INTERNATIONAL MARITIME ORGANIZATION

MARINE ENVIRONMENT

PROTECTION COMMITTEE

REDUCTION OF GHG EMISSIONS FROM SHIPS

Focus on economic elements with reference to the industry 4.0

The current challenges and their solution

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Summary

Decarbonising international shipping is technically feasible but economically challenging. This paper synthesises the principal economic barriers to reducing shipping GHGs, explains how Industry 4.0 (I4.0) technologies change the cost/benefit landscape, and proposes detailed, economically-focused solutions to accelerate uptake. Key levers include demand aggregation and price signals, public de-risking of first movers, port/infra investment, and digital interventions that cut both OPEX and capital uncertainty.

1. Introduction

Shipping moves ~80–90% of global trade and contributes ~2–3% of global CO_2 emissions. The IMO's 2023 GHG strategy tightened targets, increasing pressure on the industry to adopt low- and zero-carbon fuels and efficiency measures. Meeting these targets requires resolving a set of interlinked economic frictions: high capital and fuel cost gaps, fragmented infrastructure, regulatory uncertainty, and limited data/digital readiness. In 2025, the IMO introduced the Net-Zero Framework, building on the 2023 GHG Strategy. It includes guidelines on GHG Fuel Intensity (GFI) reduction, an economic mechanism through a Net-Zero Fund and credit trading, and well-to-wake emissions accounting.

2. Principal economic challenges

2.1 High capital cost and fleet turnover inertia

Retrofits and ordering new dual- or zero-emission vessels imply steep upfront CAPEX. Given long ship lifespans and low newbuild replacement rates, shipowners face payback uncertainty: will fuel be available/affordable, will a vessel be commercially competitive, and will regulations favour gained advantages? These questions deter early investment and create a "low maturity" trap: operators wait, markets wait, investment stalls. Survey evidence shows perceived low maturity/uncertainty of solutions is a leading barrier to decarbonisation.

2.2 Fuel cost gap and supply chain uncertainty

Zero- or low-GHG fuels (green ammonia, green methanol, e-fuels, hydrogen, biofuels) currently carry substantial cost premiums versus heavy fuel oil (or VLSFO/LNG in some contexts). Limited production capacity, immature supply chains and sparse bunkering infrastructure make price and availability uncertain — increasing both operating cost risk and logistics complexity for ship operators. Aggregating demand and achieving scale are essential to closing the premium; without that, fuel cost gaps persist.

2.3 Bunkering & port infrastructure fragmentation

Ports and bunkering facilities must invest in tanks, safety systems and logistics for alternative fuels. Investment is lumpy and location-specific: vessels that run out of compatible bunkers lose commercial flexibility. Ports face coordination and financing problems (public vs private roles), and the uneven rollout raises route-specific viability concerns for new fuels.

2.4 Financial markets, insurance & freight rate dynamics

Lenders and insurers price risk; unclear residual values for alternative-fuel vessels and uncertain compliance regimes can raise borrowing costs and insurance premiums. Freight markets are competitive and often operate with thin margins — shipowners may lack pricing power to pass on higher fuel/financing costs to cargo owners unless contract structures change. This splits incentives across actors (owners vs charterers vs cargo owners).

2.5 Data quality, digital infrastructure and workforce readiness (Industry 4.0 gap)

Decarbonisation depends on accurate operational data (fuel consumption, engine performance, emissions, routing). Many fleets lack standardised, high-quality data and digital platforms to measure, verify and monetise efficiency gains. This reduces the ability to deploy predictive maintenance, route optimisation and digital twin solutions that could lower OPEX and improve asset utilisation — i.e., the very Industry 4.0 tools that could materially reduce costs remain under-adopted.

3. Detailed solutions (economic mechanisms and implementation steps)

3.1 Close the fuel cost gap: demand aggregation + guaranteed purchase mechanisms

- *Cargo-backed offtake and fuel purchase agreements:* create long-term contracts between cargo owners, fuel producers and ship operators to guarantee demand and lower producer financing costs.
- *Green fuel crediting / 'book & claim' systems:* allow producers to scale even where physical bunkering is limited, while traceability systems (blockchain + certification) assure compliance.
- *Economic effect:* reduces producer risk, lowers LCOF (levelized cost of fuel) through scale, shortens the period to competitive parity.

3.2 Policy & market design: predictable price signals and transition finance

- *IMO GHG Fuel Standard / carbon pricing*: predictable, phased-in carbon costs shift economics in favour of low-carbon fuels; revenues can be recycled to support infrastructure or early adopters.
- *De-risking instruments:* loan guarantees, concessional finance for green ship orders, residual value guarantees to lower lender risk premia.
- Economic effect: reduces WACC for green assets and improves private investment calculus.
- In today's shipping industry, using greener fuels such as green methanol, ammonia, LNG, or biofuels helps shipowners avoid or reduce carbon taxes and emission-related penalties that apply to conventional fossil fuels. These cleaner fuels also earn credits or incentives under IMO's upcoming Net-Zero Framework and regional schemes like the EU Emissions Trading System (ETS), making them both environmentally and economically beneficial.

3.3 Port & bunkering investment: public-private partnerships and corridor strategy

- *Green Digital Shipping Corridors (GDSCs*): concentrate early investment along key routes (e.g., Asia–Europe, intra-Europe short sea), combining port infra upgrades with I4.0 trials to demonstrate operations. Port authorities can use viability gap funding, bond issuance or multilateral finance to accelerate bunkering build-out.
- *Economic effect*: reduces fragmentation risk, improves fuel availability on critical routes, fosters economies of density.

3.4 Scale Industry 4.0 adoption to cut OPEX and risk

- *Operational rollout:* equip vessels with standard sensor suites and integrated fleet platforms; apply digital twins for lifecycle optimisation; use AI for continuous voyage optimisation and just-in-time (JIT) arrival to avoid waiting-time fuel burn.
- *Data standards and marketplaces:* standardised telemetry and reporting formats let owners monetise efficiency gains (e.g., sell verified carbon reductions or bid into green freight contracts).
- *Economic effect*: lowers fuel bills, reduces maintenance cost volatility, provides verified metrics for financiers — strengthening the business case for CAPEX.

3.5 Safety, regulation and workforce training to reduce non-price barriers

- Invest in training for safe handling of novel fuels (ammonia, hydrogen) and harmonise safety/regulatory standards to lower compliance risk and insurance costs.
- DNV and others document operational challenges for ammonia/methanol that require targeted safety investment.

4. Implementation roadmap (practical steps, 0–5 years)

- *Policy clarity (0–1y):* finalize predictable IMO/national measures (GHG fuel standard, phased carbon costs).
- *Pilot corridors & PPPs (1–3y):* fund GDSCs linking ports, fuels and digital platforms.
- Scale demand aggregation (1–4y): secure off-take and cargo-backed financing for fuel plants.
- *Fleet digitalisation (0–5y):* standardise sensors, deploy digital twins and AI routing across fleets to reduce OPEX baseline.
- *Finance instruments (2–5y):* deploy guarantees, blended finance and green shipping credit lines to lower CAPEX hurdle.

5. Requisition to the MEPC:

- The economic barriers to shipping decarbonisation are substantial but surmountable through coordinated policy, financial innovation, and accelerated Industry 4.0 adoption.
- Digital tools both reduce operating costs and lower investment risk — turning them into high-leverage interventions.
- The combination of predictable policy signals (carbon/fuel standards), demand aggregation for green fuels, targeted port investments and de-risking finance can close the CAPEX/OPEX gap and unlock large-scale emissions reductions within the next decade.

References

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