Whitepaper published by

TRAFIGURA

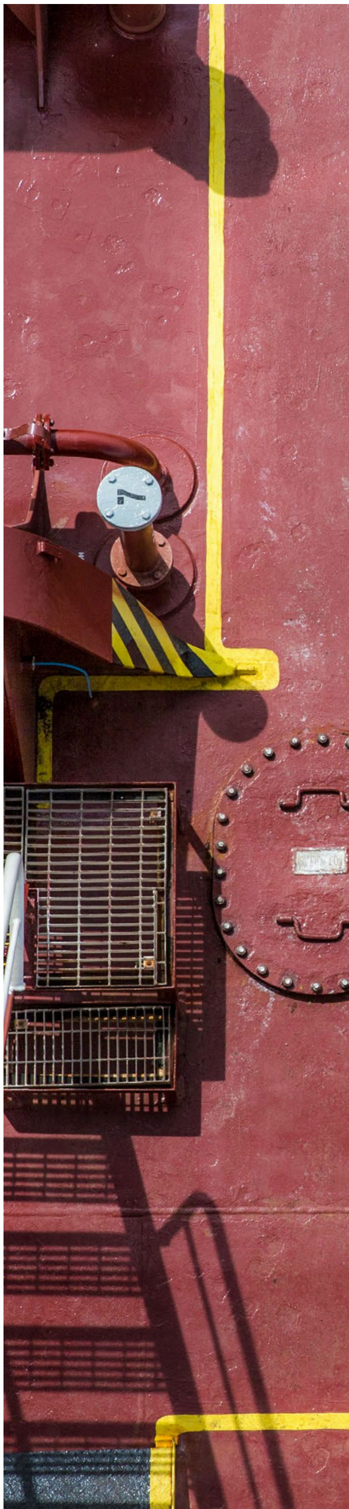
Charting a course to a greener future for shipping:

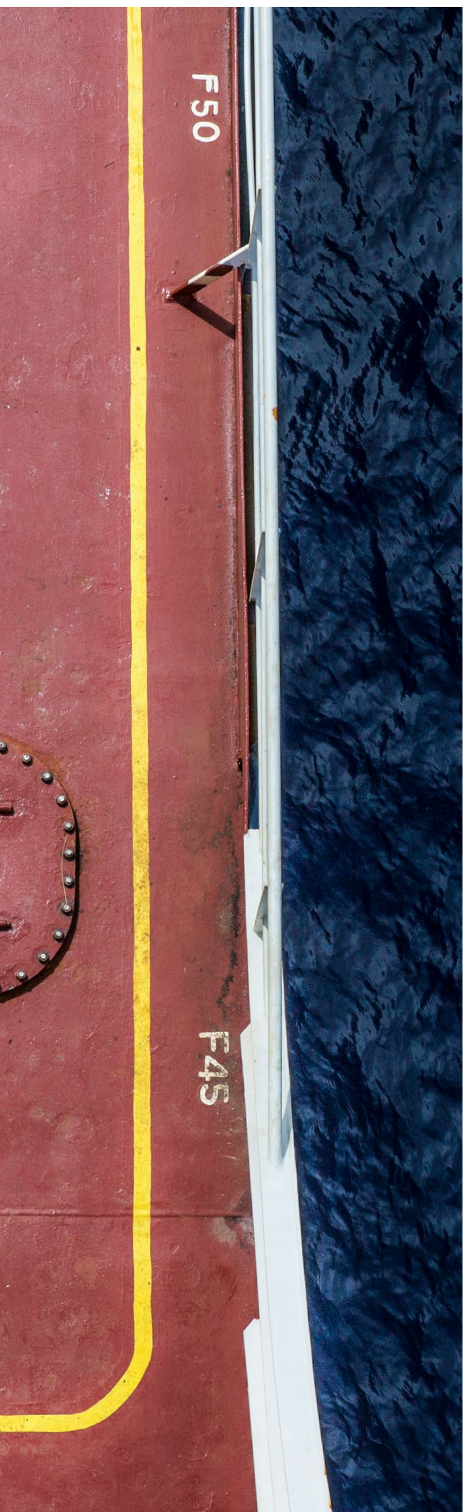
Low-emission fuel supply and the opportunity for the Global South

Margaux Moore and Rasmus Bach Nielsen, May 2023

Table of contents

Executive summary		**4**
Overview:	**A crucial window of opportunity**	**6**
Chapter One:	**Defining the challenge: transitioning to a low-emission future**	**10**
Chapter Two:	**Fuels of the future: scope of options**	**12**
	Hydrogen as a feedstock	13
	Methanol	13
	Ammonia	14
	Blue ammonia and bio-methanol	14
	The role of biofuels	15
Chapter Three:	**Low-emission fuel supply production**	**16**
	Trafigura analysis	18
	Supply summary	19
Chapter Four:	**Demand for low-emission fuels**	**20**
Chapter Five:	**Capital availability**	**22**
Conclusion and action points: the need for a carbon price		**24**
External voices		**26**
References		**28**





Margaux Moore,
Head of Energy Transition Research and Venture Investments

In her role as Head of Energy Transition Research and Venture Investments at Trafigura, Margaux Moore assesses the challenges and opportunities of the energy transition, focusing on the evolution of decarbonised transport, the integration of renewables and storage in power generation and the adoption of carbon capture and utilisation. This includes studying the potential of hydrogen, with the aim to develop and accelerate the commercial adoption of the molecule across the spectrum of Trafigura's activities in trading, logistics and retail fuelling. Margaux also leads the Group's internal power ventures fund, investing in disruptive technologies and businesses in the energy transition.

Margaux joined Trafigura in 2015 as a graduate having starting her career as a metals operator in Latin America and Singapore. She holds a BSc in International Management from Warwick Business School.

Rasmus Bach Nielsen,
Global Head of Fuel Decarbonisation

Rasmus Bach Nielsen joined Trafigura in August 2014 as Global Head of Wet Freight. During his six years in this role he was responsible for transforming the wet freight book into one of the leading global players in the market and presided over USD3.5billion of shipping asset transactions. In 2020, Rasmus took up the newly established role of Global Head of Fuel Decarbonisation with the objective of reducing the Group's shipping emission footprint. Working closely with Trafigura's Power and Renewables team, Rasmus also focuses on project origination around green fuels and their possible off-takes and serves as a Non-Executive Director for bunkering joint venture TFG Marine and as a board member of H2 Energy Esbjerg (Denmark) and of Iverson-e-Fuels. In 2022, he was ranked the 13th most influential person in global shipping in the Lloyd's List One Hundred People rankings*. In May 2023, he was elected Chair of the Sea Cargo Charter Association.

Prior to joining Trafigura, Rasmus spent 15 years with various shipowners based in Singapore, Monaco and Copenhagen.

* *https://lloydslist.maritimeintelligence.informa.com/one-hundred-edition-twelve*

Editor: Neil Hume, Corporate Affairs, Trafigura

Trafigura is one of the world's largest charterers of vessels, responsible for more than 5,000 voyages a year with almost 360 ships under management.

We provide shipping and freight services for our commercial teams across oil, metals and bulk minerals, and also third-party customers.

We have the led the industry in calling for a price on carbon, to reduce emissions and are continually looking for ways to make our fleet safer and more sustainable. To that end, we are trialling several new fuels on our owned and chartered vessels. This includes cosponsoring the development of a two-stroke engine that can run on green ammonia and investing in on-board carbon capture technology. We are one of the few operators to have tested alternative shipping fuels including LNG, methanol, LPG and biofuels on our controlled vessels.

Trafigura is also a founding member of the Sea Cargo Charter, an industry coalition established to collect, assess and report shipping emissions, and a member of the First Movers Coalition.

Executive summary

Shipping is an important industry that plays a significant role in global trade and economic growth. It is responsible for transporting the majority of all traded commodities and goods. It does so efficiently, however, this comes at a cost: 3 percent of all global greenhouse gas (GHG) emissions are attributed to shipping.[1]

The industry's current goal of reducing total annual GHG emissions by least 50 percent by 2050 compared to the 2008 baseline[2], is not ambitious enough to meet the immense climate challenge we face today. This needs to change and soon.

While technology and biofuels have a role to play, ultimately the only way to achieve deep decarbonisation of shipping is by switching to low-emission fuels (see Box 1).

With the right policy settings, we see large potential for producing two of these fuels – green ammonia and green methanol – in countries with access to abundant solar energy, wind power and land. At the same time, we see significant potential demand for low-emission fuels by the end of the decade, which should give shipbuilders, owners and project developers the confidence they need to invest in shipping decarbonisation.

We estimate the 'Global South'[3] could produce almost 4,000 exajoules per year[4] of competitively priced green hydrogen, against projected annual shipping demand of 20 to 40 exajoules.

However, this potential, which could provide developing countries with the chance to develop new export industries and create thousands of skilled jobs, won't be realised unless the shipping industry can agree on challenging decarbonisation targets and crucially implements a price on carbon.

The International Maritime Organization (IMO) has an essential role to play in this regard, as the de facto global regulator of shipping. By agreeing and implementing ambitious science-based decarbonisation targets in its revised GHG Strategy, the IMO can accelerate the development of low- and zero-emission fuels and attract the investment needed to overhaul the infrastructure of the global shipping industry and retrofit or build a fleet of ships.

2023 presents a crucial window of opportunity for the IMO, which is in the process of revising its initial GHG strategy, to make this happen.

Setting at least a 2050 net-zero emissions target with ambitious goals for 2030 and 2040, alongside the introduction of a carbon price by 2025, will help the shipping industry significantly reduce emissions. But we think the industry should aim higher and target zero emissions by 2050, a goal we believe is achievable with the right policy settings.[5]

Delaying action will only add to the eventual cost of decarbonisation. Shipping needs to act now to tackle its emissions footprint and start the journey to a sustainable and resilient future.

1 Source: Horizon The EU Research & Innovation Magazine: *https://ec.europa.eu/research-and-innovation/en/horizon-magazine/emissions-free-sailing-full-steam-ahead-ocean-going-shipping*

2 Source: IMO Initial IMO GHG Strategy: *https://www.imo.org/en/MediaCentre/HotTopics/Pages/Reducing-greenhouse-gas-emissions-from-ships.aspx*

3 There is no agreed definition of 'Global South', but for the purposes of this whitepaper we take it to mean developing or industrialising countries and regions. We use the 'Brandt Line' to show how the world is split between more developed and developing countries. Broadly, the 'Brandt Line' circles the world at a latitude of 30 degrees north, although it does move lower to include Australasia.

4 One exajoule is equivalent to around 177m barrels of oil. Source: bp Statistical Review of World Energy: *https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf*

5 Source: Global Maritime Forum. Definition of Zero Carbon Energy *https://www.globalmaritimeforum.org/content/2019/09/Getting-to-Zero-Coalition_Zero-carbon-energy-sources.pdf*

1 What are low-emission and electrofuels?

For the purposes of this whitepaper, we define low-emission fuels as those which are derived from renewable energy, biomass and waste, as well as those produced from fossil fuel sources where emissions are prevented from entering the atmosphere through carbon capture and storage. We also consider the utilisation of "unavoidable" carbon dioxide – such as for methanol produced by combining hydrogen with carbon dioxide captured either from industrial sources, air and biomass – as low-emission. We use the term electrofuels to describe shipping fuels derived from green hydrogen, which is produced from the electrolysis of water using renewable power. We see large potential to produce electrofuels, mainly in the Global South.


Rudder Angle

Overview: A crucial window of opportunity

Shipping currently generates around 3 percent of GHG emissions, a figure that without action will increase significantly by 2050.[6]

While biofuels and efficiency improvements can help reduce the industry's carbon footprint in the near term, deep decarbonisation of shipping can only be achieved if the industry switches away from high carbon fuel oil to cleaner alternatives.

To set the challenge in context, aligning the industry with a 1.5-degree temperature goal requires absolute GHG emissions reduction of 37 percent by 2030 and 96 percent by 2040, according to the Science Based Targets initiative (SBTi).[7]

Our analysis shows that there is potential to produce large volumes of so-called electrofuels in Africa, Asia and South America, to meet future demand from the shipping industry and provide countries in these regions with the chance to develop new export industries and create thousands of skilled jobs.

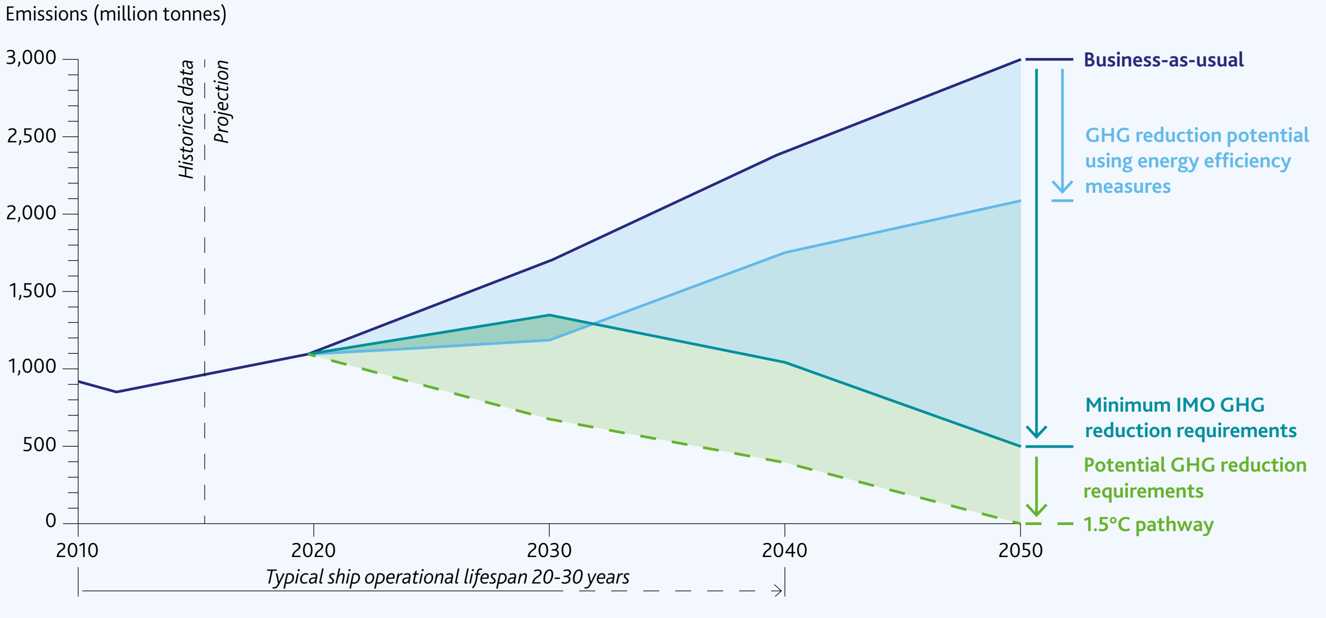
Well positioned nations, according to Trafigura research, include, but are not limited to, Argentina, Brazil, Chile, Colombia, Egypt, India and Morocco. These countries have access to abundant sources of renewable energy that could be used to produce green hydrogen – the main feedstock needed to produce electrofuels such as methanol and ammonia for shipping.

6 Source: European Commission Climate Action: *https://climate.ec.europa.eu/eu-action/transport-emissions/reducing-emissions-shipping-sector_en*

7 Source: Science Based Target Setting for the Maritime Transport Sector: *https://sciencebasedtargets.org/resources/files/SBTi-Maritime-Guidance.pdf*

2 Shipping is not on a Paris Agreement-aligned decarbonisation path

The IMO has committed to reducing GHG emissions from international shipping by **at least 50%** by 2050 (compared to a 2008 baseline), with a strong emphasis on reaching zero emissions. However, this pathway is not aligned with the goals of the Paris Agreement on climate change – i.e. keeping global warming below 2.0°C from pre-industrial times, and ideally 1.5°C.



Source: UMAS

However, the potential to produce and export these products will not be realised without the involvement of the IMO, which can help unlock the investment needed to produce low-emission fuels at scale and address ongoing concerns about future supply and demand.

The IMO can achieve this by setting at least an SBTi-aligned 2050 net zero emission target (and preferably a zero emission goal) for 2030 and 2040 in its revised GHG Strategy, alongside fuel standards and full lifecycle accounting for emissions.

Criticality, the IMO's revised plan must also include an agreed carbon price for introduction by 2025. Without a carbon levy, there is a risk of a disjointed, two-speed energy transition in shipping that favours developed economies over lower-income countries. As well as bridging the cost differential between high carbon fuel oil and hydrogen-derived alternatives, the revenues generated by a carbon levy can be used to incentivise the uptake of low-emission fuels across the world.

Concern about the future availability of low-emission fuels[8], as well as the price differential to fuel oil, are just some of the reasons why shipowners have been reluctant to invest in new vessels, which have a lifespan of 20 to 30 years, or upgrading older ones so they are capable of running on cleaner-burning alternatives.

The same is also true of the investment in the bunkering infrastructure that will be needed at major shipping hubs to facilitate the switch to cleaner-burning fuels. These projects and investments will only get the go-ahead when there is a regulatory framework that incentivises the production and usage of low-emission shipping fuels.

The Global Maritime Forum has put the cost of decarbonisation of the shipping industry between 2021 and 2050 at USD40 billion a year with the money needed for investment in "ammonia or methanol synthesis, storage and bunkering infrastructure, and new/retrofitted ships."[9]

The good news is that momentum for a carbon price is building. For example, the EU recently reached consensus on expanding the scope of its Emissions Trading Scheme to include shipping[10], while IMO members including the Marshall Islands and Japan[11] have published proposals supporting the introduction of a carbon levy.

Equally, demand is building for zero-emission shipping fuels through initiatives like the First Movers Coalition (FMC)[12], a partnership between the US State Department and the World Economic Forum.

Some members of the FMC have said that at least 5 percent of their goods will be shipped using zero-emission fuel by 2030.

Alongside "green corridors" (trades routes between major port hubs that support zero emission solutions), these commitments are helpful in stimulating early adoption of alternative shipping fuels but they are not sufficient on their own to scale up demand at the rate needed to limit global warming to 1.5 degrees.

Only IMO regulation can ensure global participation in shipping decarbonisation and help unlock the huge potential of developing countries to produce hydrogen-derived fuels.

June and July 2023 (see timeline on page 25) present a window of opportunity to make this happen. By setting a more ambitious emission reduction pathway, including a carbon levy, the IMO can unlock the financing needed to decarbonise shipping.[13]

If the IMO fails to do this, supply will not ramp up and the industry will lose another five years waiting for the next iteration of its strategy, making the transition more expensive, fragmented and tilted in favour of developed countries.

Environmental groups estimate each year of delay in tackling carbon emissions adds an extra USD100 billion to the total cost of shipping decarbonisation.[14]

8 Low-emission fuels are low-emission on a full lifecycle assessment (from production to consumption) and include CO_2, methane, nitrous oxides and other greenhouse gases.

9 Source: Global Maritime Forum: *https://www.globalmaritimeforum.org/news/the-scale-of-investment-needed-to-decarbonize-international-shipping*

10 Source: Lloyd's List: *https://lloydslist.maritimeintelligence.informa.com/LL1138070/Marshall-Islands-doubles-down-on-$100-emissions-levy-plan*

11 Source: The Maritime Executive: *https://maritime-executive.com/article/japan-submits-ambitious-carbon-tax-proposal-for-mepc-78*

12 Source: World Economic Forum First Movers Coalition: *https://www3.weforum.org/docs/WEF_First_Movers_Coalition_Shipping_Commitment_2022.pdf*

13 To align shipping with a 1.5 degree pathway requires GHG emissions reduction by 2030 and 2040 of 37% and 96% respectively, relative to a 2008 baseline, according to the independent Science Based Targets initiative (SBTi).

14 Source: Seas at risk: *https://seas-at-risk.org/general-news/why-an-ambitious-2030-target-is-so-important-for-shipping-climate-action/*

To end this section, we highlight a recent report prepared for the IMO, which found that a more ambitious decarbonisation pathway for shipping was not being limited by the "technical and commercial readiness of alternative fuels, technologies, infrastructure or shipyard readiness." The report concluded that a "clear signal of demand" was needed to enable "sufficient availability" of alternative shipping fuels such as methanol and ammonia and that signal could come from the IMO's revised GHG strategy.[15]

"There has been a tremendous shift in mindset since we called for a carbon levy in 2020 and we believe momentum is building further at the IMO for a more aggressive approach to greenhouse gas emissions," said Andrea Olivi, Global Head of Wet Freight at Trafigura. *"The industry now has a window of opportunity to drive real change and put international shipping on course for a greener future."*

15 Source: https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/FFT%20Project/Study's%20technical%20proosal_Ricardo_DNV.pdf

3 Trafigura's proposal for an IMO-led carbon levy on shipping

In a 2020 whitepaper, Trafigura called for a price on carbon emissions in shipping through the form of a global, mandatory industry levy overseen by the IMO. We argued this was needed to close the competitiveness gap between carbon intensive fuels and low or zero-carbon alternatives and said a levy of USD250 to USD300 a tonne was appropriate. We also proposed the introduction of a "partial feebate system" to help fund further research and development into low-emission fuels and also to establish a Green Climate Fund to support Small Island Developing States and developing countries disproportionally affected by global warming and rising sea levels. More than 50 countries have endorsed the idea of a mandatory carbon levy on shipping, with Japan, the Marshall Islands and the Solomon Islands taking their proposals to the IMO. Japan's proposal is for a levy of USD56 per tonne of CO_2 from 2025 to 2030, while the Marshall and Solomon Islands have called for USD100 per tonne entry price, followed by periodic increases.

www.trafigura.com/brochure/a-proposal-for-an-imo-led-global-shipping-industry-decarbonisation-programme/

Defining the challenge: transitioning to a low-emission future

The current goal of the IMO is for a 50 percent reduction in total annual GHG emissions by 2050, against a 2008 baseline. When this goal was announced in 2018, it was an important milestone for the shipping industry, which until that time had never set a climate goal.

Unfortunately, it is not enough to meet the climate challenge we face today. While energy efficiency improvements and biofuels will help lower emissions in the near term[16], deep decarbonisation of global shipping can only be achieved by switching to low or zero-emission fuels.

To align the industry with the Paris Agreement, expert groups such as the Global Maritime Forum[17] argue that scalable zero-emission fuels[18] need to make up at least 5 percent of the "bunker market" by 2030, from virtually nothing today, and rising to 27 percent by 2036.

This underlines the scale of the task facing the shipping industry but also the opportunity for countries with access to abundant solar energy and wind power. In the case of electrofuels, we also acknowledge that many countries will need to decarbonise their own electricity grids – or address existing energy shortages – before they are in a position to export hydrogen-derived fuels.

Nonetheless, we believe 5 percent zero-emission fuels in the shipping industry by 2030 is realistic and possible. But given the long lead time needed to bring projects into production – we estimate at least three to five years of development and construction are needed (see Box 5) – decisions need to be taken now otherwise the 2030 milestone will not be reached and a chance to scale up low-emission shipping fuels will be missed.

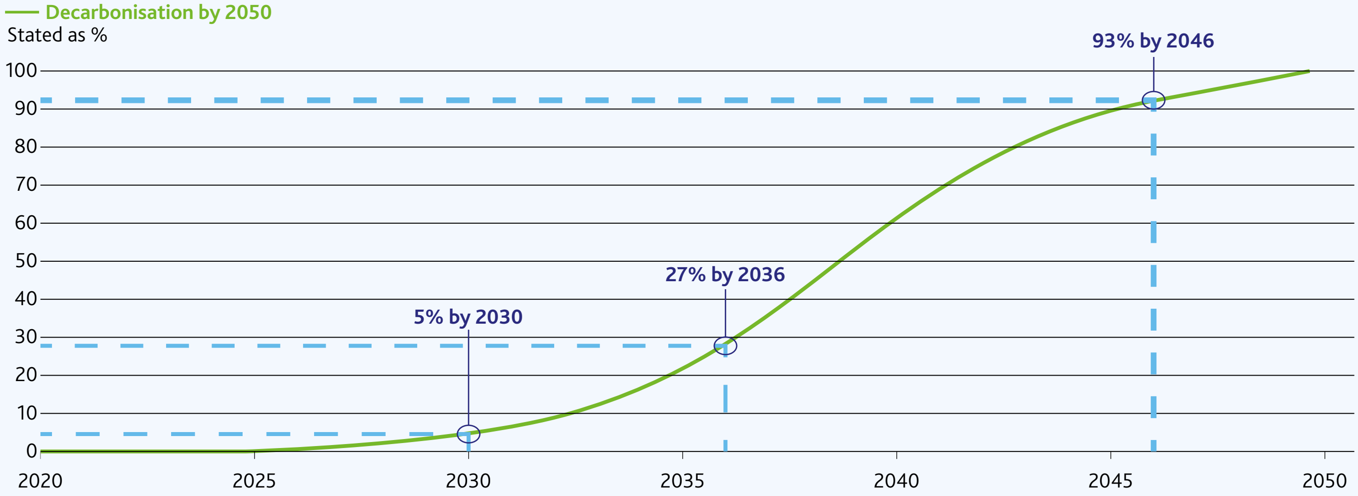
As such, there is a pressing need for the IMO to introduce a mandatory carbon levy by 2025 to address the price gap that exists between the fuels currently used to power ships and hydrogen-derived alternatives.

16 Source: Maersk Mc-Kinney Møller Center for Zero Carbon Shipping: https://www.zerocarbonshipping.com/publications/maritime-decarbonization-strategy/

17 Source: Global Maritime Forum: https://www.globalmaritimeforum.org/news/five-percent-zero-emission-fuels-by-2030-needed-for-paris-aligned-shipping-decarbonization

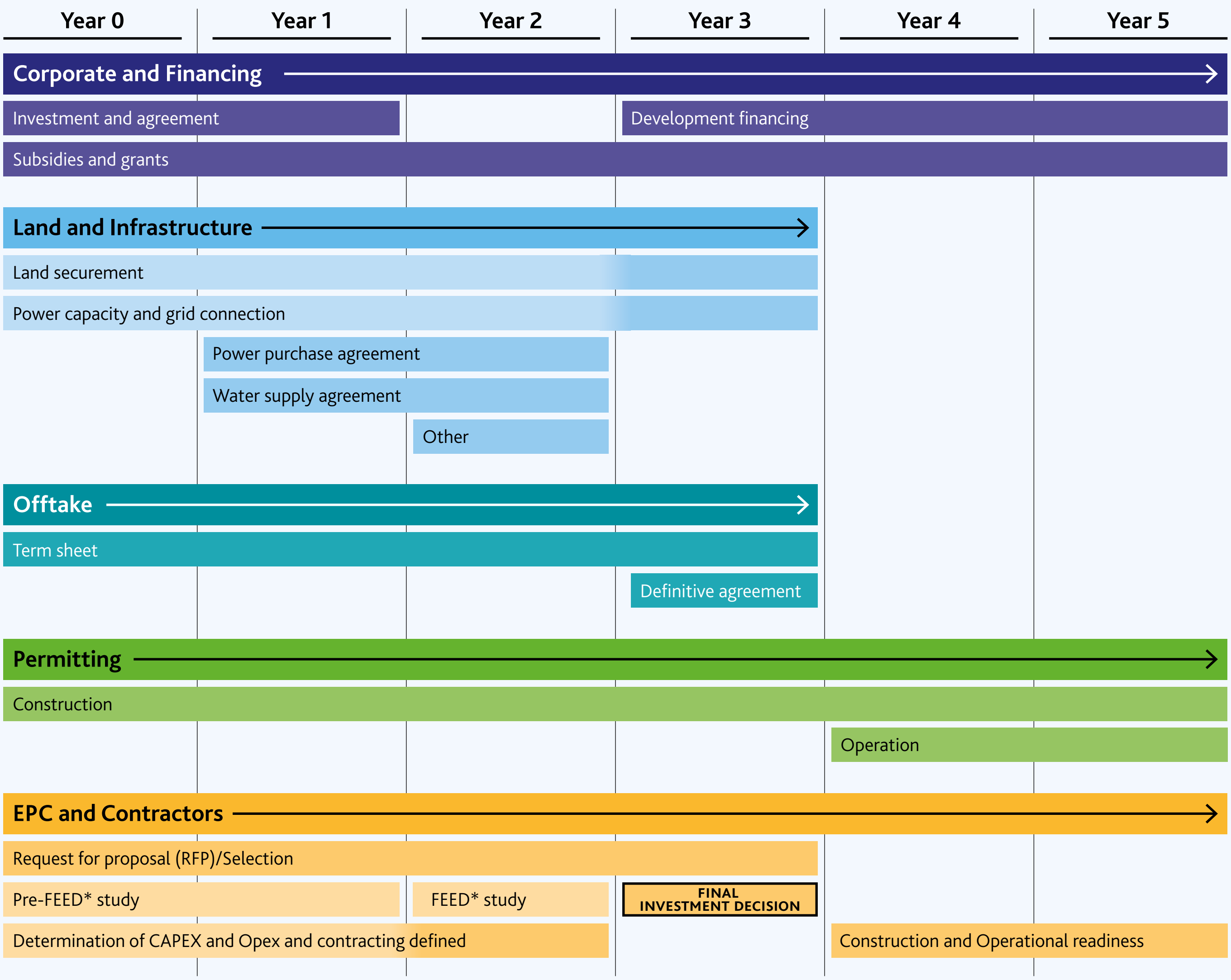
18 The Global Maritime Forum describes "scalable zero-emission fuels" as fuels that have "the potential to achieve near-zero GHG emissions on a lifecycle basis while also scaling production in line with the pace of the transition." Source: https://www.globalmaritimeforum.org/content/2021/10/A-Strategy-for-the-Transition-to-Zero-Emission-Shipping.pdf

4 Getting to net zero – low and zero-emission fuel adoption rate



Source: COP26 Climate Champions, UMAS

5 It can take up to five years to bring a low-emission fuel project online
Indicative project development schedule



*FEED: Front end engineering design

Source: Trafigura Research

Fuels of the future: scope of options

There are several ways the shipping industry can replace oil-derived bunker fuels with cleaner alternatives.

In this whitepaper, we have chosen to focus on shipping fuels derived from green hydrogen, which is produced from the electrolysis of water using renewable energy.

These so-called electrofuels include ammonia and methanol. We have taken this approach because of the huge potential to produce these fuels at scale in the Global South, as well as the development opportunities it could create. These include the creation of new industries, which could help boost energy independence, create thousands of skilled jobs and reduce fuel poverty, ensuring a just transition to a low-emission future.

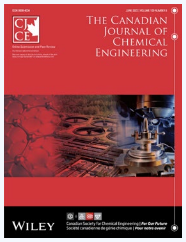
Ethanol also has the potential to be a low-emission shipping fuel although it has not garnered the same amount of attention as methanol, and further work is needed to assess its potential.

And while biofuels, particularly in the near term, will play a part in shipping's future energy mix, limitations around the availability of sustainable feedstock mean that it is unlikely to be available at the scale needed to play a key role in shipping decarbonisation. For that reason, biofuels are not covered in the whitepaper.

We also acknowledge the potential use of onboard carbon capture technology, although it faces challenges. These include large energy requirements, which can limit the net percentage capture rates, and the amount of onboard storage needed. While we can envisage carbon capture being adopted in the near term, we believe it will be limited to short voyages and on smaller vessels. For our views on LNG as a low-emission shipping fuel, see Box 6.

Overall, it is our view that shipping is transitioning to a multi-fuel future and that all products and emission reduction options will need to be adopted to align the industry with the goal of the Paris Agreement.

6 LNG – A low-emission shipping fuel?



In a 2021 peer reviewed scientific paper, Trafigura and Texas A&M University examined the potential of LNG as a lower carbon marine fuel. It found that compared to conventional bunker fuels, LNG could reduce lifecycle, or well-to-wake emissions, by up to 18 percent. Incorporating renewables-based power generation in the liquefaction process could reduce carbon emissions by a further 5 to 10 percent. However, the paper concluded that LNG was "unlikely to be the transport fuel of the future because of its carbon content." "The use of LNG as a marine fuel and the introduction of innovative solutions such as decarbonising liquefaction can reduce the life cycle GHG emissions by 20 percent to 25 percent. However, this reduction will not meet the increasing societal requirements to decarbonise shipping fully sooner rather than later."

https://onlinelibrary.wiley.com/doi/abs/10.1002/cjce.24268
Ahmad Al-Douri, Abdulrahman S. Alsuhaibani, Margaux Moore, Rasmus B. Nielsen, Amro A. El-Baz, Mahmoud M. El-Halwagi (2021)

Hydrogen as a feedstock

Hydrogen made from natural gas is already widely used in industrial processes. It can also be used to power ships with modified internal combustion engines. However, hydrogen has a low volumetric energy density and is hard to compress. Even in liquid form, its energy density is low compared to alternative shipping fuels. As such, a large amount of space is needed on board a ship to store hydrogen. Therefore, we see green hydrogen, as a feedstock for the production of electrofuels rather than a direct propulsion fuel for the foreseeable future.

Methanol

Shipped globally for over a century, methanol is a clear liquid alcohol, which is water soluble and with lower toxicity to marine life compared to other potential shipping fuels. Its main current use is in the production of industrial chemicals, including formaldehyde and acetic acid.

It is widely regarded as the most market-ready alternative fuel in terms of engine technology readiness.[19] It has chemical and physical fuel properties similar to gasoline and has some powerful supporters including Maersk, one of the world's biggest shipping companies.

Historically, methanol has been produced by reforming natural gas in the presence of steam to produce syngas which is then converted and distilled into methanol.

Green methanol is produced by combining green hydrogen (H_2) with carbon dioxide (CO_2) captured from industrial or biogenic sources, or CO_2 captured directly from the air.

However, this production technique has yet to be entirely de-risked and proven at scale. In addition, sourcing CO_2 could also be a bottleneck and is likely to be the largest constraining factor for producing green methanol.

Nonetheless, we expect orders for methanol-powered ships to increase until ammonia engines are technologically ready. At that point, we believe the order book will move gradually towards a split of vessels capable of running on ammonia or methanol.

19 Source: Wood Mackenzie: https://my.woodmac.com/reports/refining-and-oil-products-decarbonising-shipping-through-synthetic-fuels-the-global-outlook-for-marine-e-fuels-150043678

Ammonia

Ammonia, like methanol, is already a globally traded commodity. It is one of the feedstocks needed to make fertiliser and annual global production is around 185 million tonnes.[20] It is typically produced by combining nitrogen from the air with hydrogen derived from natural gas, through the Haber-Bosch process. It can also be made using green hydrogen, making ammonia a potential low-emission shipping fuel.

Supporters claim green ammonia will be the most cost-effective alternative shipping fuel in the long run[21], although internal combustion engines running on ammonia are not currently available for ships. That will soon change. Trafigura is co-sponsoring the development of a two-stroke ammonia engine with Germany's MAN Energy Solutions that could be commercially available by 2024 and ready for ship delivery in 2025.

Ammonia does have potential drawbacks. As it is highly toxic, appropriate safety standards and protocols will need to be adopted by the shipping industry. However, we are confident that the industry will be able to introduce measures to overcome these issues. Various large industrial consortiums, either current or future users of ammonia, are making this a top priority.

Indeed, an important new study that found the risks of ammonia bunkering in Singapore, a major shipping hub, were "low or mitigable".[22]

20 Source: Mission Possible Partnership: *https://missionpossiblepartnership.org/wp-content/uploads/2022/09/Making-1.5-Aligned-Ammonia-possible.pdf*

21 Source: World Bank: *https://openknowledge.worldbank.org/entities/publication/b5697ebf-30cd-5491-8e34-2edb199ae5b7*

Blue ammonia and bio-methanol

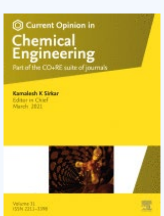
It should also be noted that ammonia can be produced using natural gas-based H_2 and considered low-emission, if the associated emissions are prevented from entering the atmosphere through carbon capture and storage (CCS). Methanol can also use alternative low-emission gas feedstocks such as biogas, or waste gasification, for example.

Large volumes of captured carbon can be stored in underground geological formations globally. Extensive mapping of compatible storage sites for CO_2 has already been done. However, CO_2 storage is contingent on availability and permitting of these sites as well as public acceptance of the practice. For example, continental Europe is reluctant to store large volumes of CO_2 underground onshore, which is why most storage projects in the region are proposed offshore. Bio-feedstocks for methanol production also risk being in short supply as alternative uses increase.

The huge incentives offered in the US Inflation Reduction Act (IRA) – President Biden's USD369 billion green energy package – could see projects capable of producing at least 18 million tonnes per year of blue ammonia, according to Louisiana Economic Development.[23]

22 Source: *https://www.gcformd.org/gcmdpapers*

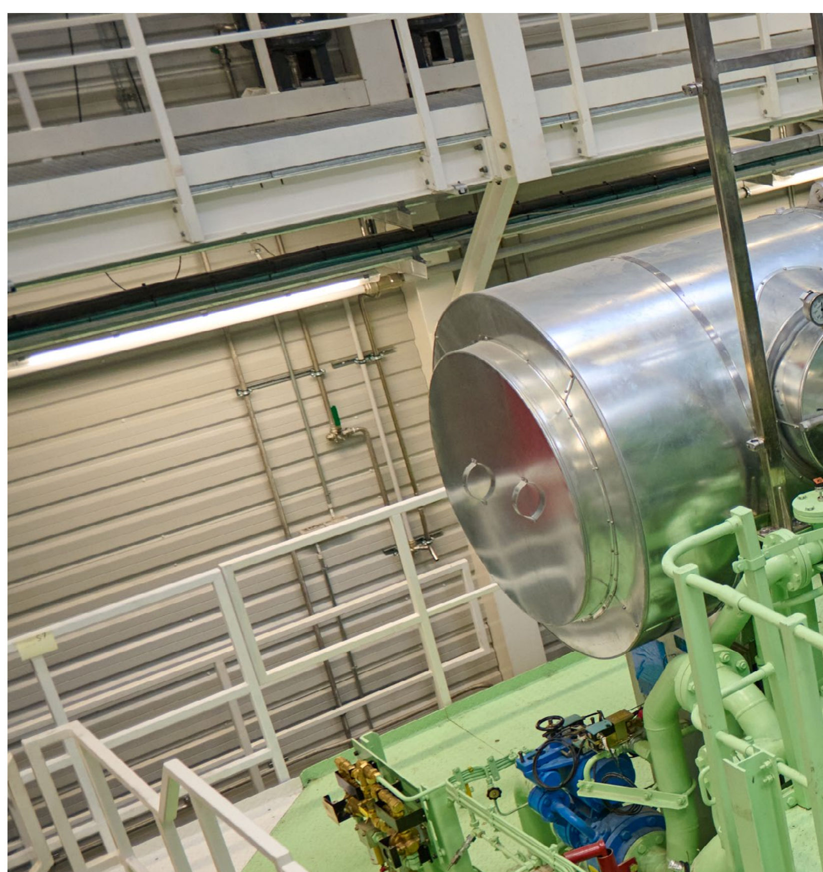
23 Source: Louisiana Economic Development: *https://www.opportunitylouisiana.gov/led-news/news-releases/news/2023/04/19/st.-charles-clean-fuels-proposes-$4.6-billion-reduced-carbon-ammonia-facility-in-st.-rose*



7 Renewable ammonia as an alternative fuel for the shipping industry

In 2021, Trafigura and Texas A&M University published a scientific paper on the potential of green ammonia. The analysis covered manufacturing approaches, energy and feedstock sources, economics and the environmental impact based on both well-to-tank and tank-to-wake bases. The paper found that green ammonia was a "promising fuel option" especially for long-distance shipping because of its low-emission footprint and that the existing supply chain for ammonia could be readily expanded to meet demand from the shipping industry. It also concluded that advances in electrolysis and renewable energy "harvesting" technologies could significantly reduce production costs.

www.sciencedirect.com/science/article/abs/pii/S2211339821000022 Fadhil Y. Al-Aboosi, Mahmoud M. El-Halwagi, Margaux Moore, Rasmus B. Nielsen (2021)



These volumes could continue to increase given the production subsidies available through the IRA. However, these volumes are unlikely to be available to the shipping industry without a carbon levy to encourage their adoption. In addition, new projects would still need three to five years to start production, underlining again the need for the start of carbon pricing in shipping as soon as possible.

8 Ethanol – an alternative fuel supply?

Ethanol has the potential to be a low-emission shipping fuel and like methanol it can be produced by combining green hydrogen with CO_2 captured from the air. However, ethanol has not attracted the same amount of attention.

Ethanol is more energy dense than methanol, requiring less storage space on board and is already an energy commodity, readily-traded globally and easy to handle. It is our understanding that ethanol can be used in methanol engines with limited retrofit. Further efforts need to be pursued to promote ethanol as a low-emission fuel for shipping.

The role of biofuels

While supply and demand for electrofuels develops, we must acknowledge the role biofuels will play.

Biofuels are a drop-in fuel which can be blended with conventional fuels and achieve some emission reduction. These fuels can be produced from a wide variety of feedstocks, including vegetable oils, used cooking oils, animal greases, forestry and agriculture waste, and other forms of biomass.

Biofuels are produced and used today in shipping – requiring virtually no retrofitting to vessels and bunkering infrastructure. However, concerns over feedstock availability mean that biofuels are unlikely to be available at the scale needed to decarbonise the entire shipping industry. We expect biofuel consumption in shipping to increase over the next decade until other low-emission and electrofuels take off.

In the next section of the whitepaper, we will consider the potential of the Global South to produce shipping fuels derived from green hydrogen. We will show that the region can produce enough competitively priced green hydrogen to satisfy demand from the shipping industry many times over and challenge natural gas based alternatives that will emerge in North America because of policies like the IRA and the Middle East.

In development: MAN Energy Solutions two-stroke ammonia engine

Low-emission fuel supply production

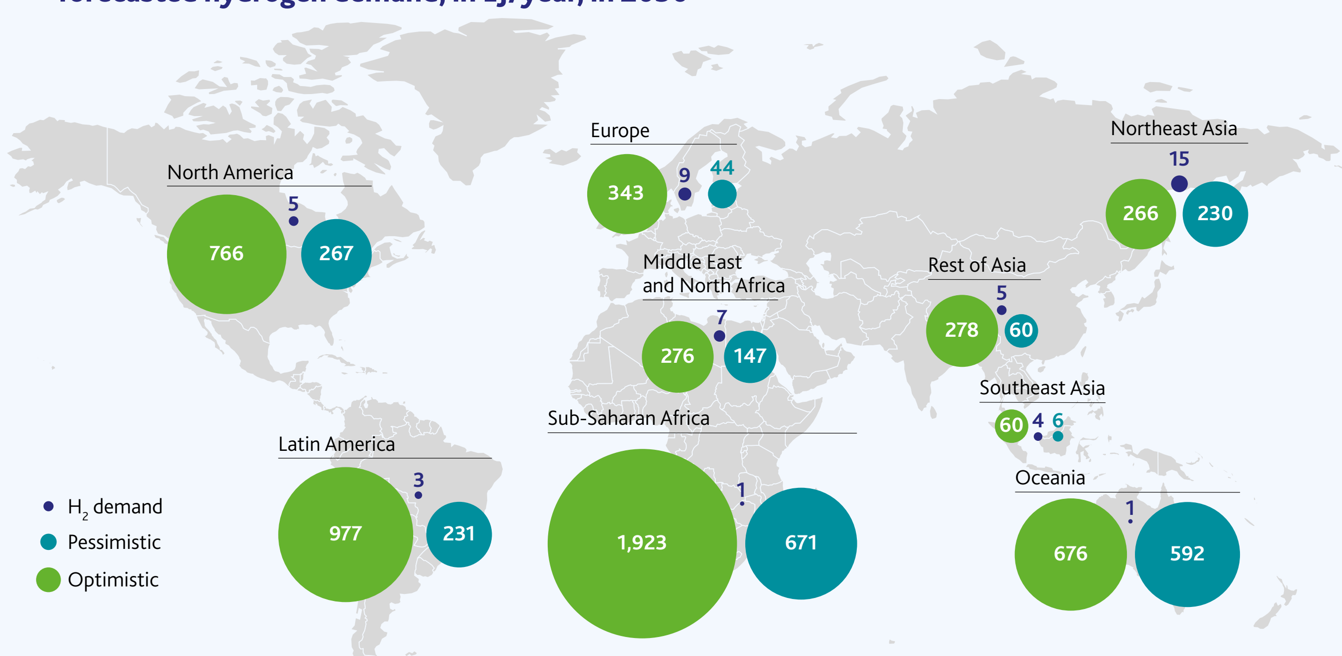
The economic viability of green hydrogen-derived shipping fuels will depend to a large extent on access to cheap renewable power. In this section, we seek to identify the regions and countries best positioned to emerge as large suppliers of electrofuels for the maritime industry.

Analysis by the International Renewable Energy Agency (IRENA)[24] found that "vast" green hydrogen production potential exists around the world – equating to more than 20 times primary energy demand by 2050 – although it varied between countries and regions depending on a number of a factors including land and water availability.

In addition, IRENA showed that the potential to produce green hydrogen below USD2.00 per kilogramme – a price that is universally considered to be economic – was "huge" and would largely satisfy forecast for the substance in 2050.

25 Source: IRENA (2022): https://www.irena.org/publications/2022/May/Global-hydrogen-trade-Cost

9 Comparison between the economic potential of green hydrogen supply below USD2/kg H_2 and forecasted hydrogen demand, in EJ/year, in 2050

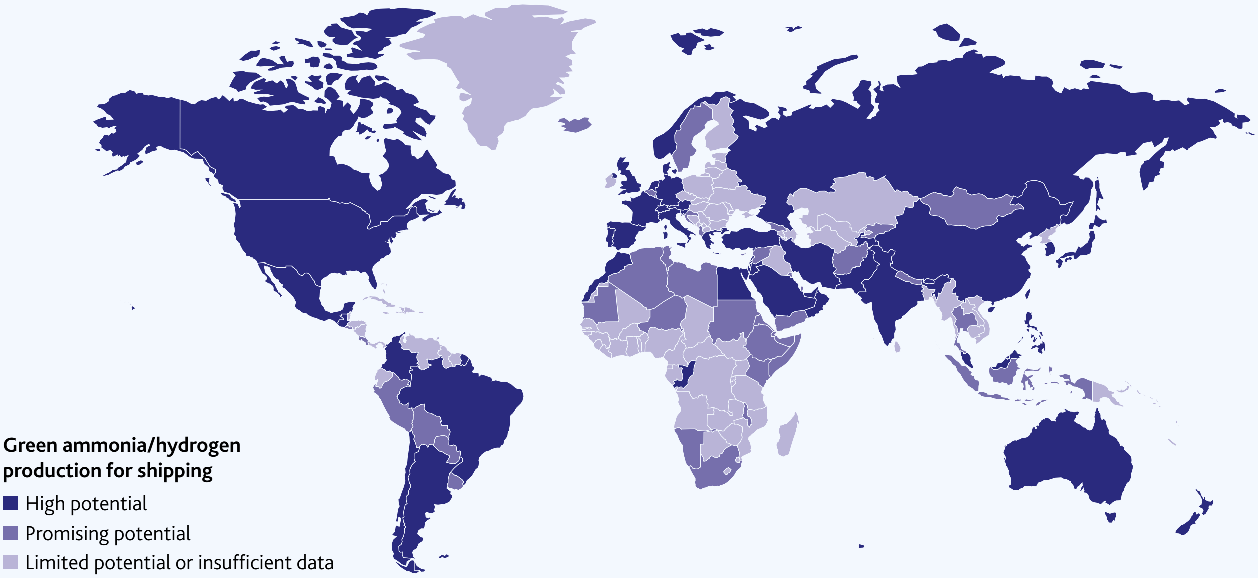


Notes: Assumptions for CAPEX 2050 are as follows: Optimistic, PV: USD225/kW to USD455/kW; onshore wind: USD700/kw to USD1,070/kW; offshore wind: USD1,275/kW to USD1,745/kW. Pessimistic, PV: USD271/kW to USD551/kW; onshore wind: USD775/kW to USD1,191/kW; offshore wind: USD1,317/kW to USD1,799/kW. WACC: optimistic, per 2020 values without technology risk across regions. Pessimistic, per 2020 values with technology risk across regions. Technical potential has been calculated based on land availability considering several exclusions zones (protected areas forests, permanent wetlands, croplands, urban areas, slope of 5 percent [PV] and 20 percent [onshore wind], population density and water stress). Total hydrogen demand, not including power sector (24 EJ/year), is equal to 50 EJ/year.

Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply any endorsements or acceptance by IRENA.

Source: IRENA

10 Heat map indicating the potential for countries to produce green ammonia/hydrogen for shipping



Source: World Bank, IBRD 45502, March 2021

The report said: "Africa combines good quality resources for photovoltaics (across the entire continent) with onshore wind (particularly in the Western Sahara and the Somali Peninsula), large areas of land and a burgeoning energy sector."

It added: "Green hydrogen provides an additional opportunity to satisfy the growing energy needs of the continent while at the same time providing prospects for economic growth and industrial development through export of hydrogen and its derivatives."

The World Bank has also looked at the potential of developing countries to produce electrofuels.

In a 2021 report, the organisation assessed all of its 189-members, including landlocked countries, to see which nations had the potential to become major producers of alternative shipping fuels.[25]

In its Green Hydrogen scenario, the World Bank report identified India as a country with high potential due to its "vast potential to generate inexpensive electricity" through solar power and other forms of renewable energy and closeness to the key bunkering hubs of Singapore and Fujairah in the United Arab Emirates. Other countries with high potential included Argentina, Brazil, Chile, Egypt, Guatemala and Morocco.

25 Source: World Bank Report, 2021, page 40

11 Global South is competitive

We believe electrofuels produced in the Global South could be two times more competitive than those produced in Europe. At USD2.00 per kilogramme of green hydrogen, the estimated production costs of electrofuels in the Global South is approximately USD750 per tonne, whereas in Europe, with higher electricity prices, it would be closer to USD1,200 to USD1,500 per tonne.[26]

Even at USD4.00 per kilogramme of green hydrogen, electrofuels produced in the Global South would still be 20 percent cheaper than electrofuels produced in Europe, where we assume a cost of USD5-6 per kilogramme for green hydrogen.

In comparison, long-term contracts for Very Low Sulphur Fuel Oil (VLSF) are currently pricing between USD600 and USD800 per tonne. When adjusted for energy density, the electrofuel alternative is 4 times more expensive in Europe and 2 times more expensive in the Global South compared to VLSF, highlighting the need for a price on carbon to ensure a level playing field. In our view, hydrogen produced in Europe will be used domestically to decarbonise heavy industry and will be transported mainly by dedicated pipelines.

26 Conversion factor: 700/2.2 = 320 versus 1,350 European ammonia/methanol price.

Source: UMAS

Trafigura analysis

As acknowledged by the authors of the World Bank report, the study did not represent a definite estimate of the economic competitiveness of a country with regards to production of hydrogen-based shipping fuels.

To address that limitation and provide a further shortlist of countries with the potential to produce green ammonia and methanol, we have used a simple competitiveness proxy: a renewable capacity factor.

Our rationale is that the more the sun shines (or the wind blows in a specific country) the lower the cost of renewable energy. Ultimately, this reduces the cost of producing a hydrogen-derived fuel.

Based on this approach, we have identified the west coast of South America, Oceania, the Middle East and Africa as regions with high potential. Drawing on the work of IRENA[27], we found sub-Saharan Africa could produce up to 1,923 exajoules per year of competitively priced green hydrogen. Overall, we think high potential regions could produce up to 3,852 exajoules per year of competitively priced green hydrogen. Exajoules are a measure of electrical energy. To put the above figure into perspective, it is equivalent to 6.5 times primary energy consumption in 2021.[28]

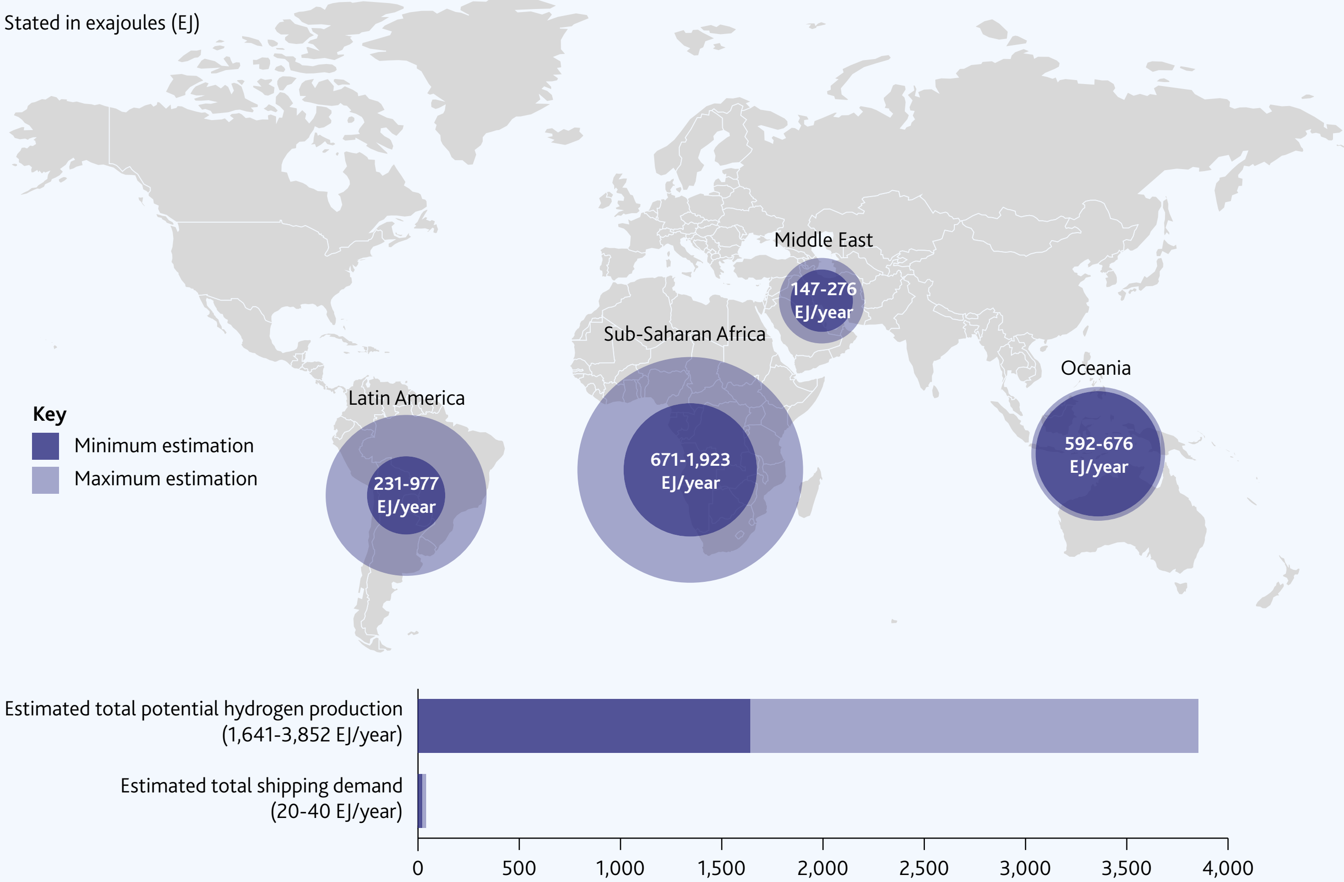
At the country level, our analysis found Argentina, Australia, Bolivia, Brazil, Chile, Colombia, India and Egypt with the renewable energy potential as well as land availability needed to supply competitively-priced low-emission shipping fuels.

27 Source: IRENA (2022): https://www.irena.org/publications/2022/May/Global-hydrogen-trade-Cost

28 Primary global energy consumption in 2021 was 595 exajoules, according to BP's Review of World Energy, while annual shipping demand is estimated at between 20 and 40 exajoules.

12 High potential regions for green hydrogen production

Our research found that Latin America, sub-Saharan Africa, the Middle East and Oceania have the potential to produce up to 3,852 exajoules of renewable hydrogen, almost 100 times the amount required to decarbonise the shipping industry.



Source: IRENA

Supply summary

In summary, our research and work by experts groups clearly shows that there is the potential to produce large volumes of renewable hydrogen and, by extension, electrofuels in the Global South.

As such, the decarbonisation of international shipping offers developing countries the chance to build new export industries and create thousands of skilled jobs.

At the same time, it could also offer these countries a source of low-emission energy for domestic use, help tackle energy poverty and ensure an equitable transition. The scaling up of renewable power also offers a potential route to energy independence for these nations.

And as IRENA notes in its report, higher project finance costs "do not necessarily impede investment in countries with higher risk profiles". The upstream oil and gas sectors show that where the revenue potential is sufficient, investment will still flow in spite of country risk.

As such, countries in the Global South can best capture these opportunities by ensuring the IMO revises its GHG strategy so it is aligned with a 1.5-degree temperature goal. This will give private investors and multilateral development banks the confidence to push ahead and support new shipping fuel projects, knowing there will be sufficient demand for their products.

This should be combined with the introduction of a carbon levy by 2025. Not only would this help stimulate demand for electrofuels, but the revenue generated through a price on carbon could be used to support projects and infrastructure in the Global South and guarantee that no country is left behind in the transition.

Unless there is clarification around these issues, then the risk of investing in the Global South will remain high and most of the 1.5-degree-aligned investment will gravitate towards developing economies who are subsiding the energy transition with huge green funding packages such as IRA and the EU's Net Zero Industry Act.

"The decarbonisation of the shipping industry must happen in a global way. We cannot afford a two-tiered transition. There is significant potential to produce hydrogen-based fuels in the Global South but that won't become a reality unless we can close the cost gap between bunker fuels and low-emission alternatives. 2023 presents a window of opportunity to make that happen. We must not waste it," Margaux Moore, Head of Energy Transition Research and Venture Investments

Demand for low-emission fuels

In the previous section, we highlighted the countries and regions well placed to develop hydrogen-based electrofuels for the shipping industry.

The next section will focus on demand and the amount of low-emission ammonia and methanol that will be needed to decarbonise shipping.

As referenced earlier, analysis[29] by the Getting to Zero Coalition suggests that scalable zero emission fuels need to make up 5 percent of the sector's energy mix by 2030, rising to 27 percent in 2036 to be Paris Agreement-aligned.

By 2030, our internal research expects global demand for bunker fuel to reach 290 million tonnes a year, or around 5 million barrels of high sulphur fuel oil per day.

Given the greater focus on efficiency from new industry regulations, we expected demand to remain at that level until 2036. Therefore, at least 14.5 million tonnes of heavy fuel oil equivalent (5 percent of 290 million tonnes) will be needed by the end of the decade.

Expressed in methanol and ammonia tonnes, and based on a calorific conversion factor of 2.2 for methanol and 2.3 for ammonia, to hit the 5 percent target by 2030 would require annual production of either 31.9 million tonnes of methanol or 33.4 million tonnes of ammonia (although it is likely to be a mixture of the two fuels).

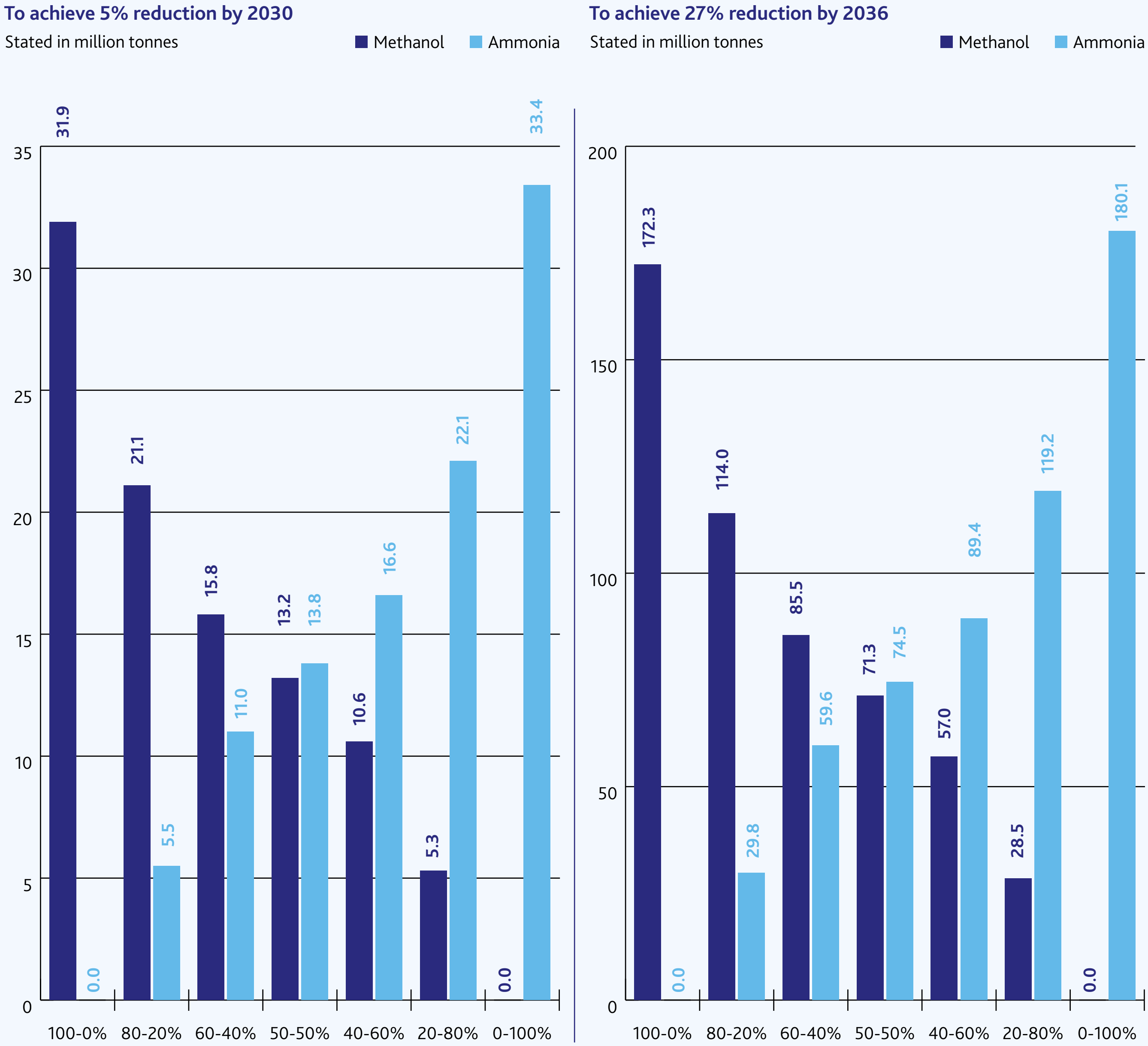
To put that figure in perspective, as of May 2023, the current order book for methanol dual-fuelled vessels will require 3-4 million tonnes of fuel by 2027 according to our research. Still, we believe this target can be achieved. Our analysis assumes that not all the methanol will be green, as most players will look to blend conventional methanol with some low-emission fuel in the near term. In addition, we are assuming a best-case scenario for methanol, where the fuel is readily available on all shipping routes and the vessel avoids operating in marine gasoil mode.

For the shipping industry to reach 27 percent low-emission fuel use by 2036, is a much harder task. In a methanol-only scenario, 172.3 million tonnes a year of the fuel would be needed by 2036. For ammonia, the equivalent figure its 180.1 million tonnes and would require a growth rate comparable to the maximum experienced by the industry in its history.

Clearly, producing this amount of hydrogen-derived fuels will require massive investment in new production plants, vessels and infrastructure. That is why it is vital to bridge the cost gap between bunker fuels and low-emission alternatives.

29 Source: Global Maritime Forum, UCL, UNFCCC

13 Future fuel mixes for the shipping industry



Metric	Volume in million tonnes
Global bunkering demand per annum	290
Current dual-fuel-methanol order book by 2025	3-4
Required supply for 5% reduction by 2030	~ 31.9 of methanol ~ 33.4 of ammonia
Required supply for 27% reduction by 2036	~ 172.3 of methanol ~ 180.1 of ammonia

Source: Trafigura Research

Capital availability

A study by University Maritime Advisory Services (UMAS) calculated the cumulative investment needed between 2030 and 2050 to fully decarbonise shipping ranges between USD1.4 trillion and USD1.9 trillion.[30]

While these are big numbers, there is a large pool of confirmed capital seeking to invest in clean energy projects that are economically viable.

Last year, global investment in the energy transition across all sectors totalled USD1.1 trillion, according to Bloomberg New Energy Finance.[31] In a new report, IRENA estimated that global investments in energy transition technologies reached a record high of USD1.3 trillion in 2022, up 19 percent from a year earlier and 50 percent from 2019.

Not only was this a new record and huge acceleration from the year before, but it was also the first time energy transition investment had matched fossil fuel investment, according to Bloomberg.

IRENA also found that the private sector provided most of the global investments in renewable energy between 2013 and 2020.[32]

This acceleration in available finance has been catalysed by growing policy support from governments focused on meeting their long-term climate goals and improving security of energy supply.

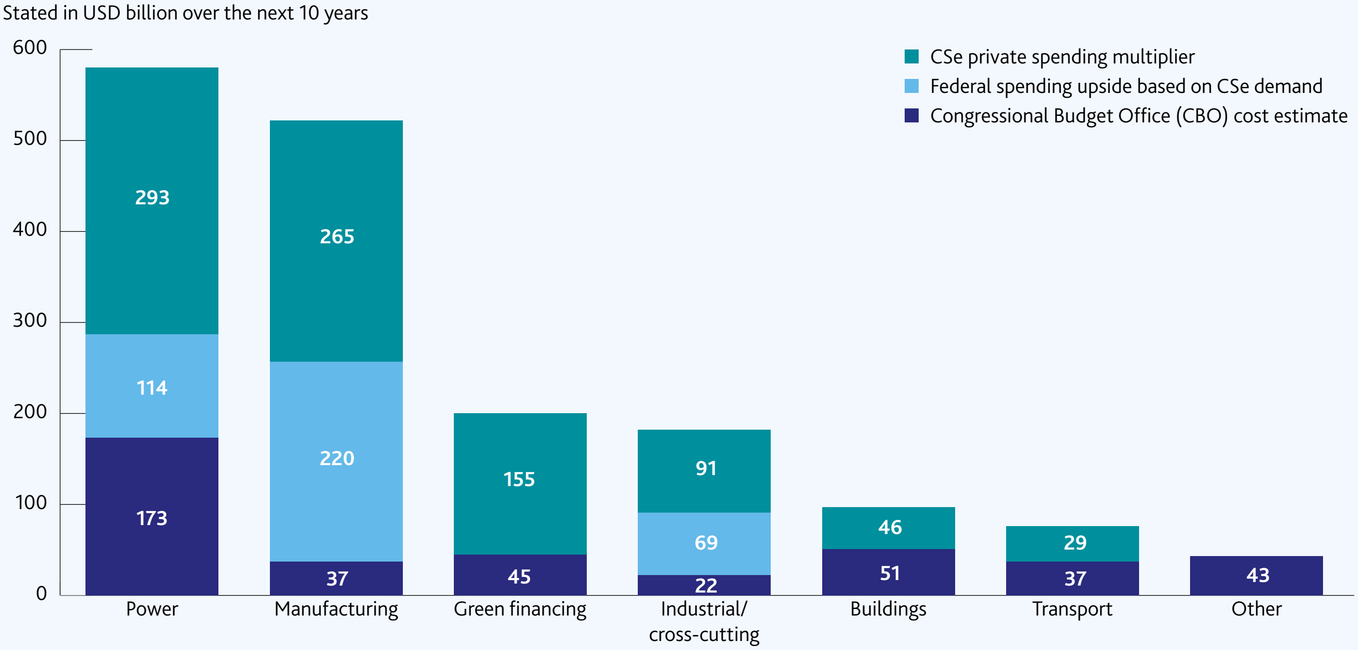
30 Source: https://www.u-mas.co.uk/new-study-by-umas-shows-that-decarbonisation-of-the-shipping-sector-is-a-whole-system-challenge-and-not-something-just-for-shipping/

31 Source: Bloomberg: https://about.bnef.com/blog/global-low-carbon-energy-technology-investment-surges-past-1-trillion-for-the-first-time/

32 Source: IRENA: https://mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net/-/media/Files/IRENA/Agency/Publication/2023/Feb/IRENA_CPI_Global_RE_finance_2023.pdf?rev=6213e7fa55ec4991a22514572e7996c5

14 Potential public and private climate-related spending – Credit Suisse estimate (CSe)

Stated in USD billion over the next 10 years



Source: CBO, Credit Suisse
https://www.credit-suisse.com/about-us-news/en/articles/news-and-expertise/us-inflation-reduction-act-a-catalyst-for-climate-action-202211.html

This is best illustrated by the IRA, where clean hydrogen producers can receive tax credits of up to USD3 per kilogramme of H_2, making many projects cost-competitive with conventional hydrogen produced from natural gas.

Furthermore, a tax credit on carbon capture will also make blue hydrogen projects more cost competitive in the US.

Overall, IRA could be a game changer for renewable energy investment in the US. Credit Suisse[33] estimates it could mobilise up to USD1.7 trillion of spending over the next 10 years, once the multiplier effect from private investment is included (see Box 14).

Some commentators believe there is a risk that funds needed to finance large-scale green hydrogen projects will now flow to the US from other parts of the world.

This is why in some regions, such as Africa and Latin America, stakeholders will need to join forces to unlock the capital needed to fund low-emission shipping fuel projects.

A recent report by the Green Hydrogen Organisation[34] on Africa's green hydrogen potential highlighted several possible actions. These included the development of private-public partnerships, the provision of credit guarantees, incentive programmes and tapping into green finance institutions.

Ultimately, green ammonia or methanol projects must secure long-term offtake agreements to unlock the financing needed to take a project through to final investment decision and beyond.

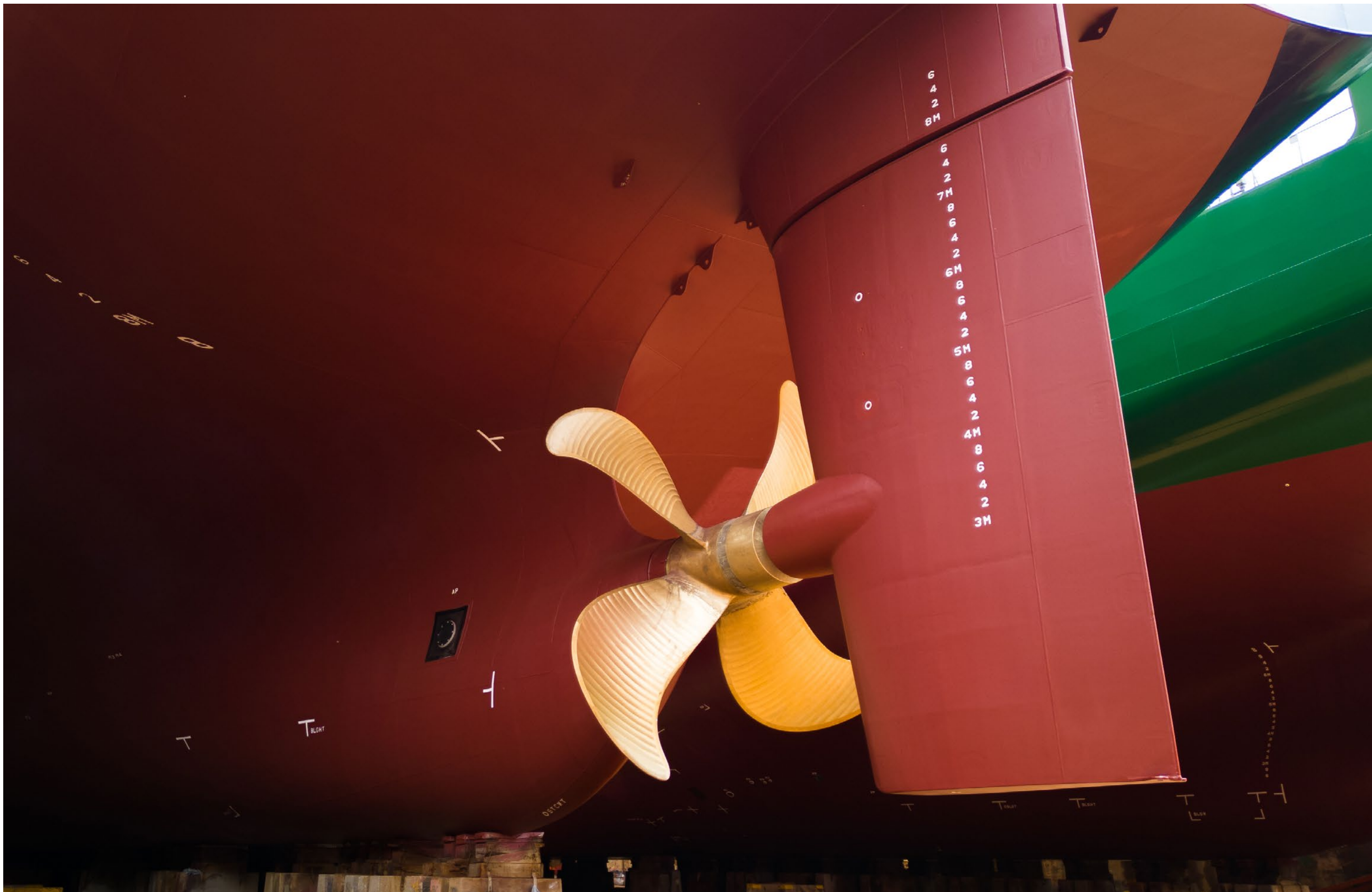
Lenders are unlikely to make significant debt pledges on greenfield projects without certainty on future demand and security on cash flow. This limits access to financing for low-emissions projects into shipping today.

And that, in turn, restricts shipowners from investing in new vessels capable of running on low-emission fuels. The same is true of port operators and pipeline operators.

To help square this circle, the shipping industry needs a bold decarbonisation strategy, and pathway to address the price gap that exists between bunker fuels and cleaner alternatives.

33 Source: Credit Suisse: *https://www.credit-suisse.com/about-us-news/en/articles/news-and-expertise/us-inflation-reduction-act-a-catalyst-for-climate-action-202211.html*

34 Source: Green Hydrogen Organisation: *https://gh2.org/article/green-hydrogen-could-sustainably-industrialise-africa-and-boost-gdp-6-12-six-key-countries*



Conclusion and action points: the need for a carbon price

Conclusion

It has been more than two years since Trafigura called on the IMO to introduce a carbon levy for shipping, in order to make low-emission fuels more competitive and economically viable and also generate funds to ensure lower income countries are not left behind during the energy transition.

Since then, a growing number of countries, including the Marshall Islands and Japan, have published their own carbon levy proposals and feedback from the latest round of IMO negotiations suggests that momentum is building towards a revised GHG Strategy that will include at least a 2050 net zero target, 1.5-degree-aligned interim targets, plus a price on carbon by 2025.

Many more countries are seeing the potential benefits of producing low-emission hydrogen-based fuels, in addition to the possible funding support through a carbon levy.

We estimate, the addition of shipping to the EU's Emissions Trading Scheme, could raise EUR1.5 billion per year to invest in low-emission fuels and infrastructure. This is just a fraction of the funding that could be made available if global IMO-led carbon pricing was introduced.

2023 offers a chance to set this process in motion and chart a course to a greener future for shipping, which is the lifeblood of global trade. A clear signal of intent to set a carbon levy and timeline must be in the IMO's revised strategy, to unlock investment and funding for electrofuels.

For the Global South, shipping decarbonisation offers a huge development opportunity. To fully realise the potential, countries in this region need to join forces and push the IMO towards the targets and goals laid out in this whitepaper. There is no time to waste.

"When it comes to decarbonisation, the shipping industry has a lot more to do. The IMO should set emission reduction targets for 2030 and 2040 that are aligned with a 1.5 degree temperature goal and strive to achieve at least net zero by 2050. It must also agree and implement a price on carbon by 2025. That's an absolute must to give shipowners the confidence to order new vessels capable of running on low-emission fuels," Rasmus Bach Nielsen, Global Head of Fuel Decarbonisation at Trafigura.

15 Action points for the shipping industry:

- IPCC-derived lifecycle GHG targets such as SBTi: 37% of reduction in 2030, 96% in 2040
- At least a 2050 net zero commitment but ideally a zero emission
- Set a carbon price for introduction in 2025
- Full lifecycle (well-to-wake) accounting for emissions
- Global fuel standards

16 Charting a course to a greener future – a suggested timeline

2023 — 26-30 June 2023:
IMO working group prepares updated GHG Strategy

3-7 July 2023:
80th meeting of IMO's Marine Environmental Protection Committee to clarify policy measures aimed at significantly reducing GHG emissions from shipping

2024

2025 — **Carbon price for shipping must be introduced**

2026

2027

Five years development required for low-emission fuels projects (2024–2029)

2028

2029

2030 — **Scalable zero-emission fuels need to account for 5% of shipping's energy mix**

2031

2032

2033

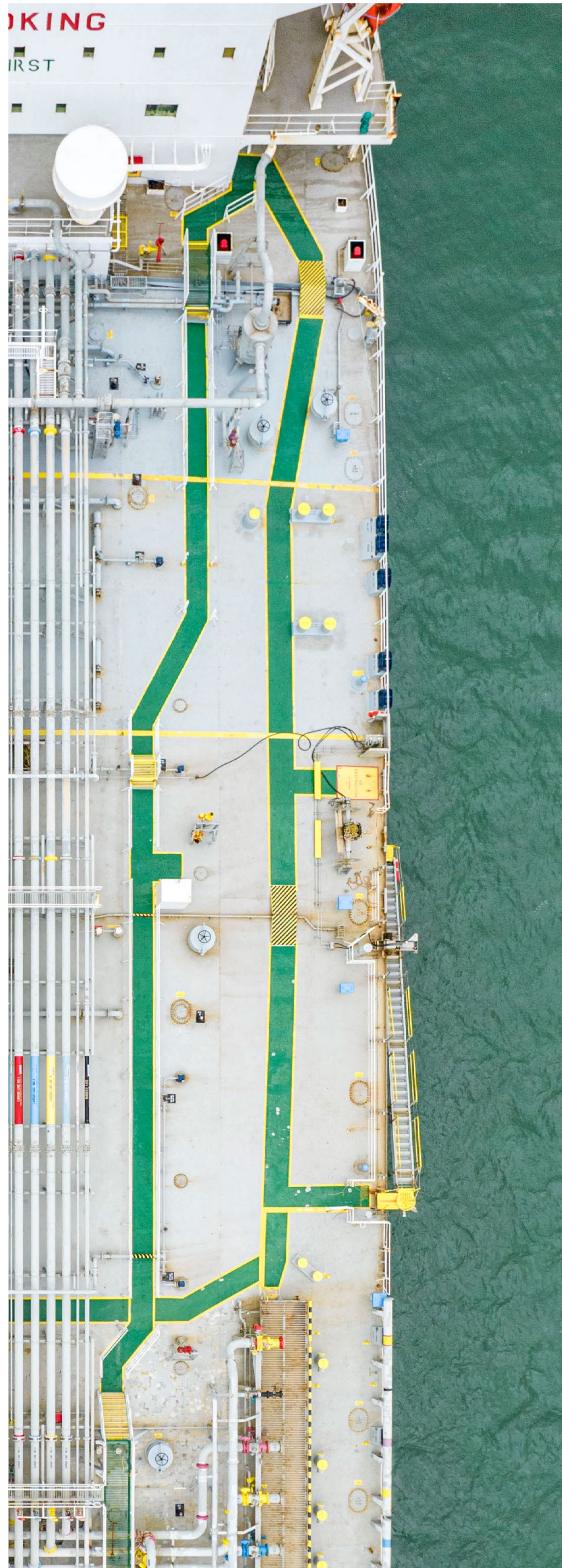
2034

2035

2036 — **Scalable zero-emission fuels need to account for 27% of shipping's energy mix**

2046 — **Scalable zero emission fuels need to account for 93% of shipping's energy mix**

2050 — **Shipping achieves net zero or zero emissions**



External voices

Katharine Palmer
Shipping Lead, (UN High Level) Climate Champion

2023 is a critical year for international shipping to decide whether it goes from a being hard-to-abate sector to a climate leader. Following the success of its 2020 whitepaper calling for a carbon price, Trafigura has shaped the industry's decarbonisation debate with the IMO now agreed on the need for an 'economic measure' to reduce emissions. This new whitepaper from Trafigura is very timely with the 80th meeting of the IMO's Marine Environmental Protection Committee (MEPC) just over a month away. Once again, Trafigura is demonstrating its leadership by clearly articulating the opportunity for a just and equitable transition away from fossil fuels through the production at scale of low-emission shipping fuels in the Global South. It is the first private sector company to publicly highlight this potential prize. With bold, ambitious and effective policy signals we can unlock near term investments that will ensure that shipping's transition is fair, inclusive and the opportunities within the Global South are realised. Now, is the time to put shipping on a 1.5°C-aligned trajectory with ambitious 2030 and 2040 targets and this requires decisive action from all parties.

Dumisani Theophelus Ntuli
Chief Director Maritime Transport Policy & Legislation, Department of Transport, Republic of South Africa

There is a fast-developing consensus that the only way to significantly reduce emissions from deep-sea maritime shipping is by changing from fossil-fuel-based bunker fuels to synthetic fuels derived from green hydrogen. And South Africa can make a sizeable contribution on demand to the production of these fuels.

We have land and sea with excellent solar and wind resources, allowing green hydrogen to be produced at scale at lower cost than most other jurisdictions. This has already been recognised by one of our key trading partners who has invested in green hydrogen projects in South Africa.

The South African government has already made several commitments to green hydrogen, including an approved hydrogen roadmap and the establishment of a Maritime Industry Taskforce Network. One of the goals is the decarbonisation of maritime transport using renewable energy.

In addition, a green hydrogen Commercialisation Strategy has been adopted by Cabinet and has been released for public comment, while three green hydrogen projects to produce green ammonia at or near ports have been identified for gazetting as Strategic Integrated Projects. The World Bank is also funding a pre-feasibility study at the ports of Saldanha and Boegoebaai for the production, storage, bunkering and even export of sustainable bunker fuels.

Knut Ørbeck-Nilssen
CEO Maritime, DNV

Decarbonisation is the grand challenge of our time for shipping. A major, but not insurmountable task that calls for great effort and collaboration across the industry and beyond. Companies will need to take a 'cooperate when you can and compete when you have to' attitude. Trafigura is proactively engaging and collaborating, becoming a founder of the Sea Cargo Charter – an excellent driver for industry transparency.

Business decisions related to decarbonisation are taken daily and doing nothing is also a decision. Facts and insights are required to support business decisions and this whitepaper strongly contributes to this. No single stakeholder can alone drive decarbonisation but everybody can do something. The IMO's vision from 2018 onwards has made shipping one of the most transparent businesses there is, with all ships required to report verified CO_2 emissions, fuel consumption and transport distance on a regular basis. This is an excellent accelerator for decarbonisation. But now all stakeholders have to play their part. Trafigura and other cargo owners can help drive maritime decarbonisation by being tackling the carbon emissions from their chartered tonnage.

Gonzalo Rafael Pantaleón Frigerio Ibar
Head of the Maritime Department of the Ministry of Transport, Government of Chile

Chile is promoting a National Green Hydrogen Strategy, which seeks to position the country as a leader in the production, consumption and export of green hydrogen and its derivatives.

We are engaging with all the stakeholders, public sector, industry, international organisations, academia and civil society, to make it a reality. In this context, we are working to develop green maritime corridors, whose early implementation will drive technological change, contributing to decarbonise maritime transport.

In this context, in Chile we acknowledge the significance of decarbonisation in all means of transportation; and we recognise the leadership of IMO in these issues, where we promote and participate in constructive discussions to reach ambitious agreements.

Dr. Uwe Lauber
CEO, MAN Energy Solutions

MAN Energy Solutions is committed to making technology available to decarbonise shipping. Developing and engineering new technology is not without risk, both technically and financially. Trafigura's co-sponsoring of our ammonia technology helped accelerate this process by allowing us to focus on the technical challenges. At the same time, the partnership has increased our confidence that global demand for low-emission shipping fuels will be there. Our partnership is an example of how companies can work together to accelerate decarbonisation. Our ammonia technology will be sailing the seas in 2025 and will help make shipping an easier-to-abate industry. After all, the technology for ambitious decarbonisation of shipping is already here; it just needs the right policy settings.

Jan Dieleman
Chair, Global Maritime Forum

This whitepaper delivers one of those missing pieces of the puzzle that essentially shows in more concrete terms and numbers how shipping decarbonisation is actually a great opportunity for both companies and many developing countries. I'm happy to see that it further develops work undertaken in the Getting to Zero Coalition on the ambition to reach 5 percent use of scalable zero-emission fuels in international shipping by 2030. For a long time, we have talked about the opportunities. This whitepaper adds a compelling presentation of these. It is a must read for all governments, maritime, energy and finance stakeholders who take actions based on facts and sound analyses.

References

Bloomberg NEF. *Global Low-Carbon Energy Technology Investment Surges Past $1 Trillion for the First Time.* 26 January 2023.
Available at *https://about.bnef.com/blog/global-low-carbon-energy-technology-investment-surges-past-1-trillion-for-the-first-time*

bp. *Statistical review of World Energy.* 2022.
Available at *https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf*

Credit Suisse. US Inflation Reduction Act: *A catalyst for climate action.* 30 November 2022.
Available at *https://www.credit-suisse.com/about-us-news/en/articles/news-and-expertise/us-inflation-reduction-act-a-catalyst-for-climate-action-202211.html*

European Commission. *Reducing emissions from the shipping sector.*
Available at *https://climate.ec.europa.eu/eu-action/transport-emissions/reducing-emissions-shipping-sector_en*

Getting to Zero Coalition. *A Strategy for the Transition to Zero-Emission Shipping.* 2021.
Available at *https://www.globalmaritimeforum.org/content/2021/10/A-Strategy-for-the-Transition-to-Zero-Emission-Shipping.pdf*

Global Data. *Blue Hydrogen Leaders* – Q2 2022.
Available at *https://www.globaldata.com/data-insights/macroeconomic/blue-hydrogen-leaders-q2-2022*

Global Maritime Forum. *Definition of Zero Carbon Energy Sources.*
Available at *https://www.globalmaritimeforum.org/content/2019/09/Getting-to-Zero-Coalition_Zero-carbon-energy-sources.pdf*

Global Maritime Forum. *Five percent zero emission fuels by 2030 needed for Paris-aligned shipping decarbonization.* 27 March 2023.
Available at *https://www.globalmaritimeforum.org/news/five-percent-zero-emission-fuels-by-2030-needed-for-paris-aligned-shipping-decarbonization*

Global Maritime Forum. *The scale of investment needed to decarbonize international shipping.* 27 March 2023.
Available at *https://www.globalmaritimeforum.org/news/the-scale-of-investment-needed-to-decarbonize-international-shipping*

Green Hydrogen Organisation. *Green hydrogen could sustainably industrialise Africa and boost GDP by 6 to 12% in six key countries – new report.*
Available at *https://gh2.org/article/green-hydrogen-could-sustainably-industrialise-africa-and-boost-gdp-6-12-six-key-countries*

Horizon, The EU Research & Innovation Magazine. *Emissions-free sailing is full steam ahead for ocean-going shipping.* 6 September 2022.
Available at *https://ec.europa.eu/research-and-innovation/en/horizon-magazine/emissions-free-sailing-full-steam-ahead-ocean-going-shipping*

International Energy Agency. *Ammonia technology roadmap.* Updated October 2021.
Available at *https://www.iea.org/reports/ammonia-technology-roadmap*

International Energy Agency. *Hydrogen Projects Database.* Updated October 2022.
Available at *https://www.iea.org/data-and-statistics/data-product/hydrogen-projects-database*

International Maritime Organization. *Initial IMO GHG Strategy.*
Available at *https://www.imo.org/en/MediaCentre/HotTopics/Pages/Reducing-greenhouse-gas-emissions-from-ships.aspx*

International Maritime Organization. *Meeting Summaries and Schedules.*
Available at *https://www.imo.org/en/mediacentre/MeetingSummaries/Pages/Default.aspx*

IRENA. *Global Hydrogen Trade to Meet the 1.5 Climate Goal: Part III. International Renewable Energy Agency, Abu Dhabi.* 2022.
Available at *https://www.irena.org/publications/2022/May/Global-hydrogen-trade-Cost*

International Renewable Energy Agency (IRENA) and Climate Policy Initiative (CPI). *Global landscape of renewable energy finance.* February 2023.
Available at *https://mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net/-/media/Files/IRENA/Agency/Publication/2023/Feb/IRENA_CPI_Global_RE_finance_2023.pdf?rev=6213e7fa55ec4991a22514572e7996c5*

Lloyd's List. *Marshall Islands doubles down on $100 emissions levy plan.* 2 September 2021.
Available at *https://lloydslist.maritimeintelligence.informa.com/LL1138070/Marshall-Islands-doubles-down-on-$100-emissions-levy-plan*

Louisiana Economic Development. *St. Charles Clean Fuels Proposes $4.6 Billion Reduced-Carbon Ammonia Facility in St. Rose.* 19 April 2023. Available at *https://www.opportunitylouisiana.gov/led-news/news-releases/news/2023/04/19/st.-charles-clean-fuels-proposes-$4.6-billion-reduced-carbon-ammonia-facility-in-st.-rose*

Maersk Mc-Kinney Møller Center for Zero Carbon Shipping. *Maritime Decarbonization Strategy 2022*. 8 December 2022. Available at *https://www.zerocarbonshipping.com/publications/maritime-decarbonization-strategy/*

Mission Possible Partnership. *Making net-zero ammonia possible.* September 2022. Available at *https://missionpossiblepartnership.org/wp-content/uploads/2022/09/Making-1.5-Aligned-Ammonia-possible.pdf*

Open Knowledge Repository Area. *Publication: The Potential of Zero-Carbon Bunker Fuels in Developing Countries.* 15 April 2021. Available at *https://openknowledge.worldbank.org/entities/publication/b5697ebf-30cd-5491-8e34-2edb199ae5b7*

Ricardo, Study on the readiness and availability of low- and zero-carbon technology and marine fuels. Available at *https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/FFT%20Project/Study's%20technical%20proosal_Ricardo_DNV.pdf*

Science Based Targets. *SBTi launches world-first roadmap for net-zero shipping by 2040.* Available at *https://sciencebasedtargets.org/news/sbti-launches-world-first-roadmap-for-net-zero-shipping-by-2040*

Science Based Targets. *Target Setting for the Maritime Transport Sector.* November 2022. Available at *https://sciencebasedtargets.org/resources/files/SBTi-Maritime-Guidance.pdf*

Seas at risk. *Why an ambitious 2030 target is so important for shipping climate action.* 13 December 2022. Available at *https://seas-at-risk.org/general-news/why-an-ambitious-2030-target-is-so-important-for-shipping-climate-action*

The Maritime Executive. *Japan Submits Ambitious Carbon-Tax Proposal for MEPC 78.* 3 May 2022. Available at *https://maritime-executive.com/article/japan-submits-ambitious-carbon-tax-proposal-for-mepc-78*

UMAS. *New study by UMAS shows that decarbonisation of the shipping sector is a whole system challenge and not something just for shipping.* 2020. Available at *https://www.u-mas.co.uk/new-study-by-umas-shows-that-decarbonisation-of-the-shipping-sector-is-a-whole-system-challenge-and-not-something-just-for-shipping*

Wood Mackenzie. *Can Maersk lead the charge to net zero by using methanol as a fuel?.* Available at *https://www.woodmac.com/podcasts/the-interchange-gang/can-maersk-lead-the-charge-to-net-zero-by-using-methanol/*

Wood Mackenzie. *Global Energy Research.* Available at *https://my.woodmac.com/reports/refining-and-oil-products-decarbonising-shipping-through-synthetic-fuels-the-global-outlook-for-marine-e-fuels-150043678*

World Bank. *The Potential of Zero-Carbon Bunker Fuels in Developing Countries.* 15 April 2021. Available at *https://openknowledge.worldbank.org/entities/publication/b5697ebf-30cd-5491-8e34-2edb199ae5b7*

World Economic Forum. *Shipping commitment.* Available at *https://www3.weforum.org/docs/WEF_First_Movers_Coalition_Shipping_Commitment_2022.pdf*


PIONEER 38


COSCO SHIPPING

Disclaimer

TRAFIGURA

Trafigura Pte. Ltd.

10 Collyer Quay #29-01/05
Ocean Financial Centre
Singapore 049315

Tel : +(65) 6319 2960
Fax : +(65) 6734 9448

www.trafigura.com

TM/0431.1
Last updated: May 2023