AIR POLLUTION AND ENERGY EFFICIENCY

FURTHER TECHNICAL AND OPERATIONAL MEASURES FOR ENHANCING ENERGY EFFICIENCY OF INTERNATIONAL SHIPPING

Further details of possible metric options to develop further technical and operational measures for enhancing the energy efficiency of international shipping

Submitted by Germany and Japan

SUMMARY

Executive summary: This document provides further details of the metric options which were presented in document MEPC 65/4/30 with a view to contributing towards the discussion on the development of further technical and operational measures

Strategic direction: 7.3
High-level action: 7.3.2
Planned output: 7.3.2.1
Action to be taken: Paragraph 50
Related documents: MEPC 65/4/19, MEPC 65/4/30 and MEPC 65/22

Introduction

1 At MEPC 65, in response to the proposal by the United States (MEPC 65/4/19), Belgium et al. noted with interest its proposal of a phased approach to further improve the efficiency of ships (MEPC 65/4/30).

2 In that session, the Committee noted that there was considerable support for the approach in the United States' proposal, especially for the data collection phase, and also that some delegations were of the view that there was a need at this stage for more ideas and additional information, especially with regard to the specific metrics for calculating efficiency.
3 As a result of the discussion, it was agreed to establish a sub-item under agenda item 4 for discussion of further technical and operational measures for enhancing the energy efficiency of international shipping, and further submissions on the proposals in documents MEPC 65/4/19 and MEPC 65/4/30 were invited to this session (MEPC 65/22, paragraphs 4.146 and 4.147).

4 The co-sponsors of this document welcome this outcome at MEPC 65 and, in accordance with its invitation, present the detailed technical explanation of each of the metric options proposed in document MEPC 65/4/30.

Option 1: Annual EEOI

**EEDI and EEOI: Consistency of policy direction to improve energy efficiency**

5 In developing the metrics for measuring efficiency, one could argue that consistency with other measures to address CO\(_2\) emissions from ships already agreed by the Organization is necessary. In order to achieve the ultimate objective to improve energy efficiency and through them reduce CO\(_2\) emissions from the shipping sector, and in order to secure such consistency, the same metric with EEDI (g-CO\(_2\)/tonne-mile) can be applied to any category of ship. Otherwise, it could be argued that it is rather difficult to evaluate, in an accurate and fair manner, the extent and effect of the policy framework concerned.

6 Further, the co-sponsors recalled that, for existing ships, a SEEMP is required to be carried on board, and, within this context, the Energy Efficiency Operational Indicator (EEOI) is suggested as a monitoring tool of "actual" energy efficiency in the following manner:

1. with regard to SEEMP, regulation 22 of MARPOL Annex VI stipulates "Each ship shall keep on board a ship specific Ship Energy Efficiency Management Plan (SEEMP)", and the SEEMP shall be developed taking into account guidelines adopted by the Organization. At its sixty-third session, the Committee adopted 2012 Guidelines for the development of a Ship Energy Efficiency Management Plan ("SEEMP Guidelines"); and

2. the SEEMP Guidelines provide an approach for shipping companies to monitor ship and fleet efficiency performance over time using, for example, the EEOI as a voluntary monitoring tool. More explicitly, within the SEEMP Guidelines (resolution MEPC.213(63)), paragraph 4.3.1 stipulates "the EEOI developed by the Organization is one of the internationally established tools to obtain a quantitative indicator of energy efficiency of a ship and/or fleet in operation, and can be used for this purpose. Therefore, EEOI could be considered as the primary tool...".

7 With regard to the details of monitoring and calculation methods of the EEOI, within the EEOI Guidelines (MEPC.1/Circ.684, approved in 2009), the EEOI is explained as the ratio of mass of CO\(_2\) emitted per unit of transport work: g-CO\(_2\)/tonne-mile. In this respect, attention should be paid to the unit of the EEOI which is the same as that of the EEDI. Therefore, the utilization of the EEOI concept for monitoring could be considered as one of the most appropriate tools for data-collection on energy efficiency from existing ships, since this approach enables the industry to focus on the improvement of "energy efficiency".

8 Since the entry into force of the MARPOL Annex VI in January 2013, ship owners and operators worldwide have started to employ "EEOI" as a primary tool to monitor energy efficiencies of their ships, including by means of new computer software which has been developed.
Arguments can be made that the EEOI would fluctuate significantly, if it were monitored and calculated on a voyage basis, since the ship would be operated in different navigation patterns, with seasonal conditions, etc. To account for these fluctuations, this option would envisage accumulating/aggregating/averaging the EEOI value for a longer period than that on a voyage basis.

In this respect, it is noted that the EEOI Guidelines suggest (MEPC.1/Circ.684, Appendix, paragraph 5) that "Rolling average, when used, can be calculated in a suitable time period, for example one year closest to the end of a voyage for that period...". Therefore, in Option 1, it is suggested that the IMO could employ the concept of the Annual EEOI (g-CO₂/tonne-mile) as a metric for data collection. The subsequent paragraphs contain further details as to how to calculate the Annual EEOI.

The expression for the Annual EEOI is described as:

$$ \text{Annual EEOI (g-CO}_2/\text{tonne-mile}) = \frac{\sum_j F_j C_j \times C_F}{m_{\text{cargo}} \times D} $$

¹ For example, Japan, in an internal study analysing its own fleet found that the values of rolling average of the EEOI could be converged in the duration of eight months. This implies that instead of EEOI on a voyage basis, the Annual EEOI could be used to indicate "actual" energy efficiency performance of ships in a relatively fair manner.
Where:

.1 $j$ is the fuel type;
.2 $FC_j$ is the annual mass of consumed fuel $j$;
.3 $C_{Fj}$ is the fuel mass to CO$_2$ mass conversion factor for fuel $j$;
.4 $m_{cargo}$ is deadweight; and
.5 $D$ is the annual distance in nautical miles.

### Table 1. Conversion factors between fuel consumption and CO$_2$ emission

<table>
<thead>
<tr>
<th>Type of fuel</th>
<th>Reference</th>
<th>Carbon content</th>
<th>$C_F$ (t-CO$_2$/t-Fuel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Diesel/Gas Oil</td>
<td>ISO 8217 Grades DMX through DMB</td>
<td>0.8744</td>
<td>3.206</td>
</tr>
<tr>
<td>2 Light Fuel Oil (LFO)</td>
<td>ISO 8217 Grades RMA through RMD</td>
<td>0.8594</td>
<td>3.151</td>
</tr>
<tr>
<td>3 Heavy Fuel Oil (HFO)</td>
<td>ISO 8217 Grades RME through RMK</td>
<td>0.8493</td>
<td>3.114</td>
</tr>
<tr>
<td>4 Liquefied Petroleum</td>
<td>Propane</td>
<td>0.8182</td>
<td>3.000</td>
</tr>
<tr>
<td>Gas (LPG)</td>
<td>Butane</td>
<td>0.8264</td>
<td>3.030</td>
</tr>
<tr>
<td>5 Liquefied Natural Gas (LNG)</td>
<td></td>
<td>0.7500</td>
<td>2.750</td>
</tr>
</tbody>
</table>

12 As an example, calculation of the Annual EEOI of a bulk carrier with 230,000(DWT) is shown below.

\[
\text{Annual EEOI} = \frac{17,381 \times 10^6 \times 3.114}{81,984 \times 230,000} = 2.87 \text{ g-CO}_2/\text{tonne-mile}
\]

Where:

.1 Fuel consumption: 17,381 tonnes/year ($C_F=3.114$);
.2 Distance sailed: 81,984 miles/year; and
.3 DWT: 230,000 (DWT).

**Data requirements for calculation of the Annual EEOI**

13 For the purpose of collecting data of the Annual EEOI, only three data sets are required:

.1 Fuel consumption;
.2 Distance sailed; and
.3 Deadweight (DWT).
14 With regard to the fuel consumption, ships are already required to keep Bunker Delivery Notes (BDN) onboard in accordance with the regulation 18.6 of MARPOL Annex VI. Therefore, the BDN data should be primarily used for measuring fuel consumption. However, it should also be noted that the data indicated in the BDN represents the supplied fuel and hence is not an accurate measurement of the fuel consumed since it includes also water or sludge. Moreover, if a ship is equipped with a flow-meter on its pipes from tank to engine, this could be a more accurate method for measurement of fuel consumption than the BDN. Therefore, if the Committee so wishes, alternative monitoring means could be considered.

15 With regard to the distance sailed, the SOLAS Convention requires a ship by regulation 28 of chapter V to keep on board a log-book which takes notes of the navigation details. The log-book shall have information, at least, on ship’s position (or distance sailed) which is reported to its company as a noon report for the duration of voyages. And since the SOLAS Convention also requires a ship by regulation 19 of chapter V to be equipped with Global Navigation Satellite System (GNSS), the data from GNSS could be used to record its position more frequently, although a ship is not obligated to record the data. These methods should be used as the minimal ways for data collection.

16 With regard to the cargo volume, it may be difficult to collect cargo volume data which would be reliable enough for the monitoring purpose. Given this potential difficulty, the cargo volume could be accounted for in the same manner as for the EEDI calculation, i.e. DWT value (for instance: 100% DWT for tanker, or 70% DWT for container ships, etc.). Although this approach might be seen as too simple and in some cases would be criticized for not accurately illustrating the actual operational conditions, the co-sponsors believe that the Committee should consider the DWT as one appropriate proxy for cargo reporting and analyse it further.

17 As noted above, there have already been other mandatory requirements relevant to these three data fields, as summarized in table 2. Therefore, it is considered that taking advantage of these other mandatory schemes for collecting data in order to measure efficiency would not pose significant administration burdens to the shipping industry.

Table 2. Three key data required for annual EEOI

<table>
<thead>
<tr>
<th>Fuel consumption</th>
<th>Bunker Delivery Note (BDN) which shall be kept on board by regulation 18 of MARPOL Annex VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance sailed</td>
<td>Log-book which shall be kept on board by regulation 28 of SOLAS chapter V and, GNSS which shall be fitted by regulation 19 of SOLAS chapter V</td>
</tr>
<tr>
<td>Cargo volume</td>
<td>DWT which is contained in the supplement to the IEE Certificate of MARPOL Annex VI</td>
</tr>
</tbody>
</table>

Option 2: Individual Ship Performance Indicator (ISPI)

18 It is often argued that most of the currently available technical/design solutions to improve efficiency tend to be of limited use on existing ships; however, for these ships, operational measures can also yield significant emissions reductions. Having this in mind, the co-sponsors suggest that the Committee could consider combining the ship’s specific technical/design efficiency and its operational performance, therefore targeting the overall efficiency of individual ships, which would have to be improved over time, on the basis of an efficiency indicator.
One way to do this would be through a CO₂ efficiency standard, reflecting the ship's operational performance and expressed in gCO₂/n-mile travelled. While understanding that including the cargo may reflect more accurately ship's transport efficiency with regards to CO₂ emissions, the Committee could consider ways in which this could be done, while avoiding overburdening the system and maintaining data confidentiality.

Using a phased-in approach, a preliminary data collection phase would require Fuel Consumption (Fc) per different fuel type (to set the Emission Factor Cf), as well as Distance (D) travelled within a given period of time, so as to allow the calculation of the ship-specific operational reference value (i.e. operational performance baseline). This data collection phase could last 2-3 years to allow for a significant data pool to be gathered.

With a view to reward existing ships that already benefit from an efficient design, it was considered useful to establish also the design efficiency of the ship, in comparison to its category and size. It is proposed to build on the general understanding within the IMO that the Estimated Index Value (EIV) regression curves (i.e. reference lines) determined by IMO resolution MEPC.215(63)² represent a fair image of the existing fleet at a certain point in time and therefore its standard technical/design efficiency. For all ship types covered by the EEDI framework, an existing ships' specific EIV is calculated³. At the same time, for any ship category (type and size), an Energy Efficiency Standard Value (EESV) is also available, being the value on the regression line for the respective category.

Each covered ship will have its own EIV compared with the EESV to see how well is it positioned amongst its fleet category in terms of design efficiency. A ratio between EIV and EESV provides a design efficiency factor. The deviation of the ship-specific factor from the category's standard will become the ship's specific Variance (Vc). This factor would account for different ship designs, by assuring that the ship's design efficiency relative to the existing fleet is reflected.

Accordingly, ships may obtain three different results:

1. Standard Reference Design (curve value): \( Vc = \frac{EIV}{EESV} = 1 \);
2. Lower Efficiency Design (above curve value): \( Vc = \frac{EIV}{EESV} > 1 \);
3. Higher Efficiency Design (below curve value): \( Vc = \frac{EIV}{EESV} < 1 \).

Should this concept be applied as a one-off measure i.e. no revision of the reference lines, the Vc remains constant. Thus, any design efficiency enhancements (e.g. changing the propeller) carried out on board the ships will be taken into account through the "operational part" of the proposal.

Although aiming at enhancing the energy efficiency of the existing fleet, it would not be fair to ask equal efforts to all ships regardless of their design efficiency, for the above mentioned reasons. Instead, it is preferable to set and apply differentiated efficiency improvements to different ships, meaning that individual ship's design specificities (speed, power and capacity) will be considered, by applying the Vc to whatever requirements are set for specific improvement (Y).

² Replaced and revoked by MEPC.231(65).
³ For ship types not yet covered by the EEDI, a similar index could be developed as these come under the framework.
Finally, the Committee could be invited to set an Efficiency Improvement Target (EIT) resulting in a ship-specific efficiency indicator, which would combine the operational performance of the ship expressed in gCO\textsubscript{2}/n-mile travelled and its design efficiency factor as follows:

\[ EIT = (\text{Operational Performance}) \cdot (\% \text{ Improvement} \times \text{Design Efficiency Factor}) \]

The Committee would be called upon to agree the improvement requirement, expressed as a percentage which would be applied to the ship-specific operational reference value (gCO\textsubscript{2}/n-mile travelled over a given period), after being corrected by the appropriate design factor. Once the standards become mandatory, each ship would be required to reduce its specific gCO\textsubscript{2}/n-mile ratio, ensuring that its efficiency indicator is reached. To this end, a second phase of data collection would be required. In principle, the scheme established for the first data collection phase could also be used although its purpose now would be to validate the achievement, i.e. compliance, with such improvements. The Committee could further consider the length of the compliance period, and whether meeting the efficiency improvement would be required to be done uniformly or averaging between ship's specific emissions during such period. Meeting this improvement requirement could be done via operational and/or technical measures, as deemed appropriate by each ship.

This scheme needs to provide robust data, ensuring a sufficient level of quality but, at the same time, be as lean as possible by using existing tools and documents already required today. Presently there are several means available to collect the required ship's data; fuel consumption and distance can be obtained through both mandatory and voluntary information: Navigational and Oil record/log books, Bunker Delivery Notes, fuel oil quality sampling and testing, on board measurements, ECDIS, Port Calls and other positioning systems like AIS and LRIT. In this context, the information provided in paragraphs 14 to 17 would also be applicable in this case.

If the Committee considers it necessary, a correction factor could be introduced into the formula in order to account for market variations caused by a certain economic cycle, and which may have an impact on ships’ performance (e.g. cargo usage factors). However, the use of such a factor has to be further analysed and is not addressed at this stage.

A practical example is set out in the annex to this document.

Option 3: Fuel Oil Reduction Strategy (FORS)

The objective of the Fuel Oil Reduction Strategy (FORS) is to reduce fuel oil consumption of individual ships by means of a standard, while securing that the maritime shipping sector can grow in a sustainable manner.

Under FORS, ships would be required to reduce their annual fuel oil consumption by a given percentage compared to a ship specific reference value. This percentage will constitute the reduction target.

\[ \text{Standard} = \text{Reference Value} \times (1 - \text{Reduction Target}) \]

The reduction target (in %) is to be decided by the Committee. The target should take into account the reduction capacity of the sector.
FORS encourages both technical and operational measures. The decision of how to best reduce fuel consumption is left to the ship owner/operator.

FORS could be implemented immediately, as all data needed is available today. If desired by the Committee, FORS can also be implemented in a phased approach: a first phase in which the reference values and the reduction target are established and a second phase in which FORS is fully implemented. The first phase mainly consists of calculations: as all data required under the formula is available, no additional data collection scheme needs to be established for setting the reference values.

**Reference values**

The ship specific reference values required under this option would be calculated in a similar way to the calculation of the fuel consumption in the Second IMO GHG study (cf. MEPC 59/INF.10, p.183 A1.5). The average 2007 operational profiles available in that study are multiplied with the actual engine power (from IHS-Fairplay) thus reflecting the original intended operational profile of a ship or the maximum possible usage of the ship in good market circumstances. Using the 2007 operational profiles (average operation time, average load, average specific fuel oil consumption of main engines and average fuel consumption of auxiliary engines and boilers) from the Second IMO GHG Study reflects a situation of a good business case prior to the economic downturn (high operational time at high speed resulting in high fuel consumption).

The ship specific main engine power is taken from the IHS-Fairplay data set on the basis of the ship's IMO number and is thus also readily available.

The fuel oil reference values are computed according to the following equation (an exemplary calculation of the ship specific reference value and reduction target is set out in annex to this document).

\[
ReferenceFuel_{Ship} = \text{InstalledEnginePower}_{Ship} \times \text{AverageOperationTime}_{Type} \times \text{AverageLoad}_{Type} \times \text{AverageSFOC}_{Type}
\]

Making use of this 2007 data set would reward early movers, as fuel consumption reduction measures that have been applied since 2007 already help the operator to comply with the reduction target under FORS. Measures incentivized by the EEDI and SEEMP are thus rewarded too.

The existing data set also avoids a situation of data collection with a regulatory aim, which may prompt strategic behaviour during that period.

The ship specific reference values are determined once and are kept constant at all stages of implementation. However, given that a ship's reference value builds on the intended operational profile of a specific ship category, redesigns or major conversions imply a change of the reference value of the ship in question and also result in an update of the ship specific reduction obligation.
**Monitoring, reporting and verification**

40 In order to assess compliance with the measure, the fuel reduction obligation of the ships is accompanied by a fuel consumption monitoring and reporting procedure. FORS requires only minimal monitoring and reporting and hence implies only a very limited additional administrative burden. Several options exist with regard to how monitoring, reporting and verification (MRV) could be designed. In the following, one of these options for MRV is set out.

41 Prior to the entry into force of the measure, an electronic database including all existing ships on the basis of the IMO ship identification number shall be set up at the central administrative body (e.g. at IMO). Flag States should thereby have access to the data of their fleet.

42 At the end of the annual reporting period (e.g. at the end of each year), ship operators have to report, in metric tonnes, the total amount of fuel that a ship has consumed within the reporting period (including the consumption of main and auxiliary engines, incinerators, boilers etc.). Fuel types other than HFO would thereby have to be specified separately. The fuel consumption data is reported to the centralized database. If possible, provisions shall be made such that the data can be transmitted electronically from the operator to that database.

43 In many cases, ship operators have data on fuel consumption already available for their internal processes and decision making (e.g. reporting to charterer) or due to other IMO regulations (e.g. the requirement to collect Bunker Delivery Notes (BDN), documentation by oil record book, required by MARPOL Annex I, regulation 17). Thus, monitoring and reporting fuel consumption data involves limited additional administrative effort for operators and the holders of the data bank.

44 The central administrative body shall compare the reported fuel consumption with the ship's standard.

45 In the regular case, the ship is compliant with the regulation and no report will be sent from the administrative body (e.g. IMO) to the flag State. The flag State will issue a certificate to the ship attesting compliance for the past period. The certificate proves that the ship has fulfilled its obligations. In the case of flag State surveys or port State inspections, ships are obliged to present the certificate to prove their compliance.

46 In the exceptional case that the reported data shows that the ship does not satisfy its obligations, the flag State receives a message from the administrative body (e.g. IMO). In that case the flag State (e.g. through RO) shall inform the ship of its failure to achieve compliance and the certificate will not be issued until the ship has made adequate provisions to achieve compliance ex post.

**Compliance and flexibility**

47 In the regular case, ships would be compliant with the regulation. In the exceptional case of non-compliance, there are different flexibility mechanisms conceivable that could be offered to ships. Ships could for example get certain flexibility over time or ships could jointly comply. Then a ship would e.g. only have to comply with its target on average over several compliance periods or several ships would have to comply only on average in one compliance period. Further possibilities for such flexibility would need to be worked out.
Conclusion

This document provides the detailed technical explanations of three alternative options for an efficiency metric, as well as applicable steps for the necessary data collection (where applicable) linked to each metric.

The co-sponsors propose that all these options be considered by the Committee and the relevant working group be invited to undertake a detailed discussion on technical elements at MEPC 66 and future meetings.

Action requested of the Committee

The Committee is invited to consider the above information and take action as appropriate.

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Two vessels of the same ship type and size (approx. 200,000 DWT Oil Tankers):

**Vessel A** is positioned 30% below the average fleet reference line (EIV regression curve) meaning a higher design efficiency, which could imply having had a better operational performance value i.e. total amount of fuel consumption to distance travelled of 8 Kg CO₂/n-mile.

**Vessel B** is positioned 30% above the average fleet reference line (EIV regression curve) meaning a lower design efficiency, which could imply having had a worse operational performance value i.e. total amount of fuel consumption to distance travelled of 10 Kg CO₂/n-mile.

Note: The operational performance values (i.e. rolling period indicator) tend to reflect both design and operational efficiencies. Nevertheless, above values are to be considered merely indicative. In fact, they could have been exactly of the same magnitude, or even the opposite, as a poor design ship (or an older vessel) could in fact have performed very-well in terms of its operation e.g. crew training/knowledge, ship maintenance, slow-steaming, etc…).

Imagining that a 10% improvement is foreseen for the two ships over certain time period:

**Vessel A** will have to lower 7% (corresponds to Vc of 0.7 – being 30% below the curve), therefore improve by an efficiency indicator of 0.56 (Kg CO₂/n-mile) i.e. reducing 560 grs CO₂ per n-mile.

\[
\text{EIT} = (8 \text{ Kg CO}_2/\text{n-mile}) \times (10\% \times 0.7) = (8 \text{ Kg CO}_2/\text{n-mile}) \times (7\%) = 0.56 \text{ Kg CO}_2/\text{n-mile}
\]

**Vessel B** will have to lower 13% (corresponds to Vc of 1.3 – being 30% above the curve), therefore to improve by an efficiency indicator of 1.3 (Kg CO₂/n-mile) i.e. reducing 1.3 Kg CO₂ per n-mile.
EIT = (10 Kg CO₂/n-mile) x (10% x 1.3) = (10 Kg CO₂/n-mile) x (13%) = 1.3 Kg CO₂/n-mile

Conclusion: Vessel B will have to do more, possibly through operational measures. Nonetheless, if technical measures are feasible, e.g. changing a propeller, although not changing the Vc, it will implicitly lower the vessel’s operational performance indicator as fuel consumption is expected to be lower, making it easier to meet the target set.

Option 3 – Example

Applying FORS to a virtual bulk carrier would result in the following reference value and reduction target: Taking a bulk carrier with 40.000 DWT and an installed engine power of 10.000 kW (main engine) and 550 kW (aux. engine), the reference value would be computed on the basis of the following data from the IMO GHG Study (MEPC 59/INF.10):

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Operation Time (Days at Sea)</td>
<td>271 days</td>
</tr>
<tr>
<td>Average Main Engine Load</td>
<td>70%</td>
</tr>
<tr>
<td>Average Aux. Engine Running Days (cumulated for all engines)</td>
<td>450 days</td>
</tr>
<tr>
<td>Average Aux. Engine Load</td>
<td>60%</td>
</tr>
<tr>
<td>Average SFOC</td>
<td>180 g/kWh</td>
</tr>
</tbody>
</table>

Thus the reference value for the bulk carrier would be:

(10.000 kW • 271 days • 70% + 550 kW • 450 days • 60%) • 180 g/kWh • 24 h = 8.837 t / year.

When assuming a reduction target of for example 1% or 5%, this would imply that the fuel consumption of this bulk carrier would have to be reduced by 88.37 or 441.83 metric tonnes respectively within a compliance period of one year.