REPORT

Navigating toward cleaner seas: *the quest for marine transport emission reduction targets*

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Introduction

Marine transport has long been recognized for its indispensable role in connecting nations and facilitating economic growth, with a share of around 90% of global trade. However, this essential industry has also been associated with significant environmental challenges, accounting for nearly 3% of the world's carbon dioxide (CO_2) emissions. The International Maritime Organization (IMO), the United Nations agency responsible for regulating international shipping, has set ambitious emission reduction targets. These targets include increased utilization of zero- and near zero-emission fuels by 2050, enabling a total greenhouse gas (GHG) reduction of at least 20% by 2030, and at least 70% by 2040, relative to 2008 levels.[*i*]

Additionally, the EU has set its own targets with the FuelEU Maritime initiative. This includes, for example, reducing GHG energy intensity index of marine fuels-based emissions from maritime transport by around 80% by 2050, compared to 2008 levels. EU targets are increasing step by step every five years, starting with a 2% reduction in 2025.[*ii, iii*]

Achieving these targets necessitates a multifaceted approach involving collaboration among various stakeholders, adherence to stringent regulations and the widespread adoption of innovative technologies.

This report delves into the current state of marine transport emissions, examines the industry's regulatory landscape, explores transition fuels and low-carbon solutions driving change, discusses the challenges and opportunities facing stakeholders and assesses cost expectations for shipbuilders, owners and operators.

Marine fuels and emissions

Between 2023 and 2050, marine transportation will experience significant growth, driven by expected increased global trade and population growth. Despite advancements in efficiency and alternative fuels, emissions from maritime shipping continue to rise – particularly in the container shipping sector, due to burgeoning e-commerce demands and expanding global supply chains. Efforts to mitigate emissions are targeted widely throughout the marine sectors, based on emissions. Emission reduction initiatives generally focus on improving vessel efficiency, transitioning to cleaner fuels, establishing carbon capture and reducing vessel speeds.

Implementing stricter environmental regulations on a global scale is a challenging effort. Overall growth in marine transportation – which may even double by 2050, according to some scenarios – outpaces these mitigation efforts, posing challenges to achieving long-term sustainability goals.

The maritime sector predominantly relies on heavy fuel oil (HFO), marine diesel oil (MDO) and marine gas oil (MGO) as traditional fuels to power vessels. While these fuels have long been the workhorses of the industry, they come with significant environmental drawbacks. HFO, in particular, is notorious for its high sulfur content, leading to the emission of sulfur oxides (SOx), nitrogen oxides (NOx) and particulate matter. These pollutants contribute to air pollution and acid rain and pose serious health risks to marine ecosystems and coastal communities. Additionally, the combustion of fossil fuels in marine engines is a significant source of CO_2 emissions, exacerbating climate change and ocean acidification.

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Transition fuels and low-carbon solutions

In response to growing environmental concerns and regulatory pressure in the marine industry, there is a significant shift toward transitioning to cleaner fuels and supportive technologies. This transition primarily involves moving away from traditional HFOs toward alternative fuels with lower emissions profiles, such as liquefied natural gas (LNG), biofuels, hydrogen and ammonia. Additionally, there is increasing interest in exploring electric and hybrid propulsion systems, especially for smaller vessels and short sea shipping routes. These efforts are driven by regulatory mandates and industry initiatives aiming to achieve decarbonization targets and mitigate the environmental impact of maritime transportation. However, challenges remain, including infrastructure development, technological readiness and cost-effectiveness that require collaborative efforts from stakeholders across the maritime sector.[*iv*]

One of the most promising alternatives as a transition fuel compared to traditional fuels is LNG. LNG offers significant environmental benefits, emitting virtually no sulfur, fewer NOx emissions and lower levels of particulate matter compared to HFO and MDO. Furthermore, LNG has the potential to reduce GHG emissions by up to 20% when produced from conventional natural gas sources and even up to 90% when derived from renewable biogas. An attractive future alternative can also be splitting liquefied biogas (LBG) or LNG's methane gas into hydrogen and solid carbon before feeding it into internal combustion engines or using it in fuel cells. This promising future technology, methane-splitting technology, is expected to meet FuelEU Maritime targets. Simultaneously, it offers competitive user cost scenarios and a chance to avoid costs of CO_2 transportation and storage as well as building new infrastructure.

The demand for newbuild ships with LNG, LBG, liquefied petroleum gas (LPG), ammonia or methanol-capable engines increased in 2023. These alternatives make up around half of the tonnage ordered last year. Compared to the previous year, this is an apparent increase from a 30% share. Looking at the bigger picture of global tonnage, 6.5% can currently operate these alternative fuels, with an increase of 1% annually.[*v*]

Biofuels represent another viable pathway toward decarbonizing maritime transport. Derived from organic materials such as vegetable oils, animal fats or algae, biofuels offer a carbon-neutral alternative to fossil fuels. Using renewable feedstocks, biofuels can significantly reduce the net GHG emissions associated with shipping operations. Moreover, advancements in biofuel production technologies, such as algae-based biofuels and synthetic fuels produced from CO_2 and renewable electricity, promise further emissions reductions and sustainability gains.

Methanol is emerging as another attractive transition fuel for the maritime industry. Produced from natural gas, biomass or renewable electricity, methanol is a versatile and clean-burning fuel used in internal combustion engines or fuel cells. Compared to conventional fuels, methanol-powered vessels emit lower levels of SOx, NOx and particulate matter, improving air quality and reducing environmental impact. Furthermore, renewable sources can produce methanol sustainably, offering a pathway toward carbon-neutral shipping.[*vi, vii*]

In addition to fuel options, there are a few other ways to reduce emissions including several types of wind-assisted systems and hull friction reduction measures like hull cleaning robots and air lubrication. It is also possible to optimize routes and travel speed in relation to expected idle times at ports. Several high-tech companies offer energy optimization tools to observe ships' efficiencies and automatically make necessary changes or at least recommendations as better options to reduce emissions. Still, many ships do not optimize the full extent of their operations, including but not limited to routing, speed, weather and so on.[*viii, ix, x, xi*]

> Still, many ships do not optimize the full extent of their operations

Challenges and opportunities of transition fuels

While transition fuels have immense potential for reducing emissions and enhancing environmental sustainability in maritime transport, they also present significant challenges and opportunities for industry stakeholders. One primary challenge is the limited availability and infrastructure for alternative fuels.

Establishing bunkering infrastructure, retrofitting existing vessels and ensuring a reliable supply chain for alternative fuels require substantial investments and coordination among stakeholders. Moreover, the higher upfront costs of transitioning to new fuel types may deter some shipowners and operators from adopting cleaner technologies, especially in uncertain economic returns.

In addition to infrastructure and technical challenges, there is likely a shortfall in the availability of carbon-neutral fuels. For example, in DNV's scenario, the shipping sector requires 17 million tonnes of oil equivalent (Mtoe) of carbon-neutral fuels by 2030. Mirroring this to global availability, figures account for up to 30%-40% of total supply.[*v*]

An infrastructure challenge example is onshore power required to enable charging of hybrid vessels' batteries at ports and supporting vessels' hotel loads is not a widely available service to enable cutting local emissions.

Looking at methanol fuel's recently increased popularity and headlines, it is necessary to remember that methanol can subsequently obtain cleaner fuel status only if produced from biological origin. An efficient CO_2 capture and storage system (CCS) may also iron out the largest increases in emissions. Otherwise, methanol fuel alone will only increase GHG emissions compared to traditional fuels.

At the same time, many other industrial sectors seek the same supply sources on a global scale. Availability challenges, combined with cost development scenarios, likely open further options on the technical side to carbon capture technologies with fossil fuels and even toward nuclear power in the longer perspective of the largest oceangoing ships.

However, despite these challenges, transition fuels also offer many opportunities for innovation, investment and collaboration within the maritime industry. By embracing cleaner technologies

and fuels, stakeholders can enhance their environmental credentials, improve operational efficiency and gain a competitive edge in an increasingly sustainability-conscious market. Moreover, transition fuels can stimulate job creation and economic growth in renewable energy production, biofuel manufacturing and green infrastructure development. Furthermore, shipowners and operators can future-proof their operations against volatile fuel prices, regulatory uncertainties and geopolitical risks associated with current mainstream energy sources by diversifying their fuel sources and reducing reliance on fossil fuels.

Regulatory environment and expected developments

The regulatory landscape governing maritime transport emissions is primarily shaped by the IMO, which sets international standards and regulations to promote environmental sustainability and safety in shipping. In 2018, the IMO adopted its Initial IMO Strategy on Reduction of GHG Emissions from Ships, aiming to reduce the total annual GHG emissions from international shipping by at least 50% by 2050, compared to 2008 levels, with further aspirations for full decarbonization. Since then, figures have been updated and still remain under development. To achieve these ambitious targets, the IMO has implemented various regulatory measures, including the reduced limit of sulfur content of marine fuels to 0.5% m/m (mass by mass) globally, reducing SOx emissions from ships and port operations.

The maritime industry can expect further developments in the regulatory framework governing emissions reduction and sustainability in shipping. The IMO is likely to introduce more stringent carbon intensity targets, incentivize alternative fuels through regulatory measures or market-based mechanisms and promote the development and adoption of innovative technologies for emissions abatement and energy efficiency improvement. Additionally, regional and national authorities may enact supplementary measures to complement IMO regulations, such as emission control areas (ECAs) with stricter emissions standards or financial incentives for green shipping initiatives.[*xii*]

Cost expectations for shipbuilders, owners and operators

The transition to cleaner fuels and technologies entails significant costs for shipbuilders, owners and operators in the maritime industry. Shipbuilders face the challenge of designing and constructing vessels compliant with increasingly stringent environmental regulations while balancing cost considerations. Incorporating fuel-efficient engines, emissions abatement technologies and alternative fuel systems adds complexity and expense to the shipbuilding process. Moreover, retrofitting existing vessels to accommodate new fuel types or emissions control equipment can be costly and time-consuming, requiring substantial investment and downtime for ships in operation. [*iv, xiii*]

For shipowners and operators, the transition to cleaner fuels and technologies also involves financial considerations. The upfront costs of purchasing vessels powered by alternative fuels or equipped with emissions-reduction technologies are typically higher than those of conventional vessels. Additionally, the ongoing operational costs associated with alternative fuels, such as LNG or biofuels, may vary depending on factors such as fuel availability, infrastructure costs and market dynamics. While some transition fuels may offer cost savings over the long term through reduced fuel consumption or lower emissions-related expenses, the initial investment required can pose a barrier to adoption for some stakeholders.

To provide context on the magnitude of these cost implications, compare the estimated operational costs associated with alternative fuels to recent years' operation costs, notably fuel costs. For example, consider LNG as a transition fuel. While LNG-powered vessels typically have higher upfront costs due to the specialized equipment required for storage and handling, they often offer significant savings in fuel costs over time. According to industry estimates, LNG prices have been relatively stable in recent years, excluding some temporary challenges on market. With the average price per metric ton ranging from USD

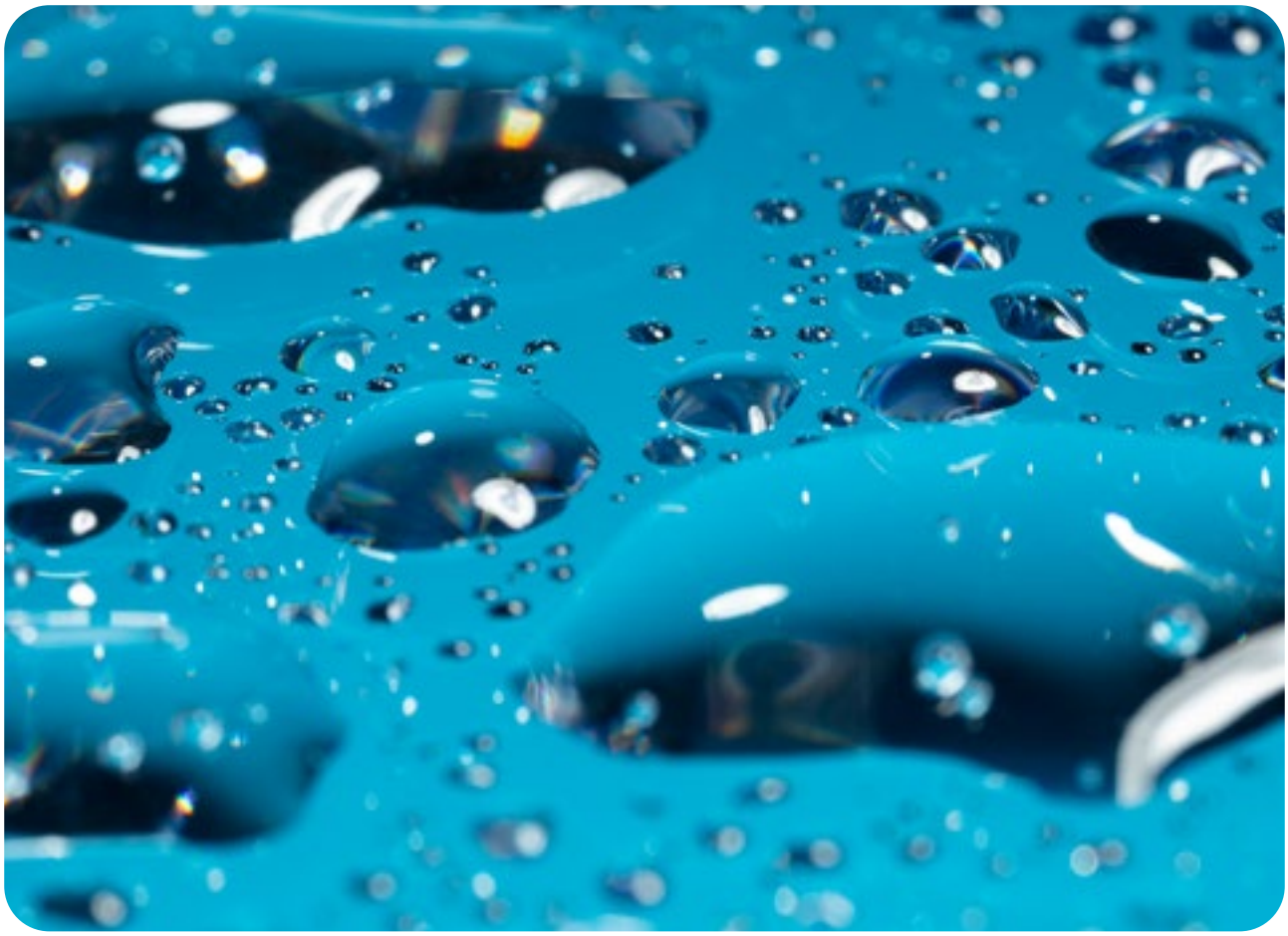
500 to 600. With LBG, prices range at least around triple to quadruple levels compared to LNG.

Compared to biofuels, traditional marine fuels such as HFO or MDO, as well as LNG, have experienced greater price volatility in average, influenced by factors such as crude oil prices, geopolitical tensions and market dynamics. For instance, in 2020, amid the COVID-19 pandemic and the subsequent decline in global oil demand, fuel prices plummeted, reaching historic lows. However, prices have since rebounded, driven by recovering demand and supply constraints, leading to increased uncertainty and volatility in fuel markets.

The expected magnitude of operational and capital investment costs for shipowners and operators will depend on various factors, including the regulatory landscape, technological advancements and market dynamics. While transitioning to cleaner fuels and technologies may entail higher upfront costs, the potential for long-term cost savings, coupled with regulatory compliance benefits, may outweigh the initial investment. Moreover, advancements in fuel efficiency, infrastructure development and economies of scale are expected to significantly reduce operational costs associated with alternative fuels over time.

While the transition to cleaner fuels and technologies presents financial challenges for the maritime industry, it also offers opportunities for innovation, efficiency improvements and long-term sustainability. By carefully evaluating the cost implications and leveraging available incentives and support mechanisms, shipbuilders, owners and operators can navigate the transition toward greener seas while ensuring economic viability and competitiveness in the global market.

Change is starting slowly in marine sector. Due to looming emission penalties and the developing global regulatory landscape, this is certainly accelerating rapidly in the near future. Another certain area is increased transportation costs from customer perspectives. With innovative solutions and collaboration, this transition phase can be turned into a positive spiral.



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