing residue from harvested coupes.

ELECTRICITY

GENERATION

Tasmania has near 100% renewable power, based primarily on hydroelectricity, augmented by wind generation, and supported by small amounts of solar, gas peaking and power import from Victoria.

In the last 12 months Tasmania's generation mix was 84.3% hydro, 15.4% wind and 0.3% gas peaking.



Source : NEM Data dashboard

Power generation in Tasmania has sufficient capacity to meet the requirements of the Tasmanian market with some spare capacity. However, the development of multiple large-scale renewable energy based green export projects will require complementary additional generation capacity to maintain balance in the Tasmanian network.

Fortunately, additional large-scale wind generation projects are already in the development pipeline. Potential onshore projects include the Jim's Plain and Robbins Island (up to 1000MW), North East Wind (more than 1000MW), Western Plains (50MW), Hellyer (220MW) Guildford (TBA), and St Patricks Plains (290MW). Further offshore projects are also in development. To progress further these projects will rely on securing offtake to achieve project sanction. The green energy export projects have the capacity to provide this offtake security.

The Bell Bay Powerfuels Project will be coupled with new wind-based generation sufficient to supply the facility's entire annual power consumption. Power firming will be provided by Hydro Tasmania using hydro generation. At nameplate capacity the average electricity demand for the Project as per the Study is 95.4 MW.

Hydro Tasmania is Australia's leading clean energy business and largest generator of renewable energy.

Hydro Tasmania generates an average of around 9000 GWh of energy annually from hydropower in Tasmania from an installed capacity of approximately 2280 MW. The inherent flexibility of hydropower enhances the ability for penetration of variable renewable energy. The Bell Bay Powerfuels project will support the further wind development of Tasmania's world class wind resource. Hydro Tasmania is able to provide energy-neutral firming services to Bell Bay Powerfuels.

DISTRIBUTION

The Bell Bay region is well serviced by TasNetworks which manages the Tasmanian electricity grid. The George Town substation is connected to the Tasmania network via the 220kV Tamar Valley transmission lines. The George Town substation also distributes 110kV to industrial users in the Bell Bay region and receives 110kV from the former Bell Bay power station and the adjacent Tamar Valley power station. George Town is also the link to the Tasmanian network to transfer power to/from the mainland via the 500MW 400kV Basslink connection.

The 100MW nominal capacity of the Bell Bay Powerfuels Project is compatible with existing distribution infrastructure, unlike substantially larger projects which would require significant network upgrades.

COST OF ELECTRICITY

The actual price of electricity will reflect the cost of development of new wind power generation and the required firming to feed the facility at a high-capacity factor. Bell Bay Powerfuels has been designed for reduced power consumption to 10% for up to 4 continuous hours to enable more commercially favourable power arrangements. The facility can also cease power use for commercial reasons.

The base case pricing assumed for the purposes of the Study was $50MWh with sensitivities down to $40MWh and up to $60MWh.

TasNetworks

TasNetworks owns and operates the electricity transmission and distribution network in Tasmania. This includes the transfer of electricity between Victoria and Tasmania via the subsea Basslink. TasNetworks assets provide power distribution to the Bell Bay / George Town / Long Reach region in close proximity to proposed Bell Bay Powerfuels sites.

WATER

ABEL Energy would like to acknowledge Tamar Estuary & Esk Rivers (TEER) program for information supplied regarding the water quality of the Tamar Estuary at Bell Bay.

SOURCE

Water is primarily required in the facility for cooling, the production of hydrogen and other utilities such as boiler feed water or firewater. Tasmania has an abundance of fresh water which is the primary source of the state's hydro power generation. The fresh water supply to the Bell Bay region adequately caters for the demands of the region. However, due to the potential for future development of several large projects in the local area, the relevant utility TasWater is planning to further expand supply. Given the timeline of the Bell Bay water supply expansion and the schedule of the Bell Bay Powerfuels Project, the Study assumed that project water requirements would be met by drawing and treating water from the Tamar Estuary. Should the TasWater supply be available earlier then this assumption can be revisited at a later project stage.

Water from the Tamar Estuary at Bell Bay is salty and cannot be depleted due to its proximity to Bass Strait. The location of the water inlet will depend on the selected site, but in all locations would consist of a deep-water intake at greater than 12 meters. It is assumed that a buried pipe is not required, but as commonly used for aquaculture inlets, thick-walled HDPE welded pipe in a single run with concrete ballast weights clamped across the pipe will be used.

The inlet intake is proposed to be a simple short riser to bring the inlet above the bottom sediments. The inlet opening is a simple open pipe with a mesh cage structure to protect against larger fish entering the pipe. The riser and the mechanical cage are both designed to allow the passage of a clearance cleaning pig at regular intervals, likely once per year, with appropriate diver attendance to open the cage and dinghy to retrieve the pig.

The inlet should have a shade structure floating just above being slightly positively buoyant to reduce light and consequent algal growth.

At nameplate capacity the Tamar Estuary water required is 10.32 ML per day.

TREATMENT

Water supply processing will include pumping and filtration to produce raw water. A proportion of the raw water is further treated by a desalination unit to produce potable water using ultra filtration pre-treatment and Reverse Osmosis (RO).

There is no requirement for chlorination of prefiltered input water and post treatment of RO water for use in the facility. A secondary demineralisation process is included for the feed water to electrolysis and boiler use. Post treatment of potable water would only be used for human consumption; however, it is assumed drinking water will be supplied by existing town water supplies.

USAGE

Raw water will be used as the cooling medium for the plants cooling water systems. The cooling water circuit consists of a larger evaporative saltwater cooling circuit, with two smaller sequential freshwater closed loop systems for plant units including electrolysis.

Potable water is used for utilities such as plant water, firewater and safety showers, and after further demineralisation as the feed to the water electrolysis unit and for boiler feedwater.

PRODUCTS

METHANOL

The Bell Bay Powerfuels facility is designed to produce AA-grade methanol, which complies with the following specifications

METHANOL (WEIGHT %)	≥ 99.85
WATER (WEIGHT %)	≤ 0.1
TOTAL ACETONE AND ALDEHYDES (MG/KG)	≤ 30
ACIDITY AS ACETIC ACID (MG/KG)	≤ 30
ACETONE (MG/KG)	≤ 20
ETHANOL (MG/KG)	≤ 10
NON-VOLATILE MATTER (MG/L)	≤ 10
SPECIFIC GRAVITY @ 20 °C	≤ 0.7928
DISTILLATION RANGE AT 760 MM HG °C	≤ 1.0 (incl. 64.6 °C ± 0.1 °C)
POTASSIUM PERMANGANATE TIME TEST AT 15 °C (MINUTES)	No discharge of colour in 30 minutes
CARBONISABLE IMPURITIES, PT-CO SCALE	≤ No. 30
COLOUR PT-CO	≤ No. 5
APPEARANCE	Free of opalescence, suspended matter and sediment
ODOUR	Characteristic, non-residual

In the Study the export facilities for the Project were designed for ships of 5,000 tonnes and 15,000 tonnes capacity which is a typical IMO Type III Chemical tanker size. If required, other ship sizes will be considered in future project phases. The export facilities include a single loading arm of 500 m^3/h export capacity. The loading time will be based on the capacity of the ship selected.

HEAT/STEAM

A potential additional product from the facility is lower grade waste heat derived from the process. This heat can be used industrially for processes such as drying and evaporation. Depending on final facility location, synergies could be realised that reduce emissions from existing industrial heating processes such as the drying of timber.

HYDROGEN

Bell Bay Powerfuels would generate significant quantities of hydrogen to produce methanol. Due to the scale of production and the existing infrastructure available, there is the potential to produce additional low-cost hydrogen for local use. There is currently no market for green hydrogen in the Bell Bay region. If a local market opportunity develops then Bell Bay Powerfuels would be well placed to cater to that market. Hydrogen for heavy transport or buses would present a potential market should hydrogen fuelled vehicles be rolled out in Tasmania.

TasPorts

TasPorts is a state-owned company responsible for Tasmanian ports including the shipping and port infrastructure at Bell Bay. TasPorts manages berths and significant industrial land holdings in the Bell Bay Advanced Manufacturing Zone (BBAMZ).

THE TASMANIAN HYDRO SYSTEM HAS A TOTAL CAPACITY OF MORE THAN 2600 MEGAWATTS AND INCLUDES 30 POWER STATIONS AND MORE THAN 50 MAJOR DAMS.

OUTPUTS

ASH

The non-combustible portion of the biomass, when combusted is collected as ash. The total ash production is 500kg per day. The small quantity of ash from the facility will be disposed as non-hazardous waste. In further project stages ABEL Energy will investigate the beneficial use of this ash. Options include incorporation into building materials or road base and returning the ash containing bio-minerals, back to forestry plantations. Wood ash consists of elements such as calcium, potassium and magnesium. These minerals can be used to raise the pH of the soil, to suit certain crops or remedy acidic soils.

WASTEWATER

SOURCE

Wastewater from the facility arises from several sources; reject water from desalination & demineralisation, cooling water blowdown, and produced water from gas treatment & the methanol plant. The bulk of the wastewater comes from sources which merely concentrate the salts and suspended solids in the source Tamar Estuary water. The suspended solids in the river water will be filtered as part of the inlet system and the backflushed solids will be directly returned to the Tamar Estuary in a dedicated spillway. Other smaller sources from gas treatment and methanol purification will contain small quantities of organics such as methanol and trace dissolved gasses. The use of a closed cooling water system protects the wastewater outfall from any leaks from the process plant, as they will be isolated to the closed loop and identified by regular water testing.

Due to the evaporation of cooling water and consumption of water in electrolysis, the wastewater from the facility has an elevated salt concentration relative to the Tamar Estuary.

SALINITY	PART PER THOUSAND	MILLIGRAM PER LITRE
TAMAR SOURCE	30	30,000
WASTEWATER DISCHARGE	43.2	43,200

The Tasmanian EPA guidelines specify protected environmental values **(PEVs)** for discharge limits into river and estuarine waters. These PEVs are intended to maintain the Tamar Estuary water quality. For discharge into the Tamar Estuary, it is clearly desirable to achieve these values either at discharge or very soon afterward. There are a series of default guideline values **(DGVs)** recently published that are recommended to help maintain the PEVs. The DGV tables refer exclusively to nutrient composition, suspended solids and dissolved gases such as oxygen. While these DGVs are published for streams leading into the Tamar Estuary, rather than the estuary itself, it is clearly desirable to achieve these values in the estuary, either at discharge or very soon afterward. The low level of organics and dissolved gases in wastewater generated by the process, results in the treated wastewater from the facility meeting the DGV parameters.

Cooling tower chemicals are not considered as part of this study in the blowdown (outlet) to the Tamar. Such chemicals would be avoided as far as possible and discharge of any modern bactericides or algicides to the Tamar will be at the consideration of later studies and in consultation with the EPA.

Total wastewater outflow to the Tamar Estuary is 7.5ML per day.

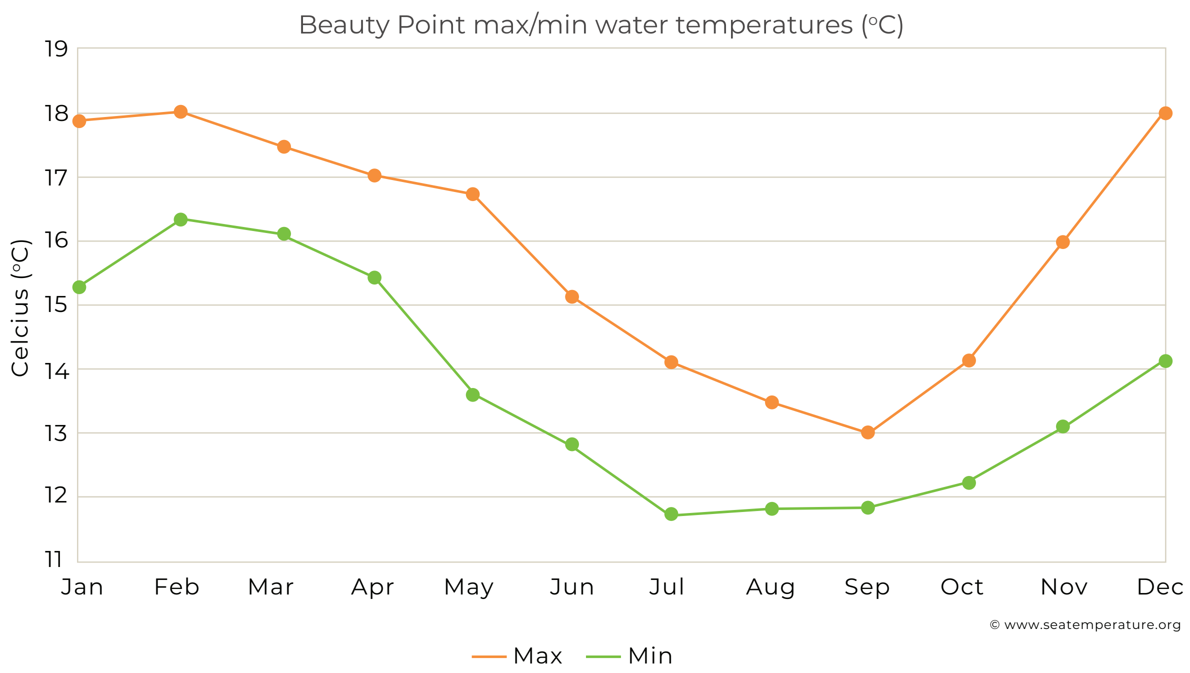
Storm water is excluded from this discharge and will be handled by a separate system and reused if possible. Rainfall on process areas will be collected in bunded areas and dedicated drainage systems which will contain and allow treatment, if necessary, prior to discharge to stormwater. Rainfall on woodchip storage areas will also be collected and treated.

Sanitary waste is assumed to be sent to sewer. The sewer is treated in either onsite treatment or the existing George Town wastewater treatment plant.

OUTFALL

Compared with the water of the Tamar Estuary the outfall water from the facility has slightly elevated salinity and temperature. Therefore, the most important outfall issue is the dilution zone – the distance that it takes for the warm concentrated brine to dilute to an irrelevant (to marine life) difference from ambient conditions. Based on evaluation of information provided by the TEER program, the upper salinity value of 36.9 ppt is likely to represent a reasonable upper environmental target value following dilution, noting the salinity in wastewater discharge is 43 ppt.

The river water temperature varies depending on the time of the year. Available data at Beauty Point which is located on the opposite bank of the Tamar Estuary and further downstream of Bell Bay show water temperatures range from an average minimum 11.5°C occurring in July-September to an average maximum of 18°C in December or January.



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MIN °C	15.3	16.3	16.1	15.4	13.6	12.8	11.7	11.8	11.8	12.2	13.1	14.1
MAX °C	17.9	18	17.5	17	16.7	15.1	14.1	13.5	13	14.1	16	18

It is anticipated however that temperatures will vary more widely near the Bell Bay site due to a wide impact of factors at different times of year. The narrower estuary and hence faster flowing nature in outgoing tides in winter, compared to the Beauty Point data, would result in lower temperatures in winter storm flows. These flows are concentrated in the deeper regions and will flow directly past the site in winter on outgoing tides. The presence of significant solar heating in slack flows during summer in the shallow bays near West Arm, Middle Arm and Middle Point creates a very significant solar warming area that can then flow toward the site on an incoming tide. The application of the Tamar monitoring program data for Longreach suggest that temperatures can vary in extremes between 6.5 and 24.5°C.

Wastewater outflow temperatures are not considered to be an issue provided sufficient dilution is achieved. Desalination does not increase the temperature of wastewater.

The wastewater outflow pipe will be a HDPE thick-walled pipe with concrete ballast weights. To achieve the desired dilution zone the outlet pipe requires a diffuser structure. This structure is expected to consist of a simple series of side port holes with short pipe lengths, to be confirmed in detailed design but known to be feasible. The purpose of the side ports is to create a high velocity which increases agitation / mixing and provides directionality to separate the high saline outlet so that more mixing occurs, thus settling of the more dense saline fraction is minimised. The ports are oriented at between 45 and 60 degrees to the vertical on opposing sides.

A mid-range port size is expected to result in a dilution of 1 in 150 at 100 meter distance from the outlet, and a dilution of 1 in 70 at the point at which the plume contacts the seabed. A multiplicity of ports is advisable to maximise mixing and avoid settling. Excessive settling of high saline outlet in the trough in the centre of the Tamar is not likely to be acceptable and would be mitigated / removed in the detailed design phase.

The specific details are not part of the scope of this study and will vary when a detailed study of the local velocity profiles is conducted. What is important here is that the desired structure is not complex, expensive, difficult to run, and does not add additional operating costs.

GASEOUS EMISSIONS

A small quantity of gas is continuously purged to prevent the accumulation of nitrogen in the methanol synthesis loop. The nitrogen is present in the biomass and liberated on combustion. This gas is predominantly hydrogen with some carbon dioxide/monoxide and nitrogen. The gas is combusted and vented in a small flare at an elevated safe location.

Breathing gas from methanol storage tanks, which is primarily nitrogen with some methanol vapour is also routed to the small flare. In the next project phases recovery of hydrogen and methanol from these streams will be evaluated.

Additionally, not all the oxygen produced by electrolysis is utilised by the biomass combustion. Excess oxygen is safely vented to atmosphere.

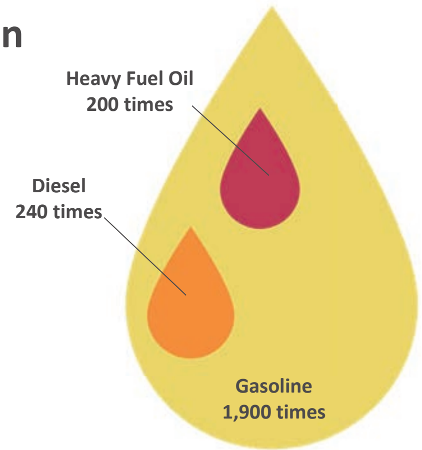
ENVIRONMENT & REGULATORY

The environmental focus of the Study was first, to determine the likely approvals pathway for the Project, and second, to indicate the required environmental impact assessment (EIA) and identify the potential impacts likely to require consideration. Potential mitigations have been identified and the information required to address and assess the issues identified.

Benefits of methanol in marine environments

- Methanol is a more environmentally benign fuel in marine environments
- In a waterbody, nearly 200 times more methanol is needed to have the same impact on fish as marine heavy fuel oil
- Methanol is biodegradable with a half life of less than 24 hours (Howard et al., 1991).

Source : Methanol Institute



Relative toxicity compared with Methanol
Based on lethal dose for fish (LC50)

APPROVALS PATHWAY

All environmental and land management legislation in Tasmania is underpinned by the Resource Management and Planning System (RPMS). This was introduced in 1993 and provides common objectives which are included as a schedule in each relevant act.

Environmental legislation applicable to the project

COMMONWEALTH

Environment Protection and Biodiversity Conservation Act 1999 (EPBCA)

Model Work Health and Safety Regulation - Safe Work Australia requirements for Major Hazard Facilities

TASMANIAN ACTS

Aboriginal Heritage Act 1975

Climate Change State Action Act 2008

Environmental Management and Pollution Control Act 1994 (EMPCA)

Includes Environmental Protection Policies (EPP) made under the EMPCA

- Air EPP
- Noise EPP

Forest Practices Act 1985

Land Use Planning and Approvals Act 1993 (LUPAA)

Nature Conservation Act 2002 (NVC)

State Policies and Projects Act 1993 (gives NEPMs state policy status)

Threatened Species Protection Act 1995

Weed Management Act 1999

STATE POLICIES

- State Policy on Water Quality Management 1997
- NEPMs likely to be relevant at Bell Bay relate to:
  1. Air Toxics
  2. Ambient Air Quality; and
  3. Assessment of Site Contamination.

LOCAL

George Town Interim Planning Scheme 2013

The EMPCA establishes the processes for assessment of activities considered to have the potential to cause environmental harm. It also relates to the management of pollution and remediation. Bell Bay Powerfuels is likely to fall within the petroleum and chemical classification which covers a total processing capacity of 200 tonnes or more per year for the manufacture or processing of any organic chemical or chemical product or petrochemical, including the separation of such materials into different products by distillation or other means. Any application proposing chemical manufacture as described above requires assessment by the Board of the EPA.

Submission of a Notice of Intent (NOI) to the EPA enables classification of the facility and determination of the approval pathway to be followed and issuing of project specific guidelines (PSGs) for the preparation of an Environmental Impact Statement (EIS).

Other matters that require consideration that fall outside the role of the EPA include hazard management, traffic, Aboriginal heritage, building works and TasWater requirements.

Impacts on Matters of National Environmental Significance (MNES) are required to be assessed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA). The MNES are defined in the EPBCA. At Bell Bay the likely MNES would relate to threatened species or ecological communities.

A self-assessment of potential for impacts can be undertaken, and if it is considered that a significant impact is likely, the project would require referral to the Commonwealth Department of Agriculture, Water and the Environment (DAWE). If EPBCA approval is required, it is possible to use the bilateral agreement between the Commonwealth and Tasmanian Governments which allows determination based on the EPA assessment under EMPCA.

The timeframe of the approvals pathway for the Bell Bay Powerfuels project including development application and appeal periods has been evaluated to be within an 18-month overall duration.

This Environmental Approvals Strategy focuses on directing the project through the EMPCA framework. There are a limited number of alternative environmental and planning legislative frameworks that exist in Tasmania, however, it is highly unlikely that the project would qualify for or benefit from using these alternatives.

The approvals under LUPAA will need to be sought from the George Town Council through the submission of a Development, Planning and Buildings Application.

Fixed statutory timeframes apply to many stages of the approval process. Some aspects of the different levels of approvals (Commonwealth, State and Local

Government) can however be run in parallel to minimise the duration of the overall process, such as the submission of a NOI, Development Application (DA) and EPBCA referral form.

PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT

The Guidelines for Preparing an Environmental Impact Statement issued by the EPA in March 2019 provide general information on matters to be considered when assessing the environmental impacts of a proposed activity. These are supplemented with key process and site-specific requirements in the PSGs.

Based on publicly available assessment information from the EPA website and previous developments at Bell Bay, the following will likely be the key issues:

- Air quality impacts - including any emissions and construction impacts.
- Noise impacts.
- Water quality impacts, including the nature and volume of any wastewater and the proposed point of discharge, site drainage and stormwater.
- Hazard management.
- Potential for contaminated land disturbance.
- Infrastructure and servicing.
- Natural values, including flora and fauna impacts.

Other matters which sit outside EMPCA but which would normally be included in the EIS (to allow assessment by Council) include:

- Bushfire assessment for hazardous use.
- Traffic Impact Assessment (TIA)
- Aboriginal heritage survey and approval of report by Aboriginal Heritage Tasmania.
- Assessment against planning requirements in the Planning Scheme.

The key matters have been considered in the context of each site. The existing conditions are summarised, the potential issues are outlined, and typical management actions and assessment requirements provided.

AIR QUALITY IMPACTS

Impacts associated with emissions from the project relate to venting or flaring of gases as well as any accidental or emergency pressure release. This includes the potential for odour to impact on nearby sensitive receptors and any hazard posed by release of emissions. Impacts as a result of construction (e.g. dust) must also be considered.

Actions: preparation of an air quality impact assessment and a inclusion of air emission management measures in a construction environmental management plan.

NOISE IMPACTS

Potential for impacts on nearby sensitive receptors, including employees at adjoining sites, is required to be assessed. Existing background noise levels in the area will be established from existing published noise measurement survey data (where available) and depending on the nature of the modelling required by the EPA, noise loggers may be placed in situ to record background data. Predicted noise levels, calculated for the boundary of the site and at nearby residential communities, will be evaluated in accordance with the provisions of the Tasmanian Environmental Protection Policy (Noise) 2009.

To determine impacts, it will be necessary to confirm the location and sound power levels of all noise sources associated with the proposed facility. Details of likely plant and machinery to be installed on site, and their respective sound power output specification data, will be provided. The combined noise level of these noise sources in the surrounding area, will be predicted, using noise modelling software and calculations in accordance with the Tasmanian EPA's Noise Measurement Procedures Manual (2008).

Action: A Noise Impact Assessment will be required to be prepared to inform the EIS.

WASTEWATER

The nature and volume of any wastewater will influence the required actions. The project is based on the use of desalinated water from the Tamar Estuary. The treated discharge returning to the river including the chemical and organic composition will determine the potential for impacts. An assessment of aquatic habitats and hydrology will be required to establish a baseline of conditions and allow an assessment of impacts. An aquatic flora and fauna assessment will be required, including observations of riverbed conditions and habitats, as well as analysis of ambient water quality and flow conditions. Flow modelling, dilution and mixing studies may be required to determine the extent and nature of impacts.

If existing water infrastructure is to be utilised, for example sanitary waste, ABEL Energy will further engage with TasWater.

Actions: Prepare an aquatic habitat and impact assessment. Prepare a stormwater management plan detailing the assessments to be undertaken and outlining the proposed stormwater management system for the development.

HAZARD MANAGEMENT

The Model Work Health and Safety Regulation prepared by Safe Work Australia identifies hazardous uses and outlines licensing and other requirements. These include preparation of safety and emergency management systems. Risks are presented by the plant, transfer systems and transport of methanol on vessels or road tankers.

The feasibility study has undertaken a Hazard Study 1 also known as HAZID which has identified key safety risks and safeguards. The proposed facility will also need to be assessed to determine whether it meets the threshold for Major Hazard Facility classification.

Action: Complete further project-based hazard studies leading to preparation of full safety documentation required by Safe Work Australia.

POTENTIAL FOR CONTAMINATED LAND

Bell Bay industrial precinct is an area containing multiple potentially contaminating activities associated with a wide range of contaminants of potential concern. Contaminants entering the atmosphere, groundwater or surface water have the potential to have migrated onto each site. In addition, many of the industrial sites have operated in the area for many decades, which further increases the occurrence of legacy contamination, which occurred when strict waste disposal and emission regulations were not enforced.

The proposed development is not a sensitive use and is consistent with the industrial nature of surrounding land uses. Key exposure pathways are through groundwater and during construction, however, the risks associated with groundwater are limited unless there is a proposal to use groundwater in the facility. The industrial nature of the proposed use limits the potential for interaction with surface water or groundwater.

A Data Quality Objectives and Sampling and Analysis Plan should be undertaken to define the type, quantity and quality of data needed to support decisions relaying to the assessment of site contamination (NEPM, 1999), in consideration of the site history and potential offsite contamination sources. The plan would define the criteria that a data collection design should satisfy, including when, where and how to collect samples and the number of samples which should be collected. If required, a Preliminary Site Investigation involving the collection of soil and water samples for chemical analysis should be undertaken in order to identify and characterise potential contaminates.

Action: Complete a Data Quality Objectives and Sampling and Analysis Plan to identify sampling requirements to address assessment criteria under the NEPM then undertake necessary sampling.

FLORA AND FAUNA IMPACTS

Current available information indicates that there is limited potential for any significant impact on ecological values. There is no mapped Tasmanian NVCA present and only limited presence of any threatened fauna. There are no threatened flora records, however the low number of records may reflect the level of survey across the locality to date. A full flora and fauna assessment will be prepared to define any habitats available on site, including the potential for devil or quoll den sites and any tree hollows in mature trees suitable for masked owl or swift parrot. Impacts will be quantified based on direct disturbance (clearance) and potential for indirect disturbance.

It is expected that appropriate avoidance and mitigation can be implemented to ensure no unreasonable impacts on ecological values occur. It is considered unlikely that the proposal on the sites will require referral under the EPBCA.

Action: Undertake field assessment to confirm potential habitats on site and assess potential impacts

BUSHFIRE ASSESSMENT FOR HAZARDOUS USE

Based on similar projects Bell Bay Powerfuels will be considered as a hazardous use for the purposes of assessing the bushfire code and details are required at the DA stage.

An Emergency Management Strategy is required, endorsed by the Tasmanian Fire Service or an accredited person, that provides for mitigation measures to achieve and maintain a tolerable level of risk. This must consider the bushfire hazard, the availability of water for firefighting purposes and access to the site for firefighting appliances. A Bushfire Hazard Management Plan in accordance with the requirements of the Tasmanian Fire Service is also required outlining appropriate bushfire protection measures.

It is expected that appropriate management planning and design can be achieved to mitigate bushfire risk.

Action: Preparation of an Emergency Management Strategy and a Bushfire Hazard Management Plan

TRAFFIC IMPACT

An assessment of the potential impacts on the safety and efficiency of road networks is required. This includes impacts of additional vehicles on the road network as well as evaluation of on-site facilities. The type and number of vehicles involved will be used to determine if any impacts are likely on the level of service and to assess whether existing road and intersection designs are sufficient for the volume and nature of traffic proposed. Increased traffic numbers during construction may require the provision of temporary parking facilities, depending on the availability of on street and on-site parking. Impacts related to the construction of any new roads, such as clearing and loss of habitats, is required to be addressed in the EIS in relevant discussions.

Bell Bay is a purpose-built industrial precinct with road networks designed specifically to facilitate the movement of large vehicles to individual development sites and to the port. Roads are wide and intersections designed to accommodate B-double vehicles. It is considered unlikely that the vehicles likely to access the site, and the volumes of traffic generated during operation, will be sufficient to impact either the safety or efficiency of local roads. Traffic during construction can be managed through the implementation of a traffic management plan.

A traffic impact assessment (TIA) is required to address the requirements of the Planning Scheme.

Action: Prepare a TIA.

ABORIGINAL HERITAGE SURVEY

Given the disturbed nature of the sites, an initial desktop assessment has been undertaken. This was submitted to Aboriginal Heritage Tasmania (AHT) to determine the potential for the presence of any sites or artefacts of interest. AHT advised that there are several Aboriginal heritage sites located within and near the Bell Bay power station site, however, due to the age of the records (14 years), there are likely inaccuracies in the site location information. Several sites were identified during the construction of the power station in 2007 with some of the artefacts identified subsurface. It appears the sites were able to be conserved in-situ during the construction of the Power Station and therefore they are considered to be still present within the property. Given the presence of known Aboriginal heritage in the vicinity of the Tamar Valley Power Station, and the known cultural richness of the surrounding area, it is likely that additional Aboriginal heritage values are present. Due to the scale of the proposal and the increased likelihood of Aboriginal heritage, an Aboriginal heritage assessment is recommended to identify whether the proposed project or related infrastructure will impact on Aboriginal heritage and to offer avoidance and mitigation advice.

Action: Undertake an Aboriginal Heritage Assessment.

THE PROJECT WILL HAVE A GROSS REGIONAL PRODUCT IMPACT OF MORE THAN $1.15 BILLION

PROJECT IMPACT

The project has the following impacts:

- Expansion of global green methanol production
- Contribution to the green hydrogen industry
- Expanding use of renewable energy
- Renewable energy supply-chain development
- Indigenous and local employment
- Economic benefit to Tasmania and Australia
- Economic diversification
- STEM education pathway
- Improved productivity from sustainable plantations

An economic impact assessment was undertaken to analyse the potential benefits resulting from the development of green methanol production facilities at Bell Bay. This assessment was completed using a REMPLAN Economic Impact Modelling (REMPLAN) model utilised to estimate the economic impacts to Tasmania in terms of employment and output.

The REMPLAN model requires project specific input to measure impacts to the Tasmanian economy. This includes direct changes in jobs or economic output and can be broken down by sector. The economic impact for this Project is comprised of two periods - construction and operations. The contribution for these phases is described below:

- Construction contribution: The corresponding contribution of the direct short term capital investment of the Project to the state. This relates to the jobs supported and value added during the construction phase. This impact occurs only over the short term and does not represent a permanent increase to the outputs of the state.
- Operations contribution: The ongoing contribution of the operations phase of the Project to the economic output, in terms of jobs and value added to the state. This represents the long-term annual expenditure of the facility, permanent creation of FTEs, and ongoing contribution to Tasmania's Gross Value-Added (GVA).

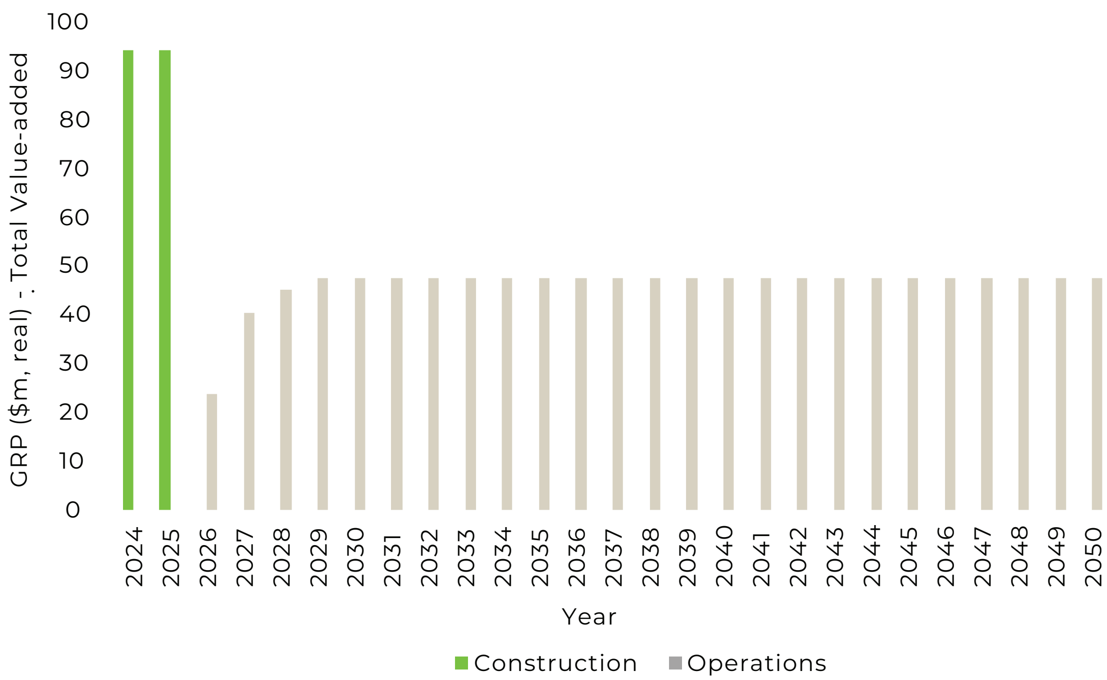
The total economic contribution of the Project has been assessed through the 'Direct', 'Supply-Chain' and 'Consumption' effects. These effects are defined below:

- Direct: Effects related to the primary operations of the Project. At a high level, this represents the direct employment impacts and value add of the facility. For this Project, this includes direct skilled employees of the Electrolyser, Biomass and Methanol plants, as well as required administration and support staff.

- Supply-Chain: The subsequent flow-on effects related to servicing sectors which increase their own output and demand for local goods and services due to the increased purchasing impacts of the Project on the economy. For this Project this could include increases across power consumption, water usage, plant maintenance materials and education.
- Consumption: The increased expenditure derived from the change in salaries and wages as a result of direct and supply-chain effects. More specifically, this measures the portion of wages and salaries from the increased employment for the Project that is spent on consumption and captured in the local economy.

Summary of economic impact[4].

	CONSTRUCTION PHASE	OPERATIONS PHASE
Years	2024 and 2025	2026 onwards
Output	over $200 million	over $100 million
Employment	Nearly 500 jobs	Over 150 jobs
Wages and Salaries	up to $50 million	up to $20 million
Value added	up to $100 million	up to $50 million



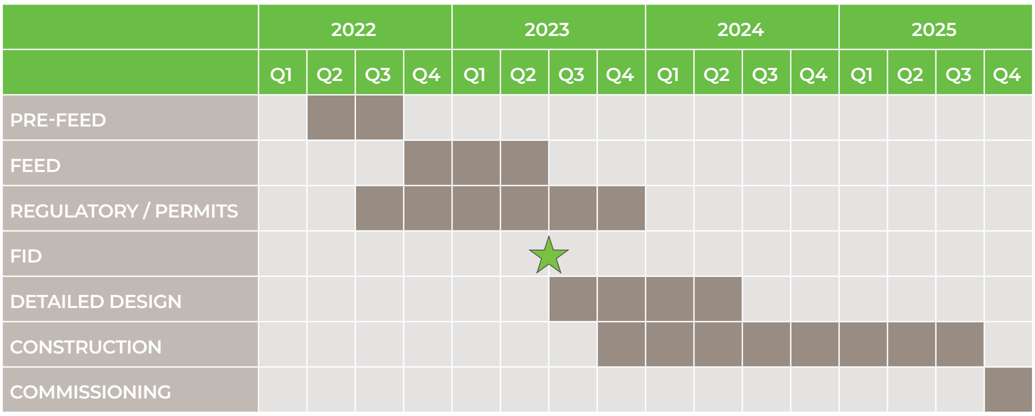
GRP impact of the Project to Tasmania

[4]$, real 2021

THE PROJECT WILL CREATE NEARLY 500 CONSTRUCTION JOBS AND OVER 150 LOCAL JOBS FOR AT LEAST 25 YEARS

IMPLEMENTATION

The project schedule is developed and maintained throughout the project phases to plan activities, determine resourcing, and identify key milestone dates. A preliminary schedule has been prepared as part of the feasibility study, forecasting a completion date in late 2025.



The project will progress through a series of phases. The project stage typically following a feasibility study is referred to as a Front-End Engineering Design **(FEED)**. The Bell Bay Powerfuels Project will firstly undertake a Pre-FEED to further investigate opportunities identified in this feasibility study and consolidate other inputs prior to launching the FEED stage. The Pre-FEED is scheduled to commence in the second quarter of 2022 with a duration of 4 months.

The finalised concept developed during the Pre-FEED will be converted to a FEED of 10 months duration starting in the fourth quarter of 2022. The function of the FEED phase is to further develop the design to improve cost and schedule certainty such that the execution design can proceed with confidence. Projects of this level of complexity undertake a FEED stage to meet a performance and cost accuracy level sufficient to enable the FID to be made. The satisfactory completion of the FID will enable the placement of orders for long lead items and commencement of detailed design. FID is expected in mid-2023.

The critical activities during this FEED period will be:

- Development of the licensor process design package (PDP) for the biomass combustion, Alkaline water electrolysis and methanol synthesis technologies.
- Development of the overall FEED study by an experienced engineering contractor.
- Further development of project safety including additional safety and risk reviews for the facility and mitigation activities.
- Regulatory and permitting activities such as the Environmental Impact Statement (EIS) and Development Application (DA) to enable both FID but also construction to proceed according to schedule.
- Further logistics modelling to develop supply chain strategy.
- Emissions modelling for the purposes of certification which will assist with international offtake agreements.
- Economic modelling to support FID and assist with fund raising for the final design and implementation phases.

ABEL Energy will also continue engagement with the local community, including landholders, utility providers and representative groups. ABEL Energy was a contributor to the Bell Bay application for the Clean Hydrogen Industrial Hubs designation and will continue to actively work with the hub consortium, being the only member who uses both clean hydrogen and CCUS. ABEL will continue to work with the Tasmania Government, local utility providers and the Bell Bay Advanced Manufacturing Zone (BBAMZ) as part of concluding the formal site acquisition. It is desirable that the site be large enough to accommodate a future expansion of the Project. Power supply agreement negotiations will continue, with the potential of fixed or market-based pricing.

Additionally, market agreements including supply, logistics and offtakes will be further developed. The FEED deliverables will enable the refinement of the project business case to provide sufficient certainty of the project's commercial and overall viability. This information will be provided to both potential investors in the final development, and as part of the Final Investment Decision (FID). A successful FID will signify that the project is commercially attractive and can proceed to detailed design and construction on its own merits.

Following FID the Project will proceed in to an execution phase including detailed design, construction and commissioning. At the completion of these steps the facility will be an operational green methanol production plant.

OPPORTUNITIES & RISKS

The Study has identified a range of opportunities and risks for the further development of the Project. Before commencing the FEED phase, it is intended to further explore these key opportunities and risks. In the Pre-FEED phase the items will be assessed, developed and potentially incorporated with the feasibility study deliverables. From this work, the scope for the FEED Phase will be refined allowing the Project to precede on an optimal and coherent basis.

Some of the key identified opportunities include:-

- Potential use of biomass gasification rather than biomass oxy-combustion for the methanol carbon source. This process has been identified as having potential for reductions in cost of methanol production and may allow greater methanol production from a given power supply.
- Opportunities to further reduce capital and operating costs.
- The project has the potential to incorporate a carbon dioxide Direct Air Capture **(DAC)** unit in parallel to the selected carbon source, to further the development of the DAC technology into a beneficial methanol product. ABEL Energy has collaborated with CSIRO to investigate the demonstration of the technology.
- Investigation of a small di-methyl ether **(DME)** unit to upgrade a portion of the methanol, for a range of uses such as dehydration, green LPG substitute, green diesel replacement or as a renewable aerosol propellant.
- Further optimisation of the site layout at Bell Bay.
- Assessing the potential of net-zero emission methanol to fuel local trucking fleets, especially in the forestry harvesting industry.

As part of the Study, ABEL Energy has undertaken a HAZID and a risk review to identify key technical, commercial and project risks. A project risk register has been developed to assess, monitor and mitigate during subsequent project phases. Some risks areas already identified include: feedstock supply, product offtakes, land access issues, technology and equipment sourcing, and project staffing.

- As one of the first movers at Bell Bay at a scale compatible with the local infrastructure, ABEL Energy has an advantage in securing access to required infrastructure, land, supply and offtake agreements.
- Biomass supply is intentionally diversified and flexible based on a range of local existing suppliers. Further cooperation with plantation managers and harvesting companies to find mutually beneficial solutions will continue in the next project phases. Water supply risk has been addressed in the Study, by using an available source with options for future optimisation. Power supply arrangements with both renewable developers and Hydro Tasmania are progressing and will be finalised prior to FID.

- Methanol offtake discussions have commenced with a range of parties, covering a wide range of applications such as maritime fuels, chemical uses, LPG replacement, mining fleet fuels and remote stationary power applications. Demand for green methanol is very strong and offtake is likely to favour applications enabling the greatest revenue and stability.
- Three available sites have been identified and ABEL Energy has advised interest and been acknowledged respectively for each site but is still subject to commercial negotiations, which will be concluded by FID.
- Lead times for equipment supply are growing especially for green technologies such as water electrolysis. Pre-existing relationships with technology suppliers is the key to reducing project timelines.
- The ability to staff a project with appropriately skilled staff in this industry is challenging. ABEL Energy has already secured key resources with hard to come by experience in project development, product marketing, supply logistics and technical roles. Specifically, the team has significant experience in methanol marketing, technology and design, water electrolysis & hydrogen production, biomass sourcing and utilisation, and power markets.

These risks will be mitigated through further development work and engagement with the local community and utility providers. A further aim of the Pre-FEED is to close out as many actions as possible prior to commencing the FEED.

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