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REDUCTION OF GHG EMISSIONS FROM SHIPS

Report of the Steering Committee on the comprehensive impact assessment of the basket of candidate GHG reduction mid-term measures
Executive summary of the report on Task 1 (Literature review)

Submitted by the Secretariat

SUMMARY

Executive summary:	This document contains the executive summary of the report on Task 1 (Literature review) of the Comprehensive impact assessment of the basket of candidate mid-term GHG reduction measures, as approved by the Steering Committee.
Strategic direction, if applicable:	3
Output:	3.2
Action to be taken:	Paragraph 2
Related documents:	MEPC 80/17, MEPC 80/17/Add.1; MEPC 81/7, MEPC 81/7/Add.1; MEPC 82/7, MEPC 82/7/1, MEPC 82/7/2, MEPC 82/7/4, MEPC 82/7/4/Add.2, MEPC 82/7/4/Add.3, MEPC 82/7/4/Add.4, MEPC 82/INF.8, MEPC 82/INF.8/Add.1, MEPC 82/INF.8/Add.2, MEPC 82/INF.8/Add.3 and MEPC.1/Circ.885/Rev.1

Introduction

1 The comprehensive impact assessment of the basket of candidate mid-term GHG reduction measures consists of five distinct and interrelated tasks (MEPC 82/7/4, paragraph 5). This document provides the executive summary of the report of Task 1 on the literature review conducted by the World Maritime University (WMU), as approved by the Steering Committee, set out in the annex. The full report on Task 1 is set out in document MEPC 82/INF.8.

Action requested of the Committee

2 The Committee is invited to consider, in conjunction with document MEPC 82/7/4, the executive summary of Task 1 (Literature review) of the comprehensive impact assessment of the basket of candidate GHG reduction mid-term measures, taking into account the full report contained in document MEPC 82/INF.8, and to take action as appropriate.

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ANNEX

EXECUTIVE SUMMARY OF THE REPORT ON TASK 1 (LITERATURE REVIEW)

Disclaimer

1 This report has been completed by the World Maritime University. It contains the report on Task 1 on the literature review of the Comprehensive impact assessment of the basket of mid-term GHG reduction measures.

2 Whilst this report has been commissioned by the International Maritime Organization (IMO), the information contained within this report represents the views of its authors. It should not be interpreted as representing the views of the IMO, or the Steering Committee on the comprehensive impact assessment of the basket of candidate mid-term measures, or the States that are represented on the Steering Committee.

3 This comprehensive impact assessment of the basket of mid-term GHG reduction measures consists of five distinct but interrelated tasks for which different reports have been prepared. Task 1 of the comprehensive impact assessment of the basket of mid-term GHG reduction measures is being undertaken solely to assist IMO's Marine Environment Protection Committee (MEPC) in making evidence-based decisions. Any information included in this report is provided solely for analytical purposes and should not be interpreted as suggestions or recommendations for how the basket of mid-term GHG reduction measures should be designed. The policy combination scenarios and any other information included in this report are provided solely for analytical purposes and should not be interpreted as suggestions or recommendations for how the basket of mid-term GHG reduction measures should be designed.

4 The designations employed and the presentation of material on any map in this report do not imply the expression of any opinion whatsoever on the part of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Context and methodology

5 MEPC at its eightieth session approved the terms of reference for the conduct of a comprehensive impact assessment of the basket of candidate mid-term measures delivering on the reduction targets of the *2023 IMO Strategy on Reduction of GHG Emissions from Ships* and invited the Secretary-General to establish the Steering Committee to act as a focal point for the Committee during the conduct of the comprehensive impact assessment. Following consideration, the Steering Committee agreed to recommend that WMU carry out the literature review as Task 1 of the comprehensive impact assessment.

6 The aim of this literature review is to identify relevant literature findings on the potential impacts of a basket of candidate mid-term GHG reduction measures comprised of a technical element, namely a goal-based marine fuel standard regulating the phased reduction of the marine fuel's GHG intensity, and an economic element, on the basis of a maritime GHG emissions pricing mechanism. This literature review has focussed in particular on the following issues: a review of the most recent published fuel/technology transition pathways for shipping, including reviews of the final energy demand and supply, and the forecast fuel and technology mixes; an analysis of the determinants of the maritime transport costs, and the pass-through of compliance costs; the findings from existing assessments of potential impact of GHG mitigation measures on the eight impact criteria in the 2023 IMO Strategy; existing literature on potential approaches to address (e.g. avoid, remedy, mitigate) impacts on States; and existing literature on the use of revenues of GHG pricing mechanisms.

7 The methodology applied in this literature review comprised a systematic literature review. The systematic literature review was undertaken by specifying relevant search terms in an abstracts and citation database of peer-reviewed literature, followed by a review of the literature found in this database, a review of the literature found using an internet search engine, as well as a review of literature references specified in this literature. In addition to the systematic literature review, an internet search engine was used to access relevant grey literature (non-peer reviewed documents).

8 Relevant literature for assessment in this review was selected by the WMU research team as well as submitted by members of the Steering Committee of the comprehensive impact assessment of the mid-term measures and the IMO Secretariat by 5 January 2024 at the latest. The literature review does not therefore take into account any new literature after 5 January 2024.

Main findings

Main findings of subtask 1: A review of most recent fuel/technology transition pathways for shipping

9 A comprehensive systematic literature review of the most recent fuel technologies and transition pathways, highlighting advantages and disadvantages of various fuels and technologies, including safety concerns and life-cycle impacts, was carried out. The analysis showed that a wide range of technologies could help reducing the GHG emissions from shipping. Wind and solar energy capture could reduce the fuel energy needs and various fuels, such as biofuels, hydrogen, methanol and ammonia, synthetic fuel oils, as well as battery electric energy storage and nuclear power, could cover the remaining energy needs.

Main findings of subtask 2: On the energy demand side, a review of the final energy demand (EJ and GWh equivalence) and energy intensity (MJ/ tonne miles) considered for the shipping sector, both current and projections to 2030, 2040 and 2050

10 The literature review found that the projections for future seaborne trade vary widely in the literature, depending on the scenarios developed in the studies. There appeared to be consensus in the literature that transport work, i.e. the amount of cargo transported over a certain distance (measured in tonne miles) would increase significantly during the decades between 2022 and 2050, with estimates of this increase varying between around 66-125%.

11 The literature predictions for the final energy demand in shipping during the decades between 2020 and 2050 varied widely. Studies assuming net-zero emissions by around 2050 expect a final energy demand for shipping ranging between 3.42 EJ and 11.9 EJ for 2050.

12 The shipping energy intensity projected by the IEA and IRENA net-zero by 2050 scenarios predict continuously decreasing shipping energy intensities from around 0.16 MJ/tonne mile in 2022 to around 0.064 - 0.080 MJ/tonne · mile by the year 2050.

Main findings of subtask 3: On the energy supply side, a review of the fuel and technology mixes (in EJ, GWh and percentage share) linked to each demand scenario, both current and projections to 2030, 2040 and 2050

13 Predictions for the future energy supply of individual fuels vary, but several studies in the literature report that ammonia is expected to reach the highest fraction in shipping energy supply amongst the fuels, with absolute energy levels between 3.41 and 5.02 EJ or 180 to 270 M tonnes (i.e. million tonnes) of ammonia per annum in 2050. Another important share in the fuel energy supply was generally ascribed to biofuels and methanol, with energy

estimates for those predicting any biofuels at all being 0.69 to 3.47 EJ in 2050, and energy estimates for methanol around 0.31 and 2.6 EJ in 2050. Estimates for hydrogen energy supply to shipping range between 0.56 to 2 EJ in 2050 (note – this refers to the direct use of a hydrogen as a fuel, rather than the use of hydrogen as a feedstock to produce other fuels).

14 The shipping energy share in 2050 was reported to be forecast as 35-100% for ammonia, 7-25% biofuel, 3-19% methanol, and 7-19% hydrogen based on the literature reviewed. Assumptions in the various literature scenarios vary widely.

15 A clear gap in the literature is the lack of explicit description of shipboard renewable energy sources, such as wind and solar energy, that will contribute to the energy supply to shipping. None of the studies examining the overall energy need or supply to shipping assessed in this literature review explicitly stated how much energy is expected to come from wind or solar sources. Wind and solar energy are energy sources, and should not be reported as energy efficiency measures, which is physically incorrect.

Main findings of subtask 4: An analysis of the determinants of maritime transport costs and of pass-through of compliance costs within the maritime supply chain

16 The assessed literature suggests that the factors influencing the costs associated with maritime transport are diverse and encompass geographical, operational, and market-specific considerations. Challenges arising from these considerations can be addressed by regulatory interventions and investment strategies, among others.

17 Adopting a basket of mid-term GHG reduction measures would have potential impacts. In the literature reviewed, increases in maritime logistics costs from rising fuels, projected at different levels (10%, 20% and 50%), revealed modest changes in trade flows, with impacts on global GDP being of less than 0.1%. However, it was noted that SIDS and LDCs may be expected to experience more pronounced adverse effects.

18 The literature review suggests that a maritime GHG emission pricing mechanism would not lead to an equivalent percentage increase in maritime or overall transport costs. This is because transport costs are only one part of the broader trade costs. Therefore, the impact of a maritime GHG pricing mechanism on imported goods' prices would be less significant than the impact on maritime transport costs.

19 In the literature reviewed, increases in shipping costs are projected to range from 0.4% to 16%, with the effect on import prices predominantly below 1%. While the proposed measures are expected to result in a general uptick in maritime logistics costs, encompassing shipping and trade costs, the magnitude of this increase remains relatively constrained.

20 The potential benefits of improving port infrastructure and trade facilitation measures are significant. The literature suggests that better port infrastructure could lead to a 4.1% reduction in average maritime transport costs worldwide, while improved trade facilitation measures could result in a 3.7% decrease in costs. Particularly for LDCs, the greatest benefits could be derived from enhanced trade facilitation, which could lead to an 8.6% decrease in costs, compared to a 0.7% decrease achieved by improving port infrastructure.

21 In recognizing the potential disproportionate impact on SIDS and LDCs from regulatory interventions, the literature assessed suggested that disbursing a significant proportion of revenues generated through carbon pricing mechanisms to these States could assist in mitigating adverse effects, ensuring a more equitable distribution of costs and benefits, alleviating their burden, and paving the way for a more sustainable and inclusive maritime transport landscape.

Main findings of subtask 5: Findings from existing assessments of the potential impact of introducing GHG mitigation measures on shipping costs and, by extension, on the eight impact criteria identified in the 2023 IMO GHG Strategy

22 The exploration of GHG mitigation measures in maritime transport within the literature reviewed offered a wide array of insights, revealing a multi-faceted landscape and a need for addressing the complexities of sustainability in this sector. At the heart of this lies the discussion about carbon pricing mechanisms, recognized in the reviewed literature as one of the key tools for guiding the industry towards net-zero GHG emissions. Through emissions taxes and trading (carbon pricing) schemes, these tools aim to incentivize the adoption of zero or near-zero GHG alternatives and to correct the competitive disparity between traditional fossil fuels and cleaner options.

23 However, implementing carbon pricing mechanisms has its complexities. The literature highlights the importance of establishing corresponding support structures to facilitate their effectiveness. Such structures must support decarbonization efforts and consider the economic implications, ensuring a delicate balance between environmental and financial sustainability. Furthermore, the assessed literature advocates a hybrid approach, echoing the 2023 IMO GHG Strategy, which emphasizes the symbiotic relationship between technical interventions and economic instruments. This holistic approach is essential to overcome the various market barriers hindering sustainability progress.

24 In parallel, the literature review shed light on the effectiveness of direct regulatory approaches. Although more straightforward in their implementation, these measures offer potential cost-effective solutions to reduce the competitiveness gap and advance decarbonization efforts. Furthermore, regional initiatives can be crucial in guiding decarbonization efforts, with some countries poised to lead the transition through abundant resources and expertise. The potential for knowledge sharing between regions, particularly between developed and developing countries, holds promise in promoting a more equitable global transition towards sustainability.

25 Implementing carbon pricing mechanisms requires overcoming challenges such as emissions allocation, stakeholder engagement, technical expertise and a strong foundation of reliable data to inform decision-making processes effectively. Therefore, the literature review highlights the urgent need for empirical evidence and rigorous research to guide future policy formulations and industrial practices.

26 As the literature review highlights, price elasticities across products and industries are indicative of different carbon pricing sensitivities. That suggests that the efficacy of mitigation measures is dependent on the traded goods. Among others, products having low value/weight ratios like fossil fuels and ores show large carbon emission reductions under moderate carbon pricing in contrast to high-value goods such as furniture and motor vehicles which show smaller reductions. It demonstrates that the intrinsic character of goods should be taken into account in assessing the impact of carbon pricing.

27 Moreover, the reviewed literature highlighted that a phased increase in carbon pricing rates, e.g. from \$75 per tonne CO_2 in 2030 and \$150 per tonne in 2040, could drive substantial CO_2 reductions but slightly raise shipping costs. Still, revenues generated from such policy measures in the reviewed literature, which are estimated to be around \$75 billion in 2030 and \$150 billion by 2040, could partially offset the economic impacts.

28 But the reviewed literature also highlighted that implementation of carbon pricing mechanisms raises several challenges and considerations including emission allocation, revenue management and stakeholder engagement. Those challenges require competence development and a solid data infrastructure.

29 This literature review concludes that there is an absence of exemplar schemes for shipping.

30 In summary, the review highlights the need of holistic, data-driven approaches to drive the sector towards a sustainable future, ensuring that economic prosperity aligns harmoniously with environmental stewardship.

Main findings of subtask 6: Existing literature on potential approaches to address (e.g. avoid, remedy, mitigate) impacts on States

31 The literature review on potential strategies for mitigating the potential impacts of mid-term measures on States is divided into two sections: section one addresses pathways describing how to mitigate, remedy and avoid the impact of the technical measures on States, and section two describes pathways of how to mitigate, remedy and avoid the impact of the economic measures on States.

Mitigating pathways in relation to technologies

32 The literature review identified 15 possible approaches of mitigating the potential impacts arising from ships adopting decarbonization technologies and fuels. The pathways may be listed as follows: (Inter) national policies and regulatory frameworks, international collaboration and diplomacy, international capacity-building and technology transfer (including skilling), investments and financing mechanisms, social, economic and environmental impact assessments, research and development support, adaptive governance and new business models, monitoring and management, public and stakeholder engagement, awareness and public acceptance improvement, infrastructure improvement, labour skilling and safety measures, economic diversification strategies, phased-in implementation, and exemptions. These pathways were considered in light of the eight impact criteria in IMO's GHG strategy.

Mitigating approaches in response to economic impacts

33 The literature review identified also the following list of possible approaches to mitigating the potential impacts arising from economic measures: a step-based increase of the carbon price (in case of a levy) to avoid extreme development and trade cap, with a view to facilitating the political implementation of a carbon pricing mechanism; boosting motivational effects of the carbon pricing mechanism in lower tax rates which could be achieved by a higher transparency in ships' emission reporting and energy efficiency rating, the introduction of a rebate mechanism and a differentiated carbon levy; assessing sustainable business models by facilitating the energy transition through a proper definition of stakeholders' interaction; considering the effect of free riders; conducting stakeholder analysis to prepare the scene for proper designing of communication channels, business models and standard connections between them; building a national dataset as lack of information is one of the major barriers to equitable energy transition in particular in the case of SIDS and LDCs; supporting slim organizations; and a well-designed carbon revenue distribution network by establishing appropriate legal and administrative frameworks, procedure for managing revenue flows, effective stakeholder engagement and accountability procedures.

Main findings of subtask 7: Existing literature on the use of revenues of GHG pricing mechanisms

34 Based on the results of the literature review, an overview of lessons learned on carbon revenue collection and distribution in the other industries were identified. The literature reported various ways of distributing carbon revenue in the other industrial sectors: Containing the burden on target groups (e.g. exemptions, preferential tax rates, rebates, gifting,

and feebate systems), using revenue to lower other taxes, promoting renewable energy and energy efficiency, using emission offsets, financing climate and environmental projects, constructing new infrastructure and retrofitting existing infrastructure, earmarking revenues for administrative costs, funding of research and development (R&D), adapting to the impacts of climate change, allocating revenue into general national budgets, and funding of cross-cutting measures.

35 Focused on the maritime industry, there is a wide range of projected carbon revenue in different studies and proposals, which is primarily due to the wide range of recommended carbon prices and assumptions. According to the literature reviewed, carbon pricing (in the case of a levy) could be collected by flag administrations, port State administrations, an international institution, a network of bunker suppliers, or directly from each individual ship to its electronic account.

36 In the study over carbon pricing mechanisms in international shipping, revenue generation and distribution were identified as key issues. In addition to achieving shipping decarbonization goals, the reviewed literature suggested recycling of carbon revenues from the shipping industry could pave the way for achieving broader climate aims and promoting greater equity, and that these revenues could be used for activities both in-sector and out-of-sector. The literature review identified the following ways carbon revenue could be distributed in-sector and out-of-sector.

37 In-sector distribution: financial support for RD&D activities; financial support for the process of policy making, administrative and enforcement costs of the carbon pricing mechanism, development of a rebate mechanism at ports, financial support for vessels' retrofit and fleet renewal, support for alternative fuel production, enhancement of maritime transport energy infrastructure and services, and capacity building, education and training.

38 Out-of-sector distribution: development of an instrument in response to the CBDR&RC principle, and capacity building and technology transfer to SIDS and LDCs.