Australian Government
Department of Infrastructure, Transport, Regional Development, Communications and the Arts

MERNAP Issues Paper: Energy Sources and Technologies

December 2023

Contents

Glossary

Energy Efficiency Measures

Advanced Engine Technologies: Some advanced engine technologies, such as enhanced fuel injection systems and waste heat recovery systems can help reduce energy consumption.

Advanced Hull Coatings: Surface roughness, caused by both physical imperfections and the accumulation of biological growth, has a significant effect on frictional resistance for a vessel's hull. Advanced hull coatings can reduce drag and, as a result, save fuel.

Advanced Propeller Technologies: Some advanced propeller technologies, such as contra-rotating propellers (CRP), podded propulsor propeller (POD), propeller ducts, pre-swirl stators, post-swirl fins and rudder bulbs, can offset the swirls generated by propellers, and thus improves propulsion efficiency to save fuel.

Air Lubrication: Air lubrication systems can decrease frictional resistance by generating a layer of microbubbles across the entire flat surface of a vessel's hull, thereby reducing fuel consumption.

Cold Ironing: Cold ironing, also known as shore power, is the process of providing electrical power from the shore to a vessel while she is docked, thereby allowing a vessel's auxiliary engines to be turned off to reduce emissions.

Digitalisation: Digitalisation technologies, such as the Internet of Things (IoT), Artificial Intelligence (AI), and autonomous shipping, have the potential to enhance the efficiency of supply chains and shipping, ultimately leading to reduced fuel consumption. The Maritime Single Window to be implemented is an example of digitalisation.

Hull Form Optimisation: Designing a hull using advanced optimisation methods can produce the most efficient form within the requirements of the vessel design and minimise resistance to save fuel.

Hybrid Diesel Battery Propulsion Systems: Marine hybrid systems store the energy produced by the diesel engines during lighter loads and releases it under heavy loads of vessels. This reduces the fuel requirement of the engines and allows it to operate constantly at maximum efficiency.

Lightweight Materials: Some lightweight materials, like aluminium and composites, can be used on vessels to reduce weight while retaining strength, resulting in reduced fuel concumption.

On-board Power Management: There are primarily two approaches to optimising on-board power consumption. The first involves implementing automatic power management systems that utilise automation to conserve power efficiently. The second approach entails the adoption of best practices and management guidelines to reduce power consumption effectively.

Power Assistance Methods: On-board power assistance approaches, like wind assistance such as Flettner rotors, towing kites, and sails, and solar assistance (solar panels), can reduce vessels' fuel consumption.

Route Optimisation: Environmental factors, such as wind speed and direction, water speed and depth, can influence fuel consumption of vessels. Route optimisation methods enable ship operators to save fuel.

Speed Reducing: Reducing speed, also known as slow steaming, is an effective measure to reduce fuel consumptions in maritime transport, however, it increases travel time.

Trim Optimisation: Trim optimisation is a way to reduce the ship resistance against the vessel's motion. It depends on several factors like the loading conditions, the speed of the vessel, the draft, the power of the main engine, and wind speed and direction. Thus, this method functions in conjunction with speed reducing and route selection.

Alternative Low Emission Energy Sources

Biofuels: Represents a class of sustainable energy sources derived from organic materials, often sourced from plants or biomass.

Bio-LNG: Biomethane can be produced via anaerobic digestion (AD) process or bio-synthetic natural gas (bioSNG) process. AD is the decomposition of biological feedstocks by micro-organisms, in the absence of oxygen. The biogas produced comprises mostly methane and CO2.

Biomethanol: Renewable methanol produced from biomass, such as forestry and agricultural waste and byproducts, biogas, sewage, municipal solid waste (MSW) and black liquor from the pulp and paper industry.

Carbon Capture, Use and Storage Systems (CCS): Systems designed to capture carbon emissions from industrial processes and make that carbon available for sequestration or commercial use.

Carbon Dioxide Equivalent: A way of expressing any GHG emission in terms of the equivalent amount of carbon dioxide that would deliver the same greenhouse effects.

Drop-in Fuel: Any fuel that could be used to replace another fuel without changing the engine or fuel system components.

E-Fuels: A type of drop-in replacement fuel. They are manufactured using captured carbon dioxide or carbon monoxide, together with hydrogen obtained from sustainable electricity sources such as wind, solar and nuclear power.

Fatty Acid Methyl Esters (FAME): are derived from fats and oils through a well-established process that is commercially operational worldwide. It is also commonly referred to as "biodiesel" and is often blended with conventional diesel. Various fats and oils, both waste materials such as used cooking oil (UCO) and waste animal fats (tallow) and non-waste like rapeseed oil and sunflower oil and can be utilised to produce FAME.

Fuel Cells (FC): A type of equipment that transforms liquid or gaseous fuel into electrical energy.

Hydrogenated Vegetable Oil (HVO): Produced through the hydro-treatment of conventional vegetable oils or waste oils and fats. It is commonly recognised as a drop-in biofuel within the maritime industry due to its compatibility with marine diesel engines. It is often referred to as 'biodiesel' in the maritime sector.

Internal Combustion Engine (ICE): An engine which generates motive power by the burning of petrol, oil, or other fuel with air inside the engine, the hot gases produced being used to drive a piston or do other work as they expand.

Tank-To-Wake: Refers solely to the emissions derived from on-board fuel combustion.

Well-To-Wake: Refers to the entire process from fuel production, and delivery to using on-board ships and all emissions produced therein.

1. Introduction

The Australian Government has legislated an economy-wide target of reaching net zero emissions by 2050. To deliver on this commitment, the Government is developing a Net Zero Plan, including six sectoral decarbonisation plans covering electricity and energy, transport, industry and waste, agriculture and land, resources and the built environment.[1] For the transport sector, the Government is developing a Transport and Infrastructure Net Zero Roadmap and Action Plan to examine greenhouse gas (GHG) emissions reduction pathways across all transport modes (road, aviation, maritime and rail), including supporting infrastructure.[2] One element of the transport sectoral plan is a Maritime Emissions Reduction National Action Plan (MERNAP).[3]

Development of the MERNAP will seek to identify and prioritise actions to decarbonise our maritime transport sector, advance the development of green shipping corridors from Australia and contribute towards reducing international shipping emissions.

The MERNAP is being prepared through a series of thematic issues papers.[4] The first issues paper on regulations and standards was released in September 2023. This second issues paper examines potential energy provision and abatement technologies for Australia's maritime sector. Future papers will consider skills and training, and international partnerships to facilitate the green maritime transition.

Through consultation on this second paper on low emissions energy provision and technologies, the Department of Infrastructure, Transport, Regional Development, Communications and the Arts (the Department) would like to better understand what the industry and community is thinking about and planning for maritime decarbonisation investments- as well as barriers to investing in and adopting those fuels and technologies. This understanding will help the development of short, medium and long-term approaches in the MERNAP to support these investments.

Submissions to this paper will be used to provide advice to Government about potential future policy settings. Submissions can be made by close of business **Friday 2 February 2024** via the MERNAP email: MERNAP@infrastructure.gov.au

2. Purpose

The MERNAP is intended to:

- support Australia's national emissions reduction targets and contribute to global decarbonisation of shipping;
- future-proof the Australian maritime sector and avoid a later accelerated, costly and disruptive transition by setting early signals;
- signal to global partners Australia's clear pathway to net zero emission shipping in our waters and ports; and
- promote an equitable transition for the maritime sector, particularly for the maritime workforce.

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[1] Net Zero - DCCEEW

[2] Transport and Infrastructure Net Zero Roadmap and Action Plan | Department of Infrastructure, Transport, Regional Development, Communications and the Arts

[3] Charting course towards zero maritime emissions for Australia | Ministers for the Department of Infrastructure

[4] Charting Australia's Maritime Emissions Reductions | Department of Infrastructure, Transport, Regional Development, Communications and the Arts

To achieve the Government's net zero objectives, attention is required in a range of low emission energy provision and technologies. This paper explores possible low emission fuels and technology solutions for the port and shipping sectors - further informing both private and public investment in the energy transition. The Department recently commissioned research[5] to conduct a literature review and research on possible energy and technological decarbonisation pathways, and their suitability for differing segments of the maritime industry. Information from this research (referred to as the literature review throughout) is presented as a scene-setter to stimulate feedback from industry and other stakeholders. It does not provide 'answers' as to which energy provision or technology is the best solution for each segment of Australia's maritime sector. The full literature review and supporting evidence and references will be release by the Department in the coming months.

Throughout the paper, questions are posed to test assumptions on likely transition investments and approaches to help inform the Department's recommendations to Government in the final MERNAP.

3. Context

In July 2023, the International Maritime Organization (IMO) revised its GHG reduction strategy for international shipping to reach net zero emissions by or around 2050 with indicative checkpoints to decrease GHG emissions by at least 20%, striving for 30%, by 2030, and by at least 70%, striving for 80%, by 2040, compared to 2008 levels. The revised strategy also includes an ambition for the uptake of zero or near-zero GHG emission technologies, fuels and/or energy sources to represent at least 5%, striving for 10%, of the energy used by international shipping by 2030. The IMO is currently developing a basket of mid-term measures incorporating technical and economic elements for adoption by 2025. Under consideration are a GHG fuel standard, where the GHG intensity of the fuel used is set to decline over time, as well as GHG pricing mechanisms.

Australia has an economy-wide net zero by 2050 target and aims to reduce total emissions by 43% below 2005 levels by 2030. Over the past two decades, Australia's domestic maritime sector has contributed around 2 million tonnes (Mt) of GHG emissions per year, accounting for approximately 0.4% of Australia's total emissions[6]. The maritime sector faces significant short- and long-term challenges in emissions reduction, necessitating careful planning and early action to achieve decarbonisation.

The Australian domestic maritime sector consists of businesses operating various types of vessels, such as passenger vessels and ferries, cruise vessels, cargo vessels, offshore support vessels, specialised vessels (aquaculture service vessels, dredgers, bunker barges, tugboats, research vessels, survey vessels, patrol vessels, pilot vessels, etc.), fishing vessels, and recreational craft. Many of these vessels are relatively small in size and are aging. This suggests that an increasing number of new-build vessels will gradually be required to replace those approaching retirement, highlighting the current opportunity for considering emissions reduction in ordering and building a new domestic fleet for the future. The capability of new vessels to use low emission energy sources and technologies will be a critical consideration in investment decisions.

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[5] The literature review was conducted by Dr Peggy Chen and Dr Hongjun Fan as an independent consultancy.
[6] Data taken from the National Greenhouse Accounts National inventory by economic sector | ANGA (climatechange.gov.au)

4. Technical Emission Reduction Measures

Drawing on the literature review, this paper discusses the three main technical emission methods for decarbonising the maritime sector: improving vessel and operational energy efficiency, using low emission energy provision, and employing carbon capture and storage technology, and asks questions for stakeholders in the maritime industry, and their energy providers, to provide feedback on feasible approaches. The paper also presents findings from our analysis of government policies and private investments in domestic low emission energy sources. Finally, the paper summarises key findings from stakeholder interviews the Department has conducted for several site-specific case studies. A glossary of technical terms used in this paper can be found immediately after the table of contents.

4.1. Energy Efficiency Measures

Improving the energy efficiency of vessels is a major decarbonisation strategy for the domestic maritime sector in the interim, while low emission marine fuels and vessels are not widely available. Minimising fuel consumption directly reduces GHG emissions. Moreover, in a future where zero carbon fuels are widely utilised, more efficient vessels can alleviate the pressure on the quantity of zero carbon fuel needed per voyage and reduce costs for operators.

The literature review has identified 14 possible fuel efficiency measures that can be used by vessel operators in Australia. These can be divided into two categories, operational and technical methods, as shown below:

- Operational methods
  - Speed reducing
  - Route optimisation
  - Trim optimisation
  - Onboard power management
  - Shore-to-ship power (cold ironing)
  - Digitalisation[7]
- Technical methods
  - Advanced hull coatings
  - Hull form optimisation
  - Lightweight materials
  - Air lubrication
  - Advanced engine technologies
  - Advanced propeller technologies
  - Power assistance methods (including wind-assisted propulsion)
  - Hybrid diesel battery propulsion systems.

The literature review suggests that the median potential for emission reduction through energy efficiency measures falls within the range of 3–32%, as shown in **Figure 1**, with the highest reduction potential attributed to speed reducing. The widest possible emissions reductions do come from digitalisation, this is attributed to the wide array of approaches under this heading.

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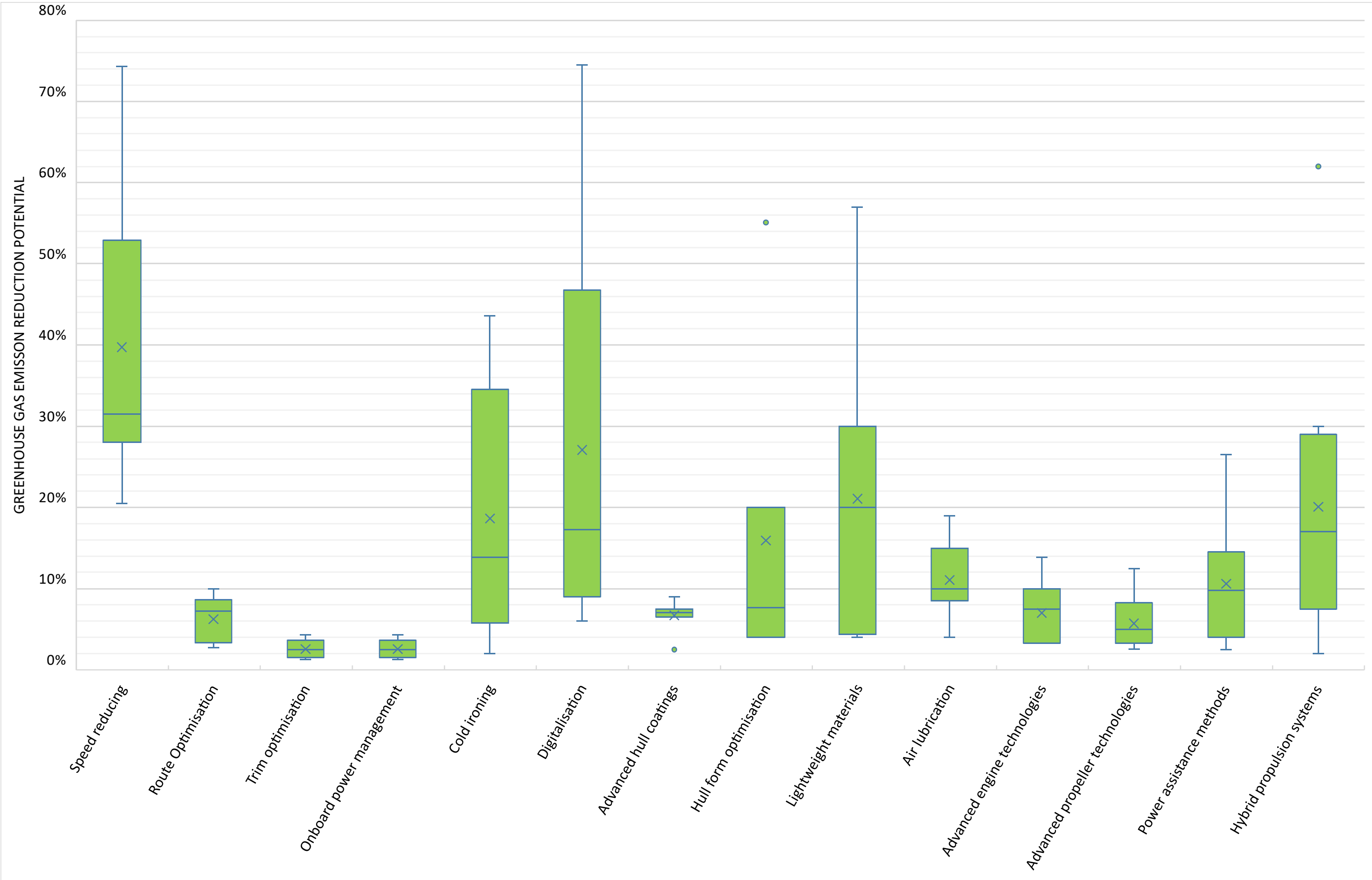
[7] Digitalisation technologies, such as the Internet of Things (IoT), Artificial Intelligence (AI), and autonomous shipping, have the potential to enhance the efficiency of supply chains and shipping, ultimately leading to reduced fuel consumptions. A Maritime Single Window is an example of digitalisation.

Figure 1: GHG Reduction Potential of Energy Efficiency Technologies



It is worth noting that some of the measures are not well-suited for domestic vessels, especially smaller ones. For example, speed reduction measures have limited emission reduction effects on low-powered engines. Digitalisation has significant emission reduction potential for international liner shipping, but limited application potential for domestic vessels. Power-assist systems like the Flettner rotor, towing kites and solar panels are not suitable for small vessels (as they take up too much room on small vessels, and add little benefit if scaled down in size)

Hence, the emission reduction potential of energy efficiency measures in the domestic maritime sector, estimated to between 5−15%, is smaller than for international shipping.

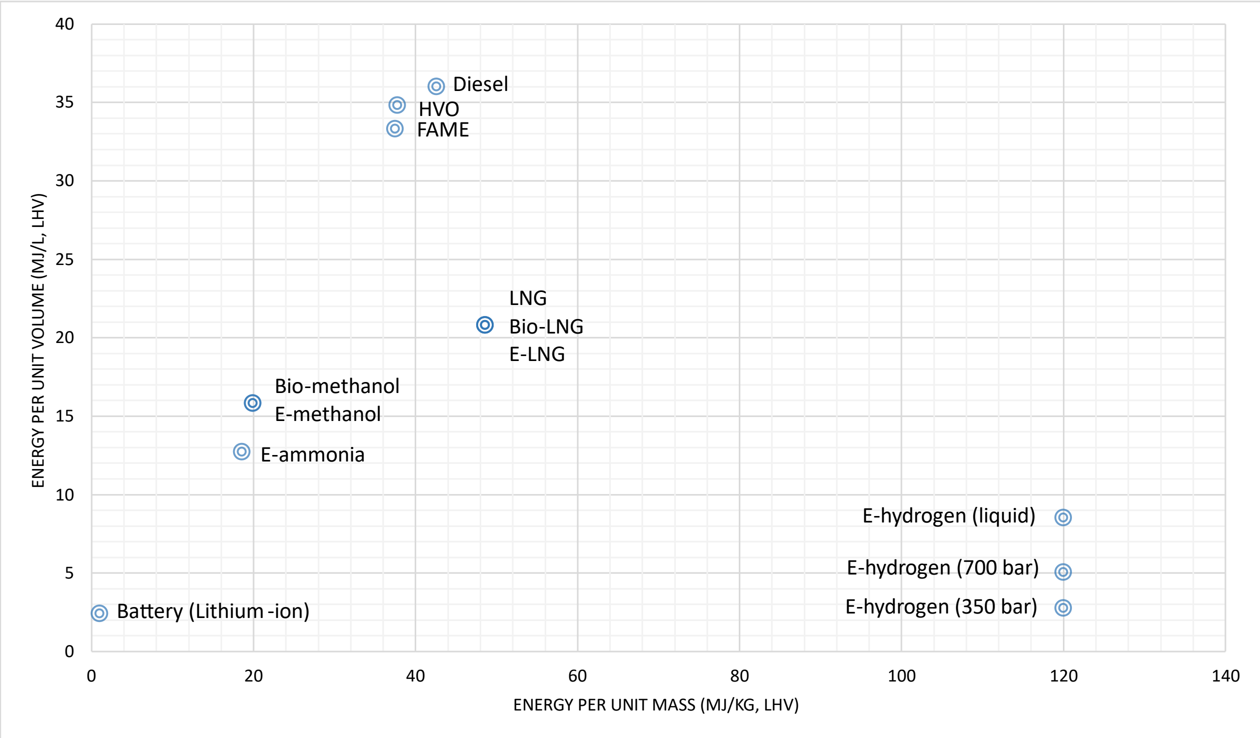
Questions for Industry Stakeholders

- *What energy efficiency measures would your / is your organisation considering utilising to reduce emissions?*
- *Is there sufficient information available to maritime industry stakeholders about energy efficiency measures? What are the barriers to accessing this information?*
- *How do the energy efficiency technologies suitable for international shipping differ in their applicability to domestic vessels?*
- *What are the barriers your organisation faces in investing in energy efficiency technologies or measures?*

4.2. Alternative Low Emission Energy Provision

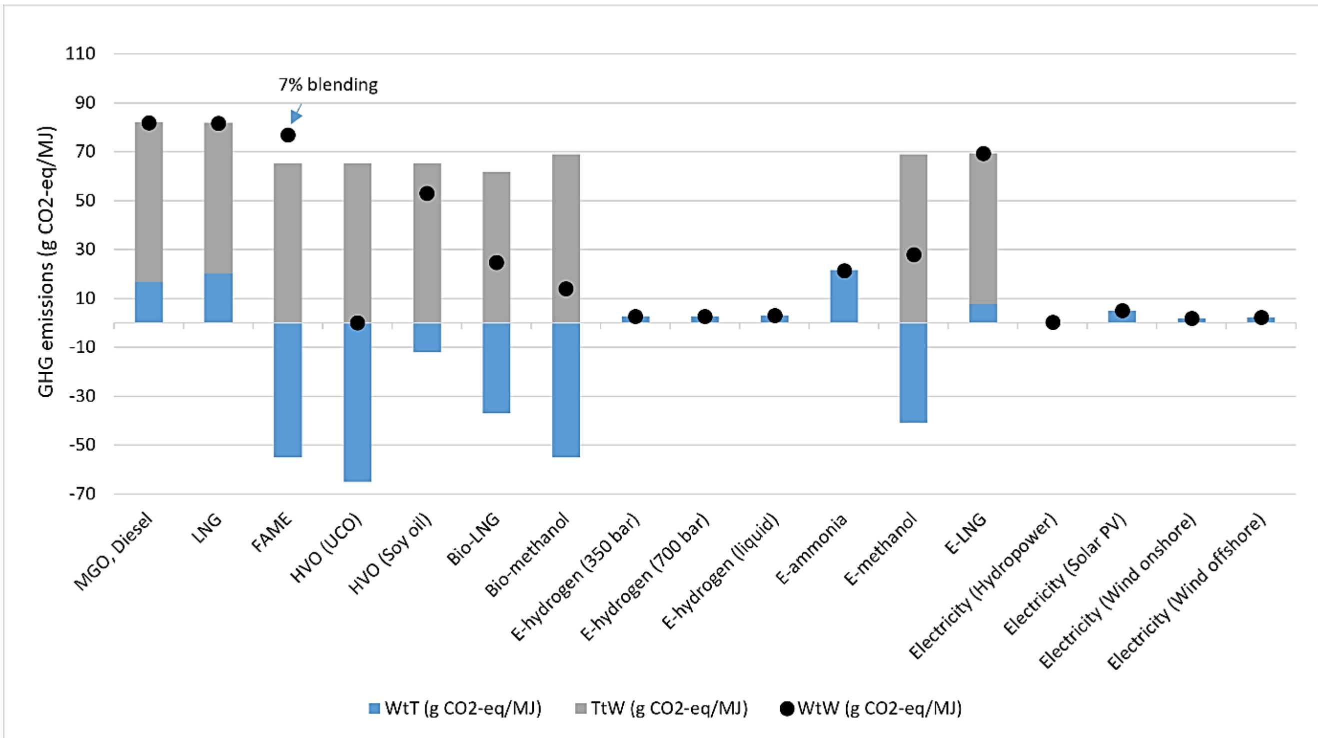
Low emission energy sources are necessary to decarbonise the maritime sector. The literature review has reviewed ten types of alternative energy provision that may be used in the maritime sector, including one lower-carbon fossil fuel (LNG), four biofuels (fatty acid methyl esters (FAME), hydrogenated vegetable oil (HVO), bio-LNG, bio-methanol), four e-fuels (e-hydrogen, e-ammonia, e-methanol, e-LNG), and lithium batteries. When evaluating these alternative energy sources, energy density from a vessel design perspective is a critical consideration. **Figure 2** presents the energy densities of the alternative energy sources. Vessel design is more sensitive to volumetric energy density, with biodiesel performing the best and lithium batteries performing the worst.

Figure 2: Energy Densities of Alternative Energy Provision



In terms of life cycle or Well-to-Wake (WtW) GHG emissions for a fuel and its use, HVO and hydrogen offer the most significant emission reduction potential. For battery electric technologies, when using renewable electricity generation, significant emissions reductions can be seen. The relatively high WtW emissions for FAME are due to the ISO 8217:2017 standard (ISO, 2017), for the blending of FAME in distillate fuels. This standard restricts blending of FAME with conventional diesel fuels to a maximum of 7%, due to its low boiling point and viscosity. There is potential to increase the blending percentage, with 20% FAME blending in diesel being widely adopted, this would further reduce WtW emissions.

Figure 3: Typical GHG Emission Reduction Potential of the Alternative Energy Source



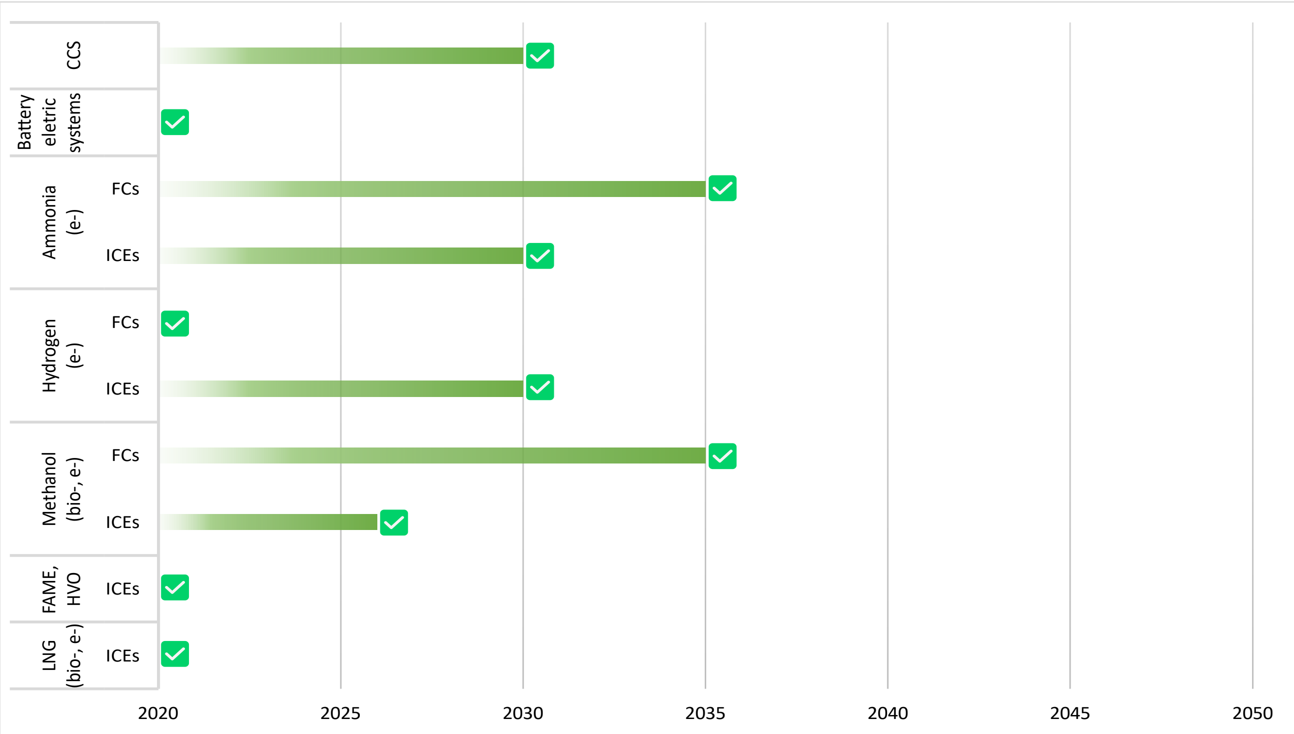
The alternative energy sources listed in this analysis may not be applicable to all domestic vessels. Most domestic vessels are relatively small in size, while the energy density of most alternative energy sources is significantly lower than that of marine diesel fuel. This results in a need for more fuel storage space, posing significant challenges for vessel design and layout. For some vessel types, such as ferries and liners, increasing the bunkering frequency in shorter route applications can improve the applicability of alternative energy sources to some extent. Furthermore, the safety risks associated with alternative energy sources make some of them unsuitable for certain vessel types. For example, the high toxicity of ammonia could be a challenge for use on passenger vessels.

Carbon Capture Use and Storage

Carbon capture and storage (CCS) technology is still in the early stages of development for onboard application in vessels, with limited successful cases worldwide. However, when considering the full life cycle of alternative energy sources, CCS can be applied in the fuel/energy production and transport stages to achieve appreciable emission reductions.

The technology maturity of various alternative energy sources on vessels is a critical factor in determining their short, medium and long-term applicability. **Figure 4** provides a timeline for the maturity of various maritime energy converters, including internal combustion engines (ICEs), fuel cells (FCs), battery technology and CCS. Depending on the application scale, among these technologies, LNG (bio or e) and methanol ICEs, and battery electric systems are the earliest matured technology, followed by e-hydrogen FCs.

Figure 4: Estimated Maturation Timelines of Energy Converters and Carbon Capture Technology



Questions for Industry Stakeholders:

- *The differing properties of each energy source means that, given current technologies, they are not appropriate for all vessel types. What are key technical considerations that your organisation considers when exploring alternate energy sources?*
- *From the following list, what are the primary barriers to investing in low emission energy sources in the maritime sector? Can you comment on what your organisation thinks about each of these factors?*
    - *Cost*
    - *Technology choice*
    - *Fuel availability/infrastructure*
    - *Regulations and standards*
    - *Safety*
- *What are the specific barriers to using each potential energy source in your organisation?*
    - *LNG*
    - *Biofuels (HVO, FAME)*
    - *E-Hydrogen*
    - *E-ammonia*
    - *E-Methanol*
    - *Battery*
- *Given many low/zero emission propulsion systems are still in the early stages of development, how is your organisation considering its medium and long-term investments in low emission energy sources?*

5. Low Emission Energy Provision Availability in Australia

The Australian Government has implemented several incentives and policies to support the development of alternative energy sources, including biofuels and e-fuels (e-hydrogen, e-ammonia, e-methanol), including investment in seven hydrogen hubs. Government and private sector investments in low emission energy sources are increasing. Port approaches to assist decarbonisation of domestic vessels include investment in shore-to-ship power and alternative fuel bunkering. For example, shore power infrastructure is currently being installed in the Bays Port precinct of Sydney Harbour. Several Australian ports, such as Port of Newcastle, Pilbara Port, and Port of Melbourne have initiated studies to assess the viability of providing hydrogen, ammonia, and methanol fuel bunkering services. **Figure 5** highlights these developments.

Figure 5: Locations of Maritime Alternative Energy Source Supply

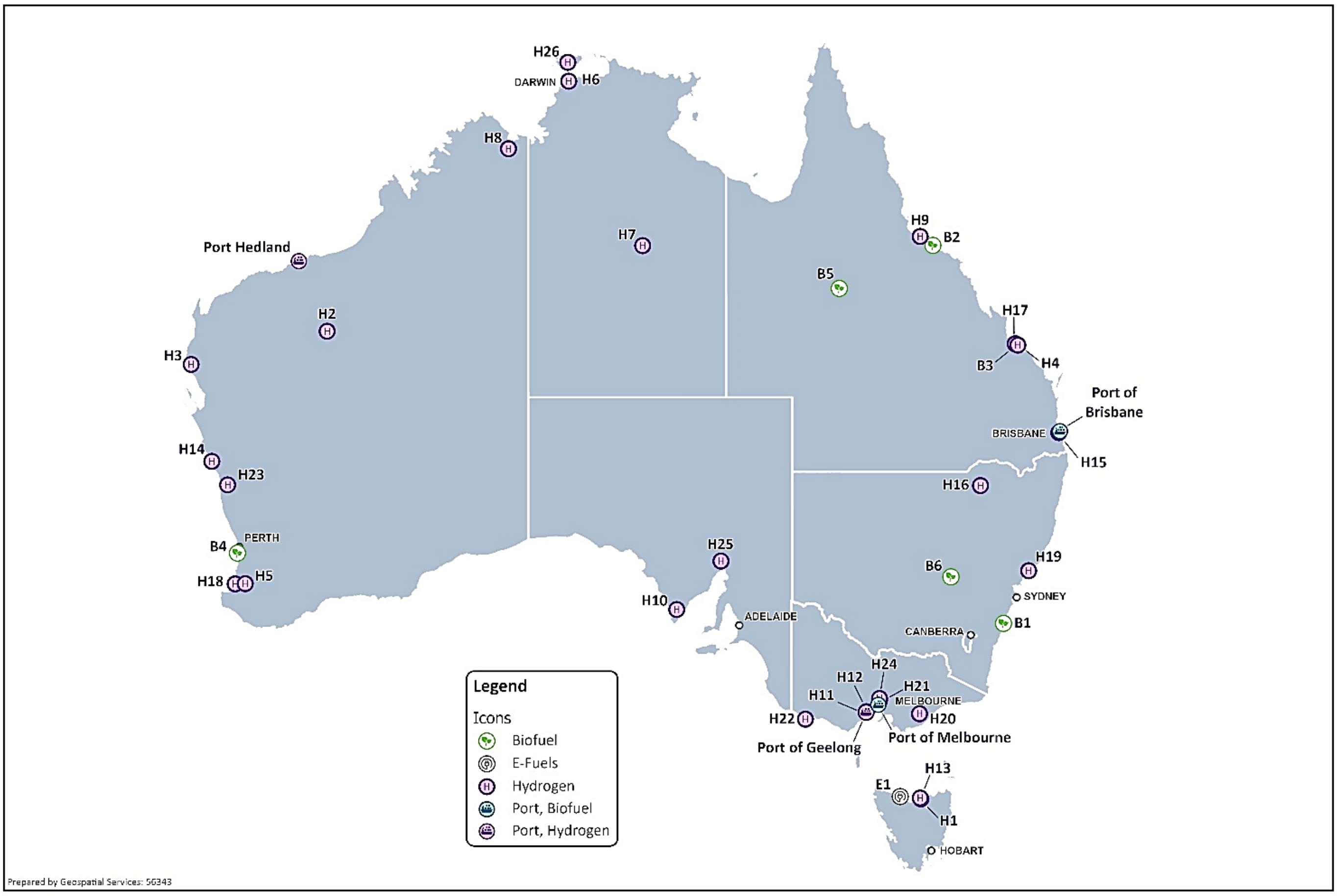


Table 1: Map Key – Locations of Maritime Alternative Energy Source Supply

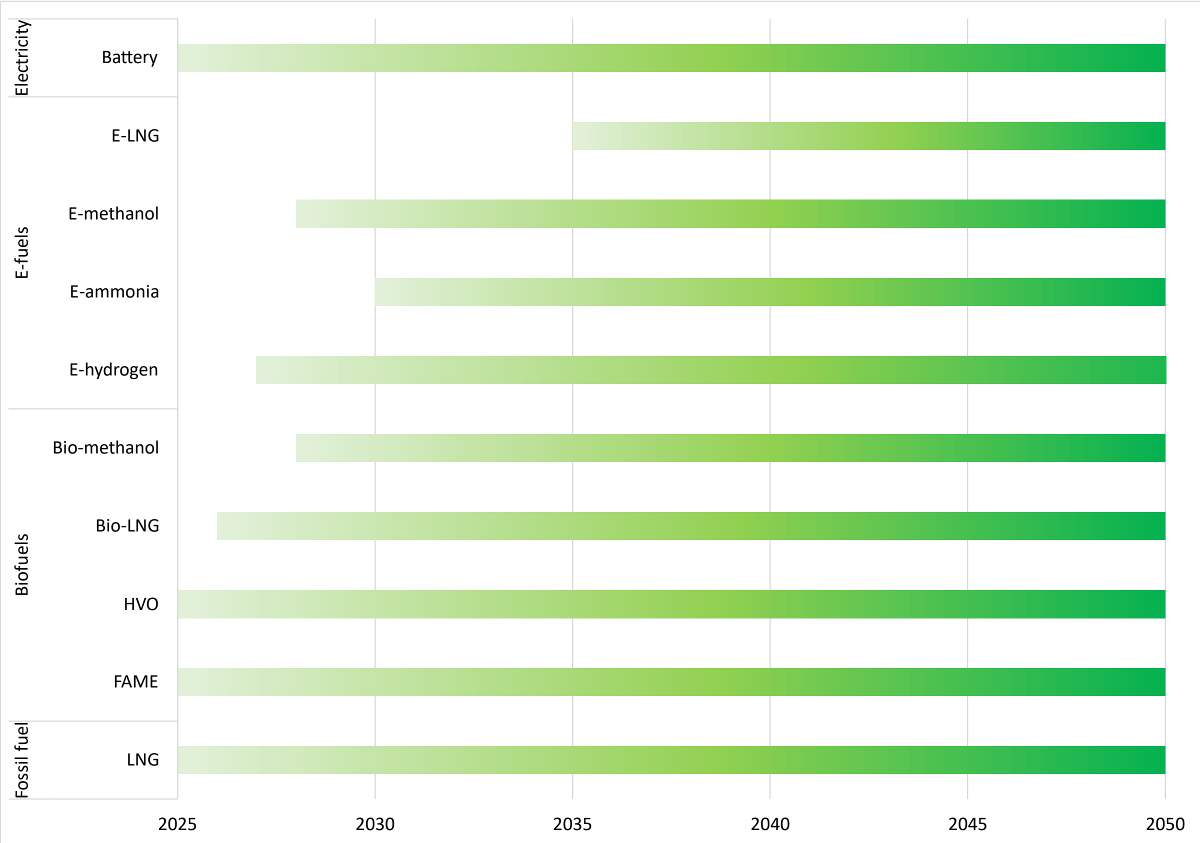
Key	Name	State	Location	Fuel Type/s	Est. Completion Date	Est. Output
B1	Manildra Ethanol Plant	NSW	Bomaderry	Ethanol	Operating	300 million litres/year
B2	Wilmar Sugar-based Ethanol	QLD	Sarina	Bioethanol	Operating	60 million litres/year
B3	Oceania Biofuel Refinery	QLD	Gladstone	SAF, Renewable Diesel	2025	350 million litres/year
B4	Kwinana Oil Refinery (BP)	WA	Kwinana	SAF, Renewable Diesel	2026	50,000 barrels/day
B5	LanzaJet	QLD	Gladstone	SAF	TBC	100 million litres/year
B6	Brightmark	NSW	Parkes	Low Sulfur Diesel	TBC	TBC
E1	HIF Tasmania eFuels Facility	TAS	Burnie	e-Fuels	2026	100 million litres/year
H1	ABEL Energy Bell Bay Powerfuels Project	TAS	Bell Bay	Green Methanol	2027	300,000 tonnes per annum
H10	Eyre Peninsula Gateway Project - Demonstrator Stage	SA	Eyre Peninsula	Green Hydrogen, Green Ammonia	2026	300,000 tonnes per annum hydrogen, 800,000 tonnes per annum ammonia
H11	Geelong Hydrogen Hub	VIC	Geelong	Green Hydrogen	2023	TBC
H12	Geelong New Energies Service Station Project	VIC	Geelong	Green Hydrogen	2024	1 tonne per day
H13	George Town Project	TAS	George Town	Green Hydrogen	2023	1.69 tonnes per day, growing to 14.9 tonnes per day over nine years
H14	Geraldton Export-Scale Renewables Investment	WA	Geraldton	Green Hydrogen, Green Ammonia	TBC	4000 tonnes per annum hydrogen, 200,000 tonnes per annum ammonia
H15	Gibson Island Green Ammonia Project	QLD	Brisbane	Green Hydrogen, Green Ammonia	2025	70,000 tonnes per annum hydrogen, 400,000 tonnes per annum ammonia
H16	Good Earth Green Hydrogen and Ammonia Project	NSW	Moree	Green Hydrogen, Green Ammonia	2025	3800 tonnes per annum ammonia, TBC hydrogen
H17	Green Methanol Feasibility Study	QLD	Gladstone	Green Methanol	2028	100,000 tonnes per annum
H18	Green Springs Project	NT	Western Davenport	Green Hydrogen	TBC	1000 tonnes per day
H19	Hunter Valley Hydrogen Hub	NSW	Hunter Valley	Green Hydrogen	2026	5500 tonnes per annum
H20	Australian Renewable Energy Hub	WA	Pilbara	Green Hydrogen, Green Ammonia	TBC	1.6mil tonnes per annum hydrogen **OR** 9mil tonnes per annum ammonia
H20	Liquefied Hydrogen Supply Chain Commercial Demonstration Project	VIC	Gippsland	Blue Hydrogen	2028	5500 tonnes per annum

H21	Melbourne Hydrogen Hub	VIC	Melbourne	Renewable Hydrogen	TBC	4.5 tonnes per day
H22	Portland Renewable Fuels	VIC	Portland	Green Methanol	TBC	200,000 tonnes per annum
H23	Project Haber	WA	Mid-West, TBC	Green Ammonia	TBC	800,000 tonnes per annum
H24	Renewable Hydrogen Hydro-Gen 1	VIC	Melbourne	Green Hydrogen	TBC	700 tonnes per annum
H25	SM1	SA	Port Augusta	Green Hydrogen, Green Methanol	TBC	TBC
H26	Tiwi H2	NT	Tiwi Islands	Green Hydrogen	2028	90,000 tonnes per annum
H3	Boolathana Project	WA	Gascoyne region	Green Hydrogen, Green Ammonia	TBC	TBC
H4	Central Queensland Hydrogen Project	QLD	Gladstone	Green Hydrogen	TBC	200 tonnes per day by 2028, 800 tonnes by 2028
H5	Collie Battery and Hydrogen Industrial Hub Project	WA	Collie	Green Hydrogen, Green Ammonia	TBC	TBC
H6	Darwin Green Liquid Hydrogen Export Project and Hydrogen Hub Development	NT	Darwin	Green Hydrogen	TBC	42,000 tonnes per annum
H7	Desert Bloom Hydrogen	NT	Tennant Creek	Green Hydrogen	TBC	410,000 tonnes per annum
H8	East Kimberley Clean Hydrogen Project	WA	East Kimberley	Green Hydrogen	2028-29	TBC
H9	Edify Green Hydrogen Project	QLD	Townsville	Green Hydrogen	TBC	150,000 tonnes per annum
Port Hedland		WA		Hydrogen (including derivatives)	TBC	Bunker
Port of Brisbane		QLD		Biofuels	TBC	Bunker
Port of Geelong		VIC		Hydrogen (including derivatives)	TBC	Bunker
Port of Melbourne		VIC		Green Methanol	2024	Bunker

Note: Information sourced from CSIRO HyResource (https://research.csiro.au/hyresource/), media releases, and stakeholder interviews).

Based on existing information in relation to energy production, readiness of technologies and infrastructure, an estimated timeline for fuel availability from 2025 in Australia is presented in **Figure 6**. **Figure 6** evaluates the marketisation (maturation) timelines of energy converters (including internal combustion engines and fuel cells) of alternative energy sources for domestic Australian vessels. The green gradient shows the likely timeframes over which the technologies will be commercially available in the domestic maritime sector. The lighter green indicates the earliest possible availability, with the darker green greater certainty of availability. The literature review suggests that battery, LNG, HVO and FAME (locally produced and imported) would be available by 2030, followed by bio-LNG, e-hydrogen, e-methanol, and e-ammonia.

Figure 6: Estimated Energy Source Availability Timelines in Australia



Note: Availability encompasses energy production, technologies and infrastructure.

Questions for Industry Stakeholders:

- *When considering alternate energy sources, how has your organisation engaged with ports and marinas?*
- *For ports and marinas are the major factors that ports and marinas consider when investigating alternate energy sources for bunkering?*
- *For regional ports and vessel operators, are there specific supply issues that may hinder the ability to bunker alternate energy sources?*
- *Is there a mismatch between available energy sources for bunkering and your vessels' fuel needs?*
- *Do opportunities exist to pool the demand for alternate energy sources across vessel owners?*

Figure 7: Bass Strait – Case Studies

6. Bass Strait Case Studies

To further our understanding of how operators are beginning to make investment decisions in low emissions energy sources and technologies, the Department conducted stakeholder interviews with organisations along defined maritime routes in Australia.

Figure 8 above shows a map of Bass Strait. Bass Strait is an important trade route between Tasmania and mainland Australia. The following case studies have been developed from interviews with four stakeholders operating in this region – the Port of Melbourne, a passenger ferry operator, a domestic shipping operator and TasPorts.

Case Study: Port of Melbourne

The Port of Melbourne is Australia's largest container and general cargo port in Australia, handling over 3.2 million TEU annually. The port supports more than 30,000 jobs and contributes $11 billion to the national economy each year. Around 3,000 ships visit the port each year across 30 commercial berths.

Port of Melbourne has a Board-approved sustainability strategy and plan. The port has set a target to achieve net zero emissions for Scope 1 and 2 by 2030 through sourcing renewable electricity for business operations and transitioning its corporate vehicle fleet and marine survey vessel to electric or zero-emissions fuel technologies. As a landlord port, Port of Melbourne's Scope 3 emissions comprise 99 per cent of its total greenhouse gas emissions. Over two-thirds of Scope 3 emissions are generated by shipping in Port of Melbourne waters and while vessels are at berth. The port has set a target to engage with shipping lines, tenants and other port users to identify opportunities to progress the decarbonisation of the port supply chain.

The port's engagement with shipping lines has led to a focus on future investments in supplying bio-methanol. This has been driven by the port's container shipping customers, many of who have new ship orders for container ships (2-3 year delivery timeline) that will be dual-fuelled with methanol. The Port of Melbourne has signed a Memorandum of Understanding with Maersk, ANL (a subsidiary of CMA-CGM), Svitzer, Stolthaven Terminals, HAMR Energy and ABEL Energy to explore the commercial feasibility of establishing a green methanol bunkering hub at the Port of Melbourne. The collaboration will examine a potential project involving the transportation of green methanol from production sites in Bell Bay, Tasmania (ABEL Energy) and Portland, Victoria (HAMR Energy) to Port of Melbourne for storage and bunkering services.

Case Study: Passenger Ferry Service

A passenger ferry service that operates in the Port Philip Bay area owns and operates 3 ferries running regular ro-ro services. The vessels are each over 20 years old, with one running off LNG (and diesel as a pilot fuel), while the other two use conventional diesel engines. Fuel usage is in the range of 5-10,000 MT of fuel per year.

In thinking through how the business can reduce its GHG emissions, fuel availability and cost is a major concern. Biodiesels or bio-LNG of the scale the business needs are not currently available, while other liquid fuels would require significant investment in new propulsion systems. Shore power is technically possible for this business, but it is a significant investment and there are uncertainties about the availability of green energy in the grid. The manager believed that there was little scope for the business to increase its ticket prices to support large investments at this time, given the current cost-of-living pressures that customers are experiencing. Given this uncertainty the company has been forced to wait before making a significant investment in decarbonising technology.

Case Study: Domestic Shipping Operator

The Department met with a representative from a shipping line to discuss their dry bulk operations across the Bass Strait (Devonport to Melbourne). The company operates 10 ships in Australia, while the key vessel on the bass strait route is a 30-year-old specialised dry bulk self-unloading pneumatic vessel. The ship consumes around 4,800 tonnes of conventional marine fuel per year, and emits around 15,140 tonnes of CO^2 equivalent GHG emissions. The operator, being part of a large multi-national shipping line is committed to reducing emissions across their fleet of vessels.

The global strategy for the operator is to transition to biofuels, with trials in their HQ country showing significant emissions reductions potential. Given the current and predicted lack of supply of biofuels in Australia, the operator is looking into the planned methanol bunkering in the Port of Melbourne, when considering future new-builds for this vessel. Moreover, as the vessel is self-unloading, there are significant GHG reductions that could be achieved through the use of shore-power. This is currently available in Melbourne, and there are some early discussions with TasPorts about possible shore power investments. The use of shore power for this vessel would also require a significant retro-fit or an entirely new build.

The operator discussed how the government can support faster action on decarbonising the maritime sector. A sectoral GHG target for the maritime sector was seen as a useful approach, as it would allow operators to pass the costs of new investments along the supply chain, while facilitating the use of alternate energy sources.

Case Study: TasPorts

TasPorts is a state-owned company responsible for eleven Tasmanian Ports and the Devonport Airport. In 2022, 14.5 million tonnes of cargo passed through TasPorts, across 2,626 port visits. The Port owns and operates 28 of its own vessels – which are the Port's largest GHG emission source, making up around 81% of the ports 5,901t CO_2e- scope 1 emissions. The Port has a net zero by 2040 target (which also includes short and mid-term targets) as well as a whole of Port sustainability plan in place.

To reach its net zero target, TasPorts is looking to implement short-term measures of investing in EVs for its fleet of light vehicles, and electrifying its heavy fleet in the medium term. These investments are supported by a largely decarbonised electricity grid (Tasmania hydro-electricity). There have also been shore power investments to date in Burnie, and further planned investments in Devonport and Hobart. TasPorts noted carbon offsets will play a role in meeting medium-term targets.

The more difficult decisions for the port sit in decarbonising its fleet of vessels and consideration of bunkering infrastructure. Currently the port has not committed to one particular fuel. This is being driven by concerns around technical readiness of differing fuel options, particularly as the Port does not traditionally commission new vessels. Cost and readiness are major factors when looking to decarbonise their own vessels. Moreover, there are coordination issues across the maritime sector – whereby differing organisations and operators are charting their own course on energy sources, making the energy source transition pathway unclear, particularly for ports.

Questions for Industry Stakeholders:

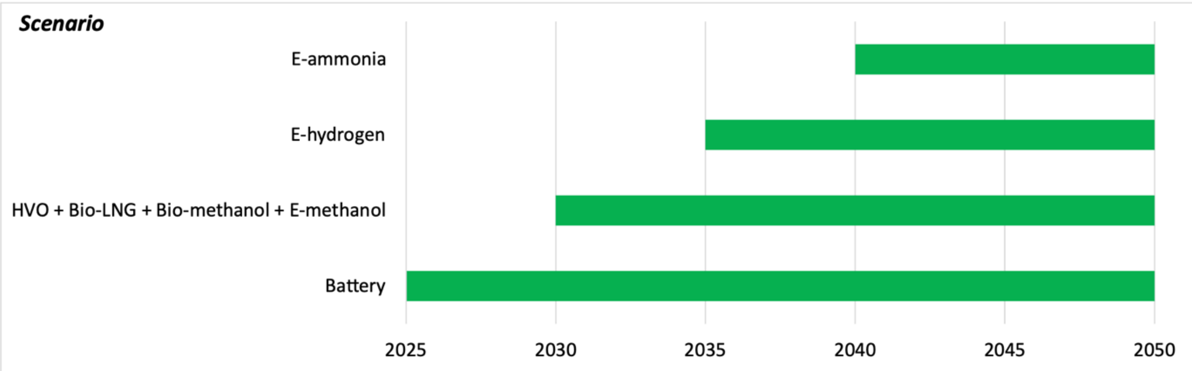
- The Case Studies represent a regionalised view of the challenges and opportunities of maritime decarbonisation. From your own region are there collective efforts being undertaken to address energy source pooled demand? If not, are there opportunities to work across operators?
- How do the local factors, such as vessel type, energy production and business structures impact how you are planning future decarbonisation activities?
- What further information about decarbonisation activities would be useful to inform other regions and operators investment decisions?

7. Energy Consumption Scenarios

According to the Australian Intergenerational Report 2023[8], the Australian economy is projected to grow at an average of 2.2% a year over the next 40 years. Therefore, there is a potential for ongoing growth in the domestic maritime market volume. Based on the domestic maritime sector's fuel consumption in 2021-22 and assuming a yearly increase of 1% in fuel consumption in a business-as-usual scenario, annual fuel consumption is projected to reach 38.97 petajoule (PJ = 10^{15} Joule) by 2050-51.

In this context, this section of the paper presents one possible energy consumption scenario, whereby a mix of low and zero emission energy sources are used to reach 38.97 PJ of energy by 2050-51. The scenario is based on the maritime sector utilising batteries from 2025, with biofuels, hydrogen and ammonia introduced in 2030, 2035, and 2040 respectively. This scenario also tests what fuel demand could look like to 2050 using both fuel efficiency and low or zero emission energy sources in the Australian maritime sector.

Figure 8: Scenario of Low Carbon Energy Technology Availability



When building the scenario, the following factors were considered:

- The selection of alternative fuels is based on WtW GHG emission reduction potential, only(?) including alternative fuels that achieve over a 65% reduction in WtW emissions compared to marine diesel fuel and assuming these alternative fuels can achieve zero emissions through the use of CCS technology at Well-to-Tank (WtT) or Tank-to-Wake (TtW) stages.
- The timelines for the maturity of onboard technologies are taken into account, with particular consideration given to the maturity of energy converters (ICEs, battery electric motors and fuel cells).
- The production of alternative fuels are considered in Australia, noting the expected production timelines and capacities depend upon domestic policity settings, market development and port readiness.

To estimate potential fuel demand across our scenario, analysis of the uptake of alternate energy sources has been projected to 2050. In these projections our analysis assumes that low and zero emission energy sources will make up 100% of energy use in the maritime sector by 2050. The analysis then assesses four possible pathways:

- **Pathway A-1 (high energy efficiency + slow alternate energy uptake)**
  This pathway involves a relatively higher uptake of energy efficiency measures, but slow use of alternative fuels. Energy efficiency measures are assumed to result in a fuel saving of 1% in 2025-26, increase by 1% annually, reach a peak of 15% annually by 2038-39 and maintain that level there after.

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[8] 2023 Intergenerational Report | Treasury.gov.au

The use of alternative fuels is assumed to start at 1% in 2025-26, increase by 1% annually until 2034-35, and then increase by 5% annually, reaching 85% of the 38.97 PJ projected demand by 2049-50 (the remaining 15% of projected fuel demand is saved through energy efficiency measures).

- **Pathway A-2 (low energy efficiency + slow alternate energy uptake)**
  This pathway involves a relatively low uptake of energy efficiency measures and slow use of alternative fuels. Energy efficiency measures are assumed to result in a fuel saving of 0.5% in 2025-26, increase by 0.5% annually, reach a peak of 5% annually by 2034-35 and maintain that level there after. The use of alternative fuels is assumed to start at 1% in 2025-26, increase by 1% annually until 2034-35, and then increase by 5.67% annually, reaching 95% of the 38.97 PJ projected demand by 2049-50 (the remaining 5% of fuel is saved through energy efficiency measures).

- **Pathway B-1 (high energy efficiency + steady alternate energy uptake)**
  This pathway has the same uptake of energy efficiency measures as Pathway A-1, but with an initially higher, linear uptake of alternative fuels. Energy efficiency measures are assumed to result in a fuel saving of 1% in the fiscal year 2025-26, increase by 1% annually, reach a peak of 15% annually by 2038-39 and maintain that level there after. The use of alternative fuels is assumed to start at 3.4% in 2025-26 and increase by 3.4% annually until reaching 85% of the 38.97 PJ projected demand by 2049-50 (the remaining 15% of fuel is saved through energy efficiency measures).

- **Pathway B-2 (low energy efficiency + steady alternate energy uptake)**
  This pathway has the same uptake of energy efficiency measures as Pathway A-2, but with an initially higher, linear uptake of alternative fuels. Energy efficiency measures are assumed to result in a fuel saving of 0.5% in 2025-26, increase by 0.5% annually, reach a peak of 5% annually by 2034-35 and maintain that level there after. The use of alternative fuels is assumed to starts at 3.8% in 2025-26 and increase by 3.8% annually until reaching 95% of the 38.97 PJ projected demand by 2049-50 (the remaining 5% of fuel is saved through energy efficiency measures).

Mapping the four pathways, within our alternate energy source scenario, gives the projected fuel and electricity demand to 2050 shown in **Figure 9** and **Figure 10** respectively.[9]

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[9] The scenario and related pathways are a modelling exercise, and as such are used primariliy to explore possible futures. The output of this exercise should be viewed in this context – as one of many possible scenarios.

Figure 9: Fuel Demand According to Different Projected Scenarios

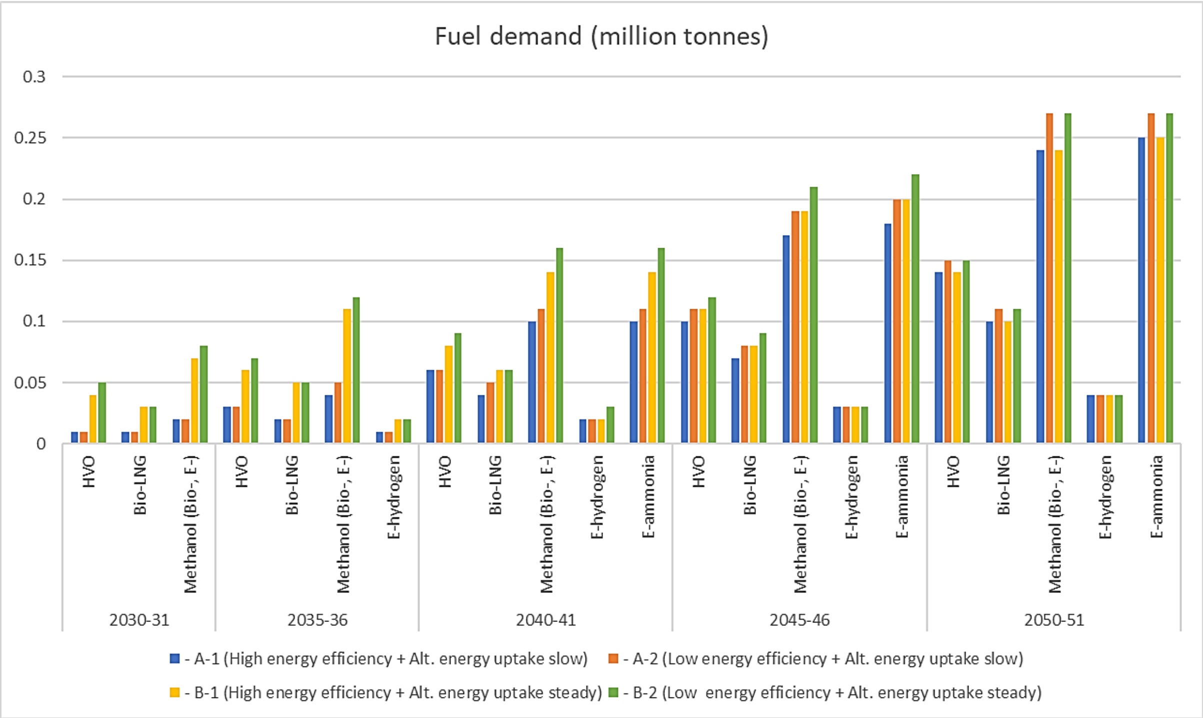
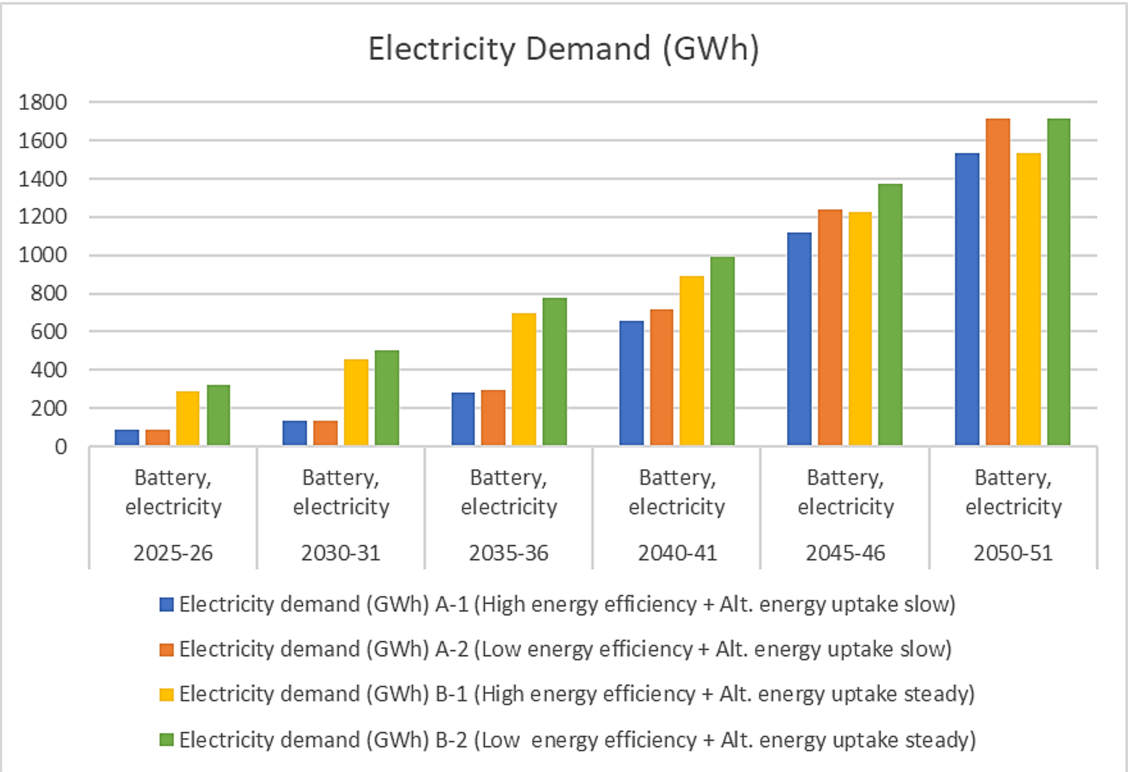


Figure 10: Electricity Demand According to Different Projected Scenarios



In 2030-31, across all pathways, the maximum demand for electricity, HVO, Bio-LNG, and methanol is projected to be 960 GWh, 0.09 Mt, 0.06 Mt, and 0.15 Mt respectively. In the fiscal year 2050-51, the maximum demand for electricity, HVO, Bio-LNG, e-methanol, and e-hydrogen will be 2057 GWh, 0.18 Mt, 0.13 Mt, 0.32 Mt, and 0.05 Mt respectively. This highlights the key role of green electricity in the grid, and that future energy sources will increase competition for green electrons. It is likely that Australia's future hydrogen and e-ammonia production capacity may meet the demands for alternative maritime energy sources estimated, considering the current investment projects mentioned above. It is important to note, that some projects of hydrogen and its derivatives are targeting export markets exclusively and this may impact the domestic supply. The analysis also suggests there may be supply challenges for biofuels and methanol, due to limited planned projects, and the maritime sector may need to rely on imports. Domestically, other industries, including land transportation, and aviation will also compete for alternative energy sources.

Questions for Industry Stakeholders:

- *Do you foresee a slow, or a steady, uptake of low and zero emission energy provision in the maritime sector? What are major factors that will drive demand for alternate energy sources?*
- *Given the evidence in relation to potential shortfalls for biofuels and methanol availability, as well as competition from other sectors, what impact is this likely to have on energy source prices into the future?*
- *How can the Australian Government support the timely adoption of alternative fuels in the domestic maritime sector?*