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REDUCTION OF GHG EMISSIONS FROM SHIPS

Inclusion of wind propulsion in the GFI formula

Submitted by IWSA

SUMMARY

Executive summary:	This document sets out how wind energy can be incorporated into the mid-term measures developed to implement the *2023 IMO Strategy on Reduction of GHG Emissions from Ships*, with reference to the technical measures currently being prepared. It further proposes an amended formula based on the work presented in document ISWG-GHG 16/2/7 (Austria et al.), which is to date the most elaborated upon formula that could be used to calculate the attained Greenhouse Gas Fuel Intensity (GFI), and which provides a concrete illustration of the technical proposal so that wind energy is accounted for equitably in the greenhouse gas emissions intensity balance for the ship.
Strategic direction, if applicable:	3
Output:	3.2
Action to be taken:	Paragraph 10
Related documents:	Resolutions MEPC.391(81) and MEPC.377(80); ISWG-GHG 15/3/1; ISWG-GHG 16/2/7, ISWG-GHG 16/2/13 and ISWG-GHG 16/2/14

Introduction

1 MEPC 81 provided an opportunity to continue discussions on legally binding mid-term measures to help the maritime industry achieve net-zero GHG emissions as set out in the *2023 IMO Strategy on Reduction of GHG Emissions from Ships* (2023 IMO GHG Strategy) (resolution MEPC.377(80)).

2 The technical element in the basket of candidate mid-term measures underlines the adoption of a global fuel standard for marine fuels, which should allow for the calculation of the carbon intensity of a ship. Several proposals were presented at MEPC 81, but nothing has yet been decided as technical discussions are ongoing. Some proposals have been elaborated upon more than others.

3 Among these is a proposal formulated in annex 1 to document ISWG-GHG 16/2/7 (Austria et al.) to allow the calculation of the carbon intensity of a ship. This proposal is sufficiently developed to enable the specification of how the energy supplied to the ship using a wind engine can be accounted for. It therefore serves to illustrate the point of this document with a clear example.

4 The general calculation of the attained Greenhouse Gas Fuel Intensity ($GFI_{attained}$) includes all energy sources used on board the ship including, in particular zero emission energy sources such as wind. In addition, the International Maritime Sustainable Fuels and Fund (IMSF&F) was considered in documents ISWG-GHG 16/2/13 and ISWG-GHG 16/2/14 (Argentina et al.) by introducing a benchmark and a reduction factor to be met per period until 2050.

5 As part of the work on the carbon intensity of ships, MEPC 81 also adopted *2024 Guidelines on life cycle GHG intensity of marine fuels* (2024 LCA Guidelines) by resolution MEPC.391(81). This assigns to the various energy sources used as fuels an emission factor on a well-to-wake (WtW) basis, and thus enables solutions to be chosen based on a reliable reference tool.

6 The use of a 'wind engine' or 'wind propulsion system (WPS)' on board ships makes it possible to reduce GHG emissions by replacing fossil fuel energy with direct renewable energy. The use of wind as a fuel is recognized in the fuel list designating fuel pathway codes in appendix 1 of the 2024 LCA Guidelines, with wind being designated as pathway 128. As such, the wind energy delivered to the ship must be considered in the ship's carbon intensity formula, the GFI.

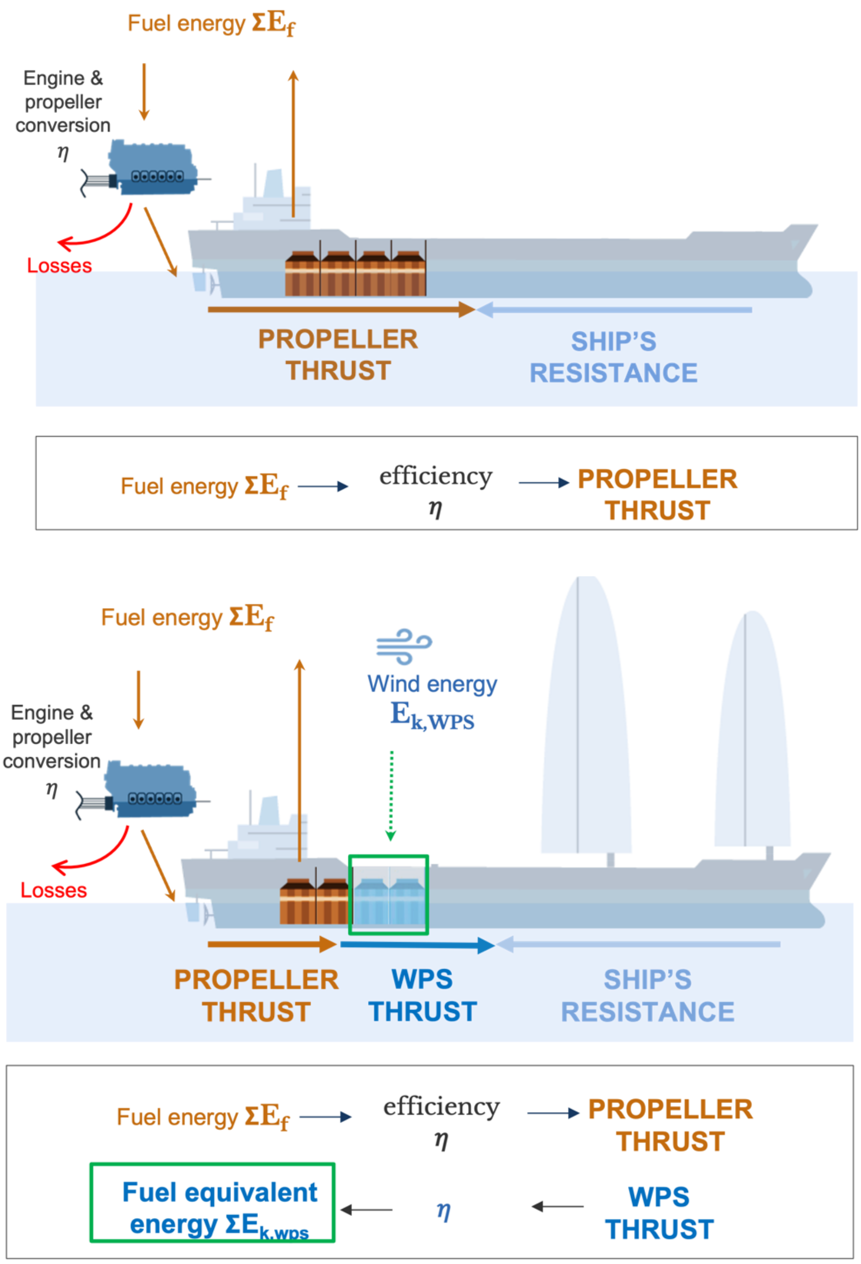
Proposed formula to calculate the wind propulsion energy delivered to the ship for the $GFI_{attained}$

7 As presented in paragraph 5 above, annex 1 to document ISWG-GHG 16/2/7, parameters related to non-fuel, zero-emission energy sources should be completed with necessary specifications on how they will be determined as appropriate and consistently with the LCA Guidelines.

8 The annex to this document presents a proposal to specify in this $GFI_{attained}$ calculation formula the inclusion of energy delivered to the ship by a wind engine (wind propulsion system) which is consistent with the related documents ISWG-GHG 16/2/7, ISWG GHG 16/2/13 and ISWG-GHG 16/2/14.

Consideration regarding comparison of fuel energy and wind energy

9 A wind propulsion system (WPS) reduces the brake power needed to sail at a given speed. The energy produced by the WPS can then be quantified in terms of the 'energy equivalent' of a conventional internal combustion engine. A conventional combustion engine generates losses during its operation, so its final energy can be estimated using the notion of efficiency (η). In the same way, the brake power demand reduction measured for example performing sea trials is then converted into a fuel energy equivalent using the main engine efficiency η_E.



Action requested of the Committee

10 The Committee is invited to consider the information provided in this document, in particular the proposed developments contained in the annex, and take action as appropriate.

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ANNEX

PROPOSED FORMULA TO INCLUDE WIND PROLUSION IN THE $GFI_{ATTAINED}$

Introduction

1 The proposed indicator requires that the contribution to the ship's propulsion provided by the Wind Propulsion System (WPS) is assessed for each compliance period throughout the ship's lifetime. There are several possible methodologies for this, some available today yet not fully standardised, and some under development.

2 There are known challenges associated with the assessment and verification of the WPS contribution in operation, such as practicality of data acquisition, measurement and model uncertainties, and monitoring of actual use of the WPS. The adoption of good practices that minimize these impacts should be encouraged by the future guidelines, which will be developed in a submission to the MEPC 83.

3 The formula outlined below proposes a clear and transparent approach to incorporating the energy contribution of WPS into the assessment.

Proposed formula

4 The attained **Greenhouse Gas Fuel Intensity** (GFI) is the total amount of Greenhouse Gases (GHG) released to the atmosphere to propel a vessel, divided by the total amount of energy used for this purpose. It is expressed in *[gCO_2e/MJ].*

5 The general calculation of GFI attained is given by equation *(1)* as set out in annex 1 to document ISWG-GHG 16/2/7 (Austria et al.)

$$GFI_{attained} = \frac{\sum_{j=1}^{N} GHG_{WtW,j} \times E_j}{\sum_{j=1}^{N} E_j} \qquad (1)$$

6 Considering that the fuel energy E_j is a product of fuel mass M_j and fuel lower calorific value LCV_j, and introducing E_k, emissionless energies, it leads to the following equation (2):

$$GFI_{attained} = \frac{\sum_{j=1}^{N} GHG_{WtW,j} \times M_j \times LCV_j}{\sum_{j=1}^{N} M_j \times LCV_j + \sum_{k=1}^{K} E_k} \qquad (2)$$

Where:

- $\mathrm{GFI}_{\mathrm{attained}}$ is the greenhouse gas fuel intensity of the energy mix *[gCO_2/MJ]*
- *j* is the fuel type
- *N* is the total number of different fuel types used during the compliance period, as reported under IMO DCS
- $GHG_{WtW,j}$ is the GHG intensity of energy type j, as defined in the IMO LCA guidelines *[$g\ CO_2/MJ$]*
- M_j is the mass of fuel type j *[t]*
- LCV_j is the lower calorific value of fuel type j *[MJ/t]*
- *k* is the mass-less, emissionsless energy type

- K is the total number of different mass-less, emissionless energy types used during the compliance period
- E_k is the total emissionless energy of type k.

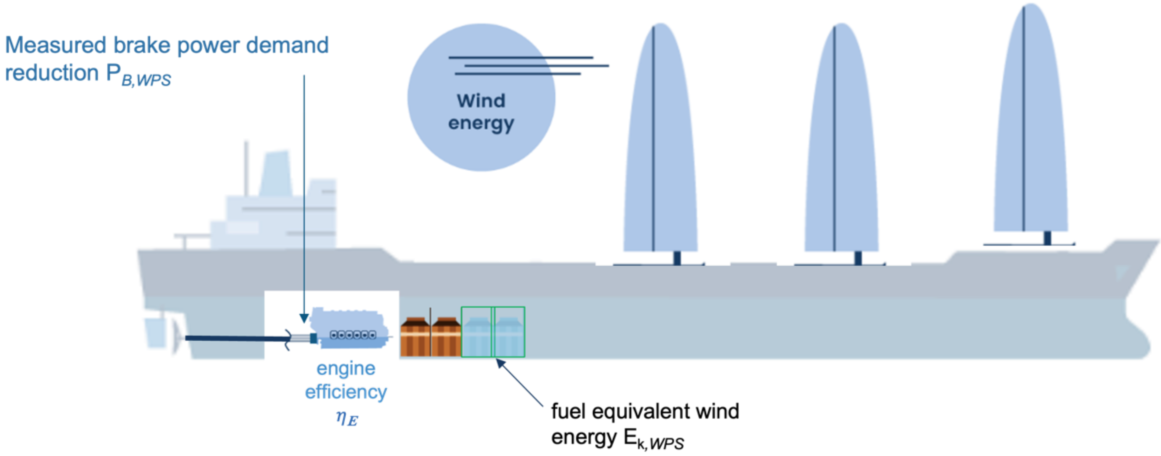
7 A Wind Propulsion System (WPS) provides thrust to the ship in the same way as a conventional propulsion system (engine + propeller), but without direct GHG emissions. It can therefore be assumed as an emissionless energy source E_k. For better understanding it will be noted $E_{k,WPS}$. In case of active systems (such as Flettner rotors/rotor sails or Suction sails/wings), some electrical power is provided by onboard gensets, which fuel consumption is already accounted for in the GFI formula by the M_j term and must not be further subtracted from $E_{k,WPS}$.

8 To make the energy produced by wind propulsion systems consistent with the energy content of a fuel as modelled in the initial GFI formula *(1)*, the energy losses between the fuel tank and the ship's propulsion must be accounted for. This is achieved by introducing a "fuel-equivalent-energy" from a wind propulsion system. Then $E_{k,WPS}$ is defined as:

$$\boldsymbol{E_{k,WPS}} = \frac{P_{B,WPS} \times Time}{\eta_E} \qquad (3)$$

Where:

- η_E is the main engine efficiency, (the efficiency between fuel energy content and engine brake power), usually available from engine shop test.
- $P_{B,WPS}$ is the Brake Power demand reduction provided by the Wind Propulsion System.



9 The proposed $E_{k,WPS}$ is a ship specific operational quantity, which is reported for each compliance period, throughout the lifetime of the ship.

Guidelines to be developed

10 As stated in the introduction, guidelines will be proposed in a further submission to define the requested level of accuracy for the $P_{B,WPS}$ assessment methodologies. Although any methodology compliant with such criteria might be acceptable, what follows outlines two promising methodologies, one that uses prediction performance and sea trial combined with logged wind, the other based on continuous performance data logging.

Sea trial performance verification combined with logged wind

11 The $P_{B,WPS}$ is derived by combining a verified performance indicator with the actual wind logged during the compliance period. The global process is outlined as follows:

WPS Performance

The performance of the installed wind propulsion system, depending on the wind conditions, is derived using recognized performance prediction methods[1] and can/shall be confirmed with a sea trial.

The performance prediction will consider the technical details of the WPS, such as the number of systems, type, size, integration with the ship and other relevant aspects.

Actual wind

The experienced wind is derived from the ship's logged positions and hindcast metocean data from recognized meteorological offices.[2] This requires that the following is logged onboard:

- Ship's position
- Date and time
- WPS on/off status

The experienced wind conditions are used to evaluate the $P_{B,WPS}$ given the validated WPS Performance model described above.

Continuous performance logging

12 This method deploys high-frequency, digital and automated data collection from multiple sources and sensors onboard the vessel. This allows for real-time monitoring and assessment of the $P_{B,WPS}$, capturing the operational performance throughout the vessel's and WPS's lifetime.

13 Some standards already exist for continuous performance measurements for ships.[3] Although these need to be adjusted to account for the performance of the WPS, they can serve as a useful reference for implementing continuous performance logging methods.

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[1] For instance, the ITTC Specialist Committee for Wind Powered Ships has recently developed guidelines for Performance predictions and Sea trials for Wind Assisted Ships, which will be published in September 2024.

[2] ERA5 from ECMWF for example.

[3] See ISO 19030, which focuses on the performance measurement of hull and propeller for conventional ships.