From Compromise to Consequence: Evaluating the IMO's Net-Zero Framework and its Implications for the EU

Final Report

For: Carbon Market Watch

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List of Acronyms

Acronym	Definition
CH_4	Methane
CII	Carbon Intensity Indicator (emissions per transport work)
CO_2	Carbon Dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
EEA	European Economic Area
ETS	Emissions Trading System
EU	European Union
GFI	GHG Fuel Intensity
GHG	Greenhouse Gas
HFO	Heavy Fuel Oil
ICCT	International Council on Clean Transportation
IMO	International Maritime Organization
ILUC	Indirect Land Use Change (impacts of biofuel production)
ISWG-GHG	Intersessional Working Group on GHG
JET	Just and Equitable Transition
LDCs	Least Developed Countries
LNG	Liquefied Natural Gas
MBM	Market-Based Measure (economic instruments to reduce emissions)
MEPC	Marine Environment Protection Committee (of the IMO)
MRV	Monitoring, Reporting, and Verification
NOx	Nitrogen Oxides
NZF	Net-Zero Framework
OECD	Organisation for Economic Co-operation and Development
RU	Remedial Unit
SIDS	Small Island Developing States
SOx	Sulphur Oxides
SU	Surplus Unit
T&E	Transport & Environment (NGO)
tCO_2eq	tonne of CO_2 equivalent
TtW	Tank-to-Wake (emissions from fuel combustion during vessel operation)
UCL	University College London Bartlett Energy Institute
UMAS	UCL Maritime Advisory Services
USD	US Dollar
VLSFO	Very Low Sulphur Fuel Oil
WtW	Well-to-Wake (lifecycle emissions assessment methodology)
ZNZ	Zero- and Near-Zero Emission Fuels

Executive summary

This report provides an in-depth assessment of the economic measure adopted at the 83rd session of the International Maritime Organization's Marine Environment Protection Committee (MEPC 83) in April 2025. The measure, commonly referred to as the IMO Net-Zero Framework (NZF), combines a GHG Fuel Intensity (GFI) standard with a two-tier carbon pricing system and represents the first binding global economic instrument to reduce greenhouse gas (GHG) emissions from shipping and the first global measure aimed at reducing emissions from a sector.[1] The study evaluates the design, ambition, and likely impacts of the NZF, benchmarks it against a high fixed GHG levy scenario, and explores options for integrating it into the European Union's regulatory framework while maintaining high climate ambition.

Key Findings

Limited climate compatibility. The NZF is likely to result in modest emission reductions—on the order of 10-15% by 2030 under current design assumptions—consistent with recent assessments from Transport & Environment (T&E) (2025a) and University College London Bartlett Energy Institute (UCL) (2025). This outcome falls short of both the IMO's indicative ambition (20–30%) and a 1.5°C-compatible pathway, which would require a 45%-emissions cut by 2030.[2][3] The shortfall is primarily due to insufficiently steep GFI reduction trajectories and low effective carbon price signals, resulting in marginal compliance costs for most ships that remain well below USD 100 per tonne of CO_2 equivalent (tCO_2eq). In other words, the current intensity-based approach does not provide strong enough incentives to achieve the absolute emissions reductions required for Paris alignment.[4]

Weak carbon price signal. The current Remedial Unit mechanism applies only to a fraction of a ship's emissions (those above the Direct Compliance GFI threshold) and does not impose a uniform price across total emissions. Thus, the nominal RU price (USD 100/tCO_2eq for Tier 1) cannot be directly compared to an economy-wide carbon tax or EU ETS allowance price. To facilitate comparison, this report estimates the effective carbon price implied by the NZF: if the fixed Tier 1 RU price of USD 100/tCO_2eq were applied uniformly across the ~10–15% of emissions that are subject to NZF pricing in the early years, it yields an effective carbon price of only about USD 10–15/tCO_2eq. This is far lower than the uniform carbon price of roughly USD 100–150/tCO_2eq typically considered necessary to drive deep

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[2] The IPCC Special Report (SR15) finds that to stay below or near 1.5 °C warming, global CO_2eq emissions need to fall by about 45% by 2030, compared with 2010 levels

[3] While this report focuses on the period up to 2030, it is important to note that the long-term trajectory of the NZF will be critical. The agreement is unlikely to drive substantial change before 2030, but its significance will lie in shaping emissions reductions beyond that point. .

[4] While the nominal carbon price set for Tier 1 Remedial Units reaches USD 100/tCO_2eq, this price applies only to emissions above the compliance threshold, typically covering just 10–15% of total emissions. As a result, the effective price signal across the fleet is closer to USD 10–20/tCO_2eq, which remains too low to significantly accelerate the shift toward zero-emission fuels. If the same price of USD 100/tCO_2eq were applied uniformly to all emissions, the climate impact would be far greater.

decarbonisation in the sector, and well below the USD 200-550/tCO_2eq range generally required to make zero-emission fuels like e-ammonia or e-methanol cost-competitive with fossil marine fuels (e.g., Very Low Sulphur Fuel Oil (VLSFO)). In short, the NZF's partial coverage and two-tier pricing dilute the price signal, undermining its climate efficacy.

Limited and unpredictable revenue potential. Projected revenues generated under the NZF are less than half of what a high-level flat carbon levy would raise. Whereas an IMO-mandated universal carbon levy of USD 100/tCO_2eq could generate on the order of USD 40–60 billion annually, the NZF's hybrid mechanism is expected to raise only around USD 10–13 billion per year (Reuters, 2025). Moreover, the design—featuring Surplus Unit (SU) banking and tiered pricing—adds volatility and diminishes predictability in revenue flows to the IMO's new Net-Zero Fund. Because ships can earn and bank SUs when over-complying, actual payments into the fund will fluctuate with market conditions, fuel availability, and compliance strategies, complicating long-term planning for decarbonisation support programmes.

Insufficient support for zero-emission fuels. Incentives for truly sustainable zero- and near-zero-emission (ZNZ) fuels (e.g. green e-methanol and e-ammonia produced from renewable hydrogen) remain too limited to close the substantial cost gap with fossil alternatives. Under current design parameters, ZNZ fuels are projected to reach only ~3–5% of the international shipping fuel mix by 2030, below the IMO's aspirational target of 5–10% IMO (2025). While the NZF is scheduled to enter into force in 2027, projections based on its design suggest ZNZ fuels will only comprise a few percent of the fleet's fuel consumption by 2030—falling short of the IMO's goal. The low effective NZF carbon price and the ability to comply through modest efficiency gains or transitional fuels mean that, with break-even carbon prices potentially reaching up to USD 550/tCO_2eq for e-methanol[5] - particularly where CO2 is sourced by direct air capture - and USD 436–515/tCO_2eq for e-ammonia,[6] the NZF signal — USD 100–380/tCO_2eq applying only to excess emissions — remains insufficient.This mismatch, combined with the scope for low-cost compliance, helps explain why, without additional policy support or stronger price signals, investment in high-cost zero-carbon fuels is likely to remain marginal.

Equity and distributional implications. Small Island Developing States (SIDS) and Least Developed Countries (LDCs), which had advocated for a high levy to secure predictable climate financing, are unlikely to benefit in proportion to their needs under the NZF. Conversely, major flag states and fuel-exporting countries may face lower compliance costs and less disruption of existing fuel supply chains under the hybrid design.[7] For example, fossil-fuel exporters and states with large conventional fleets (e.g. China, Gulf States) gain from the low price floor and the continued viability of fossil LNG, whereas climate-vulnerable states (e.g. Marshall Islands, Tuvalu) are left with an NZF mechanism that is expected to generate only modest revenues—insufficient to fund their transition and adaptation needs. In essence, the NZF's compromise design favours the preferences of large shipping nations

[5] Irena and Methanol Institute (2021) reports current commercial-scale e-methanol production costs at ~USD 800-1 600/t assuming CO2 is sourced from BECCS and at~ USD 1 200-2 400/t if CO2 is obtained by DAC. With VLSFO at ~USD 500/t, it gives a cost gap of USD 300–1100/t for one type and 700-1900/t. Using an emission factor of ~3.21 tCO_2eq/t fuel, this corresponds to a break-even carbon price of up to up to ~USD 550/tCO_2eq.
[6] ClimateWorks Foundation (2024) estimates a cost gap for green ammonia of USD 1,400–1,650 per tonne of HFO replaced; assuming ~3.2 tCO_2eq per tonne of HFO, this implies a break-even carbon price of ~436–515 USD/tCO_2eq.
[7] Radio New Zealand (RNZ) (2025). Small island states welcome strong support for shipping levy.

over the ambitious funding demands of SIDS/LDCs, raising concerns about climate justice and a Just and Equitable Transition (JET).

Implementation risks. Critical elements of the scheme remain undefined or subject to further negotiation, including default fuel emission factors, SU banking and trading rules, monitoring, reporting and verification (MRV) protocols, and mechanisms for revenue allocation. How these technical details are resolved will be decisive in determining whether the measure's nominal ambition is preserved or diluted during implementation. Weak default lifecycle emission values (for example, underestimating methane slip for Liquid Natural Gas (LNG) or lax MRV and enforcement could create loopholes that undermine the NZF's environmental integrity. Robust rules and transparency will be essential to avoid inflated compliance claims or non-compliance with minimal penalty (IMO, 2023b).

Integration into the EU policy framework. There are several pathways to integrate the IMO's global measure within the EU's regional climate policies for shipping. The analysis identifies a range of options, from simply adopting the NZF in EU waters (and potentially removing the EU ETS for shipping), to more ambitious approaches that layer the NZF on top of the existing EU ETS coverage (Öko-Institut & T&E, 2021). The most viable and climate-ambitious integration models appear to be those that maintain the EU ETS coverage of intra-EEA voyages, extend ETS coverage to 100% of extra-EEA voyage emissions, and apply the IMO NZF in parallel for extra-EEA voyages without allowing deductions for double-counted emissions cost. Such approaches preserve a strong carbon price signal within the EU while still participating in the global IMO scheme, thereby avoiding a dilution of ambition. By contrast, options that narrow the EU ETS scope or allow one scheme's payments to offset the other (so-called "cost deduction" mechanisms) risk weakening overall effectiveness, reducing EU revenues, and undermining decarbonisation incentives. In short, the EU can integrate the IMO measure in a way that complements, rather than substitutes, its own climate policies ensuring that overlapping compliance costs serve to internalise a greater share of shipping's climate impact, which still falls well below central estimates of the social cost of carbon (e.g. USD 185/tCO_2eq in 2020; Rennert et al., 2022; USD 417/tCO_2eq 2010; Ricke et al., 2018).

In conclusion, the following synthesis highlights the overarching message of this assessment: the adoption of the IMO NZF at MEPC 83 marks an important milestone. However, the current compromise—characterised by partial emissions coverage, weak price signals, and unresolved implementation details—remains insufficient to deliver the systemic change required for a 1.5°C-aligned maritime transition.

To close this ambition gap, the measure must be strengthened through:

- broader emissions coverage,
- more ambitious GFI trajectories,
- binding revenue earmarking, and
- more ambitious regional and industry action.

In parallel, progressive actors such as the EU must ensure regional policies reinforce global ambition, while supporting coherence and avoiding fragmentation.

1. Introduction

This report presents a comprehensive assessment of the IMO's NZF – the hybrid market-based measure approved in principle at MEPC 83 to reduce GHG emissions from international shipping. The focus is on the NZF's expected climate impact, its revenue-generation potential, and its implications for the uptake of zero- and near-zero-emission fuels, as well as for enabling a JET in the maritime sector. The analysis also compares the NZF's projected outcomes with those under a high carbon levy scenario and explores pragmatic pathways for integrating the IMO's measure with the EU's regional climate policies for shipping (notably the European Union Emissions Trading System (EU ETS)).

The compromise agreement – now officially termed the IMO Net-Zero Framework – introduces a two-tier hybrid system: a GHG Fuel Intensity standard combined with a RU mechanism that applies differential carbon pricing to emissions exceeding defined intensity targets. While this approach secured broad political support at IMO, it raises concerns about limited emissions coverage, low effective carbon prices, and unresolved implementation details – factors which could undermine its climate ambition and its alignment with the Paris Agreement's 1.5 °C trajectory.

Accordingly, this study:

- Examines the design, rationale, and limitations of the IMO NZF, including its GFI targets and carbon pricing elements;
- Quantifies its expected environmental and fiscal outcomes under current design assumptions (emissions reductions, revenue generation, fuel uptake);
- Compares these outcomes with a counterfactual high-ambition scenario (a flat GHG levy of USD 100–150/tCO_2eq applied across all emissions); and
- Proposes policy enhancements to strengthen ambition at both the international level (IMO) and the regional level (EU), in order to close the gap to a 1.5 °C-consistent pathway.

The report begins with a brief review of recent studies and technical analyses, which form the analytical foundation for the findings and recommendations that follow.

2. Maritime Decarbonisation and Market-Based Measures (MBMs): A Review of the Literature

2.1. Key Insights

- **Gap between ambition and action**: while the IMO's 2023 Revised GHG Strategy and recent MEPC decisions (MEPC 80 and 83) provide a necessary framework, they lack the urgency, enforcement mechanisms, and price signals required to align with a 1.5 °C-compatible decarbonisation pathway. Current GFI improvement trajectories under the IMO NZF remain too shallow, and the scope of emissions covered too narrow, to close the ambition gap by 2030 or 2040.

- **Carbon pricing and market signals**: studies consistently find that fixed levies or high carbon prices send stronger investment signals than complex trading schemes under partial coverage. CE Delft (2022) modelled the maximum feasible GHG reductions in international shipping, showing that even ambitious operational and fuel measures could achieve 28–47% emissions cuts by 2030 (with cost increases of 6–14%). By contrast, T&E (2025a) estimates that the IMO NZF would deliver only around 8–10 % total emissions reduction by 2030, with just ~15 % of a ship's emissions subject to the Tier 1 remedial unit (RU) price. This means that, even if RU prices reached USD 100/tCO_2eq, the overall decarbonisation signal remains weak compared with what is technically achievable through stronger complementary measures. Analyses by UCL and Carbon Market Watch conclude that a simple levy-type MBM would likely drive fuel switching more effectively than an ETS-style hybrid scheme – especially one with uneven enforcement or partial global coverage like the NZF.
- **Lifecycle emissions and fuel viability**: the climate credentials of alternative fuels vary widely. Lifecycle analyses by the International Council on Clean Transportation (ICCT) show that LNG offers limited net GHG benefits due to methane slip and upstream emissions. LNG may help with air quality (reducing SOx/NOx) but can undermine climate goals by prolonging fossil fuel use under lenient policies. Harmonising emissions accounting (especially adopting a robust Well-to-Wake (WtW), methodology) is essential to ensure that measures like the NZF incentivise truly low-carbon fuels rather than allow accounting loopholes. Broader environmental impacts (land-use change from biofuels, etc.) must also be considered to avoid burden-shifting (IMO, 2023a).
- **Infrastructure and operational readiness**: decarbonisation requires coordination across the maritime value chain – including fuel suppliers, ship technology, and port infrastructure. Studies highlight that regional infrastructure gaps could hinder the uptake of new fuels. For example, DNV (2024b) and Global Maritime Forum (2025) identify port readiness challenges (e.g. for ammonia bunkering in key hubs), while Tan et al. (2023) analyse LNG bunkering risks along Asia-Pacific routes. Such findings underscore that policies like the NZF must be complemented by investments in supporting infrastructure and technology deployment to be effective.
- **Equity and regional differentiation**: multiple stakeholders (T&E, ICCT, Carbon Market Watch) have called for MBM revenues to be earmarked for R&D and fleet upgrades in SIDS, LDCs, and other developing regions. Without targeted support, there is a risk of over-burdening the Global South or exacerbating disparities in access to clean fuel technology. The principle of common but differentiated responsibilities is often invoked to argue that funds from a global MBM should help finance climate action in less-developed maritime nations.

  Policy design recommendations: recent research suggests the value of simulation-based models that capture how shipping companies might respond to carbon pricing. Such models incorporate behavioural changes (like speed reduction, route optimisation) and market dynamics (fuel price differentials, elasticities of demand). Some studies also explore flexible mechanisms like SU trading and pooling, which could improve cost-effectiveness by allowing over-performing ships to sell credits to under-performers. Such approach could also accelerate the uptake of zero emission capable vessels, whose benefits are shared across a wider fleet, rather than requiring every ship to pursue marginal efficiency gains that may primarily incentivise short term measures like biofuels blending. Overall, the literature indicates that a more adaptive and robust policy design is needed – one that aligns high-level ambition with on-the-ground realities of the maritime sector, and that includes safeguards to ensure environmental integrity (such as strict MRV and default values to prevent greenwashing).

2.2. Literature review[8]

The transition to zero-emission shipping has gained momentum through international agreements, yet significant gaps remain between ambition and implementation. The literature underscores the complexity of aligning global regulatory efforts, economic incentives, fuel transitions, and technological readiness. Recent policy shifts – notably the IMO's Revised GHG Strategy adopted in 2023 (MEPC 80), which included commitments to develop a GHG fuel standard, a global MBM, and LCA guidelines – have provided a foundation. However, assessments from the UCL (Smith et al., 2025) and UMAS (2025) indicate that the measures agreed at MEPC 83 still fall short of the pace required for Paris-aligned decarbonisation. These decisions, while providing a positive directional signal (e.g. by indicating a move away from fossil LNG in the long term), lack the scope and enforcement strength needed to catalyse a full-sector transformation by 2030 or 2040.

Earlier analyses by Det Norske Veritas (DNV, 2023) and the Maersk Mc-Kinney Møller Center for Zero Carbon Shipping (2025) identified limitations in the IMO's then-proposed GHG Fuel Standard and MBM plans – particularly the insufficient carbon price signal to displace incumbent fossil fuels at scale. These insights foreshadow the shortcomings of the NZF: T&E (2025a) warns that the current GFI trajectory, with its modest intensity reduction requirements, may unintentionally prolong the use of fossil LNG, delaying the shift to truly zero-carbon fuels. The same report highlights the risk of carbon lock-in and calls for stronger baseline targets and regionally differentiated incentives to avoid complacency.

Another key challenge is the absence of harmonised WtW emissions accounting. Differences in lifecycle boundary definitions and emission factor assumptions can lead to inconsistent comparisons that often favour conventional fuels (with well-established data) over emergent alternatives. For example, Zamboni et al. (2024) show that if only Tank-to-Wake emissions are counted, some biofuels or LNG can appear cleaner than they truly are when upstream emissions are considered. These discrepancies undermine the coherence of measures like the Carbon Intensity Indicator (CII) and NZF. Establishing standardised WtW methodologies is critical to ensure fair comparisons and to guide investments toward fuels that genuinely achieve deep GHG reductions.

At the same time, research on carbon pricing in other sectors provides context. According to the World Bank (2023), carbon pricing initiatives, e.g. ETS, carbon taxes, covered about 23% of global GHG emissions in 2023, but coverage in international transport remains minimal. The IMO's NZF will initially price only ~10–15% of international shipping emissions, meaning that even a USD 100/tCO_2eq price yields a weak average incentive signal. Studies by UCL (2022, 2023) and UMAS (2025) suggest that fixed-levy systems – especially if revenues are used to subsidise zero-carbon fuels – could generate stronger early investment signals than

[8] A detailed summary of the key studies informing this literature review is provided in Appendix A, which offers further methodological and empirical context for the analysis presented in this report.

a gradually tightening intensity standard or a volatile credit-based system. Stable pricing mechanisms are also found to be more equitable for developing countries than complex trading schemes, which can concentrate benefits among larger players.

Carbon Market Watch (2024) further stresses that MBM effectiveness hinges on design integrity. Past experience (e.g. in the EU ETS) shows that free allowances, offsets, or lax caps can seriously erode real-world impact. Well-designed carbon pricing, by contrast, with robust enforcement and revenue recycling, can both enhance ambition and address equity concerns.

Lifecycle analysis remains central: ICCT (2022, 2025) demonstrates that LNG yields only marginal CO_2 benefits and entails significant methane emissions, aligning with critiques by Chatham House (2022) and Lindstad & Rialland (2020) that question LNG's role as a "transition" fuel. Such findings reinforce calls to limit any credit given to LNG under MBMs and to ensure policy support is directed toward genuinely low-carbon options.

Finally, equity and regional differentiation are recurrent themes. Organisations such as T&E, Carbon Market Watch, and ICCT consistently argue that a portion of MBM revenues must be devoted to capacity-building and infrastructure in the Global South. Without such redistribution, carbon pricing could disproportionately burden smaller and developing country fleets. Recent studies support more sophisticated policy models that incorporate equity—simulating different revenue allocation schemes, compensation measures, or differentiated requirements—to ensure fairness alongside effectiveness. Appendix A provides a comparative summary of recent research findings, highlighting how various MBM design choices impact both environmental outcomes and equity considerations.

3. Outcome of MEPC 83 and Evolution of the IMO Economic Measure

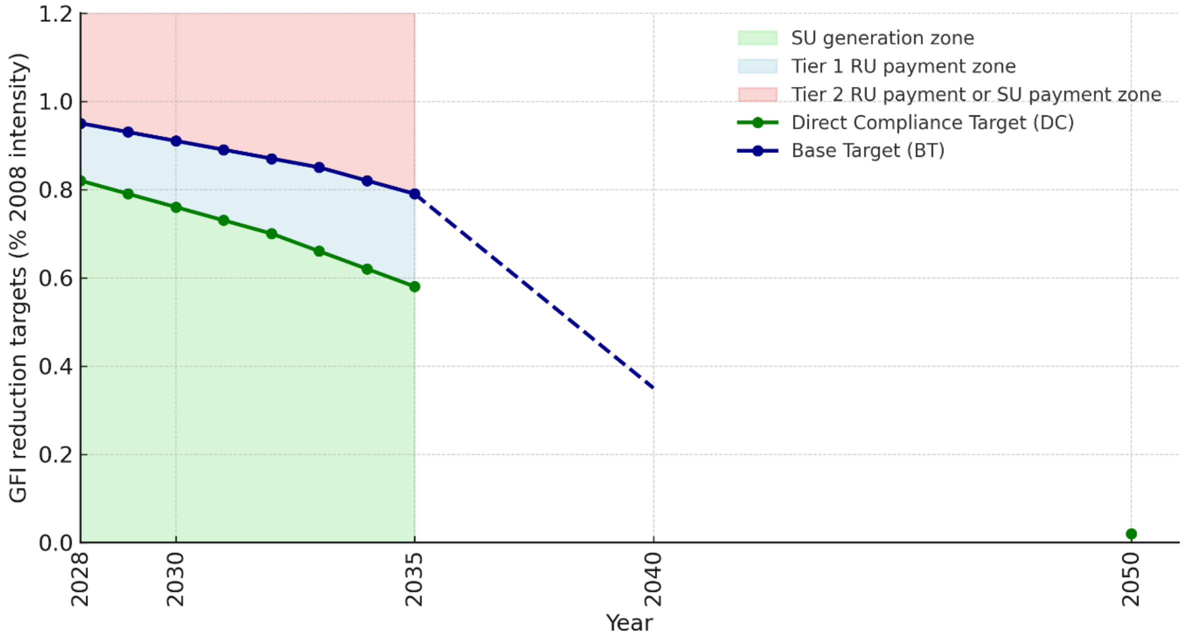
The 83rd session of the IMO's MEPC marked a significant milestone in international maritime climate policy. Building on negotiations at the Intersessional Working Group on GHG (ISWG-GHG 19) in March 2025 and in the previous months, MEPC 83 reached agreement in principle on the structure of the IMO's first binding global economic measure targeting GHG emissions from shipping.

The adopted measure consists of a two-pillar hybrid system designed to reduce the lifecycle GHG intensity of marine fuels while creating differentiated economic incentives for compliance. Pillar 1 is a GFI regulation that establishes mandatory, progressively tightening targets for the WtW GHG emissions per unit of energy used by ships (see Figure 1). Two tiers of GFI targets will apply: a Base Target, which all vessels must meet to avoid penalties, and a more ambitious Direct Compliance Target, which incentivises faster uptake of ZNZ fuels. Ships meeting the Direct Compliance Target – typically by using low-carbon or zero-carbon fuels – will earn SUs that can be banked for up to two years or sold to other ships to offset compliance deficits. They will also escape any form of carbon pricing under the scheme. The initial reduction factors, or Z-factors, have been set for 2028 through 2035, with further targets to be agreed by 2032 and an indicative 2040 Base Target already identified. This GFI requirement creates a form of flexible compliance mechanism within what is otherwise a direct regulatory approach.

The measure agreed at MEPC 83 represents a historic first: the adoption of a binding global economic instrument to reduce GHG emissions from international shipping. Its architecture – combining a GFI standard with differentiated carbon pricing – establishes a hybrid compliance structure and creates a dedicated IMO Net-Zero Fund to recycle revenues into climate action (supporting innovation, ZNZ fuel uptake, and climate finance for developing states).

While this design improves regulatory clarity and provides a mechanism for climate funding, it also introduces carbon-price volatility through SU trading, which may undermine predictability and complicate investment planning. Under the current agreement, the Tier 1 Remedial Units (RUs) price is fixed at USD 100/tCO_2eq until at least 2030. A higher price of USD 380/tCO_2eq for Tier 2 RUs – applicable to emissions above the Base Target (i.e. for more severe non-compliance) – has been proposed and is reflected in the draft NZF text[9]. These prices apply only to emissions above the respective thresholds, not to a vessel's total emissions, which sharply limits the share of emissions actually subject to a carbon price. According to T&E (2024), only about 10–15% of emissions are likely to fall under the NZF's pricing scope during the initial years. Over time, as the GFI targets tighten, this share may increase – but that will depend on enforcement, fleet turnover, and zero-carbon fuel availability.

Figure 1. Illustrative decline of GFI compliance targets over time under IMO NZF



Source: authors' own calculations

Note: Z-factors (percent improvement targets) are currently set through 2035, with an indicative Base Target for 2040. Under the NZF:

- Ships meeting the Direct Compliance Target generate SUs (credits for over-performance)
- Ships between the Direct and Base Targets must surrender Tier 1 RUs
- Ships failing to meet the Base Target must surrender Tier 2 RUs (or use banked/transferred SUs to offset)

The measure agreed at MEPC 83 represents a significant step forward, marking the adoption of the first binding global economic instrument to reduce greenhouse gas (GHG) emissions from international shipping. Its architecture—combining a GFI standard with differentiated carbon pricing—establishes a hybrid compliance structure and creates a dedicated Net-Zero Fund under the IMO NFZ to support climate action in developing countries and promotes the

[9] The IMO NZF text was approved but not formally adopted at MEPC 83. Formal adoption will be subject to a vote in the next MEPC/ES.2 meeting in October 2025.

global uptake of zero- and near-zero-emission fuels (ZNZ fuels). While the mechanism is designed to enhance administrative clarity and funding visibility, the inclusion of Surplus Unit (SU) trading introduces carbon price volatility, which could undermine predictability and complicate investment planning for ZNZ fuels infrastructure and clean fuel uptake.

While speculative discussions with stakeholders suggest that SU prices may stabilise somewhat below Tier 2 RUs' levels—potentially in the USD 150–300/tCO_2eq range depending on expiry rules and market liquidity—this remains highly uncertain and will depend on final rule design and market behaviour. In the IMO framework, vessels that outperform the Direct Compliance Target can generate SUs, which can be banked or traded to offset Tier 2 obligations. Initial market estimates suggest SUs may trade below the USD 380 Tier 2 price. For example, some analysts project SU prices as low as USD 312/tCO_2eq by 2028 (Jordan, 2025), while broader market modelling anticipates a range between USD 150–350/tCO_2eq, depending on supply and demand factors, fuel types, and expiry rules (Global Maritime Forum, 2025).

In summary, while the MEPC 83 measure sets a valuable political precedent and provides a foundation for future ambition, it does not yet offer a credible pathway to deep decarbonisation. Its current design—featuring an 8% GFI reduction Base target by 2030 and a partial carbon pricing mechanism—translates to only modest emissions cuts (8–10% by 2030). Without major enhancements to price levels, GFI reduction trajectories, enforceable sustainability criteria, and binding funding commitments for ZNZ fuel infrastructure and support for developing countries, the measure will fall far short of aligning international shipping with the Paris Agreement and the IMO's own climate strategy.

Using the Tier 1 RU price of USD 100/tCO_2eq and assuming roughly 14% of emissions are above the threshold, the effective average carbon price across all emissions is estimated at only ~USD 14/tCO_2eq.[10] This limited price signal is unlikely to drive major changes such as large-scale fuel switching or slow-steaming. Moreover, Tier 2 RUs function more as a penalty for extreme non-compliance than a true carbon price across the board. The ability to generate and trade SUs (by overachieving the Direct target) introduces a quasi-market mechanism, but SU price levels will remain uncertain and highly sensitive to the rules set (banking limits, etc.).

The current framework also risks locking-in transitional fuels that could delay full decarbonisation. Fossil LNG, for example, remains economically attractive under the NZF's mild incentives, despite its at best limited and uncertain climate benefits when upstream methane emissions are accounted for and high upstream methane emissions.[11] Similarly, if sustainability criteria for biofuels remain weak, there is a risk that cheap, but high-ILUC biofuels could be used for compliance, undermining true climate gains. More detailed sustainability safeguards are expected to be developed in the implementation phase, but their absence in the agreed framework weakens early investment signals for truly zero-carbon solutions.

On the positive side, the measure includes forward-looking elements: ships that overachieve (beat the Direct target) can bank or sell SUs, and a share of the revenue from RU purchases is intended to support first movers (via a fuel cost reimbursement scheme) and developing

[10] Carbon Market Watch (2025) and Transport & Environment (2025a) estimate that this design will result in less than 15% of total emissions being priced under Tier 1 RUs through 2035.
[11] LNG may sometimes have no benefit at all, depending on leakage rates and LCA scope.

countries' needs. However, given the low effective price and uncertain revenue volume, these incentives are unlikely to close the significant cost gap for zero-carbon fuels in the near term.

The second pillar introduces differential carbon pricing. Vessels that fail to meet the Direct Compliance Target but comply with the Base Target must purchase Tier 1 RUs, contributing to the IMO Net-Zero Fund at a lower rate. Ships that also fall short of the Base Target must surrender Tier 2 RUs, reflecting a higher penalty for non-compliance. Tier 1 RUs are priced at USD 100/tCO_2eq, and Tier 2 RUs at USD 380/tCO_2eq, applicable at least until 2030.

Ships exceeding their targets may generate SUs, which can be banked or traded. This mechanism allows underperforming vessels to use acquired SUs instead of purchasing Tier 2 RUs, balancing environmental ambition with cost-effectiveness.

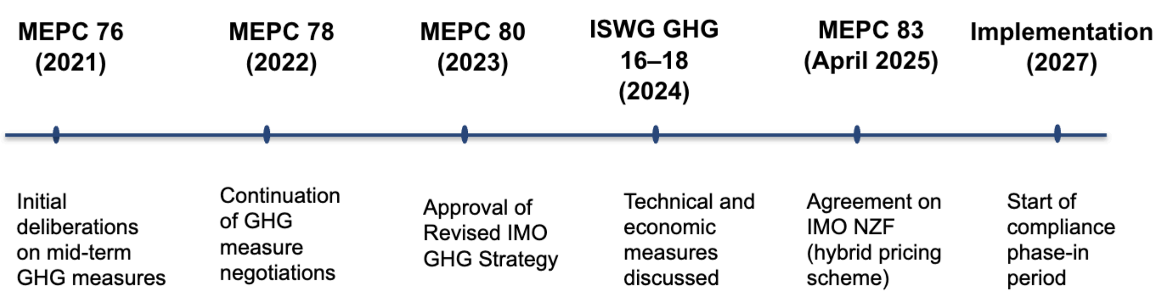
Revenue collected from this system is intended to support several objectives: rewarding early adopters of ZNZ fuels through partial reimbursement, funding capacity building and infrastructure in developing countries, and advancing the IMO's JET principles, as enshrined in the 2023 GHG Strategy.

This approach builds on proposals from SIDS and LDCs calling for a high-ambition levy and predictable financing to support equitable transition. However, operational guidelines for revenue earmarking remain under discussion. Analyses by T&E (2025) and UCL (2025) indicate that the NZF, in its current form, may fall short of generating the revenue required to meet its equity and infrastructure objectives.

In parallel, MEPC 83 endorsed the gradual tightening of CII reduction factors, agreed to amendments to lifecycle GHG assessment guidelines, and began defining default values for fuel attributes. These measures aim to strengthen the overall decarbonisation package.

The agreed text remains in draft form, pending formal adoption at an extraordinary MEPC session scheduled for October 2025. Entry into force is expected in 2027 emissions will be the first subject to the emissions reductions and pricing under the NFZ, allowing time for industry compliance planning and fuel strategy adjustment (see Figure 2).

Figure 2. NZF key milestones timeline



Source: authors' own elaboration

In summary, while the MEPC 83 outcome sets a valuable political precedent, it does not yet offer a credible pathway to deep decarbonisation. With only an ~8% GFI cut by 2030 and limited emissions coverage, expected emissions reductions are modest. Without substantial improvements – higher price levels, steeper GFI trajectories, enforceable sustainability criteria, and binding commitments to fund ZNZ infrastructure – the NZF is likely to fall short of both the Paris Agreement goals and even the IMO's own stated climate objectives.

A further quantitative analysis of the Base and Direct targets is presented in the next section, using the reported Z-factors and emissions projections to assess alignment with decarbonisation pathways.

4. Assessment of Climate Compatibility and Ambition

This section assesses the climate compatibility and ambition of the IMO's NZF. By examining projected trends in total GHG emissions, the analysis sheds light on key weaknesses in the scheme's design. It evaluates the mechanism's architecture, potential risks and limitations (including the rebound effect and the banking of units), and briefly compares the NZF to alternative pricing approaches in terms of environmental ambition, predictability, and equity. The section also identifies implementation uncertainties and provides recommendations for strengthening the framework, particularly from an EU climate policy perspective.

4.1. Target definition:

The 2023 IMO GHG Strategy sets the overarching ambition for the maritime sector, including indicative checkpoints of 20–30 % absolute GHG reduction by 2030 and at least 70 % by 2040 (both relative to 2008 levels), as well as the aim to reach net-zero GHG emissions by around 2050. It does not, however, establish compliance mechanisms, Z-factors, or Direct Compliance (DC) targets.

These elements were introduced later under the NZF adopted at MEPC 83 in 2025. The NZF operationalises the strategy by defining the Base Target (BT) and Direct Compliance (DC) pathways for GHG Fuel Intensity (GFI) reduction, together with the associated crediting and pricing mechanisms. Our analysis focuses on these NZF targets and mechanisms.

In parallel, the IMO also operates the Carbon Intensity Indicator (CII) framework, which sets progressively stricter annual operational efficiency benchmarks (in grams CO_2 eq per tonne-mile) and rates ships from A (best) to E (worst). From 2026 onward, these benchmarks tighten each year, requiring continuous efficiency gains. While the CII is entirely separate from the NZF, in practice it could reduce GFI values and indirectly influence NZF compliance outcomes. For example, analyses by T&E (2024) and UCL (2024) suggest that including CII-driven improvements could increase total emissions-reduction potential from around 8 % under the NZF's Base Target alone to roughly 10 % by 2030. However, this interaction is not modelled in our estimates, which are based solely on the NZF.

Within the NZF's BT/DC structure, it is worth noting that the banking of units within the NZF could weaken overall ambition if not controlled. Over-compliance in early years (achieving better than required GFI) could allow some vessels to accumulate SUs and use them to offset future non-compliance, especially once targets tighten. If a large surplus is banked, the fleet might meet later targets on paper without actually improving performance at that time. This risk underscores the importance of designing SU limits or expiry to ensure early gains are not simply used to delay later action. In contrast, alternative approaches like a uniform carbon levy would offer more predictable price signals and avoid such complexities, albeit without the flexibility that the NZF provides.

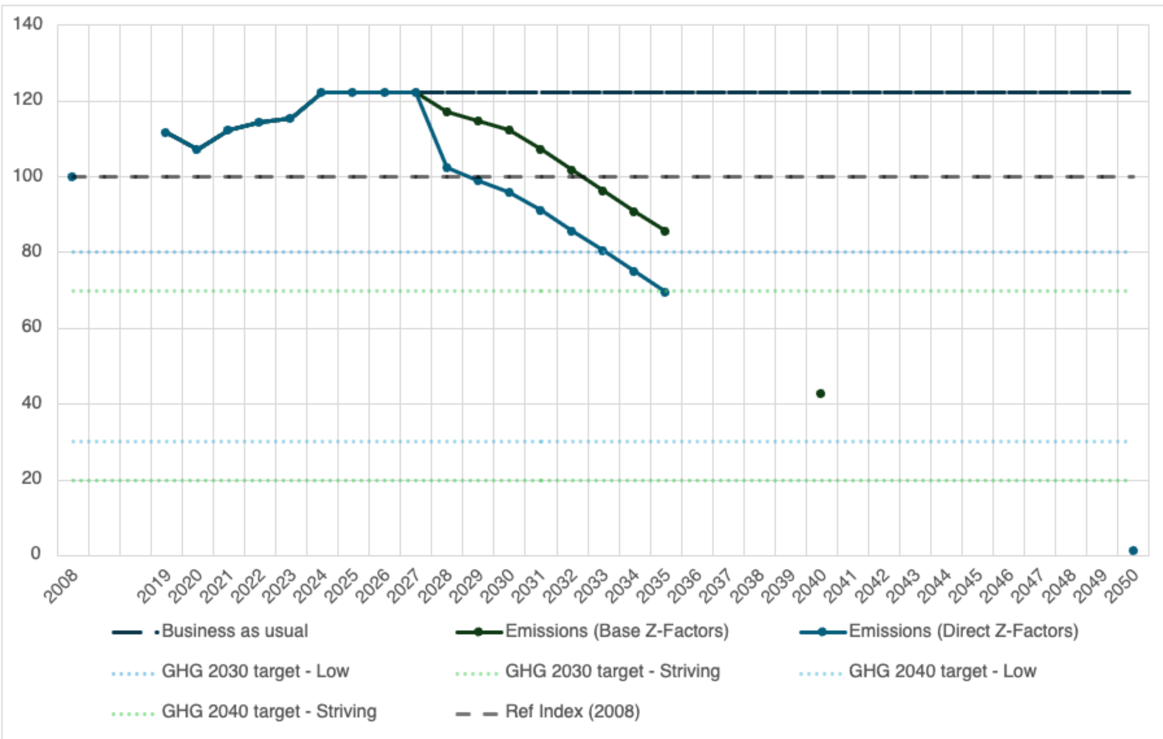
4.2. Analysis

Figure 3 shows the evolution of total GHG emissions from international shipping, indexed to the 2008 baseline (2008 = 100). Emissions for 2008 are drawn from the IMO's GHG Fourth Study (IMO, 2020). Emissions from 2019–2024 are indexed based on OECD data, providing an up-to-date trajectory to the eve of NZF implementation. This allows a direct comparison of absolute emissions reductions versus the 2008 baseline under various scenarios.

The analysis first evaluates the compatibility of the IMO's announced Z-factor trajectory with its own emissions reduction strategy (IMO, 2023c), assuming that total emissions from 2025 to 2028 remain roughly stable at 2024 levels. Even assuming full compliance with the NZF's GHG Fuel Intensity (GFI) requirements, the current Z-factors — multipliers that adjust a ship's GFI score based on its use of specific fuels or technologies — are insufficient to meet the NZF targets on time. Model results indicate that, at the present Z-factor levels, the 2030 Base Target (BT) would be missed by roughly 40%, while the Direct Compliance (DC) target would not be reached until around 2035 — a delay of about five years. This shortfall could be further exacerbated by the NZF's SU's banking provisions, which risk allowing early over-compliance to offset future under-performance without genuine decarbonisation.

This outcome is not surprising, given that the Base Z-factor pathway calls for only an 8% improvement in GFI by 2030 and does not account for post-2008 growth in trade volumes. If shipping activity continues to expand, intensity improvements at this level will be far too modest to deliver the absolute emissions reductions needed. While the current NZF Z-factor trajectory extends only to 2035, in theory a steeper path thereafter could still approach net-zero by 2050. However, such a back-loaded approach would almost certainly mean missing interim climate objectives and would require extremely aggressive reductions between 2030 and 2040 to catch up. In practice, delaying action makes the end goal exponentially harder to achieve

Figure 3. Projected evolution of total GHG emissions from international shipping (Indexed to 2008 = 100)



Source: authors' own calculations, IMO (2020), OECD database

Note: the 2050 data point is illustrative and not based on a defined IMO NZF target, as the Z-Factor trajectory beyond 2035 remains to be negotiated. Emissions projections are indexed to 2008, in line with IMO's adopted baseline reference

4.3. Critical limitation: The rebound effect

A major limitation of the NZF's current approach lies in the risk of a rebound effect. By targeting reductions in GHG intensity (emissions per transport work) rather than absolute emissions, the framework could inadvertently encourage higher overall activity. In simple terms, making each tonne-mile more carbon-efficient (and potentially slightly cheaper) may lead to more demand for shipping – whether in higher cargo volumes, longer routes, or increased voyage frequency.

Such behavioural and market responses could offset the gains from improved efficiency, dampening the net reduction in total GHG emissions. If shipping becomes more efficient and operating costs per unit cargo fall, the industry might carry more cargo or extend supply chains further, leading to emissions growth that eats into the intensity-based savings. Intensity targets alone do not ensure total emissions decline; they must be paired with measures to curb growth in activity if we are to guarantee absolute emissions cuts.

To reflect this risk, our simulation model incorporates a conservative assumption of 3% annual growth in maritime transport activity (in line with historical trends in trade and fleet usage). If one does not account for such growth in policy scenarios, one might overestimate the CO_2 abatement achieved. Indeed, when factoring in a modest growth rate, the projected emissions trajectory under the NZF looks significantly worse, especially relative to the IMO's absolute reduction targets for 2030 and 2040. Ignoring growth could thus undermine the credibility of the NZF as a pathway to net-zero.

To address the rebound issue, complementary measures may be required – such as absolute emissions caps, operational limits (e.g. speed regulations or voyage frequency controls), or policies to manage demand (e.g. incentives for shorter supply chains or localised production). These could ensure that efficiency gains translate into actual emissions reductions rather than being cancelled out by increased activity.

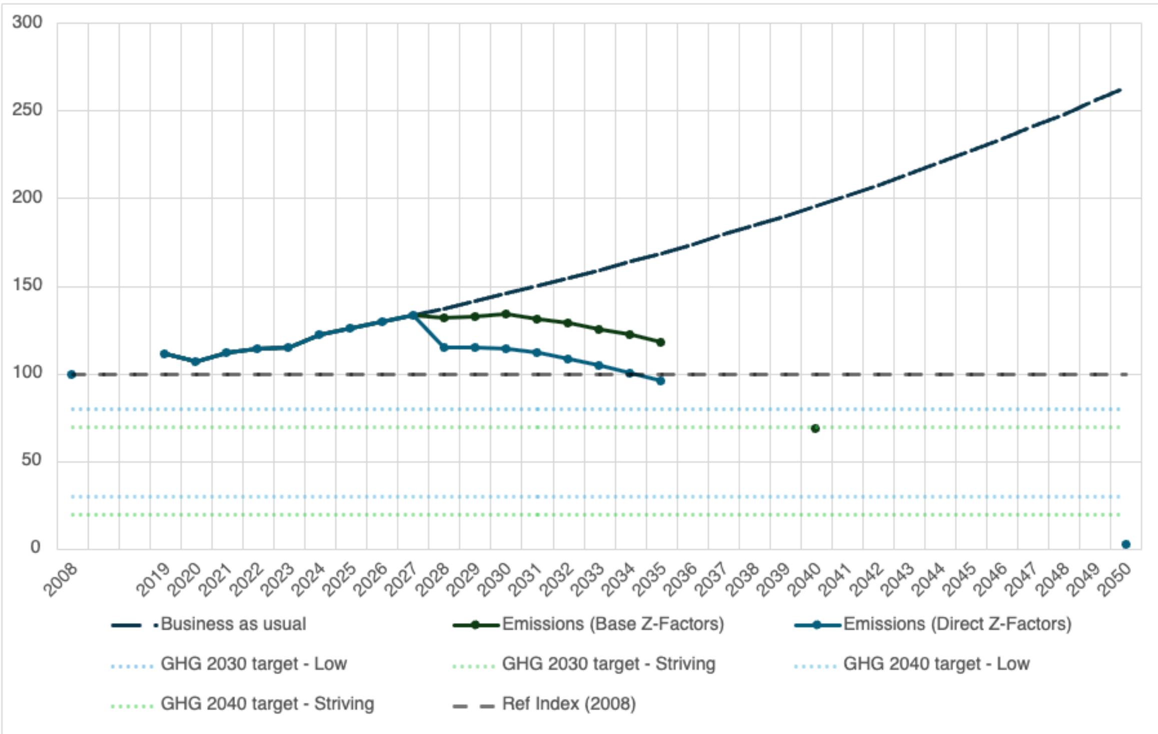
4.4. Data collection and simulation

This subsection details the data sources and simulation methods used to quantify the impact of the rebound effect and to assess the NZF's overall effectiveness under various growth and compliance scenarios.

Figures 4 and 5 present results from our simulation model. The methodology is as described above: Observed emissions data from 2008 to 2024 (as in Figure 3) form the historical baseline. From 2024 onward, we project two cases: one with zero growth (Figure 3 - for comparison) and one with a sustained 3% annual growth in activity. In both cases, from 2028 onward the NZF's GFI requirements (Z-factors) are applied. Figure 4 corresponds to the scenario including 3% growth. Figure 4 shows that when trade growth is factored in, the overshoot of the 2030 Target grows to about 65% (versus a 40% miss in the no-growth scenario). Even the Direct Compliance pathway, while delivering greater reductions than the Base Target, still falls short of the NZF's 2030 objective, underscoring the need for steeper Z-factor adjustments or complementary measures. Notably, under growth assumptions, total emissions continue to rise well into the 2030s before eventually turning downward. This demonstrates that intensity improvements alone are insufficient to produce absolute emissions cuts if the sector continues to expand.

Figure 4 shows that when maritime trade is factored in, the GFI strategy fails to meet any of its intermediary targets, despite improvements in per-tonne-mile efficiency.
In both cases, the IMO's current framework appears incompatible with its own interim goals, once trade-driven growth is considered. While carbon intensity improves, total GHG emissions continue to rise well into the 2030s — a trend that undermines the effectiveness of an intensity – based pathway alone.

Figure 4. Projected evolution of total GHG emissions from international shipping (Indexed to 2008 = 100) – assuming 3% annual growth

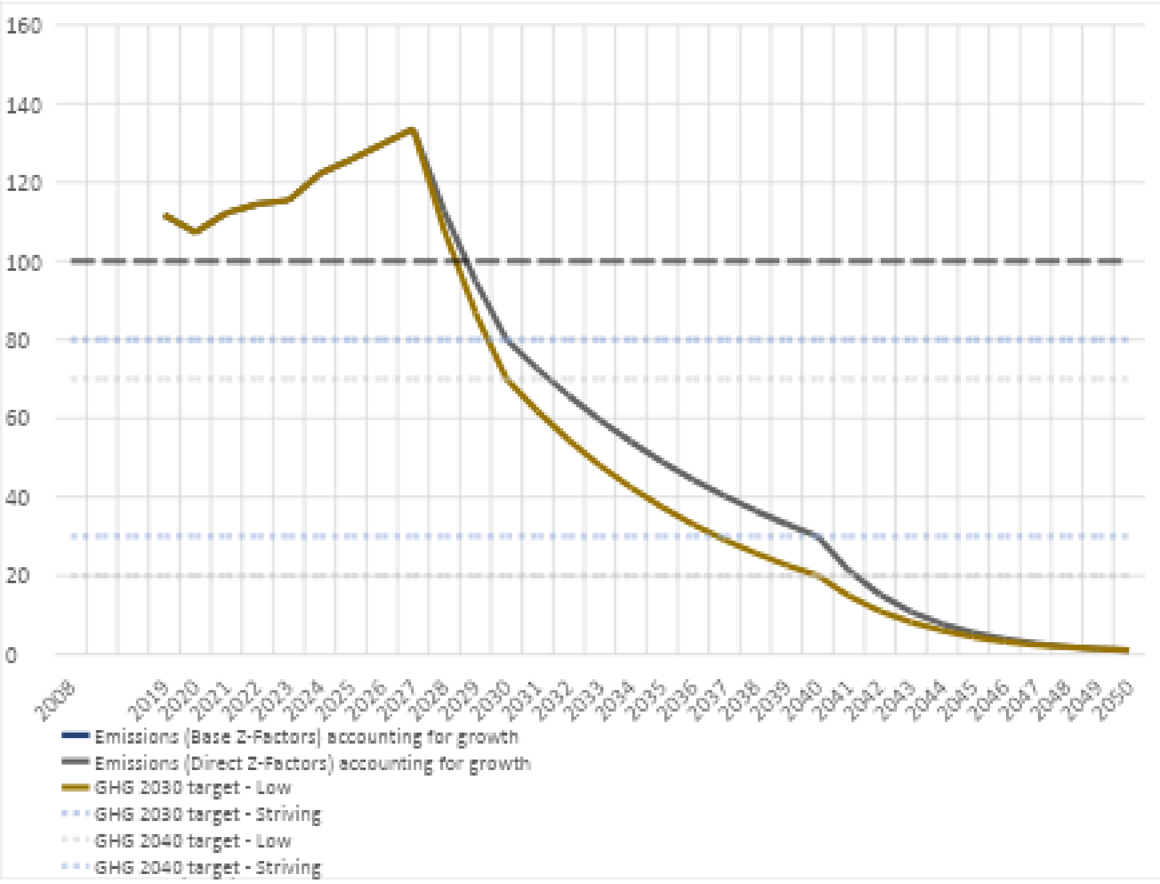


Source: authors' own calculations, IMO (2020), OECD database

We then tested how much more ambitious the Z-factors would need to be to meet the IMO's absolute emission reduction objectives under a growth scenario. Revised Z-factors with significantly steeper annual GFI reductions – up to ~21.7% per year over 2028–2030 – were modelled. These could, in theory, realign emissions with the IMO's 2030 and 2040 targets (see Figure 5). If implemented fully, such an aggressive trajectory would meet both the interim and 2050 goals, but it would demand a virtually unprecedented scale of change: rapid deployment of zero-emission vessels, major retrofitting of the fleet, and huge investments in fuel supply infrastructure within a very short period. The political and operational feasibility of this level of acceleration is highly questionable.

Figure 5. Projected reduction of total GHG emissions with revised Z-Factors

(Indexed to 2008 = 100) – 3% growth scenario



Source: authors' own calculations, IMO(2020), OECD database
Note: all data are compatible with the associated table

Table 1. Projected reduction of total GHG emissions with revised NZF Z-factors (indexed to 2008 = 100) - 3% annual growth scenario

IMO NZF objectives	Absolute emissions (Index 2008 =100).	Applicable period	Required annual Z-factor (Fractional GFI improvement)
Base Target - 2030	80	2028 - 2030	0.1815 (18.2% annual)
Direct Compliance Target - 2030	70	2028 - 2030	0.2171 (21.7% annual)
Base Target - 2040	30	2030 - 2040	0.1198 (11.98% annual)
Direct Compliance Target - 2040	20	2030 - 2040	0.1434 (14.34% annual)
Base Target - 2050	1	2040 - 2050	0.3090 (30.9% annual)
Direct Compliance Target - 2050	1	2040 - 2050	0.2805 (28.05% annual)

Source: authors' own calculations based on IMO NZF targets and OECD (2023c). Assumes 3% annual growth in transport work and constant improvement rates within each period

In summary, while the NZF marks progress compared to a business-as-usual trajectory, its current design is not compatible with the IMO's interim climate goals once realistic trade growth is factored in. Strengthening the ambition – through steeper Z-factors, safeguards against the misuse of credit banking, and possibly adding absolute caps or complementary measures – will be essential to align international shipping with a 1.5 °C pathway. Without such enhancements, the NZF will likely deliver incremental efficiency gains but fall well short of the deep emission cuts required by 2030 and 2040.

5. Revenue Potential, Equity, and Implications for Transition Support

The revenue generation capacity of the IMO's NZF is a critical determina nt of its ability to support a JET, scale up ZNZ fuel and deliver on the IMO's 2023 GHG Strategy Objectives. While the measure approved *in principle* at MEPC 83 establishes a foundational structure — via Tier 1 and Tier 2 RUs, SUs, and a dedicated Net-Zero Fund — it has not yet been formally adopted and therefore remains subject to change. It also remains uncertain whether the current design can raise the necessary finance to deliver a transformational impact.

5.1. Revenue potential and modelling assumptions

To date, no comprehensive study has modelled the full revenue implications of the MEPC 83 hybrid scheme. However, preliminary assessments by stakeholders such as T&E and the UCL Energy Institute suggest that the NZF's revenue potential will remain limited compared to a high fixed levy MBM applied to total emissions. This is due primarily to the relatively low Tier 1 RU price (USD 100/tCO_2eq), which was set to ease compliance costs, and the fact that only about 10–15% of emissions are priced under the scheme. Even with moderate levels of non-compliance, annual revenue generation would still fall short of the amount required to catalyse a transformative shift towards zero-emission fuels.

Although Carbon Market Watch (2024) and CE Delft (2022) did not directly assess this specific hybrid scheme, their respective evaluations of fixed carbon levy scenarios suggest that carbon prices below USD 100/tCO_2eq generate insufficient funding and weak behavioural signals. Based on various modelling exercises (e.g., World Bank, 2023), a threshold of at least USD 100/tCO_2eq applied broadly across emissions is typically considered necessary to reshape fuel investment and uptake dynamics across the sector.

In this context, our own indicative analysis (Appendix B) explores six NZF design variants assuming global maritime emissions of approximately 1,100 MtCO_2eq/year. Table 2 presents illustrative revenue estimates, showing potential revenue scales under these scenarios.

These estimates show that, in its current form, the NZF would generate only a small fraction of the revenue that could be raised under a flat global carbon levy covering all emissions. Even under optimistic assumptions about the uptake of Tier 2 RUs and SUs, revenue remains significantly below the level required to drive widespread fuel switching and infrastructure deployment.

Table 2. Illustrative annual revenue estimates under different NZF design scenarios

Scenario	Estimated Emissions Coverage	Assumed Price (USD/tCO_2eq)	Estimated Annual Revenue (USD bn)
NZF Base Case (Tier 1 RU only)	~14% of total emissions	100	15.4
NZF High Coverage	~20% of total emissions	100	22.0
NZF + Tier 2 RU Compliance	25% of fleet under pricing → 15% exposed to Tier 2 pricing	150	24.75
NZF + Tier 2 & SUs (high-coverage sensitivity)	30% of fleet under pricing → 15% exposed to Tier 2/SUs	380	78.1
Flat Levy (USD 150)	100% of emissions	150	165.0
Flat Levy (USD 250)	100% of emissions	250	275.0

Source: authors' own elaboration. See Appendix B for assumptions.
Note: For Tier 2 and SU-based scenarios, revenue is calculated assuming only the portion of emissions exceeding the base target (approx. 15%) is priced at the Tier 2 or SU level.
These figures assume:

- The GFI standard becomes more stringent over time.
- A moderate level of non-compliance in the fleet.
- SU prices stabilise near Tier 2 RU levels (USD 380/tCO_2eq).

Revenue estimates are indicative and highly sensitive to:

- Compliance behaviour
- Enforcement
- Market design and liquidity
- Expiry rules for SUs

5.2. Interpretation and link to existing studies

The limited scope of emissions priced under the NZF—restricted to those above the Direct Compliance Target—effectively reduces the carbon price signal to around USD 10–15/tCO_2eq across total emissions. In contrast, fixed-levy approaches or full-scope ETS like the EU ETS price 100% of emissions, providing stronger incentives and more predictable revenues.

The predictability of revenues under the hybrid system is also more variable. Because ships can earn SUs by outperforming the Direct Compliance Target and bank or transfer these units for up to two years, the volume of payments into the IMO NZF will fluctuate depending on market conditions, fuel availability, and operators' compliance strategies. This introduces uncertainty that complicates long-term planning for decarbonisation support programs.

Despite these limitations, the measure creates an institutional framework for dedicated, ring-fenced funding. Revenues collected through Tier 1 and Tier 2 contributions will be channelled into the IMO Net-Zero Fund, which has explicit provisions to:

- Reward early adopters of ZNZ fuel through partial reimbursement of costs.
- Support developing countries, including SIDS and LDCs, with targeted investments in infrastructure, technology transfer, and training.

These features represent a significant departure from earlier IMO measures that lacked clear revenue recycling mechanisms. However, the T&E (2025b) briefing cautions that without binding commitments on the scale and allocation of funding, the mechanism risks being perceived as an incremental compliance cost rather than a genuine enabler of a fair and equitable transition.

In particular, the support for the uptake of ZNZ fuel is likely to remain constrained under the current design. Even if partial reimbursements are made available through the IMO NZF, the price differential between fossil LNG and green hydrogen-derived fuels—such as e-ammonia and e-methanol—remains substantial. Pre-IMO deal analyses indicate that zero-emission fuels often cost two to three times more than fossil alternatives (ICCT, 2022; Zamboni et al., 2024). To close this cost gap, more ambitious carbon pricing combined with stable, long-term revenue streams would be needed.

Our findings broadly align with previous estimates by T&E and the UCL Energy Institute (see Table 3), reinforcing that price level alone is insufficient: the share of emissions covered, and the credibility of enforcement mechanisms are equally important for both environmental effectiveness and financing capacity.

Table 3. Comparison with existing studies

Source	Scenario Modelled	Revenue Estimate	Coverage Assumption	Notes
T&E (2025c)	High fixed levy	~USD 60 bn/year	100% emissions	Assumes USD 150/tCO_2eq applied to full emissions
Smith et al., 2025	Fixed levy	USD 60–90 bn/year	100% vs partial	Pure levy model with full coverage
Smith et al., 2025	Hybrid (levy + compliance)	USD 15–30 bn/year	~20–40% emissions (non-compliant share)	Depends on compliance thresholds; lower coverage in early phases
This Report	NZF hybrid + flat levy	USD 15 bn (NZF), USD 165–275 bn (levy)	14–30% (NZF), 100% (levy)	NZF range reflects realistic early-phase revenues under MEPC 83 design; higher values (e.g. USD 78 bn) are flagged in Table 2 as high-price, high-coverage sensitivities only. See Appendix B for methodology and assumptions.

Source: authors' own elaboration

To maximise impact, the IMO should:

- Expand emissions coverage (e.g., lowering the Direct Compliance threshold).,
- Raise Tier 1 RU price floors beyond USD 100–150/tCO_2eq and consider setting Tier 2 RU prices above USD 400/tCO_2eq to create a stronger incentive for decarbonisation and reflect the higher marginal abatement costs associated with non-compliance.

- Ensure predictable, equitable revenue allocation to SIDS, LDCs, and ZNZ infrastructure.

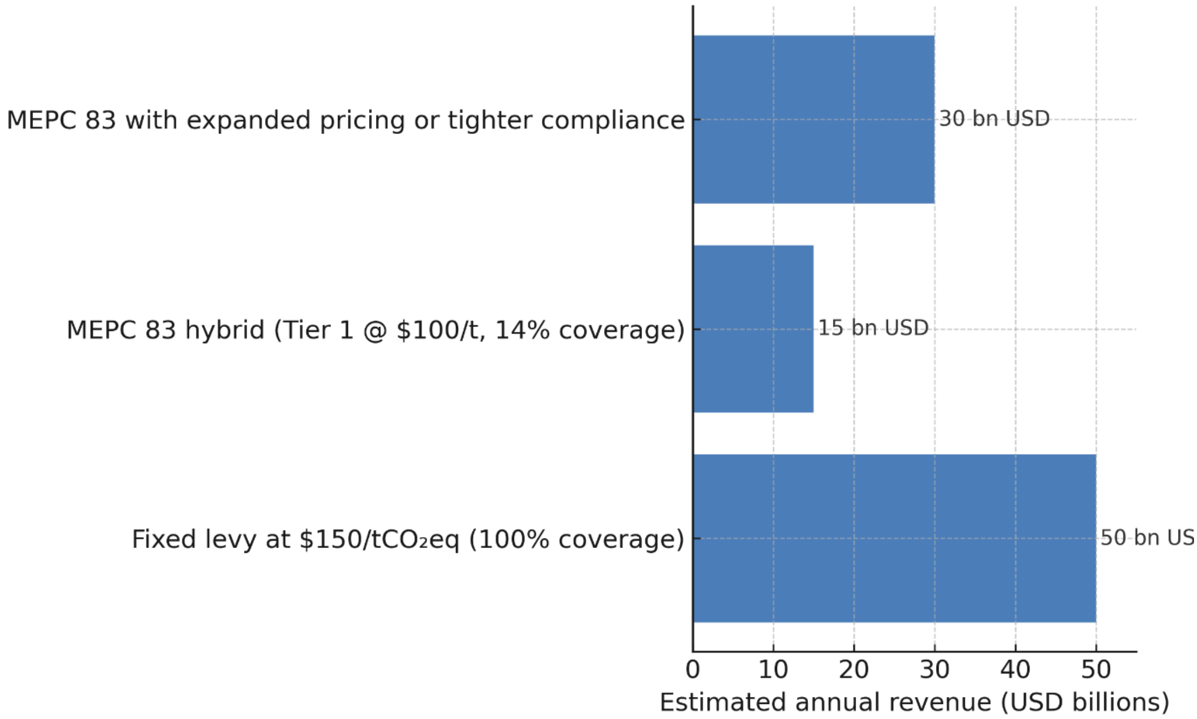
Regional schemes like the EU ETS should complement IMO efforts by covering a greater emission share and earmarking funds for global maritime transition support.

5.3. Comparison with high fixed-levy projections

In contrast, a flat levy of USD 150/tCO_2eq would predictably generate substantially higher and more stable revenue flows. According to the World Bank, a global shipping carbon price could raise USD 40–60 billion annually between 2025 and 2050. This level of funding would be sufficient to subsidise renewable fuel uptake and support large-scale decarbonisation efforts in developing countries.

By comparison, the MEPC 83 hybrid system is expected to deliver substantially lower revenues—likely less than half this amount—due to its limited emissions coverage, the relatively low Tier 1 contribution rate, and broad compliance flexibility through credit transfers or fuel blending. Revenue volatility introduced by SUs further complicates long-term financing and planning.
These comparative outcomes are summarised in Figure 6 and Table 4 below, which illustrate projected annual revenues under different pricing scenarios, including a high fixed levy and variants of the NZF.

Figure 6. Comparative revenue estimates under different IMO pricing scenarios



Source: authors' own elaboration

Despite its limits, the NZF creates an institutional framework for ring-fenced funding with provisions to reward early adopters and support developing countries—marking a significant advance over prior IMO approaches.

Table 4. Comparative Revenue Estimates under Different IMO Pricing Scenarios

Scenario	Estimated Revenue (billion USD/year)	Source/Assumption
Fixed levy at USD 150/tCO_2eq (100% coverage)	50	World Bank (2023), Carbon Market Watch (2024)
MEPC 83 hybrid (Tier 1 @ USD 100/tCO_2eq, 14% coverage)	15	Author calculations (Appendix A); aligned with T&E/UCL EI
MEPC 83 with expanded pricing or tighter compliance	30	Author-modelled hypothetical scenario (based on IMO 2025 RU pricing, assuming higher Tier 2 use and reduced SU banking)

Source: authors' own elaboration

In conclusion, while the NZF creates a new framework for linking compliance to transition finance, its current parameters are unlikely to deliver the scale of funding required for Paris alignment. Stronger price signals, broader coverage, and stricter SU rules would be necessary to close the gap between ambition and delivery.

6. Differentiated Impact by Fuel Type and Country

The measure agreed at MEPC 83 creates a compliance framework that, by design, promotes some fuels over others while distributing costs and benefits unevenly among countries. The combination of a GFI regulation and two-tier carbon pricing offers flexibility, but the NZF's modest overall ambition means that incentives are only partially aligned with Paris Agreement goals. This section examines how the hybrid NZF measure affects different fuel types and how its costs/benefits are distributed across country groups.

6.1. Fuel-Type Impacts

Under the NZF, certain fuels are implicitly favoured by the mechanism's design while others are disadvantaged.

ZNZ Fuels: Truly zero-emission fuels – such as e-ammonia, e-methanol, and other green hydrogen-derived fuels – are in principle promoted through the generation of SUs for ships that over-achieve their GFI targets. In addition, the NZF's revenue recycling via the IMO Net-Zero Fund may provide partial reimbursements for the cost premium of these fuels (though specific criteria are still under negotiation). The intent is to use part of the Tier 1 and Tier 2 contributions to incentivise early adoption of high-cost, low-carbon fuels. However, the effective carbon price under the NZF (estimated at only ~USD 10–15/tCO_2eq on average) is far too low to close the cost gap between truly zero-emission fuels and cheaper transitional alternatives. For example, if only ~15% of a ship's emissions are priced at USD 100/tCO_2eq (Tier 1), the average price signal is ~USD 15/t – an order of magnitude below the ~USD 200-550/tCO_2eq price that studies indicate is needed to make green ammonia or e-methanol competitive with fossil LNG or fuel oil. Without stronger price signals or additional national/regional measures (like higher EU ETS prices or stricter fuel mandates), the uptake of ZNZ fuels under the current NZF design is expected to remain marginal by 2030.

LNG: By contrast, fossil LNG stands to benefit disproportionately under the NZF's parameters. LNG already offers a modest GHG intensity advantage over conventional marine fuels, which helps operators meet the GFI targets without switching to zero-carbon fuels. An industry assessment (SEA-LNG, 2025) notes that under the NZF framework, LNG pathways yield the best short-term economic returns compared to VLSFO, due to a combination of easier GFI compliance and lower Tier 1 RU costs for the small share of emissions that exceed the Direct target. This suggests a high risk of fossil LNG lock-in – i.e. investment in LNG infrastructure and vessels might accelerate, locking the sector into a fuel that is incompatible with net-zero goals beyond 2030. Such an outcome would contradict Paris-aligned decarbonisation pathways (which require a rapid phase-out of all fossil fuels, including LNG, by mid-century). While LNG may temporarily help some ships reduce their GHG intensity, it remains a methane-emitting fossil fuel whose use beyond 2030 is difficult to reconcile with deep decarbonisation.

Certain biofuels (especially advanced biofuels) can also help ships comply with GFI targets if their lifecycle emissions factors are low enough. In theory, sustainable biofuels could provide a bridge solution. However, in the absence of stringent sustainability criteria, there is a risk that biofuels with significant ILUC or biodiversity impacts could be used to meet targets cheaply, undermining the mechanism's environmental integrity. Currently, no binding safeguards are in place under the IMO framework to exclude high-ILUC biofuels or ensure rigorous LCA for biofuels – this remains to be addressed in forthcoming guidelines. Thus, while biofuels might be counted as compliant fuels under the NZF, their true climate benefit could be questionable unless strict rules are adopted.

Conventional Fossil Fuels (HFO, VLSFO): Traditional heavy fuel oil and marine gasoil will face increasing compliance costs under the NZF, as ships failing to meet the Base Target (BT) will typically incur both Tier 1 and, where applicable, Tier 2 Remedial Unit (RU) payments. In the short term, however, the combined effective carbon price (around USD 15–25/tCO_2eq) remains modest, which may be insufficient to drive a rapid shift away from these fuels. Operators might choose to pay the relatively low RU fees and continue with business-as-usual, especially if zero-carbon fuels and new technologies are not readily available or remain more expensive. Over the longer term, as GFI standards tighten and if carbon prices rise, we would expect fossil fuels to lose competitiveness – but that depends on strengthening the NZF's parameters.

Table 5 summarises the relative incentives by fuel type under the NZF as currently designed.

Table 5. Relative incentives by fuel type under the NZF (MEPC 83 framework)

Fuel Type	Compliance Incentive	Lock-in Risk	Notes
E-fuels (e-ammonia, e-methanol)	Moderate	Low	Encouraged via SUs/reimbursements, but current price levels too low to close cost gap
Biofuels	Moderate	Medium	Can qualify if LCA emissions are low; but ILUC and sustainability concerns if criteria are weak

LNG (fossil LNG)	Moderate (short-term)	High	Benefits from easier GFI compliance and low RU costs now; could be phased out later as targets tighten, but near-term lock-in is a concern
Conventional Fossil Fuels (HFO, VLSFO)	Discouraged	Medium	Subject to Tier 1 and Tier 2 fees; modest initial penalties may not deter use in short term, but sustained pricing and stricter standards will reduce competitiveness over time

Source: authors' own elaboration of NZF incentives (based on NZF design and external studies)

The table highlights that the NZF's design implicitly favours LNG and certain biofuels over truly zero-carbon options at present price levels. Without intervention, shipowners have an economic incentive to choose transitional fuels (like LNG) that meet the GFI targets cheaply, rather than invest in zero-emission solutions which remain costly.

6.2. Country-Level Impacts

The impact of the NZF measure varies sharply across countries, raising concerns about equity. SIDS and LDCs – many of whom were among the strongest proponents of a high flat levy (on the order of USD 100–150/tCO_2eq) to generate substantial climate finance – are poised to see relatively limited benefits under the hybrid system. These countries are the most vulnerable to climate change and could have gained from a robust, predictable carbon levy that could fund adaptation and transition needs. However, the compromise reached at MEPC 83 reflects the preferences of major flag states and fuel-exporting nations, prioritising lower cost burdens over higher revenues.

In practice, this means industrialised and high-volume shipping nations (including China, Brazil, and large fuel exporters in the Gulf) benefit from the NZF's low price floors and the continued viability of LNG. Their ships face relatively small compliance costs and can often meet GFI targets through minor tweaks or cheaper fuels. Conversely, SIDS and LDCs will likely see only modest financial flows into the IMO's Net-Zero Fund – on the order of a few billion dollars globally – far below what a high-levy scenario could deliver. According to T&E (2025), the scale of funding under the NZF may be less than half of what a flat USD 100/tCO2eq levy would have generated for climate action in these vulnerable states.

As shown in Table 6, the framework implicitly favours certain country groups over others.

Table 6. Countries/groups most likely to benefit vs. those disadvantaged by the NZF

Likely Beneficiaries	Likely Disadvantaged
Major flag states (Panama, Liberia)	SIDS and LDCs (e.g., Marshall Islands, Tuvalu)
Fossil fuel exporting countries (Qatar, UAE)	Countries with limited capacity to subsidise fleets or invest in ZNZ technology

Source: authors' own elaboration

The "beneficiaries" are those who advocated for a weaker measure – they avoid heavy levies and maintain their competitive advantage or fossil fuel export business in the short term. The "disadvantaged" are those who had pushed for a robust pricing mechanism to generate climate funds; they end up with a mechanism that is unlikely to deliver the scale of support they need.

Finally, the ambition of the NZF will ultimately depend on how key design and implementation elements are defined and enforced in the coming years. Table 7 summarises five critical components – from default emission factors to compliance enforcement – and outlines the potential risks if these are weakened or poorly specified.

Ensuring robust rules, transparent verification, and effective compliance measures is essential to avoid loopholes, inflated compliance claims, or diluted climate impact. These technical considerations will guide upcoming IMO negotiations and working groups as the NZF framework is operationalised.

Overall, Section 6 shows that the NZF's design creates winners and losers both in terms of fuel types and country interests. To improve climate alignment and equity, future work on the NZF should strengthen incentives for truly clean fuels (e.g. via higher prices or direct mandates) and ensure that the most climate-vulnerable countries receive a fair share of the benefits (through targeted revenue allocation). Clear differentiation in these aspects will be key to increasing the mechanism's effectiveness and acceptability.

Table 7. Key design elements of the NZF and associated risks if ambition is weakened

Element	Description	Risk if Ambition is Weakened
Default Emission Factors	Default lifecycle emission factors for each fuel (especially critical for LNG, biofuels, e-fuels)	Inflated "paper" compliance if overly low factors are assigned to high-carbon fuels (e.g. underestimating LNG methane slip)
SU Banking and Trading Rules	Rules governing how SUs can be banked, when they expire, and how they can be traded/transferred.	Over-allocation and price dilution if unlimited banking or speculative trading is allowed (could flood future periods with cheap credits).
Verification Procedures (MRV)	Methods for verifying ships' GFI compliance and reported emissions, as well as RU payments.	Weaker overall compliance and potential cheating if MRV is non-transparent or inconsistent across flags; could undermine trust in system.
Revenue Allocation Mechanisms	Guidelines for earmarking and disbursing funds from the IMO NZF (e.g. share for SIDS/LDCs, technology R&D, etc.).	Failure to deliver a JET if revenue is not ring-fenced for SIDS/LDCs and ZNZ projects; funds might be captured by industry interests.
Compliance Enforcement	Penalties and sanctions for ships or states that persistently fail to comply or that falsify data.	Risk of widespread non-compliance if enforcement is weak or penalties are minimal – the measure could then exist on paper but not in practice.

Source: authors' analysis of NZF design parameters

7. How the EU could transpose and apply the IMO Net-Zero Framework within its own regulatory framework

As the EU advances its maritime decarbonisation agenda, integrating the forthcoming global measures from the IMO – particularly the NZF – raises important questions of compatibility, ambition, and regulatory coherence. A range of policy options for incorporating the IMO's NZF into the EU's climate instruments (the EU ETS for maritime and the FuelEU Maritime regulation) has been identified. Table 8 provides a comparative overview of possible integration pathways for the NZF within the EU ETS, detailing for each option the scope of EU ETS coverage, a description of the approach, and its main advantages and disadvantages.

While several options – including the extreme of removing the EU ETS entirely for shipping (Option 1), or narrowing its geographical scope (Options 2–4) – have been considered, these are generally seen as politically unlikely or environmentally insufficient. Such approaches would weaken the EU's regulatory leverage, reduce ETS revenues, and risk undermining the climate ambition needed to meet the EU's 2030 and 2050 targets. By contrast, Options 5 through 9 offer more viable and robust pathways that preserve or even enhance the EU's climate ambition while accommodating the IMO measure. These options retain or extend the current scope of the EU ETS – with either partial (50%) or full (100%) coverage of extra-EEA voyage emissions – and introduce the IMO NZF in parallel. A key point of divergence among them is whether to allow cost deductions for overlapping emissions (i.e. letting operators subtract IMO payments from their EU ETS obligations). Some options (notably 5 and 8) include such a deduction mechanism, ostensibly to avoid "double charging" industry, whereas others (6, 7, 9) exclude deductions to maintain a stronger price signal.

Notably, Options 5 and 8 allow ship operators to deduct payments made under the IMO NZF from their EU ETS compliance costs. This approach is often promoted by industry to ease the burden of overlapping schemes. However, even combined, the IMO's RU prices and the EU ETS allowance prices remain well below the estimated social cost of carbon. Adding the IMO's ~USD 15/t effective price to the EU ETS price —around €70/t (≈USD 80/t at 2025 exchange rates)—still yields a total carbon price that is far below these benchmarks. Recent research places the social cost of carbon in the range of USD 185–538/tCO_2eq. For example, the U.S. Environmental Protection Agency (2023) estimates about USD 255/t for 2025, while updated meta-analyses and climate–economy projections (Tol, 2025) suggest values spanning USD 185–538/tCO_2eq. These figures represent the estimated full environmental damages of CO_2 emissions and indicate that significantly higher cumulative carbon prices would be required to internalise shipping's climate impact and make e-fuels commercially competitive (Lloyd's Register, 2025; IRENA, 2025). Therefore, from a climate perspective, cost deduction mechanisms risk weakening the EU ETS's signal without actually "over-charging" in any absolute sense – shipping would still be paying far less than the societal cost of its pollution. Cost deductions would also reduce EU ETS revenues (all of which must be earmarked for innovation or member state climate programs) and could introduce administrative complexity.

In addition to transposing the IMO NZF without weakening the EU ETS, it will be important to maintain certain elements of the EU's existing Fit for 55 shipping legislation, in particular the FuelEU Maritime regulation. Two provisions are especially critical: the ban on high-emission first-generation biofuels, and the onshore power supply (OPS) mandate for container and passenger ships. These elements should remain central in EU policy, even as regulators explore ways to align FuelEU with the IMO NZF and reduce double-reporting.

Table 8. Comparative overview of integration options of IMO NZF into the EU ETS

Option	EU ETS Scope	Description	Pros	Cons
1	Removed (EU ETS eliminated for shipping)	Apply IMO NZF to both intra-EEA and extra-EEA voyages; scrap the EU ETS for shipping entirely.	Simplifies global alignment (single system).	Drastically lowers EU climate ambition and revenues; EU loses control/influence.

2a	Intra + partial extra (50% extra-EEA, as current)	Keep current EU ETS scope (100% intra, 50% extra); overlap with NZF (which covers all intra- and extra-EEA) but deduct IMO NZF payments.	Some EU ETS revenue retained; partial alignment.	Carbon price signal weakened by deductions; complex to administer; lower overall ambition.
2b	Intra + no extra (exclude extra-EEA)	Limit EU ETS to intra-EEA voyages only; overlap with NZF (which covers all intra- and extra-EEA) but allow NZF cost deduction for intra-EEA.	Simplifies scope (EU ETS purely intra-EEA).	Greatly reduces coverage (drops the 50% extra-EEA currently covered); lower ambition & revenues.
3a	Intra + partial extra (50%)	Keep current EU ETS scope (100% intra, 50% extra); overlap with IMO (which covers all intra- and extra-EEA); no deductions for NZF payments.	Maintains higher carbon price and EU revenue; no dilution of signal.	Industry faces double payments on extra-EEA half (higher cost); potential opposition from shipping sector.
3b	Intra + no extra	EU ETS covers intra-EEA only; overlap with NZF (which covers all intra- and extra-EEA). No deductions.	Reduces overlap but does not eliminate it, since the NZF also applies to intra-EU international voyages.	Great loss of coverage (EU ETS only intra-EEA); ambition and revenue greatly reduced for EU.
4	Intra only	EU ETS scope narrowed to intra-EEA only (like EU vs CORSIA approach in aviation); NZF applies to only to extra-EEA.	Avoids any double regulation; aligns EU scope fully with IMO.	Loses EU ETS revenue from extra-EEA voyages (≈€2–3 billion/year); overall weaker ambition (extra-EEA only at IMO's low price).
5	Intra + 50% extra (current scope)	Keep current EU ETS scope; allow operators to deduct NZF costs from their EU ETS obligation on the 50% extra-EEA portion.	Preserves EU ETS on paper and adds IMO funding; somewhat maintains ETS integrity.	Administrative complexity; reduces carbon price signal on extra-EEA portion and cuts EU revenues; could undermine ETS if IMO price is lower (which it is).
6	Intra + 50% extra (current scope)	Keep current scope; no cost deductions. Ships pay NZF for extra-EEA + EU ETS for 50% of extra-EEA (and 100% intra).	Maximises combined price signal and revenue; simple concept (just add NZF on top for extra-EEA half).	Higher compliance costs (industry pushback likely due to "double" costs on extra-EEA half).

7	100% intra + 100% extra (full scope)	Extend EU ETS to 100% of emissions on all voyages (intra + extra); do not implement NZF regionally (opt EU out of NZF).	Very high revenue and strong single price signal; EU fully controls ambition (could exceed IMO's).	Politically very difficult (EU commitment to IMO, global backlash); duplicative of IMO scheme (EU seen as undermining IMO).
8	100% intra + 100% extra (full scope)	Extend EU ETS to 100% of voyages; also implement NZF; deduct NZF payments from EU ETS obligations.	Retains very high ambition and acknowledges IMO scheme; generates substantial revenue (from ETS minus deductions).	Legally and politically complex; deduction mechanism needed; essentially two overlapping systems with accounting adjustments.
9	100% intra + 100% extra (full scope)	Extend EU ETS to full scope; also implement NZF in parallel; no deductions. Operators fully participate in both.	Highest combined price signal; full revenue from EU ETS plus IMO fund contributions; strong message on climate leadership.	Most expensive for industry (would face EU ETS on all emissions + NZF on top); significant pushback expected; coordination challenges.

Source: authors' own elaboration based on a CMW internal note

Note: The EU has no ability to unilaterally change the scope of the IMO NZF. These options should therefore be interpreted as theoretical alignment scenarios as a matter of completeness rather than legally or politically feasible measures

By contrast, Options 6, 7, and 9 exclude any form of cost deduction. These pathways preserve regulatory integrity and climate ambition by maintaining a strong carbon price within the EU while supporting global decarbonisation through a parallel IMO scheme. From an effectiveness and fairness standpoint, not allowing deductions aligns more closely with the EU's long-term climate commitments and the European Green Deal objectives. Although industry may object to paying for both systems ("double coverage"), it can be argued that such overlapping costs are justified given the under-pricing of shipping's climate externalities to date.

Implementing these pathways would require legal and technical adjustments, especially regarding alignment between the EU and the IMO MRV systems, and clarity around jurisdictional overlap. Options 5 and 6 maintain the current EU ETS scope (100% intra-EEA + 50% extra-EEA) and are more readily implementable in the short term, while Options 7 to 9 involve a full extension of the EU ETS to 100% of emissions from extra-EEA voyages. Although politically more challenging, these latter options would deliver the strongest carbon price signal, the highest revenues, and the most comprehensive emissions coverage (Umweltbundesamt, 2023; T&E, 2025b).

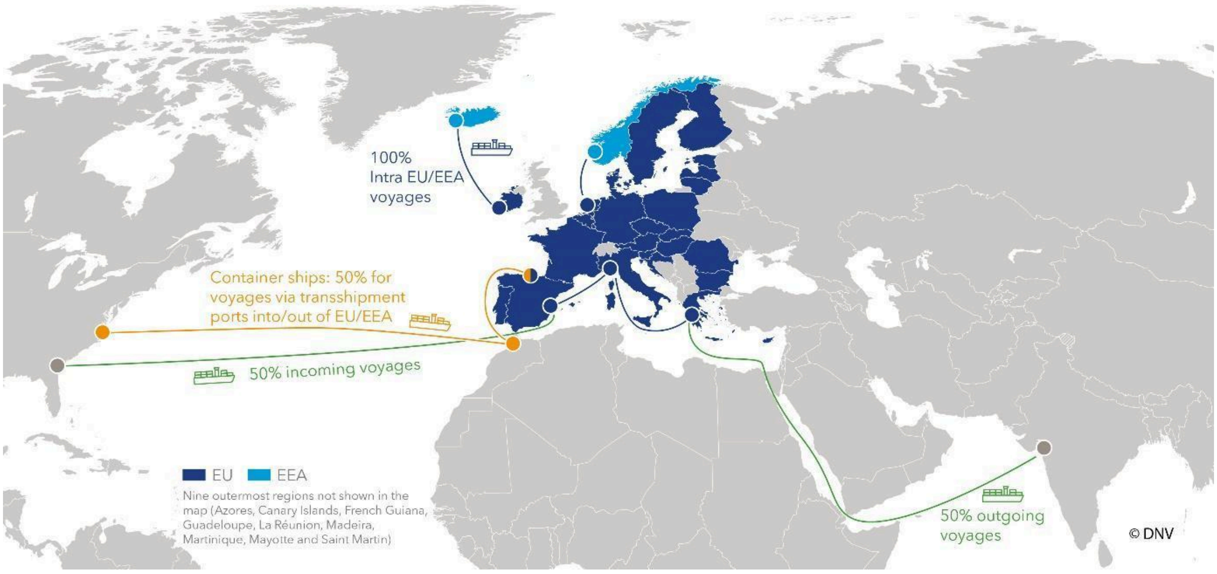
To ensure effective alignment between international and EU-level climate regulation, the European Commission should consider advancing the timeline for its assessment report on the IMO NZF. Currently, the Commission is mandated to report by spring 2027 (18 months after NZF adoption) on the scheme's compatibility with the EU ETS. If this assessment were brought forward to mid-2026, it could feed into the scheduled 2026 review of the EU ETS for maritime. That way, any necessary legislative adjustments or coordination measures could be adopted in time to harmonise EU and IMO approaches by the NZF's entry into force (expected in 2027). Early alignment would help prevent regulatory misalignment or missed opportunities for synergy.

Ultimately, the EU's strategic challenge is not to choose between regional or global measures, but to coordinate them effectively – while firmly maintaining its own climate objectives under the European Green Deal and its Paris Agreement commitments. Figure 7 illustrates the current regional application of the EU ETS to maritime transport: it covers 100% of emissions from intra-EEA voyages and 50% from voyages between the EEA and third countries. (Specific provisions apply to certain cases like transshipment hubs and outermost regions, but these nuances aside, it's a primarily route-based scope). The IMO's NZF, by contrast, is a global ship-based system independent of voyage routes or flags, applying to all international shipping emissions under member states' jurisdiction. The two systems thus operate on different principles – one territorial, one global performance-based – and are not directly comparable in coverage.

Unlike the EU ETS, which is geographically bounded and enforced based on voyage routes, the IMO NZF applies independently of route or flag, provided the ship falls under a compliant member state. As such, while both systems aim to reduce emissions from shipping, they operate under fundamentally different principles—territorial enforcement versus performance-based global compliance—and are not directly comparable in terms of geographic coverage.

In conclusion, the EU has a key role to play in ensuring that its own ambitious maritime climate measures remain a benchmark for global progress, with the IMO's NZF providing a complementary foundation for broader international cooperation. By adopting flexible, coordinated approaches that combine regulatory ambition with practical feasibility, the EU can reinforce its leadership in maritime decarbonisation. Strategic coordination will be critical to avoiding unnecessary complexity and ensuring coherence between the EU and IMO regimes. Importantly, this does not mean that overlapping compliance costs must be avoided at all costs. Given that even combined EU ETS and IMO NZF payments remain well below the social cost of carbon – for example, around USD 255/tCO_2 in 2025 (U.S. EPA, 2023) and USD 185–538/tCO_2 according to updated meta-analyses (Tol, 2025) – a degree of cumulative pricing may in fact be necessary to drive the fuel transition and to reflect the true environmental impact of shipping emissions.

Figure 7. The Scope of the EU ETS Directive for Maritime Emissions



Source: DNV 2024a report

8. Conclusions

8.1. Summary of the findings of the study

This study has examined in detail the compromise measure adopted at MEPC 83, which introduces a two-tier hybrid system combining a GFI standard with differentiated carbon pricing. The assessment benchmarked this mechanism against the alternative of a high, fixed GHG levy and evaluated its implications for climate ambition, revenue generation, fuel market incentives, and distributional equity among states.

Several key findings emerge from the analysis.

Partial alignment with climate goals. While the measure represents an unprecedented step towards establishing binding global carbon pricing in shipping, its design falls short of aligning with the decarbonisation trajectory required under the Paris Agreement. The combination of a relatively shallow GFI baseline and low to moderate price levels—expected to remain far below USD 100–150/tCO_2eq—means the measure is likely to deliver only incremental emission reductions. According to modelling and literature reviewed, the expected impact corresponds to a 10–15% reduction in GHG emissions by 2030 relative to 2008 levels, which is insufficient to meet either the IMO's higher ambition target or the emissions pathway consistent with limiting warming to 1.5°C.

Revenue generation likely limited and variable. The hybrid system is projected to generate modest (USD 15bn p.a.) and unpredictable revenues compared to a high fixed levy scenario (+USD 60bn p.a.). SU banking and transfer mechanisms will likely dampen the carbon price signal and create fluctuations in annual revenue flows into the IMO Net Zero Fund. As a result, the measure's capacity to finance large-scale support for the deployment of ZNZ fuels and to fund a JET in developing countries will remain constrained.

Risk of fossil. The measure's compliance thresholds and pricing structure create a strong risk of perpetuating the economic viability of fossil LNG. Under current cost differentials and anticipated penalty levels, LNG remains an attractive option for meeting GFI targets while avoiding deeper investments in renewable fuels. The absence of binding lifecycle emission caps or stringent default methane slip factors further increases the likelihood that LNG will remain entrenched in the fuel mix beyond what is compatible with long-term decarbonisation.

Limited incentives for truly zero-emission fuels. Although ships surpassing the Direct Compliance Target can generate SUs and receive partial reimbursement of additional fuel costs, these incentives are insufficient to close the cost gap with e-methanol, e-ammonia, and green hydrogen-derived fuels. The estimated uptake of ZNZ fuels under this mechanism is likely to remain between 3% and 5% by 2030, falling short of the IMO's indicative target of 5–10%.

Equity and distributional concerns. The measure's impact will be uneven across countries and fleet types. SIDS and LDCs, which have been strong proponents of a high fixed levy to ensure predictable funding for transition and adaptation, stand to benefit relatively little from the compromise scheme. By contrast, major flag states and fossil fuel exporters will see lower compliance costs and less disruption of existing fuel supply chains.

Implementation risks remain high. The environmental integrity of the scheme will depend heavily on the finalisation of technical guidelines. Key elements—including default emission factors, SU rules, revenue earmarking, and MRV protocols—are still to be defined. There is a substantial risk that these elements could be shaped in ways that further dilute the ambition of the measure.

Required increase in the EU framework's climate integrity to make up for NZF's lack of ambition. The study identified several pathways for incorporating the IMO measure into the EU's regulatory framework (EU ETS and FuelEU Maritime Regulation). Partial integration models that preserve EU ETS scope for intra-EEA voyages, extend it to cover 100% of extra-EEA voyages' emissions, and apply IMO payments for extra-EEA voyages in parallel appear to offer the best balance between maintaining climate ambition and regulatory coherence. However, any integration will require complex adjustments to monitoring and compliance systems. Given the limited climate ambition of the IMO NZF in its current form, strengthening the EU framework becomes imperative. A more robust EU climate architecture can compensate for global shortfalls and play a catalytic role in driving international progress through ambitious regional measures and proactive engagement at the IMO.

In conclusion, the MEPC 83 compromise establishes an important precedent by putting a price on maritime emissions and creating a framework for sector-wide compliance. Yet without significant strengthening—through higher carbon prices, tighter GFI trajectories, enforceable revenue earmarks, and robust implementation rules, the measure will likely deliver only gradual improvements rather than the transformational change required to decarbonise shipping in line with the Paris Agreement.

8.2. Risks from unresolved implementation details

While the MEPC 83 measure represents a significant step forward, many crucial implementation details remain to be defined through technical guidelines and procedures. The ambition and effectiveness of the framework will depend heavily on how these elements are finalised, particularly in five critical areas (see Table 9). These unresolved elements create two primary risks.

Table 9. Key unresolved design elements and risks

Element	Description	Risk if Ambition is Weakened
Default Emission Factors	Default lifecycle emission factors for each fuel (especially LNG, biofuels, e-fuels)	Inflated compliance claims if conservative (low) emission factors are set for fossil-based fuels
SU Banking and Trading Rules	Rules for banking, expiration, transferability of SU	Over-allocation and price dilution if unlimited banking or speculative trading is allowed
Verification Procedures (MRV)	Verification of GFI compliance and carbon payments	Weaker compliance if MRV is non-transparent or inconsistent across flags
Revenue Allocation Mechanisms	Definition of earmarking percentages for NZF disbursements	Failure to deliver JET if revenue is not ring-fenced for SIDS/LDCs and ZNZ fuels
Compliance Enforcement	Sanctions for persistent non-compliance or fraud	Risk of widespread non-compliance if enforcement is weak or penalties are minimal

Source: authors' own elaboration

Dilution of environmental effectiveness. If emission factors or compliance rules are set too leniently, the measure will effectively legalise fossil LNG lock-in.

Revenue Leakage or Misallocation. Without binding revenue earmarking, funds may be diverted away from capacity building or subsidies for zero-emission fuels.

8.3. Policy Recommendations - Strengthening the IMO NZF and EU Implementation

To align the IMO NZF with a 1.5°C-compatible decarbonisation pathway and ensure environmental integrity, stakeholders—particularly the European Union—should focus on reforming its structural design, strengthening implementation, and closing loopholes.

Raise ambition through stronger GFI targets and price signals. The current Z factors (Base and Direct Compliance Targets) and RU prices are insufficient to drive the large-scale fuel switching required for deep decarbonisation. The EU and like-minded states should encourage to advocate for growth-adjusted GFI reduction trajectories aligned with the IMO's 2023 Strategy striving targets (e.g., –30% by 2030 and –80% by 2040 relative to 2008). Tier 1 and Tier 2 RU prices must be raised well above current levels, which deliver an effective carbon price of only USD 10–15/tCO_2eq across most of the fleet — far below the USD 200-550/tCO_2eq typically required to make ZNZ fuels competitive. Price floors of at least USD 100/tCO_2eq should be established, with automatic adjustment mechanisms linked to inflation and ambition reviews.

Constrain SU use to preserve price integrity. The SU mechanism can reward early action but must not undermine carbon prices. SUs should have strict expiry rules (e.g., valid for no more than two compliance periods), quantity caps, and limits on transferability between fleets or vessel types. Consistent with NZF rules, SUs should only offset Tier 2 RU obligations, while Tier 1 compliance must be met through direct RU purchases.

Apply robust lifecycle accounting to all fuels. Default lifecycle GHG emission factors must fully capture methane slip, upstream emissions, and indirect land-use change (ILUC) impacts — particularly for transitional fuels such as LNG and biofuels. Conservative factors should be applied to close loopholes and prevent fuels with high hidden climate impacts from qualifying cheaply.

Establish transparent and enforceable MRV systems. Monitoring, reporting, and verification (MRV) rules must include harmonised methodologies, third-party audits, public access to compliance data, and meaningful penalties for misreporting or manipulation. This will safeguard environmental credibility and ensure trust in the system.

Mandate binding and transparent revenue allocation. Revenues from Tier 1 and Tier 2 RUs should be ring-fenced and transparently managed. A minimum of 75% should be dedicated to: Deployment of ZNZ fuels (especially e-ammonia and e-methanol from green hydrogen), wind propulsion, and JET support for SIDS and LDCs. Failure to deliver JET revenue is not ring-fenced for SIDS/LDCs and ZNZ fuels remain a significant concern; clear allocation rules are needed to ensure these objectives are prioritised given the limited revenue potential of the hybrid NZF.

Strengthen EU integration to raise global ambition. The EU is advised to embed IMO-aligned GFI targets into FuelEU Maritime, maintain and expand the EU ETS maritime scope to all intra-EEA and extra-EEA voyages, and ensure RU payments to the IMO NZF do not exempt ships from ETS obligations on overlapping routes. EU policies should send consistent, high-ambition price signals that make sustainable technologies—including high-cost abatement options like e-fuels and wind propulsion—commercially viable. By combining more ambitious GFI targets, higher and stable carbon prices, strict SU controls, robust MRV, and binding revenue earmarks, the IMO NZF can move beyond incrementalism and contribute meaningfully to Paris-aligned decarbonisation. The EU has a dual role: to push for these reforms internationally while ensuring its own maritime climate policies reinforce, rather than dilute, global ambition.

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Appendix A. Impacts and Policy Relevance from Maritime Decarbonization Literature

Reference	Environmental Impact	Economic Impact	Policy Relevance
Agarwala (2022)	LNG methane slip (3.5-5%) undermines climate gains	Bunkering infrastructure costs USD 500M/port for LNG infra	Argues against subsidising LNG infrastructure
Carbon Market Watch (2024)	Emphasises that full emissions coverage and high carbon prices are essential to drive decarbonisation; well-designed ETS and levy-based systems can both be effective if they ensure broad and meaningful pricing.	Notes that levies may offer greater price predictability, while ETSs can provide dynamic pricing and market efficiency; the effectiveness of hybrid models depends on implementation and coverage.	Underlines that the priority is to ensure all emissions are priced, whether via a levy, ETS, or hybrid MBM; concerns arise when large shares of emissions go unpriced or when exemptions weaken market signals
CE Delft (2022)	Assesses hybrid GFI + levy policy options	Compliance costs vary 2-3x by vessel type and fuel	Provides evaluation tool for MEPC policy assessment
DNV (2023)	LNG infrastructure risk stranding under stricter rules	Hydrogen infrastructure needs USD 100B+/yr	Highlights transition risk of fossil-aligned assets
ICCT (2022)	E-ammonia has 80% lower WTW emissions than LNG, depending on pathway	2-3× higher cost than fossil fuels today	Reinforces case against LNG as transition fuel
IMO (2023a)	Projects only 20% emissions cut by 2030 under current measures	Requires USD 1.4T total investment to 2050	Establishes official ambition gap baseline
Lindstad and Rialland (2020)	Cruise sector LNG use delays true decarbonization	USD 20M/vessel retrofit costs	Critiques sectoral loopholes in pollution strategy
T&E (2025a)	Weak GFI baseline extends fossil LNG viability	Regional compliance burdens vary significantly	Exposes loopholes in MEPC 83 and life-cycle gaps
UMAS (2025)	Stresses need for global GHG limits aligned with 1.5C	Flags risk of low carbon prices under surplus trading	Equity-centred analysis for Global South impacts
Zamboni et al. (2024)	Green methanol and ammonia show lowest full-cycle emissions	Bottlenecks add 15-20% costs in immature supply chains	Recommends fuel standards that reflect lifecycle reality
Zhao et al. (2025)	Operational measures (slow steaming) cut 15% CO_2eq now	Digital tools reduce costs by 8-12%	Supports phased transition combining tech and policy

Appendix B – Revenue Calculation Methodology

This appendix outlines the assumptions and calculations used to derive the revenue estimates presented in Section 5.1. All scenarios assume a global maritime emissions baseline of 1,100 MtCO_2eq/year. Annual revenue is calculated using the formula:
Revenue = Emissions × Effective Coverage (%) × Average Price (USD/tCO_2eq)
All figures are rounded to the nearest tenth of a billion USD for clarity.

Scenario – NZF Base Case (Tier 1 RU only)
Effective Coverage: ~14% of total emissions
Assumed Price: USD 100/tCO_2eq
Calculation: 1,100 × 0.14 × 100 = 15.4 billion USD/year

Scenario – NZF High Coverage
Effective Coverage: ~20% of total emissions
Assumed Price: USD 100/tCO_2eq
Calculation: 1,100 × 0.20 × 100 = 22.0 billion USD/year

Scenario – NZF + Tier 2 RU Compliance
Coverage: ~25% of fleet emissions under pricing
Tier 2 Exposure (assumed): ~15% of emissions priced at Tier 2 RU level
Assumed Price: USD 150/tCO_2eq
Calculation: 1,100 × 0.15 × 150 = 24.8 billion USD/year

Scenario – NZF + Tier 2 & Surplus Units
Coverage: ~30% of fleet under pricing
Tier 2/SU Exposure (assumed): ~15% of emissions priced at Tier 2/SU level
Assumed Price: USD 200/tCO_2eq
Calculation: 1,100 × 0.15 × 200 = 33.0 billion USD/year

Scenario – Flat Levy at USD 150/tCO_2eq
Coverage: 100% of emissions
Assumed Price: USD 150/tCO_2eq
Calculation: 1,100 × 1.00 × 150 = 165.0 billion USD/year

Scenario – Flat Levy at USD 250/tCO_2eq
Coverage: 100% of emissions
Assumed Price: USD 250/tCO_2eq
Calculation: 1,100 × 1.00 × 250 = 275.0 billion USD/year

Notes:
The "average price" in hybrid NZF scenarios reflects a simplified estimate based on assumed unit values and does not account for detailed tiered contributions across ships
For Tier 2 and Surplus Unit scenarios, only the share of emissions exceeding the base target is priced at the higher rate
These figures are illustrative and sensitive to real-world variables, including:
Compliance behaviour and stringency of GFI targets
Final pricing rules and expiry policies for units
Market liquidity and enforcement levels under the IMO NZF
Note: The 10–15% figure refers to the share of emissions likely to be priced under the NZF in its early implementation phase, while the 20–25% estimate reflects the total projected GHG emissions reduction by 2030, accounting for both pricing effects and fuel intensity standards