Richard Rischbieth Churchill Fellowship to Research

Global Best Practice Zero-Carbon Shipping Technologies and Business Models

Andrew Dickson

2024 Churchill Fellow

Source: www.shipmap.org

THE WINSTON CHURCHILL MEMORIAL TRUST

Report by Andrew Dickson, Churchill Fellow

2024 Churchill Fellowship

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Signed Andrew Dickson

Date 12 / 11 / 2025

ITINERARY

Visual itinerary

Visual itinerary (Source)

Itinerary

Date of Visit	Place	Meetings with
6 June 2025	Singapore	Global Centre for Maritime Decarbonisation
10-12 June 2025	London, UK	International Maritime Organisation, University College London, Anemoi Marine, Eastern Pacific Shipping, Clarksons
13 June 2025	Portsmouth, UK	BAR Technologies
16-17 June 2025	Gothenburg, Sweden	Personal travel to attend the EVS38 Electric Vehicle (EV) Conference
19-20 June 2025	Saint-Nazaire, France	Wind For Goods Conference, Neoline, International Windship Association, Association Wind Ship
23 June 2025	Lorient, France	Zéphyr & Borée, Windcoop
26 June 2025	Le Havre, France	TOWT (French shipping company)
30 June 2025	Marseilles, France	CMA CGM (French shipping company)
2 July 2025	Amsterdam and Rotterdam, Netherlands	Port of Rotterdam

4-7 July 2025	Utrecht, Netherlands	Personal travel to visit bidirectional EV charging infrastructure in Utrecht
8 July 2025	Leer, Germany	University of Applied Sciences Emden-Leer
11 Jul 2025	Copenhagen, Denmark	Knud E Hansen
18-26 July 2025	Marshall Islands	GIZ; Marshall Islands Shipping Company; Australian Embassy; National Energy Office, Ministry of Environment; Waan Aelon in Majel (WAM); SV *Juren Ae*; Ministry of Transportation, Communications and Information Technology

Table 1: Meetings during my trip

Meetings prior to my trip

Date	Meeting with
19 March 2024	Martina Reche-Milanova, PhD student, Technical University of Denmark
21 October 2024	Bryan Comer, The International Council on Clean Transportation
10 December 2024	Greg Johnston, Advanced Wing Systems
17 December 2024	Australian Maritime Safety Authority (AMSA)
9 March 2025	Angas Macdonald, Maritime Emissions Reduction Coalition (MERC)
12 March 2025	Blue Wasp Marine
25-26 March 2025	Wind Propulsion Asia Summit, Singapore
4 April 2025	Michael Vahs, University of Applied Sciences Emden-Leer
26 May 2025	Ambassador Ishoda, Ambassador of the Republic of the Marshall Islands to the Republic of Korea

Table 2: Meetings prior to my trip

Meetings after my trip

Date	Meeting with
30 July 2025	Smart Green Shipping
16 September 2025	Australian Department of Foreign Affairs and Trade
8 October 2025	Pete Nuttall, Micronesian Centre for Sustainable Transport

15 Oct 2025	Australian Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts
Various	Multiple follow up meetings with, and introductions between, stakeholders I met through my Churchill Fellowship

Table 3: Meetings after my trip

ACKNOWLEDGEMENTS

"It takes a village."

My Churchill Fellowship has involved rich collaboration and support from a very wide range of people including **Henry Rischbieth** (CF 2000) and family, who generously sponsored my Churchill Fellowship in the name of the late Dr Richard Rischbieth; my family for their support during my long absence; **Taryn Lane** (CF 2016) and **Deirdre Cooke** (CF 2012) for their encouragement and advice during my application process; my friends **Anke** and **Jill** for accompanying me in northwest France and Copenhagen respectively; **Derek Ellard** from GoSailCargo, an outstanding boat designer who has devoted many years to wind powered cargo ships; **Gavin Allwright** from the International Windship Association for advice, contacts and tireless leadership and advocacy; and **Michael Vawser** and **Bridget O'Donnell** for letting me stay onboard their canal boat on the Thames in London (and Michael, for giving me my first break into renewable energy in 2004). Thanks also to the South Australian selection committee for the Winston Churchill Trust, and the 2024 South Australian cohort.

In chronological order of my itinerary, people who met with me or who helped to arrange meetings included:

Australia: Derek Ellard (Go Sail Cargo), Greg Johnston (Advanced Wing Systems), Dan Lack (former NOAA maritime decarbonisation expert), Angus & Christine McDonald (Maritime Emissions Reduction Coalition), Kenneth Goh (Knud E Hansen); and Darryl Evans and Vlad Jotic (CMA CGM).

Singapore: Vaughan English and Joey Ng (Braemar), Sanjay Kuttan and Grace Lian (Global Center for Maritime Decarbonisation).

England: Camille Bourgeon (International Maritime Organisation); Professor Tristan Smith (University College London); Baiqian Jiang and Sai Mannem (Anemoi Marine), Mirtcho Spassov (Eastern Pacific Shipping); Giles Lane (Clarksons); and John Cooper, Yıldız Saraç Williams and Oliwia Gałecka (BAR Technologies).

France: Lise Detrimont (Association Windship); Jean Zanuttini (Neoline); Guillaume Le Grand and Diana Mesa (TOWT); Victor Depoers (Zéphyr & Borée); Erwan Gambert (Windcoop); Cesar Hardelay, Remi Menard and Chan Nyein (CMA CGM).

The Netherlands: Martijn Coopman (The Port of Rotterdam), Giovanni Bordogna (Blue Wasp Marine), Frank Nieuwenhuis (Econowind).

Germany: Michael Vahs, Henrik Richter-Alten and Siegfried Wagner (Hochschule Emden/Leer University of Applied Sciences); Peter Schenzle (Indosail).

Denmark: Martina Reche-Vilanova (DTU - Technical University of Denmark), Jesper Kanstrup (Knud E Hansen).

Marshall Islands: Pete Nuttall (Micronesian Center for Sustainable Transport); Raffael Held, Marie Goss and Geovannie Johnson (GIZ); Ambassador Albon Ishoda (RMI Ambassador to South Korea); Alson Kelen (WAM); Danny Wase (Marshall Islands Shipping Company); and Phil Philippo (Secretary, Ministry of Transportation, Communications and Information Technology).

EXECUTIVE SUMMARY

> *"Sometimes the best discoveries are rediscoveries. We have a green, efficient, cost-effective solution ready to help the industry meet its goals now. We have to realise that there's no need to reinvent the wheel. We can look back to go forwards, rediscovering the huge potential of wind. Let's keep it simple. It's time to set sail."*
>
> **Bertrand Charrier**, who worked with Jacques Cousteau four decades ago on the development of a the suction sail (Source)

The global shipping sector is the backbone of international commerce, and yet it is largely out of sight and out of mind for most people.

It is a sector which has transformed dramatically in the last century, in terms of the size and number of ships it employs, the volume of goods it transports, the technologies it uses to standardise cargo handling and to facilitate inter-modal transfer of this cargo, the energy it uses for ship propulsion, the technologies it has adopted to increase safety for mariners, and the connection of bodies of water via canals to reduce shipping distances and timeframes.

Global shipping moves over **80% of the world's merchandise trade by volume**. As of 1 January 2024, the world merchant fleet comprised around **109,000** propelled seagoing vessels of at least 100 gross tons (GT), with a total carrying capacity of about **2.35–2.4 billion deadweight tonnes** (UNCTAD, *Review of Maritime Transport 2024*). Fleet statistics using a higher size threshold (300 GT and above) show on the order of **60,000** merchant ships worldwide (ISL, 2024).

Shipping fuels are cheap but are highly polluting. They are essentially the thick sludge at the bottom of the barrel of the oil refining process. The shipping sector consumes around **300 million tonnes of fuel** per year, which emits around **1 billion tonnes of CO2** per year.

If the shipping sector was a country, it would emit more greenhouse gases than Germany and more than double those of Australia. And on a business-as-usual trajectory, shipping emissions are projected by the IMO to rise 20–40% by 2050.

Notably, **about a third of all shipping (by volume) is involved with transporting energy** commodities in the form of crude oil, refined petroleum products, liquefied natural gas (LNG), liquefied petroleum gas (LPG), and coal. **This makes the shipping of energy the largest single category in global seaborne trade, ahead of bulk agricultural goods or containerised cargo.**

The dominance of fossil-energy transport means that shipping is deeply intertwined with the fossil fuel economy, both as an **enabler** and as a **consumer**. Decarbonising shipping thus means tackling both the **fuel <u>used</u> by ships**, and **fuels <u>transported</u> by ships.** Even if ships become carbon-free, the sector's role as the **carrier of fossil energy** will continue to link it to global emissions until energy trade patterns shift. Clearly, if the world is to address serious climate change, it needs to decarbonise shipping and reduce its consumption of fossil fuels.

Decarbonisation pathways include **alternative fuels** such as methanol, ammonia, biofuels and LNG, each of which has issues which limit the ability to scale, or to be affordable to shipowners on tight commercial margins, or to contain enough emissions; and **operational measures** such as slower steaming for lower fuel consumption; greater use of shore based power to replace onboard generators whilst in port; and for smaller coastal vessels, electric propulsion and batteries or fuel cells.

And then there is the wind. **Wind assisted ship propulsion** (WASP) is rapidly emerging as **one of the few mature, immediately deployable tools** to get the maritime sector well into its decarbonisation journey. This is not a nostalgic nod to traditional sailing vessels of the past, but includes a proven set of modern wind propulsion technologies which are ready to scale.

WASP directly reduces energy demand, and uniquely amongst the range of decarbonisation pathways, it is both **fuel-agnostic** and **fuel-complementary.** Whichever alternative fuels are ultimately adopted, wind propulsion consistently reduces fuel demand, lowering costs and emissions simultaneously, and these energy and cost savings may well be the measure which allows shipowners to **afford** alternative fuels in the future.

Project Introduction, Description and Purpose

My Churchill Fellowship project enabled me to dive deeply into the world of wind assisted ship propulsion (WASP). I visited some of the leading WASP innovators in Europe and in the Marshall Islands over a six-week period in June-July 2025, including WASP technology developers, shipping companies, naval architects, researchers, peak bodies, ports and the International Maritime Organisation.

I gained a broad understanding of the state of technology, the rate of deployment and the adoption drivers and barriers.

Current awareness and understanding of WASP in Australia is low: Australia is well away from the main centres of WASP innovation, and yet shipping and decarbonisation are profoundly important to Australia:

- Australia is located relatively far away from its key trading partners. Over 99% of Australia's international trade by volume moves by sea, and roughly four-fifths of its international trade by value (79–80%).
- The Australian continent and its 60,000km of coastline will be heavily impacted by climate change.

With the knowledge and networks I have developed during my Fellowship, I can raise awareness about the potential of wind assisted shipping and can connect Australian maritime innovators to potential partners and customers.

And given the growing imperative for Australia to deepen its relationships with its Pacific neighbours, I can assist Australia to shape meaningful contributions to Pacific nations who are existentially threatened by rising sea levels, and who have already started adopting wind powered ships in their own domestic shipping fleets.

"*Nothing is more powerful than an idea whose time has come*."

Paraphrasing **Victor Hugo** (Source)

Intended Audience

Maritime sustainability innovators in Australia and beyond

Australian Government officials, particularly those focussed on the maritime sector, decarbonisation and Pacific relations

Non-Government Organisations committed to sustainability and decarbonisation

Conclusions and Recommendations

There is much that Australia can do to embrace wind assisted ship propulsion as a key pillar of maritime decarbonisation:

1. It could provide **funding** for additional vessels in the Pacific, either as design and procurement of a new vessel(s) or the charter of an existing vessel:
    - It could deliver **bilaterial funding** to Pacific countries who seek to reduce their imported fossil fuels and improve their balance of trade by replacing conventional domestic ships with wind assisted ships, as the Republic of the Marshall Islands has done with German Government funding assistance since 2017.
    - It could contribute towards **multilateral funding** for new Pacific wind-powered cargo ships and capacity building:
        - One multilateral funding possibility is to partner with countries like France, Germany or Japan, who are wind assisted shipping pioneers, who have WASP technologies ready to deploy, and have existing Pacific interests and relevant decarbonisation programs.
        - Another multilateral funding possibility is through a proposed bid to the Green Climate Fund for a fleet of up to 10 wind assisted ships for the Pacific, with co-financing and in-kind contributions from a variety of government and non-government funders.

2. It could deliver **training** to Pacific nation mariners using Australian vocational training providers such as the Australian Maritime College and TAFE Queensland. The latter already delivers training for crews of the patrol boats donated by Australia through the Pacific Maritime Security Program, which is a great foundation to expand from.

3. It could **support Australian WASP innovators** to bring their products to market, particularly given their apparent suitability in the Pacific and the successful precedent of France in pursuing such economic development opportunities with wind assisted shipping.

4. It should **remain steadfast** in its support for the decarbonisation policies of the International Maritime Organisation, consistent with its own domestic decarbonisation targets and policies.

5. It could support other (non-WASP) maritime decarbonisation opportunities including:

    - **Electrifying outboard motors** in the Pacific, to replace expensive imported fuels with electric outboard motors and swappable batteries which are recharged using solar panels,
    - Supporting the adoption of **kit-based small vessels** in the Pacific, to speed up the construction and deployment of efficient wind and electric powered small vessels for everyday use, and
    - **Electrifying Australian ferries**, to extend transport electrification in Australia to the domestic maritime sector and to develop capabilities which can be commercialised in the Asia Pacific region and beyond.

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INTRODUCTION

For the last 21 years I've been working to harness renewable energy to reduce emissions and combat the serious issue of climate change. I've developed on-grid wind and solar farms, and most recently, export-oriented wind and solar farms which would produce renewable hydrogen to help **decarbonise hard-to-abate sectors including shipping** and steelmaking.

Despite their promise in theory, renewable hydrogen projects face significant commercial challenges, particularly when there is no universal price on carbon. By way of illustration, to replace one tonne of heavy fuel oil with ammonia (a leading contender as an alternative shipping fuel) would require over 2.1 tons of ammonia for equivalent calorific value. The ammonia will be 3 or 4 times the cost per tonne than conventional fuel, especially if it is produced using renewable energy. The new fuel bill would therefore be around **8 times more expensive**. And in addition to the cost, the supply chains required to produce, distribute and bunker the new fuels will be complex and will take a long time to scale.

Low carbon fuels are needed, but there are better ways to start decarbonising shipping.

In 2022 I discovered the nascent world of modern wind assisted ship propulsion, and my curiosity was piqued. I grew up racing sailboats, I was in the Royal Australian Navy for 10 years and I've been a renewable energy project developer for over 20 years, so **I know the power of the wind**.

I was extremely fortunate to undertake a Churchill Fellowship to dive deeply into the world of WASP, which gave me the opportunity to meet some of the leading innovators in this field. I spent 5 weeks in Europe and 9 days in the Marshall Islands and came home with a much deeper understanding of the opportunities and challenges which WASP pioneers face.

In contrast to alternative fuels, **wind energy is available everywhere, is available today, is available at the point of use (so no fuel supply chains are needed) and with zero fuel cost**. And as I discovered on my Churchill Fellowship, **WASP can readily save 10-20% of shipping fuel costs and emissions** on many ships, and in some cases, much more than that.

This report does not seek to become an authoritative reference on WASP, but to provide a broad overview and then to focus on the questions: "**How can I contribute to it? And how can Australia?**"

KEY WORDS AND ACRONYMS

Key Words

wind propulsion, wind assisted ship propulsion, wind assisted propulsion systems, maritime decarbonisation, shipping, sail cargo

Acronyms

CII	carbon Intensity Indicator
CH_4	methane
CO_2	carbon dioxide
DWT	dead weight tonnes
EEXI	Energy Efficiency Existing Ship Index
EU	European Union
EU-ETS	EU Emissions Trading Scheme
GFI	GHG Fuel Intensity standard
GHG	greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Corporation for International Cooperation)
GT	gross tonnes
IEA	International Energy Agency
IMO	International Maritime Organisation
IWSA	International Wind Ship Association
MEPC	Marine Environment Protection Committee
LNG	liquid natural gas
LPG	liquid petroleum gas
NO_x	nitrogen oxides
SO_x	sulphur oxides
RMI	Republic of the Marshall Islands
TEU	twenty-foot equivalent units
WAM	Waan Aelõñ in Majel (Canoes of the Marshall Islands)
WAPS	wind assisted propulsion system
WASP	wind assisted ship propulsion

Overview of the Global Shipping Sector

The global shipping sector is the backbone of international commerce, and yet it is largely out of sight and out of mind for most people.

It is a sector which has transformed dramatically in the last century, in terms of the size and number of ships it employs, the volume of goods it transports, the technologies it uses to standardise cargo handling and to facilitate inter-modal transfer of this cargo, the energy it uses for ship propulsion, the technologies it has adopted to increase safety for mariners, and the connection of bodies of water via canals to reduce shipping distances and timeframes.

Around 80–90% of world merchandise trade (by weight) travels by sea. The global merchant fleet reached 112,500 vessels with 2.44 billion deadweight tonnes (DWT) in January 2025. (*UN Trade & Development*). This fleet consists of many different types and sizes of vessels which carry many different types of cargo, as follows:

Oil tankers

Figure 1: Crude oil tanker (Source: Wikimedia Commons)

Oil tankers carry oil products including unrefined crude oil and refined oil products. **Crude oil tankers** move large quantities of unrefined crude oil from the point of extraction to refineries. **Product tankers**, generally much smaller, are designed to move refined products from refineries to points near consuming markets.

Oil tankers are segregated into a variety of size categories, shown in Table 4.

Class	Size in DWT
Product tanker	10,000 - 60,000
Panamax / Medium Range tanker	60,000 – 80,000
Aframax / LR1 (Long Range 1)	80,000 – 120,000
Suezmax / LR2 (Long Range 2)	120,000 – 200,000
VLCC (Very Large Crude Carrier)	200,000 – 320,000
ULCC (Ultra Large Crude Carrier)	320,000 – 550,000

Table 4: Oil tanker classes

Bulk carriers

Figure 2: Handymax bulk carrier
(Source: Wikimedia Commons)

Bulk carriers are specially designed to transport unpackaged bulk cargo, such as grain, coal, ore, forest products, steel coils or cement in their cargo holds.

As with oil tankers, bulk carriers are segregated into a variety of size categories, routes and ports, as shown in Table 5.

Class	Size in DWT	Typical use / routes
Small / Mini Bulk Carrier	up to 10,000	Short-sea trades, river/coastal routes, small ports with limited draft
Handysize	10,000 - 39,999	General dry bulk (grain, coal, fertilizers), flexible for smaller ports, self-geared
Handy / Handymax	40,000 - 49,999	Similar cargoes but more volume; can still access mid-sized ports
Supramax	50,000 - 59,999	Common modern class; self-geared with 4–5 cranes; ideal for global tramp trades
Ultramax	60,000 - 65,000	Slightly larger, efficient new-design Supramax ships
Panamax	60,000 - 79,999	Max size for old Panama Canal locks (≤32.3 m beam); coal, grain, ore
Kansarmax	80,000 – 85,000	Optimised for Port Kamsar (Guinea, bauxite exports)
Post-Panamax / Baby Cape	85,000 – 119,999	Too large for Panama Canal, smaller than Capesize
Capesize	120,000 – 200,000	Iron ore & coal on long-haul routes (Brazil/WA to China); too large for Panama/Suez
Newcastlemax	200,000 – 210,000	Max size for Newcastle coal terminals; very common in coal trade
Very Large Ore Carriers (VLOC)	200,000 – 320,000	Long-haul iron ore (e.g. Brazil–China); often chartered by Vale or BHP
Ultra Large Ore Carriers (ULOC)	> 320,000	Vale's *Valemax* class; among the largest ships ever built

Table 5: Bulk carrier classes

Note: **DWT (Deadweight Tonnage)** = total carrying capacity (cargo + fuel + stores + ballast + crew, etc.), not just cargo. **Cargo tonnage** is typically ~85–90% of DWT for bulk carriers.

Container ships

In contrast to bulk carriers, which transport unpackaged goods, container ships transport goods in standardised containers, which dramatically simplify cargo handling and allow inter-modal transfers of cargo between ships, trucks, trains and barges. **Container ships carry about 90% of the world's seagoing non-bulk cargo**.

Containers are standardised into two lengths: 20 feet (defined as one 'twenty-foot equivalent unit' (1-TEU)) and 40 feet (two 'twenty-foot equivalent units' (2-TEU)). The capacity of each container ship is measured by the number of TEUs it can carry.

Figure 3: Container ship (Source: Wikimedia Commons)

As with oil tankers and bulk carriers, container ships are classified by their sizes and capacities, as follows:

Class	Capacity (TEU)
Small feeder	up to 1,000
Feeder	1,001 - 2,000
Feedermax	2,001 - 3,000
Panamax	3,001 - 5,100
Post Panamax	5,101 - 10,000
New Panamax (or Neopanamax)	10,000 - 14,500
Ultra Large Container Vessel (ULCV)	14,501 and higher

Table 6: Container ship classes

Roll-on/roll-off ships

Roll-on/roll-off (RORO or ro-ro) ships are cargo ships designed to carry wheeled cargo such as cars, motorcycles, trucks, semi-trailer trucks, buses, trailers, and railroad cars. These vehicles are typically driven on and off the ship on their own wheels.

RORO vessels have either built-in or shore-based ramps or ferry slips that allow the cargo to be efficiently rolled on and off the vessel when in port. While smaller ferries that operate across rivers and other short distances often have built-in ramps, the term RORO is generally reserved for large seagoing vessels. The ramps and doors may be located in the stern, bow, or sides, or any combination thereof.

Figure 4: Large passenger / vehicle RORO ferry
(Source: Wikimedia Commons)

Of the many different types of ROROs, two worth highlighting are RORO passenger ferries, which transport passenger vehicles as well as their passengers, and pure car carrier (PCC) or pure car/truck carriers (PCTC), which only carry new automobiles.

Figure 5: Pure Car Carrier RORO vessel
(Source: Wikimedia Commons)

Cruise ships

Cruise ships are essentially floating resort hotels, combining accommodation, dining, entertainment, and transport into one platform that follows seasonal itineraries (Caribbean, Mediterranean, Alaska, Pacific etc.) and relies heavily on port tourism economies. Modern vessels are very large (often 100–250,000 GT) with thousands of passengers and crew, so “hotel loads” (air conditioning, galleys, laundry, lighting) can rival propulsion energy, making efficiency and shore-power readiness important. The sector spans everything from small expedition ships to mega-ships; deployment is highly seasonal and sensitive to geopolitics, weather, and port capacity.

Figure 6: Cruise ship (Source: Wikimedia Commons)

Number of ships globally

The approximate number of each major type of ship listed above is as follows:

Category	Number
Oil tankers (>100GT)	11,500
Bulk carriers	13,000
Container ships	5,600
Roll on/roll off ships	1,500-1,600
Cruise ships	300

Table 7: Global numbers of key ship types

The merchant fleet reached 2.44 billion DWT in January 2025, with an average vessel age of 12.5 years by capacity. Bulk carriers (42.7%), oil tankers (28.3%), and container ships (14.0%) dominate global capacity (UNCTAD, *Review of Maritime Transport 2024*, Table II.1), with the remaining 15% including LNG/LPG carriers, chemical tankers, ferries, and offshore vessels.

Notably, **about a third of all shipping (by volume) is involved with transporting energy** commodities in the form of crude oil, refined petroleum products, liquefied natural gas (LNG), liquefied petroleum gas (LPG), and coal. **This makes the shipping of energy the largest single category in global seaborne trade, ahead of bulk agricultural goods or containerised cargo.**

The dominance of fossil-energy transport means that shipping is deeply intertwined with the fossil fuel economy, both as an **enabler** and as a **consumer**. Decarbonising shipping thus means tackling both the **fuel *used* by ships**, and **fuels *transported* by ships.** Even if ships become carbon-free, the sector's role as the *carrier of fossil energy* will continue to link it to global emissions until energy trade patterns shift.

Shipping fuels

The most common types of shipping fuel are:

- **Heavy Fuel Oil (HFO)**. This is the thick, tar-like residual oil left over after crude oil has been distilled to extract lighter fractions such as gasoline, diesel and jet fuel. It is essentially the bottom of the barrel - a dense, high-viscosity fuel composed of long hydrocarbon chains, asphaltenes, sulphur, metals, and other impurities. Because of its low cost and high energy content, HFO has long been the dominant fuel for large ocean-going ships, especially bulk carriers, tankers, and container ships. However, it burns dirty, producing high emissions of sulphur oxides (SO_x), nitrogen oxides (NO_x), particulate matter, and black carbon, as well as CO_2.
- **Very Low Sulphur Fuel Oil (VLSFO)**. This is a marine fuel with a sulphur content of no more than 0.5%, introduced to comply with the International Maritime Organization's (IMO) 2020 global sulphur cap. It was developed as a cleaner alternative to traditional HFO, which typically contained up to 3.5% sulphur before 2020. Since 2020, VLSFO has become the dominant global marine fuel, accounting for about 70–80% of total bunker sales. Ships that didn't install "scrubbers" largely switched from HFO to VLSFO to meet IMO 2020 compliance.
- **Marine Gas Oil (MGO)**. This a refined, distillate-based marine fuel similar in composition to diesel. It is much lighter, cleaner, and less viscous than HFO or VLSFO and is widely used in smaller vessels or for auxiliary engines on larger ships.
- **Liquefied Natural Gas (LNG)**. This is a low-sulphur, lower-carbon alternative marine fuel increasingly used to comply with tightening emissions rules and to begin decarbonising the shipping sector. It consists mostly of methane that has been cooled to about –162 °C, reducing its volume by roughly 600 times, so it can be stored and burned in ship engines. Whilst it has lower sulphur and CO_2 emissions than oil, methane emissions from the production, transport and storage of LNG is a significant problem, given the climate forcing characteristics of methane. Over a period of 20 years, 1 tonne of methane traps roughly 84 times more heat than 1 tonne of CO_2. Over 100 years, the effect declines to about 30 times stronger, because methane breaks down faster in the atmosphere (mostly converting into CO_2 and water). Methane's short-term impact on climate is immense - it's a "climate accelerant". LNG is not the solution for maritime decarbonisation.

In 2023, ships ≥5,000 GT reported fuel consumption of 211 million tonnes. Of this, 93.5% was conventional petroleum-based fuels (HFO, LFO, Diesel/Gasoil), and 6.5% alternative fuels such as LNG and biofuel blends.

Shipping is one of the largest single consumers of fossil fuels. The sector consumes a little over **300 million tonnes of fuel per year** (mostly oil-based), which is equivalent to roughly 5–6 million barrels of oil per day.

Shipping emissions

Global shipping makes up 2.6 - 3% of total annual greenhouse gas emissions, broken down as follows, based on latest figures from the International Maritime Organization (IMO, 2024) and the International Energy Agency (IEA, 2023).

Category	Value	% of Global Emissions	Source / Year
International shipping (IMO definition)	830 million tonnes of CO_2	2.1–2.3% of global CO_2 emissions	IMO GHG Study 2024 (data through 2022)
Domestic + international shipping combined	1.05 billion tonnes CO_2	2.6–3.0%	IEA, 2023 estimates
Including non-CO_2 (CH_4, N_2O, black carbon)	1.1 billion tonnes CO_2-eq	3% of total GHGs	IMO / IEA combined assessments

Table 8: Shipping emissions

These figures **include** international shipping (voyages between two different countries (~90% of sector emissions) and domestic shipping (voyages within one country's waters (~10%) but **exclude** fishing, military, and small inland vessels.

So, roughly **a gigatonne per year** of CO_2-equivalent emissions comes from the world's ships, which is **larger than Germany's total national emissions**, and is **more than double Australia's national emissions**.

A comparison of the emissions from the shipping sector and other sectors is as follows:

Sector	Approx. Annual CO_2-eq Emissions	% of Global Total	Comment
Electricity & heat production	13.5 Gt	36%	Largest single source; mainly coal- and gas-fired power
Industry (manufacturing & construction)	9.0 Gt	24%	Includes steel, cement, chemicals
Agriculture, forestry & land use	7.0 Gt	18%	Methane and N_2O dominate
Road transport	5.8 Gt	15%	Cars, trucks and buses
Aviation (domestic + international)	1.0 Gt	2.5%	Similar scale to shipping
Shipping (domestic + international)	1.0 Gt	2.6-3%	Roughly equal to aviation

Table 9: Comparison of shipping with other sectors

Within the transport sector, a breakdown of emissions by transport mode is as follows:

Mode	% of Transport CO_2	Notes
Road	72%	Cars, trucks
Aviation	12%	Mostly jet fuel
Shipping	10–11%	Dominated by large ocean-going vessels
Rail & others	5%	Relatively minor

Table 10: Breakdown of emissions by transport mode

Shipping emissions rose approximately 20-30% between 1990 and 2020, tracking trade growth. Projecting into the future, the IMO expects emissions could rise 20–40% by 2050 under a business-as-usual scenario.

Shipping Decarbonisation Policies, Targets & Pathways

Despite being a conservative sector with relatively tight commercial margins, the shipping sector has been relatively progressive in its efforts to decarbonise. Partly this has been driven by the peak body for shipping, partly by regional or national decarbonisation ambitions, and partly by financial and market pressures.

IMO Policies

The **International Maritime Organization** (IMO) is the United Nations' specialised agency responsible for regulating shipping on an international level, ensuring that maritime transport is safe, secure, environmentally sound, efficient and sustainable. The IMO's current decarbonisation framework is anchored in the **2023 IMO GHG Strategy** (adopted at the IMO's **Marine Environment Protection Committee (MEPC)** 80 meeting in July 2023). This sets the vision for net-zero greenhouse gas emission from the shipping sector "by or around 2050", plus indicative checkpoints to cut total annual GHGs by at least 20% (striving 30%) by 2030 and at least 70% (striving 80%) by 2040, compared with 2008 emissions. It also calls for zero/near-zero-GHG fuels/energy to supply at least 5% (striving 10%) of shipping energy by 2030.

To deliver near-term cuts, mandatory "short-term measures" entered into force on 1 January 2023: the **Energy Efficiency Existing Ship Index (EEXI)** for technical efficiency of existing ships, and the **Carbon Intensity Indicator (CII)**, which rates annual operational efficiency. Persistently poor performance triggers a corrective action plan that must be submitted and implemented to improve efficiency. CII results are reported to the IMO each year.

For the medium term, IMO Members are developing a "basket" of measures comprising a **goal-based marine fuel standard** (phasing down fuels' well-to-wake GHG intensity) and an **economic element** (a pricing/levy or similar incentive). MEPC 81 advanced the technical and economic architecture.

In April 2025, MEPC 83 approved draft provisions (collectively called the **Net-Zero Framework**) to start achieving achieve this, which were a groundbreaking if cautious step forward in shipping decarbonisation, combining **fuel intensity standards** with a **global carbon pricing and trading mechanism**; introducing a **Net-Zero Fund** to finance cleaner fuels and support developing nations; and strengthening existing short-term efficiency measures and introducing broader environmental initiatives.

Though seen as historic progress, the MEPC 83 outcomes are **regarded more as a victory for multilateralism than for the environment**, and in its proposed form wouldn't achieve the IMO's target of GHG emissions reductions from shipping of 20–30% by 2030, and net-zero "by or around" 2050.

The situation became much worse between 14 and 17 October 2025, when the MEPC measures were due to be ratified at a scheduled Extraordinary Session (MEPC83-ES) at the IMO headquarters in London. After filibustering, heavy lobbying and threats by several member states, which sought to prevent maritime decarbonisation, a vote on MEPC83's Net-Zero Framework measures was deferred by 12 months and the meeting was adjourned without agreement.

Regional Policies

The European Union's Emissions Trading System (ETS) has achieved significant maritime decarbonisation impact.

The EU's twin measures, **EU ETS for maritime (from 2024)** and **FuelEU Maritime (from 2025),** push decarbonisation from two angles: a **carbon price** and a **fuel standard**. Under the ETS, cargo and passenger ships ≥5,000 GT pay for verified emissions on 100% of intra-European Economic Area (EEA) voyages and port calls and 50% of extra-EEA legs, phased in as 40% of emissions in 2024, 70% in 2025, and 100% in 2026. Coverage expands to offshore ships in 2027. Practically, this puts a cost on CO_2 and rewards slower steaming, better routing, and cleaner fuels on EU-linked trades.

FuelEU Maritime complements the ETS by ratcheting down the "well-to-wake" GHG intensity of energy used on board, starting with a 2% reduction vs. a 2020 baseline in 2025, 6% by 2030, and then accelerating toward 80% by 2050. It applies to 100% of energy on intra-EEA voyages/port calls and 50% on extra-EEA legs, and builds in flexibility via banking, borrowing and pooling across ships. FuelEU also drives shore-power/zero-emission at berth: from 2030, container and passenger ships >5,000 GT must achieve zero emissions at berth in specified EU ports (typically via OPS).

Together, ETS (price signal) and FuelEU (performance standard) are reshaping EU shipping routes' economics toward efficiency upgrades, shore-power readiness, uptake of low carbon fuels, and a strong driver for the adoption of Wind Assisted Ship Propulsion.

After the deferred outcome of MEPC83 in October 2025 (see above), regional measures such as those in the EU-ETS provide a continued basis for maritime decarbonisation, at least in part, whilst global measures continue to be negotiated.

Financial and market pressure

The **Poseidon Principles** (for ship finance and marine insurance) and the **Sea Cargo Charter** (for cargo owners/charterers) push decarbonisation by hard-wiring climate alignment into money and contracts. Signatories commit to measure, disclose, and benchmark the greenhouse gas performance of their loan books, insured fleets, or chartered voyages against IMO-aligned trajectories, using standardized carbon-intensity metrics from verified fuel and distance data.

Annual public scorecards create reputational and competitive pressure, while portfolio targets and "climate alignment" clauses steer capital and cargo toward more efficient ships, cleaner fuels, and transparent data-sharing. In practice, these frameworks influence lending terms, insurance appetite, and chartering decisions (e.g. engine and fuel choice, implementation of WASP systems), accelerating the adoption of technical upgrades and operational measures and helping to price transition risk across the maritime value chain.

Decarbonisation Pathways

Given the huge variety of ship types, sizes and routes, there is no silver bullet for maritime decarbonisation. No one technology or energy source works equally well in all use cases. Instead, maritime decarbonisation requires a combination of approaches.

Operational efficiency measures

Operational measures can cut maritime emissions quickly and cheaply by squeezing more efficiency from existing ships and voyages.

The biggest lever is **speed optimisation**: using weather-, current- and congestion-aware routing to avoid heavy seas and arrive "just in time," so engines run at lower, steadier loads without idle time at anchor.

Voyage and port-call optimisation integrate estimated times of arrival with berth readiness, reducing waiting, auxiliary use, and unnecessary manoeuvring. Onboard, digital twins and energy-management systems help crews fine-tune trim, ballast, and engine speeds, while continuous hull and propeller performance monitoring triggers timely cleaning and low-friction coating schedules.

Engine measures like power limitation, adaptive autopilot, shaft-generator use, and smarter hotel-load management (air conditioning, lighting) further reduce fuel use. Better cargo planning and stowage, along with crew training and feedback loops, lock in gains, typically delivering meaningful, scalable emissions cuts across fleets without waiting for new fuels or major retrofits.

Shore power and port optimisation

Shore power and port optimisation cut emissions by tackling time and energy use at berth and on approach. High voltage shore connection lets ships shut down auxiliaries and plug into the grid via standardized high voltage gear and frequency conversion, eliminating NO_x, SO_x, PM, and most CO_2 at berth, especially impactful where grid power emissions intensity is low.

Ports amplify the benefit with smart berth planning and "just-in-time" arrivals so vessels slow-steam instead of queuing, then turn around faster through integrated terminal systems that coordinate pilots, tugs, gangs, bunkering, and inspections. Digital port call platforms and real-time slot management shorten idle time and reduce manoeuvring, while demand-response tariffs and green-berth incentives nudge ships to connect early and stay connected.

Together, renewable grid power plus tighter port logistics reduce fuel burn, cut local air pollution, and improve schedule reliability without waiting on new ship designs.

Technical retrofits

Technical refits can target the hydrodynamic and mechanical inefficiencies that waste fuel. Advanced low-friction hull coatings and proactive hull cleaning reduce roughness and biofouling, cutting resistance across the speed range. Propeller upgrades, higher-efficiency profiles, larger diameter at lower rpm wake-conditioning devices (e.g., ducts, fins) that straighten propeller inflow, raise open-water efficiency and recover rotational losses. Air-lubrication systems inject micro-bubbles along the flat bottom of the hull to lower skin-friction drag, with best results on beamy ships running steady routes. Together with fairing/bulb tweaks and shaft-line improvements, these refits can deliver material, persistent fuel and CO_2 savings, often in the mid-single to low-double-digit range depending on baseline condition, trading pattern, and follow-through on maintenance.

Electrification and hybrid systems

Ship electrification (replacing combustion engines with electric motors and batteries or fuel cells) is already practical for smaller, short-route vessels including ferries, inland cargo, workboats, and harbour craft, where predictable duty cycles and frequent port calls suit batteries. Like electric vehicles onshore, the options offshore include both fully electric and hybrid setups.

Full-electric setups pair robust battery packs with megawatt-class shore chargers for “opportunity charging” at each port visit, delivering zero-emission, low-noise transits over tens of nautical miles.

Plug-in hybrids extend range by combining batteries with high-efficiency generators or fuel cells, using electric drive for departure/arrival and hotel loads while reserving engines for longer legs. These systems often incorporate regenerative energy capture during overspeed to charge the batteries, or use auxiliary generation, together with smart energy-management which prioritises low-rpm, high-torque efficiency. Design trade-offs (weight/space, thermal management, fire safety, and lifecycle costs) are addressed with modular packs, liquid cooling, class-approved protection, and data-driven maintenance, yielding lower operating costs and major cuts in CO_2 and local air pollutants on short-sea corridors.

Alternative fuels

Alternative fuels offer multiple decarbonisation pathways, each with trade-offs across cost, maturity, safety and well-to-wake emissions.

- **Methanol** is the quickest drop-in alternative fuel: dual-fuel engines are commercially available, fuel is liquid at ambient conditions, and green methanol can cut GHGs sharply if produced from renewable hydrogen and biogenic/CO_2 feedstock—though tank volumes rise and NO_x control is still needed.
- **Ammonia** is a promising long-term alternative fuel: it contains no carbon, it can be produced from a low carbon renewable energy pathway or from steam methane reforming (which does emit carbon), and dual fuel ammonia engines and fuel cells are becoming commercially available. On the other hand, ammonia has toxicity issues which need to be managed carefully, upstream green ammonia supply is currently very limited, and emissions of NO_x and N_2O (which are both greenhouse gases) must be tightly managed.
- **Hydrogen** enables true zero-carbon operation via fuel cells or combustion engines. but volumetric energy density is poor (compressed/cryogenic tanks) which causes space and range penalties for ships. If hydrogen is adopted as an alternative fuel (energy source), it would likely be in smaller ships or as a methanol/ammonia precursor. But supply cost will be an ongoing challenge, especially if it is produced using renewable electricity.
- **LNG** cuts SO_x and particulate matter and can reduce CO_2 compared with oil fuels, yet “methane slip” (the release of methane during LNG production, transport and storage) can erode its climate benefits. Synthetic methane can improve this methane slip.
- **Biofuels** are near drop-in for existing engines and infrastructure, but sustainability, availability and cold-flow limits vary; certification and feedstock scrutiny are essential.

Wind Assisted Ship Propulsion

Through the continued advocacy of the International Windship Association (IWSA) and its members, the true value of wind-assist is being articulated and better understood by shipping stakeholders, and policy measures are broadening thinking from a **fuel-centric** approach to an **energy-centric** approach.

Wind is not a fuel and is not an energy efficiency measure, but it is instead a form of propulsive energy which is available at point of use, is available more-or-less everywhere, is available now, and with zero fuel cost. It can be deployed quickly and can be retrofitted onto existing ships or deployed onto newbuild ships, it requires no fuel handling systems, no fuel storage tanks which reduce cargo volume, and can be controlled by computers and require minimal crew intervention or training.

Wind-assist also directly reduces energy demand, and, uniquely amongst the range of decarbonisation pathways, it is **fuel-agnostic** and **fuel-complementary.** Whichever alternative fuels are adopted, wind propulsion consistently reduces fuel demand, lowering costs and emissions simultaneously. These energy savings and cost savings may well be the measure which allows shipowners to **afford** alternative fuels, which will be significantly more expensive than conventional shipping fuels.

In the EU-ETS, wind assisted ship propulsion (WASP) is supported in two reinforcing ways. First, by **pricing CO_2 on EU-linked voyages**, it turns every tonne of fuel saved by wind into **fewer EU allowances (EUAs) which must be bought and surrendered**. Second, ETS revenues finance the **EU's Innovation Fund**, which awards grants to scale clean maritime technologies, including projects that combine **wind propulsion.** These measures are a key enabler for the European WASP innovation I visited during my Churchill Fellowship, and which are described below.

At the IMO level, whilst the proposed MEPC 83 measures did not issue a "wind-propulsion clause" which explicitly favours WASP, they tightened efficiency rules and proposed a carbon price, effectively rewarding WASP installations.

WASP now carries greater compliance value and financial savings, positioning it as **one of the few mature, immediately deployable tools** to meet the regional and global maritime decarbonisation frameworks.

Wind Assisted Ship Propulsion (WASP)

History

Figure 7: Cutty Sark (Source: Wikipedia)

Until just over 100 years ago, wind power was effectively the only energy source available to power large commercial ships.

Wind power was effective, but it lacked the convenience and safety of modern ships. This was only partly to do with sails, however. The lack of radio communication, accurate weather forecasting and safety technologies, plus the use of wooden hulls, oil lamps and a workforce which was unregulated and often underage, contributed a lot to the danger and unpredictable voyage times that we still mentally associate with wind powered ships of old.

Coal and oil became the dominant forms of energy for the shipping sector just over a century ago, as they did for so many different sectors, including power generation. The change was rapid: fossil fuels reduced the number of crew required to operate ships, they allowed ships to operate on more predictable schedules, and they allowed the size and cargo capacity to grow dramatically. By the end of the First World War, wind-powered commercial ships were virtually extinct.

Figure 8: Tres Hombres (Source: Wikimedia Commons)

Several old sail powered cargo ships have remained in service since the demise of mainstream sail cargo ships, such as those operated by Fairtransport including Tres Hombres. But these are very much the exception.

Sailing technologies have improved greatly in recent years, partly due to the innovation in offshore yacht racing and the America's Cup. Experience and technology from competitive sailing has laid the foundation for modern wind assisted ship propulsion systems.

WASP Technologies

The first mental image I had when learning about WASP was of spinning wind turbines mounted on the decks of ships, and I've since discovered that many people have that same initial mental image. But the reality is quite different. WASP technologies don't generate electricity to power electric motors, but instead they create aerodynamic lift to propel ships forwards, reducing the need for propulsion from the engines, thereby reducing fuel consumption.

There are many different types of WASP technology, each with their own applications, strengths and limitations, as introduced below.

Soft sails

These are the nearest modern equivalent to traditional canvas sails but are shaped and operated in new ways. There are a variety of soft sail WASP technologies, from traditional and modern "gaff rigs" to Bermudan rigs and Indosail rigs. These types of sails have been used on small and large boats for centuries and have the great benefits of being low-tech and easy to maintain (essential if operating in remote locations) and most mariners and sailors are very experienced and familiar with their operation.

Soft sails have their downsides, however. Sail materials degrade with constant exposure to the elements (particularly to ultraviolet light), and the rigs (masts, supporting wires) cannot readily scale to the sizes needed for big commercial ships. The Bermudan-rigged vessels operated by TOWT (see below) use 52m tall carbon fibre masts which are at or near the size limit for such masts.

Figure 9: Bermudan rig (Source: TOWT)

Figure 10: Indosail rig (Source: GIZ LCST project)

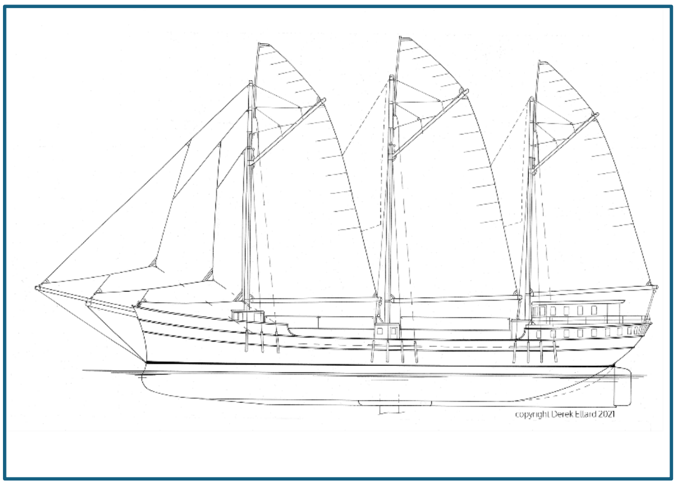

Figure 11: Modern gaff rig (Source: GoSailCargo)

Figure 12: Smart Modular Wing rig (Source: Advanced Wing Systems)

Flettner rotors

Flettner rotors make use of the Magnus effect to create lift. Rotors are tall cylinders mounted vertically, which spin along their long axis, driven by electric motors. Wind flows around the spinning cylinders and is deflected in a way which creates lift perpendicular to the direction of wind flow, as shown below. It is counterintuitive!

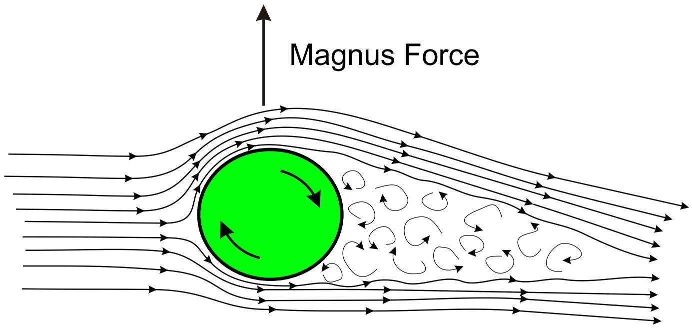

Figure 13: Magnus Effect
(Source: Wikimedia Commons)

Figure 14: Flettner rotors installed on a bulk carrier
(Source: Anemoi)

The marine potential from this phenomenon was first demonstrated by German aviation engineer Anton Flettner in the 1920s, who fitted rotors to the ship Buckau and sailed it successfully across the Atlantic in 1925.

Many companies now develop and deploy such rotors including **Anemoi Marine Technologies** (UK), **Norsepower** (Finland), **Eco Flettner** (Germany) and **Dealfeng** (China).

Solid wing sails

Figure 15: Solid wing sails (Source: BAR Technologies)

Figure 16: Solid wing sails (Source: Smart Green Shipping)

Solid wing sails are like aircraft wings with their flaps extended, mounted vertically. Two or more solid foil sections can be rotated on their long axis to create lift and propulsive force.

The wing sections are generally made of composite material, like that used to manufacture wind turbines.

Companies developing solid wing sails include **BAR Technologies** (UK), **OceanWings** (France), **Smart Green Shipping** (UK) and **GT Wings** (UK).

Suction sails

Suction sails are similar to solid wing sails, but with the addition of fans at the top of the wing section to suck air upwards through the wing structure and reduce delamination of airflow on the leeward (downwind) side of the sail, to maximise lift.

Companies developing suction sails include **bound4blue** (Spain) and **Econowind** (Netherlands).

Figure 17: Suction sail (**Source**: bound4blue)

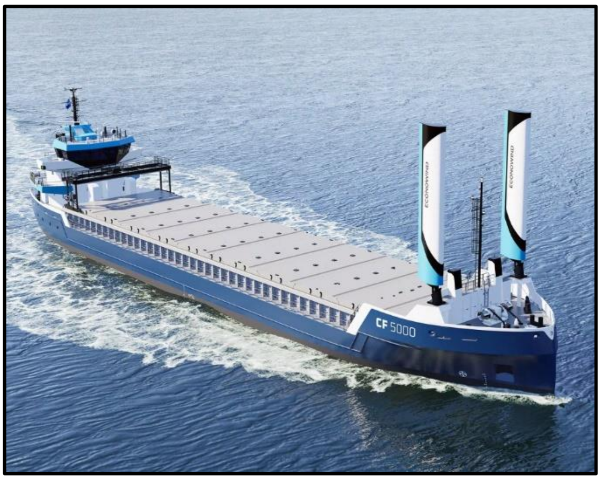

Figure 18: Suction sail (Source: Econowind)

Kites

Figure 19: Kite (Source: Wikimedia Commons)

Kites are soft aerofoils which can be flown above a ship, controlled with cables and winches. Whilst they can provide excellent performance downwind, they become ineffective at other points of sail and have the risk of becoming fouled on ship hardware. For these reasons, kite systems have struggled with commercial adoption.

Several companies have developed marine kite systems including **Airseas**, **Beyond the Sea**, **CargoKite** and **Kite Dynamics**.

SolidSail

A unique and relatively new type of sail is the SolidSail from the French shipyard company Chantiers De L'Atlantique. This is full rig (main sail and jib) mounted on a symmetric boom and a carbon mast, all of which can rotate 360° to adjust to different wind angles. The sails are solid rectangular fibreglass panels with carbon frames, which can be 'flaked' (folded) down onto the boom structure when not in use. This system can be integrated into a ship hull and ship operations relatively easily.

Figure 20: SolidSail demonstrator (Source: BoatIndustry)

Two newbuild ships with SolidSails are worth highlighting: *Neoliner Origin* (a 136m Roll-on/Roll-off ship which was commissioned in Nantes, France on 13 October 2025 – see below), and the *Orient Express Corinthian*, a luxury cruise ship currently being fitted out in Saint-Nazaire, France.

SolidSails is the arguably the newest form of WASP technology for the maritime sector. It will be interesting to observe their real-world performance and their durability.

DynaRig

Figure 21: Dynarig (Source: North Windships)

Another unique sail, which is a modern version of regular square rigs of old, is the DynaRig from North Windships. It is based on 1960s designs from the German engineer Wilhelm Prölß and has the appearance of the rigging of a 19th-century clipper ship, but with curved yards (horizontal spars) which give it solid upwind performance as well as downwind performance.

Currently, DynaRigs have been installed only on large luxury yachts, but they are also incorporated into designs for new wind-powered cargo ships from Canadian company Veer.

WASP performance

As shown above, there is a lot of variety in types of wind-assisted ship propulsion technologies. Some have been used on large ships and refined for centuries (soft sails), some for about a century (Flettner rotors), some for decades (kites), and others are more recent (wing sails, suction sails and SolidSails).

With a scale-up in deployment of these systems (see the **WASP Deployment Statistics** section below), the experience with operating these systems is increasing quickly, and verified data on their real-world performance is becoming available.

TOWT vessels are primarily powered by their sails, with minor backup power and port manoeuvring provided by the engines. On the Le Havre to Guadeloupe route, TOWT vessels drastically reduce greenhouse gas emissions per tonne transported and per kilometre travelled, with 90% less CO_2, 98% less sulphur oxides, 92% less nitrogen oxides and no methane. Whereas regular container ships emit approximately 20g of CO_2 per tonne per km (20 gCO_2 / t·km), TOWT vessels on this route emit as low as 1.59 gCO_2 / t.km, a reduction of 92%.

BAR Technologies' 37.5m-high **WindWings** save on average around 1.5 tonnes of fuel per day per sail, which corresponds to a CO_2 emission reduction of around 4.5 tonnes per day per sail. A typical ship will have between 2 and 4 WindWings fitted, which would result in savings of up to 6 tonnes of fuel and 18 tonnes of CO_2 per ship per day.

Union Maritime's newbuild tanker fitted with WindWings, ***Brands Hatch***, had a stunning maiden voyage in which her three WindWings sails displaced 12.8 tonnes of fuel in just 24 hours, or 4.3t per wing, equating to 13t of CO_2 avoided per WindWing per day. Sustained peak performance of over 18 tonnes per day was seen for a full 6 hours. This was achieved whilst fully laden and whilst maintaining strong sailing speeds in challenging weather. In favourable conditions, the vessel achieved more than a third of its propulsion from wind power alone, proving the ability of the WindWings to deliver not only impressive peak results but also reliable efficiency over extended periods.

Anemoi Marine's rotors achieved an average 9.1% net propulsion fuel and emissions savings, or 1.9 tonnes of fuel per day and 7.0 tonnes of CO2 per day (well-to-wake) on the Kamsarmax bulk carrier **TR Lady**. The test, analysed by Lloyd's Register Advisory, encompassed voyages in the Indian Ocean, South Atlantic, North and South Pacific, Southern Ocean and around both the Cape of Good Hope and Cape Horn, along with some of the busiest shipping routes, including the Strait of Malacca. Data from eight consecutive Laden and Ballast legs were analysed to provide the long-term average of the fuel and emissions savings.

Bound4blue's 22m eSAIL suction sails were assessed for a year of operation onboard the Ro-Ro vessel **Ville de Bordeaux**, which transports Airbus aircraft subassemblies from Europe to the United States. The average daily fuel saving was 1.7 metric tonnes, with peak savings of as much as 5.4 metric tonnes per day.

These are all very impressive results, and show that in practice, each major WASP technology can achieve significant fuel and emissions savings. Thousands of ships can have these sails retrofitted (noting that there are currently about 25,000 tankers and bulkers combined, and over 1,500 roll-on/roll-off vessels) or can be installed on newbuild ships, which gives a sense of the scale of potential decarbonisation through the adoption of WASP technologies.

WASP performance is not just due to the installed hardware, but also due to software:

- Shipping companies have long used weather routing services to avoid bad weather, ensure accurate passage times and reduce safety risks, but those services have been expanded to route vessels to optimise the performance and fuel savings from their installed WASP systems. Companies offering these services include Vaisala, ABB, and Ascenz Marorka.
- Most WASP systems are largely controlled by computers, and the algorithms, sensors and actuators used to trim (adjust) the WASP systems for varying weather conditions continue to improve.

As WASP deployments increase on newbuild ships, a variety of design changes in hull shapes are likely, to allow better sailing performance. These changes include the sizing and positioning of rudders, changes to hull shape to reduce leeway, different deck designs which improve the aerodynamic efficiency of the sails, and so on. We're in the early days of modern wind assistance technologies, and there are lots of gains to be made as wind propulsion systems are adopted, refined and scaled.

The recent Ph.D. thesis "*Wind Propulsion Systems for Commercial Ships: Modelling, Design, and Economic Optimization*" by Dr Martine Reche-Vilanova from the Technical University of Denmark gives an excellent overview of the design and optimisation considerations for modern wind assisted ship propulsion.

WASP comparison

When I was in Copenhagen, I discussed the complexities of wind assisted ship propulsion with Jesper Kanstrup, senior naval architect from a ship design firm called Knud E Hansen. I asked him the question "*Does wind assisted propulsion* *make sense for commercial ships*?" He answered: "*It can make sense, yes, but it depends on many things: vessel type, voyage routes & speeds, prevailing winds, ports, ship owner / charterer appetite and so much more*."

Whilst all WASP technologies can deliver meaningful fuel and emission reductions, they are not all universally applicable to all ships and all routes.

At one extreme, kites deliver good performance when ships are sailing downwind (in the direction of the wind), but performance quickly tapers off as the wind shifts across the beam (side of the ship).

Rotors, on the other hand, perform best when the wind is directly across the beam (perpendicular to the direction of travel), and the direction of spin of the rotors can be reversed depending on which beam the wind is across. But as the wind swings further forward towards the bow, the propulsive force from the rotors reduces and the rotors become a source of aerodynamic drag rather than aerodynamic lift.

Soft sails, suction sails and wing sails perform comparatively well upwind (with the wind between the beam and the bow), as well as downwind. They are more versatile across a variety of wind directions and speeds.

The most difficult use case for WASP technologies currently is large container ships. Container ships sail much faster (between 16 and 22 knots, typically) than tankers or bulk carriers (typically 12-14 knots), which creates extra apparent wind (headwind), which limits the choice of WASP technologies for the reasons described above. Container ships also require unimpeded deck access to allow shore-based cranes to load and unload containers, and sails would restrict this access. Finally, container ships stack containers very high above the deck level, so there are limited structural options to mount sails, unless they deploy container-based technologies such as those offered by Advanced Wing Systems. Small feeder container ships have fewer such restrictions, and designs are appearing for small container ships with WASP technologies (eg from Zéphyr & Borée), but large container ships remain difficult.

Bulk carriers and tankers, on the other hand, sail slower and have fewer loading/unloading restrictions, so it is unsurprising that most WASP installations to date are on these vessels. There are tens of thousands of such vessels suitable for WASP deployment, either as retrofits or newbuilds.

WASP deployment statistics

Currently (October 2025), **77** large merchant ships have been installed with wind propulsion systems and a further 7 are "wind-ready": awaiting or undergoing WASP installation. This corresponds to over **4.3 million DWT** of shipping.

More than **130** ship installations of wind propulsion systems are on order, most for delivery in 2025/26. By the end of 2025, there should be **100** ships installed. **The number of ships installed with WASP roughly doubles each year**.

As the sector is developing so rapidly, these pages from the International Windship Association are useful references for up-to-date WASP statistics:

- Current list of WASP-enabled vessels: https://www.wind-ship.org/vessel-list/
- Location of WASP-enabled ships: https://www.wind-ship.org/vessel-tracker/

In June 2025, at the completion of the Wind for Goods Conference in France, I interviewed Gavin Allwright (Secretary General of the International Windship Association) for an overview of the WASP sector:

Video link: https://drive.google.com/file/d/1Vwny94K6swhNbnZFYuNjTvN_YL9ZTuxR/view?usp=sharing

As Gavin describes, the UK Clean Maritime Plan (2019) and its underpinning research (Frontier Economics/UMAS/CE Delft) project that wind-assisted propulsion could be installed on **up to 40,000 ships by 2050**: about 45% of the global fleet. For nearer-term context, the Clean Maritime Plan cites EU/CE Delft scenario work in 2016-17 indicating **up to 10,700 installations by the end of 2030** (15% of the fleet, mostly bulkers and tankers and Ro-Ros). COVID has likely delayed this by around 18 months, but growth could potentially accelerate again to achieve these targets.

Issues affecting the rate of deployment of WASP include:

- **Fuel price**: When fuel prices are low, the incentive to deploy WASP is also low. As fuel prices increase or become more volatile, and as it is becoming apparent that alternative fuels will initially be very expensive, the incentive to deploy WASP increases.
- **Policy**: Strong and ambitious policies will drive demand for WASP technologies, together with other decarbonisation technologies and approaches. The main policy driver currently is the EU-ETS, whilst global policies through the IMO continue to garner disagreement.
- **Perception**: WASP is still new for many shipping stakeholders, which creates a barrier for widespread adoption. As more WASP is deployed on more ships, and as verified WASP performance is widely promulgated, this perception will change and WASP will be seen as a viable and scalable solution that is available immediately.

Beyond the number of installed or ordered WASP systems, there is clear evidence of laying down of foundations for future growth in the WASP sector:

- WASP production capacity is growing and lead times are shortening;
- the learning curves in producing, installing and operating WASP systems are driving costs down and performance and confidence up;
- WASP experience is accumulating amongst ports, ship owners and charterers, Class societies and investors;
- standardised WASP assessment approaches are being developed and agreed upon for performance validation;
- the scale of investment entering the sector is increasing, including debt financing with repayments associated with fuel savings; and
- the pipeline of new installations and WASP designs is expanding.

On a personal note, as a long-term renewable energy developer, WASP feels to me today as solar photovoltaic (PV) felt two decades ago. Deployment of solar PV started out modestly but then grew very quickly, and today over 50% of households in my home state of South Australia have solar PV systems fitted, and rooftop solar occasionally provides the entire electrical demand in South Australia. WASP deployments may follow a similar path if the policy settings are right and if shipping companies and customers act boldly to embrace the benefits that WASP can deliver them.

Featured WASP innovators

There has been a lot of quiet WASP innovation underway for the last 15 years or so, mostly in the UK and Europe (France, Germany, the Netherlands, Scandinavia and Spain). I made these countries the focus for the bulk of my Churchill Fellowship trip. The remainder of my time was in the Marshall Islands in the middle of the Pacific Ocean, where WASP innovation is also well underway and where I believe Australia's contributions can best be focussed.

Over the course of my Churchill Fellowship trip, I had the opportunity to meet some of the world's leading WASP innovators, which was a real privilege. It proved difficult to see many WASP-enabled ships unfortunately, because they were busy in commercial operation or (in Neoline's case) completing construction and commissioning. A brief description of some of these vessels and innovators follows:

BAR Technologies / WindWings

BAR Techologies emerged in 2017 from America's Cup yacht racing and Formula 1 car racing worlds, bringing deep capabilities in computational fluid dynamics and modern composite materials to the design and development of WASP systems.

Figure 22: WindWings (Source: BAR Technologies)

BAR's sail technology, called WindWings, comes in two variants:

- the original 37.5m high version (steel and composite sections with hydraulic and electric controls, with a central fixed section and movable sections fore and aft), and
- a smaller, newer 24m high version (composite only, fully electric, with a fixed section forward and two trailing sections).

WindWings have been installed on 3 vessels to date, with 12 newbuild tankers on order to be launched between 2026-2028. One of the leading shipping companies to embrace WingWings is the UK shipping company Union Maritime, which is deploying wind propulsion on a total of 34 newbuild tankers. Union Maritime has also become an investor into BAR Technologies, indicating confidence in BAR's products and in the future of the wind-assisted ship propulsion market. The outstanding performance of WindWings on the maiden voyage of Union Maritime's newbuild ship *Brands Hatch* is described elsewhere in this report.

I recorded a brief video with Oliwia from BAR Technologies at the Wind for Goods Conference in June 2025:

Video link: https://drive.google.com/file/d/1Js-V8d6H1QT7fLR6x85HNusrogxd8pdV/view

Anemoi Marine Technologies

Figure 23: Anemoi production (**Source**: Anemoi)

Anemoi Marine Technologies is a UK-based developer of Flettner rotors. 25 rotor sails from Anemoi have been installed on 13 vessels to date, with an additional 20 units on order scheduled for delivery by Q2 2026.

Anemoi has invested heavily in production facilities in China, and currently has capacity of 250 units per year, positioning it well for anticipated growth in demand for WASP systems.

Anemoi has two different sized product variants: a 5m diameter / 35m high rotor, and a 3.5m / 24m high rotor.

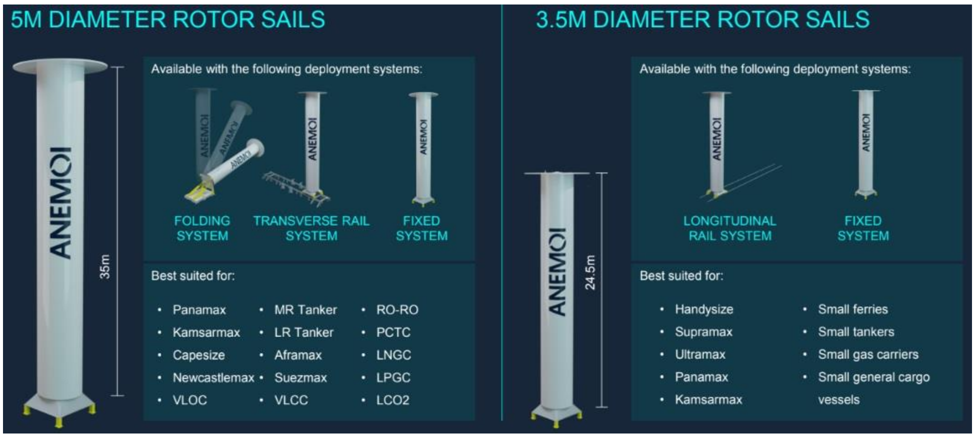

Figure 24: Anemoi product variants (**Source**: Anemoi)

Anemoi's rotors can be installed with the ability to be moved to allow access for ship loading and unloading, either by tilting down to the deck, or by moving on longitudinal or transverse rails. Rotors can also be easily redeployed between vessels as driven by business requirements, maximising the return on investment into the WASP systems.

“Team France”

France has a very rich maritime history. French sailors often lead the world in high-performance sailing in races like the Vendee Globe, Imoca and The Ocean Race. The technologies and industrial capabilities developed for these races has laid a solid foundation for French companies to thrive in the development and deployment of WASP technologies, and in the establishment of new shipping companies like TOWT, Zéphyr & Borée and Neoline, which embrace wind power for deep decarbonisation outcomes. “Team France” (my expression) is pursuing the significant economic development opportunities which maritime decarbonisation presents.

One place where this capability and innovation is evident is in Brittany at Lorient, which is also called “La ville aux cinq ports” ("the city of five ports”: military, fishing, commercial, passengers and yachting). Lorient hosts **Zéphyr & Borée** and **Windcoop** (see below), it is home to some of the best sailing teams including Banque Populaire, Charal and Orient Express Racing Team. Lorient is also the location of specialist carbon fibre manufacturers which make masts for TOWT and SolidSail.

Zéphyr & Borée

Figure 25: Canopée (Source: Zéphyr & Borée)

Zéphyr & Borée, based in Lorient, is a French low-carbon shipowner best known for conceiving the vessel *Canopée*, the 121-m open-top Ro-Ro built for ArianeGroup logistics. *Canopée* was designed by French naval architects VPLP and is fitted with 4 OceanWings rigid wing-sails, each 30m tall and 363m² in area. *Canopée* entered service to shuttle Ariane 6 rocket components between Europe and French Guiana, targeting ~30% fuel savings depending on route and schedule.

Zéphyr & Borée has several other projects including **Williwaw**, which will operate 5 new container vessels equipped with rigid wings and dual diesel-methanol propulsion in two new Atlantic shipping lines from Europe to the USA. These shipping lines will offer a carbon footprint 80% lower than that of existing container shipping services.

Zéphyr & Borée also co-founded the cooperative **Windcoop**, which is also developing a fleet of sail-powered container ships. The first vessel is currently under construction in Turkey at RMK shipyards (the same firm which recently constructed the new Ro-Ro vessel *Neoliner Origin* (see below), and once it commences operations in 2027, it will operate the France–Madagascar line in 30 days.

TOWT

TOWT (TransOceanic WindTransport) (TOWT) is a French sail-cargo carrier scaling wind-propelled liner services on North Atlantic routes from its base in Le Havre. In August 2024 it took delivery of its first newbuild vessel, the 81 m, 1,200-tonne-capacity *Anemos*, from French shipbuilder Piriou and shortly after began its maiden transatlantic voyage to New York. Sister ship *Artemis* followed the same season and has also been shipping goods across the Atlantic.

Cargo can be loaded and unloaded on TOWT vessels using onboard cranes which avoid the need for port-side cranes, making the TOWT vessels well suited to secondary ports with minimal shoreside facilities. This short video demonstrates TOWT cargo handling.

Figure 26: TOWT Vessels Anemos and Artemis (Source: TOWT)

TOWT publishes live vessel tracking, and it positions its shipping service as schedule-reliable, commercial sail shipping rather than niche demonstration. TOWT has also established the transport label "**ANEMOS"** (ἄνεμος or "wind" in ancient Greek), a world-first guarantee of carbon-free navigation on wind powered cargo ships. The ANEMOS label can be adopted on all products transported by TOWT from the four corners of the Atlantic, notably from Latin America, the Caribbean, the Azores and Cornwall.

TOWT is expanding its fleet to 8 vessels, and is currently constructing 6 more vessels in Vietnam. The new vessels will enable TOWT to expand its operations beyond the Atlantic, potentially to Africa and the Pacific.

Neoline

Neoline has just commissioned a 136m Roll-on Roll-off vessel called ***Neoliner Origin***, which will operate across the Atlantic between Saint-Nazaire (France), Baltimore (USA), Halifax (Canada), and Saint-Pierre-et-Miquelon (off Newfoundland, Canada). The vessel was built by RMK Marine in Türkiye, was launched in January 2025, subsequently had its two SolidSails installed, and was commissioned at its home port of Nantes in France on 13 October 2025.

Neoliner Origin is fitted with two **SolidSail** rigs (see below) from Chantiers de l'Atlantique, which stand 76 metres high, have a combined sail area of approximately 3,000 m² and notably can fold down to enable the vessel to fit under the bridge near its home port of Nantes, France. With a cargo capacity of 6,300 tons, the *Neoliner* is capable of carrying up to 321 cars, 265 20-foot containers, or 125 40-foot containers. Early committed customers include Renault Group, Beneteau, Manitou, Michelin, Hennessy, Clarins, Longchamp, and Rémy Cointreau.

Neoline frames its service as a first industrial-scale sail-cargo line aimed at large, repeat volumes with materially lower lifecycle emissions than conventional Ro-Ro tonnage.

Figure 27: Neoliner Origin (Source: Neoline)

SolidSail

SolidSail is an innovative new rig developed by Chantiers de l'Atlantique, a large shipbuilding company in Saint-Nazaire, France. Chantier de l'Atlantique is one of the world leaders in designing, manufacturing, installing and commissioning of highly complex ships and marine facilities, and it has used its industrial capabilities to develop and manufacture SolidSail.

The most visible early installation of SolidSails is Neoline (above), but another unique vessel has recently been fitted with 3 SolidSails. Orient Express Corinthian, which will become the world's largest sailing yacht, with 54 luxury cabins.

Not all WASP innovation takes place in the "Global North". Innovation is also underway in the "Global South", in regions which have deep and long maritime histories and cultures, and which face existential threats from climate change and rising sea levels. I visited the Marshall Islands to observe and understand the innovation underway there.

Marshall Islands / GIZ

The Republic of the Marshall Islands (RMI) is located centrally in the Pacific Ocean, roughly halfway between Hawaii and Papua New Guinea. It consists of 29 atolls and 5 low-lying islands, spread over an ocean area of about 2 million km^2 and with a total land area of around 180 km^2, which is less than the size of Liechtenstein. Its population is around 37,000, half of whom live on RMI's main island of Majuro.

RMI as a country plays an outsized role in global shipping as one of the world's largest ship registries: the RMI Maritime Registry ranks among the top three by tonnage. The nation is also a leading voice in international climate diplomacy, strongly advocating for ambitious emissions reductions and decarbonisation of maritime transport, given its extreme vulnerability to rising sea levels and ocean changes caused by global warming.

Since 2017, RMI has been working with the German Corporation for International Cooperation (GIZ) on a project called Expanding Low-Carbon Sea Transport in the Republic of the Marshall Islands (LCST). The funding is supplied by the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), through the International Climate Initiative (IKI), and the program is managed by GIZ.

The LCST project consists of 3 components:

- An **"inside lagoon"** component which involves training and prototyping of traditional and innovative canoe building through Waan Aelõñ in Majel (WAM), and undertaken in conjunction with the University of Applied Sciences Emden Leer in Germany. This has produced designs and construction guides for a catamaran design and a proa design, and the construction and operation of initial vessels of both designs.
- An **"inter atoll"** component which has developed and constructed a new type of Pacific Islands supply vessel with wind-assisted ship propulsion, the SV *Juren Ae*.
- A **"capability building component"** for RMI Government officials to actively participate in global climate change and shipping negotiations, including at the International Maritime Organisation, and to train RMI crews to operate the SV *Juren Ae*.

The SV *Juren Ae* was constructed in South Korea and was delivered to RMI in July 2024, and it is now operated by the Marshall Islands Shipping Corporation as part of its domestic fleet, alongside another sail-powered vessel SV Kwai and 5 conventionally powered cargo ships. These ships deliver food, fuel, general supplies and people to communities on RMI's outer islands and atolls, and they bring copra (dried coconut flesh) back to Majuro for processing: the major source of income for these communities.

I was fortunate to spend 9 days in the Marshall Islands learning all about this project after earlier visiting the University of Applied Sciences Emden Leer in Germany to learn about the technical design process. I visited WAM and interviewed its director Alson Kelen, I met with the General Manager of the Marshall Island Shipping Corporation Danny Wase, and I had a thorough tour of the SV *Juren Ae* whilst she was at anchor in the Majuro lagoon and interviewed its skipper, Captain Teitera:

Video link: https://drive.google.com/file/d/1KOBu_TPfwAPSGR-sEAbqE4vwCcBiPUBe/view

These two videos convey the maritime innovation underway in RMI:

Video link: https://youtu.be/xsWx47FloWo?si=6FZPycoBh2l1BTBq

Video link: https://youtu.be/K-aTV5tGBCE?si=aCMNywd1S9mI2EAd

Besides decarbonisation, the key benefit of wind powered cargo ships like the SV *Juren Ae* in RMI's domestic fleet is a reduction in operating costs by dramatically reducing the need for imported and expensive shipping fuels. Cheaper operation means they can potentially operate more frequently, which increases connectivity and quality of life for these communities.

Wind-powered cargo vessels can also unlock the potential for new trade: trade which is commercially unviable when reliant on expensive shipping fuels. RMI and Pohnpei in the Federated States of Micronesia have identified an opportunity for a mutually beneficial new trade.

It is difficult to grow fresh fruit, vegetables and lumber in Majuro due the lack of suitable land. Fresh food is therefore imported, generally by air freight, and is expensive. Pohnpei, on the other hand, can readily grow fresh food and lumber, but it needs more animal feed, particularly for pigs. An opportunity exists for Pohnpei to export fresh food and lumber to Majuro, and for Majuro to export copra back to Pohnpei. Wind powered ships are cheaper to operate than conventionally fuelled ships, which improves the economics of such a trade.

RMI and Pohnpei signed a Letter of Intent in May 2025 to collaborate on the acquisition and operation of a sailing vessel to develop this trade, and to contribute to regional economic development.

There must be many more examples like that across the Pacific. More wind powered cargo ships can help unlock future economic development in the Pacific.

What Can Australia Do?

Context

The Australian mainland plus Tasmania has approximately 36,000km of coastline. This figure increases to approximately 60,000km of coastline when including its many islands. Australia is located relatively far away from its key trading partners. Over 99% of Australia's international trade by volume moves by sea, and roughly four-fifths of its international trade by value (79–80%).

Clearly, shipping is fundamental to Australia's economy, environment and standard of living.

Australia no longer owns and operates its own international shipping line, following the privatisation of Australian National Line (ANL) in the late 1990s. The liner business was sold to French company CMA CGM in December 1998, and the bulk shipping business was sold to Auscan Self-Unloaders (a Canada Steamship Lines subsidiary) in May 1999.

Australia's shipping services are now delivered by a mix of global carriers, regional lines and domestic coastal operators:

- Global container lines (including MSC, Maersk, CMA CGM (incl. the ANL brand in Oceania), COSCO Shipping, OOCL, Hapag-Lloyd, ONE, Evergreen, PIL, ZIM and others) run regular services to the main Australian ports.
- Regional & feeder carriers (including Swire Shipping, Pacific Direct Line (PDL), Neptune Pacific Direct Line (NPDL) and others) link Australia with NZ and the Pacific Islands.
- Commodities (iron ore, coal, grain, bauxite, alumina, etc.) move largely on the spot/tramp market via owners like Oldendorff Carriers, Pacific Basin, Berge Bulk, CSL, Gearbulk, plus major shippers (BHP, Rio Tinto, FMG, Glencore, GrainCorp etc) chartering tonnage for their own business requirements.
- A mix of international tanker operators and charterers service oil refineries and terminals (for Viva, Ampol, bp etc).
- SeaRoad and Toll/Team Global Express operate dedicated Ro-Ro/container services across Bass Strait; TT-Line (Spirit of Tasmania) carries passengers and freight. Various operators run coastal voyages under temporary licences as needed.

A list of specific ways in which Australia could support maritime decarbonisation and wind assisted ship propulsion is as follows:

Recommendations: Australian support for WASP & maritime decarbonisation

There is much that Australia can do to embrace wind assisted ship propulsion as a key pillar of maritime decarbonisation:

1. Funding new vessels in the Pacific

With a range of mature WASP technologies ready to deploy, with the success of the Low Carbon Sea Transport project between the Republic of the Marshall Islands and the German Government, and with a clear desire of Pacific countries to decarbonise shipping and reduce their imported fossil fuels, it is time to scale wind assisted ships in Pacific fleets.

Australia can directly contribute to this via:

Bilateral funding for a newbuild vessel

Australia could initiate and fund a similar project to the Low Carbon Sea Transport project between the Republic of the Marshall Islands and the German Government, to fund the development and procurement of another wind assisted vessel, plus associated training and capability building.

Multilateral funding for newbuild vessels

Australia could contribute towards **multilateral funding** for new Pacific wind-powered cargo ships and capacity building:

- One multilateral funding possibility is to partner with countries like France, Germany or Japan, who are wind assisted shipping pioneers, who have WASP technologies ready to deploy, and have existing Pacific interests and relevant decarbonisation programs.
- Another multilateral funding possibility is through a proposed bid to the Green Climate Fund for a fleet of up to 10 wind assisted ships for the Pacific, with co-financing and in-kind contributions from a variety of government and non-government funders.

Funding to charter an existing vessel

Another approach to get another vessel into Pacific waters is to charter an existing, operational wind powered vessel, such as a vessel from the French company TOWT. Two vessels of this design are operational in the Atlantic, and 6 more are currently under construction in Vietnam. One of these new vessels would be available for purchase or charter from early 2026, and could provide new, wind-powered, regional shipping options in the Pacific. It could provide an ideal vessel to service the proposed Majuro to Pohnpei route, carrying fresh food, copra and lumber. Notably, a charter of such a vessel would come fully crewed, so it wouldn't require a lead time of training new staff from the Pacific to become operational, yet it would provide an ideal training platform for new Pacific crew members who are delivered training through the programs contemplated above.

2. Delivering Pacific maritime training

Through my Churchill Fellowship I learned of a clear need for better training for Pacific mariners, including specific training on the operation and maintenance of wind-assisted ships. Several localised training initiatives are currently underway in the Pacific (e.g. training facilities and programs funded by GIZ in the Marshall Islands), but these initiatives appear to be disjointed from each other and are under-resourced. This is an area where Australia could have impact.

Australia has several good options for the delivery of high-quality maritime training, including:

- TAFE Queensland, which was contracted by the Australian Department of Defence to deliver the Pacific Maritime Training Services program, a component of the Pacific Maritime Security Program. It also delivers training to the Australian Pacific Training Coalition (APTC), an Australian government initiative that delivers vocational training to Pacific Island nations.
- the Australian Maritime College, which is part of the University of Tasmania, and delivers a broad range of education and training to the maritime sector.

Such training should be scoped and delivered in close conjunction with stakeholders with experience / capability / interest in Pacific maritime training delivery, including the Micronesian Centre for Sustainable Transport, the Pacific Blue Shipping Partnership, GIZ LCST, WAM and the University of Applied Sciences Emden/Leer.

3. Supporting Australian WASP innovators

The SV *Juren Ae* in the Marshall Islands is a significant step forward for the Pacific, being a newbuild cargo vessel with primary wind propulsion, owned and operated by a Pacific nation. It was designed in a close collaboration between the Marshall Islands, GIZ LCST and the University of Applied Sciences Emden/Leer from Germany.

Juren Ae provides an example of the potential for new wind-powered cargo ships to replace more conventionally powered domestic cargo ships in the Pacific, which can further reduce the need for imported and expensive shipping fuels. Decreased operating costs improve the balance of trade for Pacific nations, and can allow them to deliver shipping services to their outlying communities with higher frequency, which will improve quality of life.

Future ships may be based on the current design of the *Juren Ae*, or they could be entirely different designs to suit different domestic and regional requirements.

The Australian company **GoSailCargo** has designed a range of wind-powered vessels which could be well suited to Pacific requirements, including the Electric Clipper 180 (with cargo capacity of 900 tonnes or 36 TEUs, plus up to 12 passengers); Electric Clipper 132 (with cargo capacity of 180 tonnes or 8 TEUs, plus up to 12 passengers); Electric Clipper 100 (with cargo capacity of 180 tonnes (98 pallets or 4 x 20' containers or 2 x 40' container + 20 pallets) plus 6 passengers); Electric Clipper 74 (with cargo capacity of 1 x high-cube 20' container + 16 x pallets and break-bulk cargo to 40 tonnes, plus 4 passengers in cabins and another 4 in a passenger pod) and the Sienna 65 Schooner (with cargo capacity of 4 pallets + break-bulk to 6 tonnes, plus 4 passengers).

Another prominent Australia WASP innovator is **Advanced Wing Systems**, which is developing and commercialising lightweight, rapidly deployable, modular wing sails which can be retrofitted to existing vessels or fitted onto newbuild vessels and is offered as a performance-based commercial model.

Funding for detailed design and construction of one or more vessels with these Australian innovations could deliver a uniquely Australian contribution to wind-assisted ships in the Pacific, and could result in economic development outcomes in Australia by utilising local services providers including naval architects and shipyards, following the successful path being forged by France.

4. Strong political support at the IMO

Given the difficulties in reaching global consensus on maritime decarbonisation at the International Maritime Organisation (as demonstrated at the MEPC83 Extraordinary Session meeting from 14-17 October 2025), Australia should **maintain clear and consistent support for IMO's Net-Zero Framework for maritime decarbonisation**.

This support would be consistent with the current Australian Government's commitment to address climate change through a broad suite of domestic measures including the **Climate Change Act 2022,** (which legislated a 43% cut in national emissions from 2005 levels by 2030 and net zero by 2050); the reformed **Safeguard Mechanism,** the **Capacity Investment Scheme, Rewiring the Nation** the **New Vehicle Efficiency Standard, Hydrogen Headstart,** and Australia's recently updated its **Nationally Determined Contribution** under the Paris Agreement, which commits Australia to an economy-wide 62–70% reduction in net greenhouse gas emissions below 2005 levels by 2035.

5. Other (non-WASP) maritime decarbonisation opportunities

Maritime decarbonisation is a big challenge which will require a variety of technologies and approaches, including but not limited to wind assisted ship propulsion. Other non-WASP opportunities for Australia include:

Electrifying Pacific outboard motors

On remote Pacific islands, petrol for outboard motors can cost as much as A$6 per litre, which is exorbitantly expensive. There is an opportunity for small vessels in the switch from petrol to electric outboards, which offer the potential for mobility powered by batteries which can be recharged using solar panels, thereby removing the dependence on petrol. The Australian company E Class Outboards offers such electric outboard motor plus battery combinations. A number of Australian companies could develop simple and robust solar charging solutions for such batteries.

Kit-based small Pacific vessels

Through the Low Carbon Sea Transport project in the Pacific, WAM has developed two small vessels (a and a proa) for intra-atoll use in the Marshall Islands. Marshall Islanders learn how to construct, operate and maintain these vessels, which are built "from scratch" using stitch and glue techniques. These traditional techniques work well but are relatively time consuming.

A different approach, which could increase the number of such vessels available to Pacific communities, is to use a "kit-based" approach adopted by Scruffie Marine to cut timber panels with a CNC (Computer Numerical Control) machine, which is very precise and quick. CNC machines could be deployed in the Pacific for this task. This would have the spin-off benefit of new fabrication skills and capabilities in the Pacific, which could be applied to other local requirements and industries.

Electrifying Australian ferries

If Australia is to achieve its updated Nationally Determined Contribution (NDC) under the Paris Agreement, which includes a 2035 emissions reduction target of 62-70% below 2005 levels, it would need to reduce Australia's emissions by roughly half from the current level. Five decarbonisation priorities have been identified: clean electricity across the economy; lowering emissions through electrification and efficiency; expanding clean fuel use; accelerating new technologies; and increasing net carbon removals.

Considering the sub-sectors of the inshore domestic commercial maritime sector in Australia (commuter ferries, fisheries, tugs, pilot vessels, aquaculture and tourism), and noting maritime innovation trends overseas (particularly in Europe and New Zealand) and with Australian shipbuilders Austal (the world's largest builder of fully customised high-speed passenger ferries) and Incat (manufacturers of the world's largest electric vehicle, the ferry China Zorrilla, scheduled to commence operation connecting Uruguay and Argentina), the quickest decarbonisation potential is with the electrification of ferries.

Anecdotally, through participation in Maritime Emissions Reduction Coalition events, emissions per passenger on existing Australian ferries can be over twice as high as they would be if passengers drove their personal cars over the equivalent distances, given the diesel fuel consumption and emissions of such ferries. Electrification can dramatically reduce emissions from ferries, and 117 such ferries in Australia are suitable for electrification.

Whilst there are local ferry operators willing to innovate with ferry electrification, including SeaRoad Ferries and NRMA Marine, there is notable lack of Commonwealth Government funding programs which are suited to this challenge. This requires a change in policy focus and funding eligibility criteria.

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Conclusion

The shipping sector consumes around **300 million tonnes of fuel** per year, which emits around **1 billion tonnes of CO_2** per year. If the shipping sector was a country, it would emit more than Germany and more than double that of Australia.

If the world is serious about addressing climate change, it needs to address the emissions from the shipping sector.

Despite a range of possible decarbonisation pathways including alternative fuels, operational measures such as slow steaming and better passage routing, **wind assisted ship propulsion** is rapidly emerging as **one of the** f**ew mature, immediately deployable tools** to get the maritime sector well into its decarbonisation journey. This is not a nostalgic nod to traditional sailing vessels of the past, but includes a proven set of wind propulsion technologies which are ready to scale.

WASP directly reduces energy demand, and uniquely amongst the range of decarbonisation pathways, it is both **fuel-agnostic** and **fuel-complementary.** Whichever alternative fuels are ultimately adopted, wind propulsion consistently reduces fuel demand, lowering costs and emissions simultaneously, and these energy and cost savings may well be the measure which allows shipowners to **afford** alternative fuels in the future.

Australia is located relatively far away from its key trading partners. Over 99% of Australia's international trade by volume moves by sea, and roughly four-fifths of its international trade by value (79–80%). The Australian continent and its 60,000km of coastline will be heavily impacted by climate change. It is clearly in Australia's interests to seriously address maritime decarbonisation.

This report recommends a series of measures which Australia could take to support maritime decarbonisation globally through the UN, regionally with our Pacific neighbours, and locally in Australia.

Trip highlights and snapshots

A Churchill Fellowship is a gift.

Not only are Churchill Fellows provided with an opportunity to meet with subject matter experts all over the world, but they are actively encouraged to incorporate personal experiences into their journey. The journey is perhaps even more important than the subject matter.

My trip had many personal highlights including:

Visiting the busiest port in the world and the busiest port in Europe, **Singapore** and **Rotterdam** respectively.

Visiting ports of historical significance:

Portsmouth, where the First Fleet departed England for Australia on 13 May 1787; where Matthew Flinders departed on 18th July 1801 in HM Sloop Investigator to carry out a survey to chart the entire coastline of the then unknown continent of Terra Australis; where Lord Nelson's victorious flagship from the Battle of Trafalgar in 1805, HMS Victory (the world's oldest naval ship still in commission) is on display; where the remains of Henry VIII's flagship Mary Rose is on display, having been resurfaced from the Solent sea bed in 1982; and where a large proportion of mobilisation to retake Europe through the D-Day landings were focussed. Portsmouth is the historical 'ground zero' for a former Navy officer and history buff, and despite many trips to the UK, it's taken a Churchill Fellowship to finally visit Portsmouth.

Honfleur, which saw the departure of a number of European explorers, in particular in 1503 of Binot Paulmierde Gonneville to the coasts of Brazil; in 1506, local man Jean Denis departed for Newfoundland island and the mouth of the Saint Lawrence; and in 1608 an expedition organised by Samuel de Champlain founded the city of Quebec in modern-day Canada. Further back in history, it would have seen the passage of the Romans exiting the River Seine for the British Isles.

Attending the **Wind for Goods** Conference in Saint-Nazaire, France, where some of the key global innovators in wind powered shipping were in attendance, and interviewing Gavin Allwright and Oliwia Galecka.

Seeing World War 2 artefacts on the French coast: Massive U-boat pens in Saint-Nazaire and Lorient, seeing the site of the Operation Chariot raid in Saint-Nazaire, and seeing the D-Day landing beaches at Arromanches in Normandy.

Seeing the 1,000-year-old **Bayeux tapestry**, the 70-metre-long embroidered linen cloth that chronicles the events leading up to and including the Norman conquest of England in 1066, culminating in the Battle of Hastings.

Seeing the unique island **Mont St Michel** off the coast of Normandy, France.

Meeting a range of companies and organisations pioneering wind assisted sailing propulsion: **ANEMOI , Eastern Pacific Shipping**, **BAR Technologies**, **Neoline**, **Grain de Sail**, **Zéphyr & Borée**, **Windcoop**, **TOWT**, **CMA CGM**, **Econowind, Hochschule Emden/Leer University of Applied Sciences, Knud E Hansen, GIZ, WAM** and the **Marshall Islands Shipping Company**.

Getting onboard **SV *Juren Ae*** in Majuro Atoll and having a tour and video interview with the skipper Captain Teitera.

Meeting **Alson Kelen** and learning about the fantastic initiative **Waan Aelõñ in Majel** (WAM) in the Marshall Islands, which is bringing back traditional Marshallese sailing vessels and assisting young Marshallese people to develop skills and pride.

Having the opportunity to meet old friends and colleagues around the world including Barney, Alicia, Louise, Audrey, Alex and Helen in London; Mia, Charlie and Lisa in Paris; Martijn in Rotterdam; Arnie in Amsterdam; Leon and Josh in Utrecht, Anke, Ronald and family in Hamburg and Jill in Copenhagen.


ANEMOS


giz Project Office


giz Project Office
LOW CARBON SEA TRANSPORT


JUREN AE

Dissemination and Implementation

Since my return to Australia in July 2025, I have been actively disseminating and activating what I learned on my Churchill Fellowship.

I have had numerous follow up conversations with WASP stakeholders I met overseas, and I have introduced local WASP innovators to overseas stakeholders.

I have had initial meetings with key Australian stakeholders including:

- Department of Foreign Affairs and Trade
- Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts
- Australian Maritime Safety Authority

In October 2025 I was interviewed on a podcast to describe what I learned about zero carbon shipping:

On Spotify: https://open.spotify.com/episode/3HGB0ocQCBzP4bRcAqz9Ia?si=25d969364e214a95

On YouTube: https://youtu.be/XAiqGdJy6Cw?si=JB05JV-UGmXW7tgh

Also in October 2025 I wrote this article on RenewEconomy: https://reneweconomy.com.au/global-shipping-is-facing-winds-of-change-despite-chaos-and-confusion-from-the-petrostates/

This dissemination and implementation will continue:

- I am pursuing meetings with the Australian Maritime College and TAFE Queensland to discuss the opportunity for Australia to develop and deliver training to mariners in the Pacific region, with a particular emphasis on WASP-specific training requirements.
- I attended the Discover Maritime Futures Conference in Sydney, organised by the Maritime Emissions Reduction Coalition, where I discussed my findings and I learned more about domestic maritime decarbonisation.
- I am scheduled to present my trip findings at the next Maritime Emissions Reduction Coalition event in November 2025.

Contact details

I invite contact from anyone who is interested in maritime decarbonisation in general, and wind assisted shipping in particular. I can be contacted via my page on the Winston Churchill Trust website here:

https://www.churchilltrust.com.au/fellow/andrew-dickson-sa-2024/