DNV Maritime Forecast To 2050

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Abstract - The maritime industry is transitioning towards decarbonization due to stricter regulations and the need to reduce greenhouse gas (GHG) emissions. The International Maritime Organization (IMO) aims to cut GHG emissions by 20% by 2030 and achieve zero-emission shipping by 2050. This requires adopting new technologies, fuels, and solutions to minimize energy consumption and emissions. New ships must meet future energy efficiency and GHG reduction demands to remain viable through 2050. This transition also impacts shoreside infrastructure and energy industries, increasing demand for renewable energy, sustainable biomass, carbon storage, and alternative fuels. The interplay between shipping, energy, and fuel production influences strategies for shipowners and fuel producers, with uncertainties about carbon-neutral fuel availability. Emerging technologies that reduce emissions without relying on limited carbon-neutral fuels are crucial. Compliance pooling regulations can drive investment in high CAPEX decarbonization solutions. The development of ship technologies and fuel infrastructure will shape the future fuel mix of shipping.

Keywords: Decarbonization; GHG emissions; IMO zero-emission shipping; energy efficiency; renewable energy; carbon storage; alternative fuels; compliance pooling; fuel infrastructure.

INTRODUCTION

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REGULATIONS FOR DECARBONIZATION

A. *International Maritime Organization (IMO)*

The IMO aims to reduce GHG emissions from shipping by 20% by 2030, targeting 30%, and by 70% by 2040, striving for 80%, compared to 2008 levels, with a goal of net-zero emissions by around 2050. The 'IMO net-zero framework' for MARPOL Annex VI will be adopted in 2025 and enforced by mid-2027. This includes technical requirements to lower GHG intensity of marine fuels and an economic mechanism for pricing GHG emissions. Lifecycle assessment (LCA) guidelines and onboard carbon capture regulations are in development. The Carbon Intensity Indicator (CII) and Energy Efficiency Existing Ship Index (EEXI) regulations are under review, with revisions expected by spring 2025.

B. *European Union (EU))*

The EU Emissions Trading System (ETS), effective January 1, 2024, requires shipping companies to purchase and surrender emission allowances for CO2 emissions within EU and EEA ports. From 2025, general cargo and offshore vessels must report GHG emissions, with larger ships included from 2027. Methane and nitrous oxide emissions must be reported starting in 2024 and will be included in the ETS from 2026. FuelEU Maritime, effective January 1, 2025, mandates ships above 5,000 GT to meet annual well-to-wake GHG emissions intensity requirements.

C. Fleet Compliance Pooling

FuelEU Maritime and the IMO are developing a fleet compliance system allowing ships to collectively meet GHG intensity targets. Ships with positive GHG fuel intensity (GFI) balances can sell excess emission units to those with negative balances or pool compliance balances. Financial settlements will be necessary for fleets with ships from different companies or trades. The IMO is considering a central body to buy or sell emission units, setting a price floor and ceiling. FuelEU Maritime includes a penalty mechanism as a compliance cost ceiling.

SHIP TECHNOLOGIES AND FUELS: OUTLOOK

A. Status Of Fuel Technology transition

The maritime industry is advancing towards larger ships with dual-fuel propulsion, with 7.4% of operational ships and 49.5% of order book tonnage using alternative fuels like LNG, methanol, and LPG as of June 2024. LNG is popular in containerships and car carriers, while methanol-fuelled ships are increasing. Ammonia and hydrogen-fuelled ships are emerging despite technological challenges.

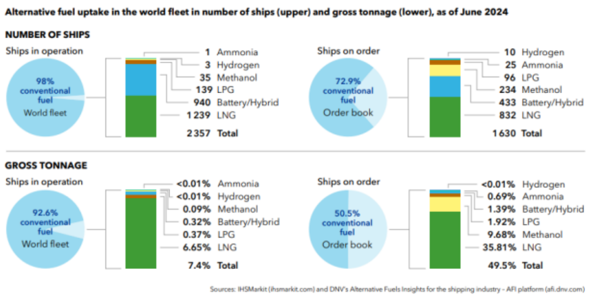

Fig. 1 Alternative fuel uptake in the world fleet in number of ships (upper) and gross tonnage(lower), as of June 2024

The shift towards alternative fuels is evident, with more methanol-capable large ships expected by 2030. The industry is committed to reducing GHG emissions, with an increase in LNG bunker vessels and expanding methanol bunkering infrastructure. Converting ships to new fuels is complex and costly, but operators like Maersk and Hapag-Lloyd are considering methanol conversions. The Global Maritime Forum reports 373 zero-emission pilot projects, focusing on hydrogen and ammonia. The development of bunkering vessels and green corridors is crucial, with ongoing pilot projects and regulatory support driving progress.

B. Outlook for the readiness of onboard fuel technologies

To maintain commercial attractiveness and asset value through 2050, new ships must be designed for lower energy use and GHG emissions. This includes flexibility for future fuel conversions, adequate fuel storage, and balanced safety requirements without significantly impacting capacity. Implementing these features during the newbuild stage can reduce future conversion costs and time. Currently, most large deep-sea ships use diesel engines, contributing significantly to CO2 emissions. Engine manufacturers are developing new engines and retrofit packages for alternative fuels, with shipowners increasingly investing in dual-fuel engines. Methane and methanol engines are widely available, while ammonia engines for large ships and hydrogen engines for smaller ships are expected to become available soon, driven by market demand and regulatory developments.

C. Reducing onboard energy losses by technical energy-efficiency measures

To maintain commercial attractiveness and asset value, ships must pair future fuel and technology changes with increased energy efficiency. Operational and technical measures can reduce emissions by at least 15%, saving 40 Mt of fuel and 120 MtCO2 emissions. As GHG emissions are priced and carbon-neutral fuels raise costs, energy efficiency becomes crucial. Reducing onboard energy use is vital due to the lower energy density of carbon-neutral fuels. Technologies like Waste Heat Recovery (WHR) systems, organic Rankine cycle (ORC) processes, and wind-assisted propulsion (sails, Flettner rotors) can enhance efficiency, saving 3% to 15% in fuel. These measures are essential for transitioning to alternative fuels.

D. Unlocking energy-saving potential through digital-enabled optimization

Digital-enabled energy savings on voyages can be achieved through learning from past experiences, real-time optimization, minimizing system degradation, and maintaining high performance via optimized cleaning and maintenance. Digital ship technologies are crucial for realizing energy-saving potential, complementing alternative fuel technologies and energy-efficiency measures. The maritime industry is undergoing a digital transformation, with modern ships becoming sophisticated sensor hubs generating data with increased satellite connectivity. Upgrading older ships to the required digital capability can be challenging and costly. Improved vessel performance and voyage planning can lead to emissions reductions, but contractual structures in shipping can act as barriers. Effective digital information handling is essential for accurate GHG emissions reporting, enhancing ship operations and achieving energy savings.

ALTERNATIVE FUEL PRODUCTION AND DEMAND: OUTLOOK

The shipping industry must significantly reduce its energy use to meet 2030 targets, requiring between 10% and 100% of the world's carbon-neutral fuel production. Maritime will compete with other sectors for these fuels, necessitating robust chain of custody models like Mass Balance and Book and Claim to certify sustainability and GHG intensity. A book and claim model can enhance fuel availability by reducing the need for separate infrastructure. Increasing global carbon-neutral fuel production is crucial to achieve the IMO's goal of a 20-30% reduction in GHG emissions from shipping by 2030, relative to 2008 levels. Adequate infrastructure for distribution, storage, and bunkering is also needed. Shipping competes with land transport, aviation, and industry for sustainable biomass, renewable electricity, sustainable CO2, and fossil energy with carbon capture and storage (CCS). Currently, sustainable and carbon-neutral fuels like diesel, methane, methanol, ammonia, and hydrogen are scarce, highlighting the need for a holistic approach to integrate shipping within the broader decarbonizing world.

A. Existing fuel supply

In 2023, ships of 5,000 GT or more trading internationally consumed 213 Mtoe of fuel oil, with nearly 95% being fossil fuels like heavy fuel oil, light fuel oil, and diesel/gas oil. LNG consumption was around 11 million tonnes (13 Mtoe) in 2022, slightly less than in 2021, making up about 5% of the total volume. In 2019, domestic and fishing fleets consumed 57 Mtoe, according to the IEA. The IMO Data Collection System (DCS) includes fuel consumption from domestic trades for ships that also trade internationally within the same year. Biofuels, the most widely used carbon-neutral fuels in shipping, can be blended with various marine fuels. In 2023, biodiesel blends accounted for over 7% of bunker sales in the Port of Rotterdam and around 1% in the Port of Singapore, totaling an estimated 0.4 Mtoe of pure bio-based diesel, up from 0.3 Mtoe in 2022. Additionally, Rotterdam reported sales of 750 tonnes of bio-methanol, while Singapore reported sales of 300 tonnes.

B. Demand for carbon neutral fuels

The DNV Maritime Forecast to 2050 report simulates the demand for carbon-neutral fuels in shipping by 2030, aligning with the IMO GHG Strategy's goal of zero or near-zero GHG emission technologies accounting for at least 5% of total energy consumption. DNV explored 16 policy scenarios to achieve a 20% GHG emission reduction by 2030 compared to 2008 levels. To meet this target, well-to-wake GHG emissions must be reduced through carbon-neutral fuels, onboard carbon capture, or energy use reduction. Energy-efficiency measures could reduce consumption by 4% to 16%, with high levies showing the greatest impact. Estimated demand for carbon-neutral fuels in 2030 ranges between 7 and 48 Mtoe, and for fossil fuels with CCS between 2 and 31 Mtoe.

C. Supply of carbon-neutral fuels

This DNV has mapped global projects for carbon-neutral fuel production for shipping, including electro-, bio-, and blue versions of fuel oils, methane, methanol, ammonia, and hydrogen. The estimated cumulative capacity for 2030 ranges between 44 and 63 Mtoe, with shipping needing 10% to 100% of this to meet IMO targets. The supply increase is mainly due to new ammonia projects, with a significant leap from 63 Mtoe in 2030 to 83 Mtoe in 2031 for the High-availability scenario. Scaling up production by reusing fossil-fuel refineries and co-locating new plants with existing facilities can reduce environmental impacts, costs, and lead times. Biofuels like bio-methanol, biodiesels, and biomethane are more mature in the short to medium term.

D. Infrastructure for carbon-neutral fuels

Increasing carbon-neutral fuel production requires robust infrastructure for distribution, storage, and bunkering. While methanol, methane, and biodiesel can use existing infrastructure, ammonia and hydrogen infrastructure is less developed. Repurposing natural gas pipelines for hydrogen is cost-efficient. The European Hydrogen Backbone (EHB) initiative aims to create a connected hydrogen network. The World Ports Climate Action Program’s port readiness level (PRL) tool shares ports’ readiness for alternative fuels. Successful methanol bunkering has been demonstrated in Rotterdam, Gothenburg, and Singapore. Singapore plans methanol bunkering by 2025. Ammonia and hydrogen bunkering have been tested in Singapore, Norway, and San Francisco Bay, highlighting infrastructure’s critical role in the transition.

E. Chain of Custody – rules for fuels from production to ship

Chain of Custody is an important concept in decarbonization efforts. It is used to ensure the validity of emission-reduction claims in a supply chain. International standard ISO 22095:202070 has defined Chain of Custody as a process by which inputs and outputs and associated information are transferred, monitored, and controlled as they move through each step in the relevant supply chain. In the context of decarbonization, it is used to define a set of Chain of Custody models that can keep track of GHG emissions for a product or service along a supply chain from origin to final user. The ISO standard has further defined a set of models for Chain of Custody that can be applied

EMERGING TECHNOLOGIES TO REDUCE DEMAND FOR CARBON-NEUTRAL FUELS

Emerging technologies can reduce the maritime industry’s reliance on limited carbon-neutral fuels. Shore power, which emits fewer GHGs than ship generators, should be incentivized and regulated, potentially covering up to 7% of ships’ energy consumption in port. Electrification with batteries, especially for short voyages, and battery swapping logistics in ports can reduce investment needs. CO2 storage demand from shipping to meet 2030 goals ranges from 6% to 160% of global capacity. Efforts focus on renewable power, nuclear power, blue hydrogen with carbon capture, and green hydrogen by electrolysis. Technologies like electrification, carbon capture, and nuclear propulsion offer alternative decarbonization routes, highlighting regulatory challenges.

A. Electrification

The direct use of shore electricity, or ‘cold ironing,’ powers ships in port, eliminating the need for generators. Electrification options include fully battery-powered ships and hybrids with batteries and generators or fuel cells. Ferries, with short voyages, lead in electrification using plug-in hybrid solutions. Battery hybridization enhances energy efficiency through peak shaving and load optimization. As ships become more energy-efficient and battery technology advances, plug-in hybridization will suit longer routes and larger vessels. However, electrification depends on robust infrastructure for electric power delivery from shore, emphasizing the need for infrastructure development to support electric-powered maritime operations.

B. Carbon Capture and Storage

Efforts to reduce GHG emissions from shipping include capturing CO2 from carbon-based fuels and storing it. The Maritime Forecast to 2050 details the value chain for onboard carbon capture and the carbon storage industry's development. Demonstration projects aim to showcase this process. Regulatory bodies like the IMO and the EU are integrating these technologies into their frameworks. Shipowners' decisions to adopt onboard carbon capture depend on factors like extra fuel consumption, cargo space impact, and frequent port stops. Despite challenges, the limited availability and high prices of carbon-neutral fuels make onboard carbon capture and storage a viable option.

C. Nuclear Propulsion

Nuclear propulsion is being reconsidered for ships due to its advantages of no emissions, no bunkering, low weight, and high design speeds, despite challenges like security concerns, complex monitoring, non-proliferation issues, social/political risks, and high CAPEX. Currently, about 160 vessels, mainly naval aircraft carriers, submarines, Russian icebreakers, one merchant ship, and a floating nuclear power plant, use nuclear reactors. While nuclear propulsion offers strategic benefits like extended range and autonomous operations, its adoption in commercial shipping has been limited. The technology can decarbonize ships independently of other carbon-neutral alternatives, but faces significant regulatory, public perception, and business model challenges for building, operating, and decommissioning ships.

DECARBONIZATION OF SHIPPING: PATHWAY

Building on our previous modelling, we investigate the conditions under which uptake of certain fuel types will accelerate with decarbonization towards 2050, finding that:

Small changes in fuel prices can significantly alter fuel mixes, and decarbonizing shipping will double container transport costs. Onboard carbon capture could become crucial for reducing shipping emissions. As biofuel and electrofuel production grows and carbon capture projects increase blue fuel output, shipping must maximize energy efficiency to mitigate potential carbon-neutral fuel shortfalls. The fuel transition is moving towards LNG, methanol, and ammonia, with carbon-neutral fuel production starting. Uncertainties in regulation, fleet growth, and energy costs influence this transition. Using an updated GHG Pathway Model, we explore scenarios for decarbonization, investigating conditions that accelerate the uptake of specific fuels towards 2050. We estimate the increased transport costs of decarbonization for container, tank, and bulk segments.

A. Exploratory scenarios where different fuels gain a significant market

The shipping industry is exploring various decarbonization technologies like LNG, methanol, LPG, ammonia, hydrogen, ferry electrification, and onboard carbon capture. Biodiesel use is increasing, with large-scale plans for methanol, ammonia, and hydrogen production and carbon storage. However, uncertainties in cost, efficiency, and availability make projections challenging. Scenarios aim to achieve the IMO's decarbonization goals of a 70% GHG reduction by 2040 and 20% by 2030, relative to 2008 levels. These scenarios consider changes in fuel prices, CAPEX, CCS deposit costs, and nuclear availability, resulting in different future fuel mixes. Biofuels are currently low-cost but may rise due to competition, while electrofuels are expected to decline in price.

Four exploratory scenarios have been presented in the latest 2024 version of DNV Maritime to Forecast 2050.

B. ***Increased transport costs from decarbonization***

In 2022, DNV highlighted the total CAPEX needed for decarbonizing shipping. This year, the focus is on the relative increase in total operating costs, including CAPEX, OPEX, CO2 price, fuel costs, and CCS deposit costs. By 2050, cost intensity is expected to increase by 69-75% for bulk carriers, 70-86% for tankers, and 91-112% for container vessels. Scenario 1, with high biofuel availability and lower CCS costs, requires the least CAPEX. Shipping costs could rise by 90-450 USD/TEU by 2030 using carbon-neutral fuels.

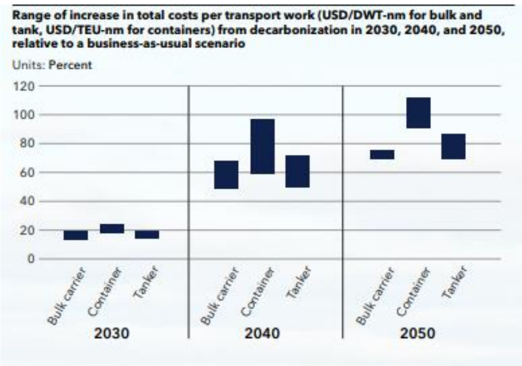

Fig. 2 Range of increase in total costs per transport work (USD/DWT-nm for bulk and tank, USD/TEU-nm for containers) from decarbonization in 2030,2040,2050, relative to a business-as-usual scenario

The IMO's decarbonization goals could lead to cost increases per tonne-mile of 16-40% in 2030, 56-71% in 2040, and 71-85% in 2050.

Recommendations And Conclusion

Ship owners should take immediate steps to reduce energy consumption and explore all available decarbonization options. Emphasizing fuel flexibility and considering a long-term fuel strategy are crucial for future-proofing their operations. DNV offers comprehensive support in these areas, providing expertise to evaluate decarbonization options, advice on achieving fuel flexibility, and partnership in developing long-term fuel strategies. By leveraging DNV's knowledge and resources, ship owners can effectively navigate the transition towards more sustainable and energy-efficient shipping practice

References

[1] The 8th edition of DNV's Maritime Forecast to 2050.