INTERNATIONAL MARITIME ORGANIZATION

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INTERSESSIONAL MEETING OF THE WORKING GROUP ON REDUCTION OF GHG EMISSIONS FROM SHIPS
6th session
Agenda item 2

ISWG-GHG 6/2/3
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FURTHER CONSIDERATION OF CONCRETE PROPOSALS TO IMPROVE THE OPERATIONAL ENERGY EFFICIENCY OF EXISTING SHIPS, WITH A VIEW TO DEVELOPING DRAFT AMENDMENTS TO CHAPTER 4 OF MARPOL ANNEX VI AND ASSOCIATED GUIDELINES, AS APPROPRIATE

Revised proposal for goal-based energy efficiency improvement measure utilizing Energy Efficiency Existing Ship Index (EEXI)

Submitted by Japan and Norway

SUMMARY

Executive summary:	This document provides a revised proposal for goal-based energy efficiency improvement measure utilizing Energy Efficiency Existing Ship Index (EEXI), which refines the initial proposals on EEXI submitted by Japan (MEPC 74/7/2) and Norway (ISWG-GHG 5/4). This document is structured in accordance with the note by the Chair (ISWG GHG 6/1/1), addressing the issues raised at MEPC 74. As a supplement to this document, an initial impact assessment of the proposed EEXI is submitted separately in document ISWG-GHG 6/2.
Strategic direction, if applicable:	3
Output:	3.2
Action to be taken:	Paragraph 56
Related documents:	MEPC 72/17; MEPC 73/19; MEPC 74/18, MEPC 74/7/2, MEPC 74/5/5, MEPC 74/INF.23; ISWG-GHG 5/4/1, ISWG-GHG 5/4 and ISWG-GHG 6/1/1

Introduction

1 The Marine Environment Protection Committee (MEPC), at its seventy-fourth session, considered a number of concrete proposals for candidate short-term measures including proposals on energy efficiency improvement measure on existing ships as submitted by Japan (MEPC 74/7/2) and EEDI for existing ships as submitted by Norway in document ISWG-GHG 5/4 ("Energy Efficiency Existing Ship Index (EEXI)", hereafter), which are built upon fundamentally the same framework, namely chapter 2 and chapter 4 of MARPOL Annex VI.

2 Following the discussion at the Committee, several key elements have been noted, such as: all measures would be considered further; the measures should be implemented before 2023; the measures should be practicable, implementable and verifiable and any mandatory measures would be incorporated within MARPOL Annex VI; the measures should also be balanced and global in nature resulting in a level playing field; and the measures should be goal-based (MEPC 74/18, paragraph 7.37). Accordingly, the Committee instructed the Working Group to further consider concrete proposals to improve the operational energy efficiency of existing ships, with a view to developing draft amendments to chapter 4 of MARPOL Annex VI and associated guidelines, as appropriate.

3 In preparation for ISWG-GHG 6, the Chair of the Working Group has provided a note for facilitation of the further consideration of the measures, identifying issues that should be addressed in submissions (ISWG-GHG 6/1/1). The note by the Chair provides an indicative list of the main elements which would be beneficial to include in submissions to ISWG-GHG 6 for further consideration.

4 In light of the above background, this document provides a revised proposal for goal-based energy efficiency measure utilizing Energy Efficiency Existing Ship Index (EEXI), which refines the initial proposals on EEXI submitted by Japan (MEPC 74/7/2) and Norway (ISWG-GHG 5/4). This document is structured in accordance with the note by the Chair (ISWG GHG 6/1/1), addressing the issues raised at MEPC 74. As a supplement to this document, an initial impact assessment of the proposed EEXI is submitted separately in document ISWG-GHG 6/2.

Basic concepts of EEXI

5 In line with the discussion at ISWG-GHG 5 and MEPC 74, the proposed revised EEXI is a mandatory measure developed upon following concepts:

.1 goal-based approach;

.2 level playing field;

.3 practicable, implementable and verifiable; and

.4 implementable before 2023.

Goal-based approach

6 Goal-based approach, allowing broad options to achieve energy efficiency improvement, should be the fundamental basis for regulatory measures. There is no "one-size-fits-all" measure in the shipping and shipbuilding sectors for energy efficiency improvement. Energy efficiency of existing ships can be improved by multiple ways, depending on circumstance of each ship. Allowing flexibility to choose different options will ensure the most cost-effective ways for each ship to implement the measure.

7 In contrast, if the measure was prescriptively limited to a specific option (e.g. operational speed limit), it may hinder technical innovation and further bring uncertainties in the level of GHG emissions reduction. For example, if operational speed limit was flatly applied to all ships under the same category, then innovative low-emission ships should slow down to the same level as inefficient conventional ships should. Such policy measure would unfairly treat innovative ships. Furthermore, since inefficient conventional ships are allowed to speed up to the same level as efficient innovative ships do, more CO_2 will be emitted from those inefficient ships.

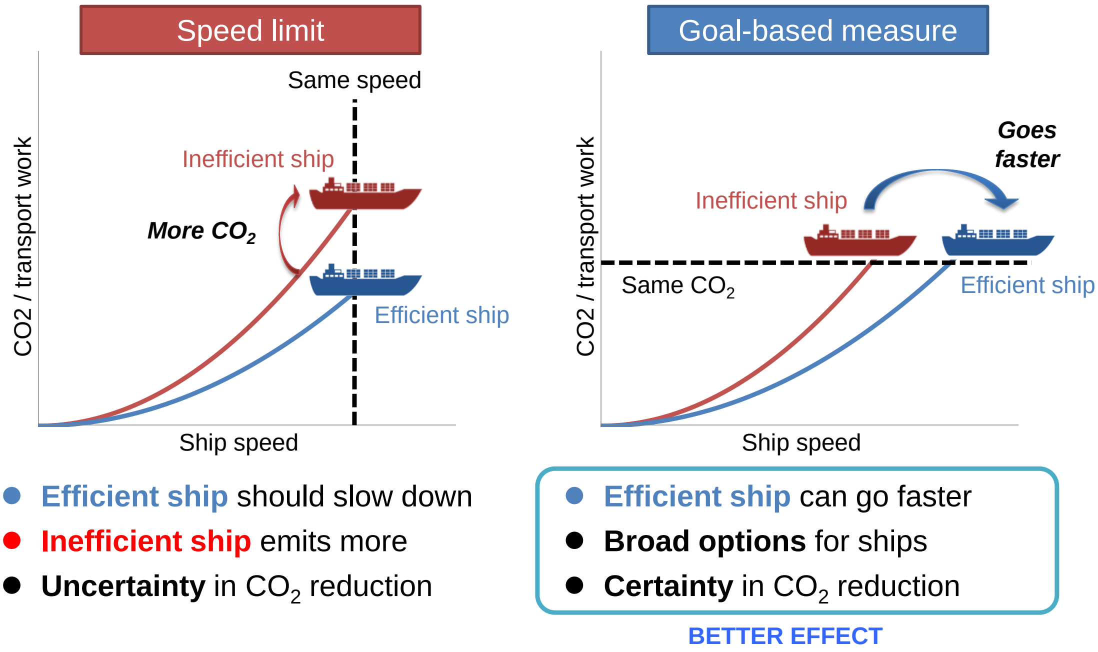

Figure 1: Speed limit and goal-based measure

8 Therefore, EEXI is developed as a goal-based measure in an easily enforceable way, which allows any options to meet the requirement as long as such options are verifiable and controllable. If a ship prefers saving capital cost, the ship can choose the shaft/engine power limit to the optimum level. If a ship prefers higher speed, the ship can choose installing energy saving devices (e.g. optimally-designed propellers) or switching to alternative fuels (e.g. LNG, blending with bio-diesels or co-combustion with Hydrogen gas). It is up to each ship to decide which option to take.

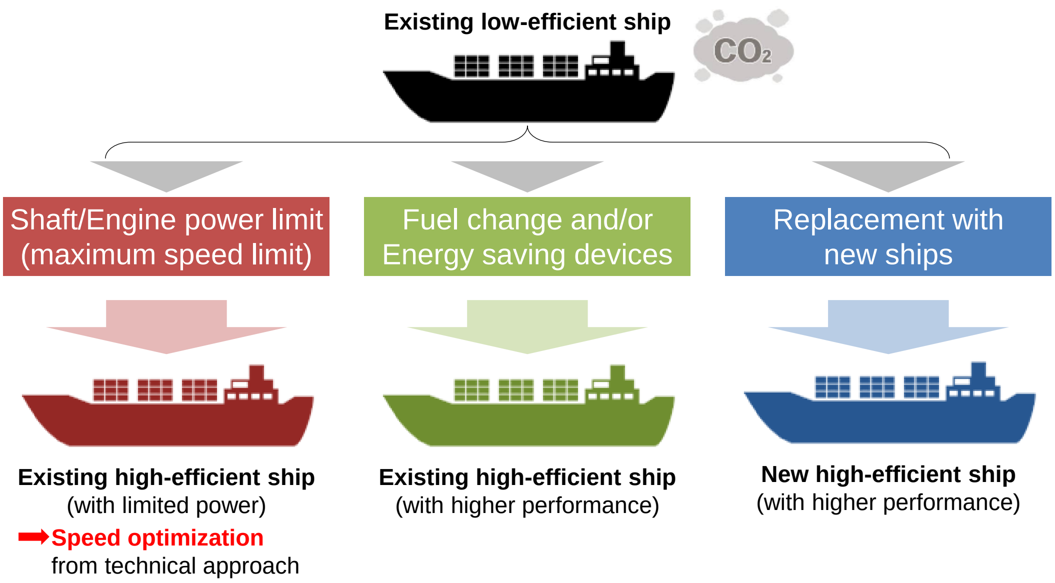

Figure 2: Concept of goal-based measure

Level playing field

9 Fair treatment to all ships is another important aspect to secure level playing field. Therefore, EEXI is developed as a regulatory framework under MARPOL Annex VI, which is applied and enforced robustly and globally regardless of the flags under the principle of non-discrimination and no more favourable treatment.

10 Besides, in applying new measures on existing ships, efforts which have already been made by each ship should be carefully taken into account in order to secure fairness among the ships. Some existing ships might be designed to have superior environmental performance, while others might not. Such divergence among existing ships should be quantified and reflected in the regulatory measure.

11 Therefore, EEXI captures such "efforts" in a quantitative and objective manner. EEXI will be calculated and documented by the Administration or the recognized organization in a transparent method (see paragraph 21). By introducing the same target of energy efficiency for all ships under each category (ship type and size), the ships having superior design (better attained EEDI or EEXI) will be required less further improvement than those with inferior design.

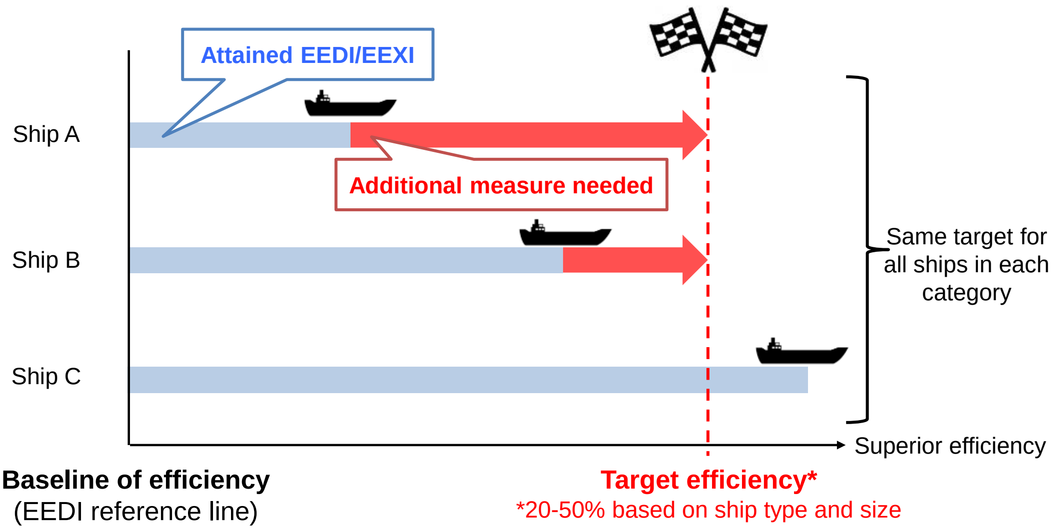

Figure 3: Application of the same target in each category

Practicable, implementable and verifiable

12 Operational energy efficiency of a ship depends on various factors including i) technical factors; ii) business-related factors; and iii) external and uncontrollable factors. Even if ships with identical design were operated in the same route, schedule and cargo, their operational efficiencies will be different because of other external factors such as weather and sea conditions.

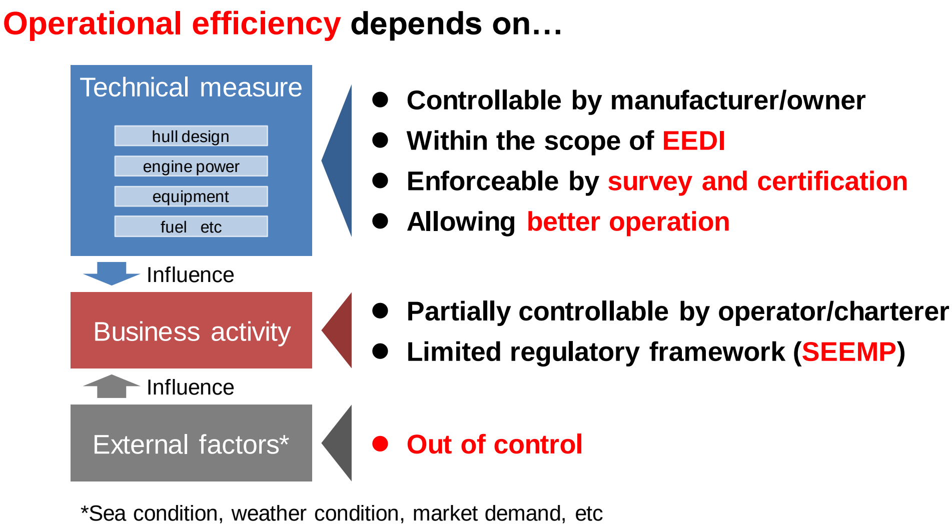

Figure 4: Factors affecting operational efficiency of ships

13 Therefore, in order to ensure practicability and implementability, the measure should address controllable and enforceable factors among aforementioned factors influencing the ship's operational efficiency (see figure 4).

14 For these reasons, EEXI evaluates and controls technical factors such as engine power, equipment and fuels. These factors substantially influence the ship's operational efficiency and can be documented before the ship engages in operation. Since EEXI does not prescriptively regulate business activity or external factors such as weather and sea conditions, ships will not be penalized due to factors beyond their control.

15 Furthermore, unless the measure is enforceable, robust compliance will not be secured and thus the level-playing field of the international shipping market will be seriously distorted.

16 EEXI is built upon existing framework under MARPOL Annex VI, so that robust enforcement in accordance with the Organization's system of survey and certification is ensured. After the application date of such mechanism, EEXI requires the survey to be conducted before the ship engages in operation. Therefore, unlike operational requirements that can only be enforced through retroactive inspections and where there is no alternative compliance mechanism if a ship does not meet the requirement, EEXI prevents non-compliant ships to be operated in advance.

Implementation before 2023

17 Implementation of EEXI can start immediately after its entry into force. EEXI is certified in document-based calculation by the Administration or the recognized organization without substantial cost. If a ship chooses engine power limit (EPL) as an option to meet the EEXI requirement, it can be conducted in within a day without drydocking. Unlike EEDI certification for new ships, existing ships are not necessarily required to conduct sea trials so that there is no need to suspend their operation for several days for the EEXI certification.

18 Following the timeframes for the development of an amendment to MARPOL Annex VI noted at MEPC 74 (table 1 of document MEPC 74/WP.9/Add.1), it is possible that EEXI enters into force in 2022, resulting in implementation before 2023. In order to do so, draft amendments attached to this document should be considered and approved by MEPC 75 or MEPC 76, and associated work such as development of guidelines and impact assessments should be conducted in parallel (see table 6 below).

Structure of EEXI

19 Reflecting the above concepts, EEXI is proposed to be developed in the following regulatory framework under MARPOL Annex VI, consisting of three policy pillars:

.1 calculate current energy efficiency performance (attained EEDI/EEXI);

.2 for ships not meeting the mandatory requirement (required EEXI), improve its energy efficiency performance; and

.3 survey and certification (IEE Certificate).

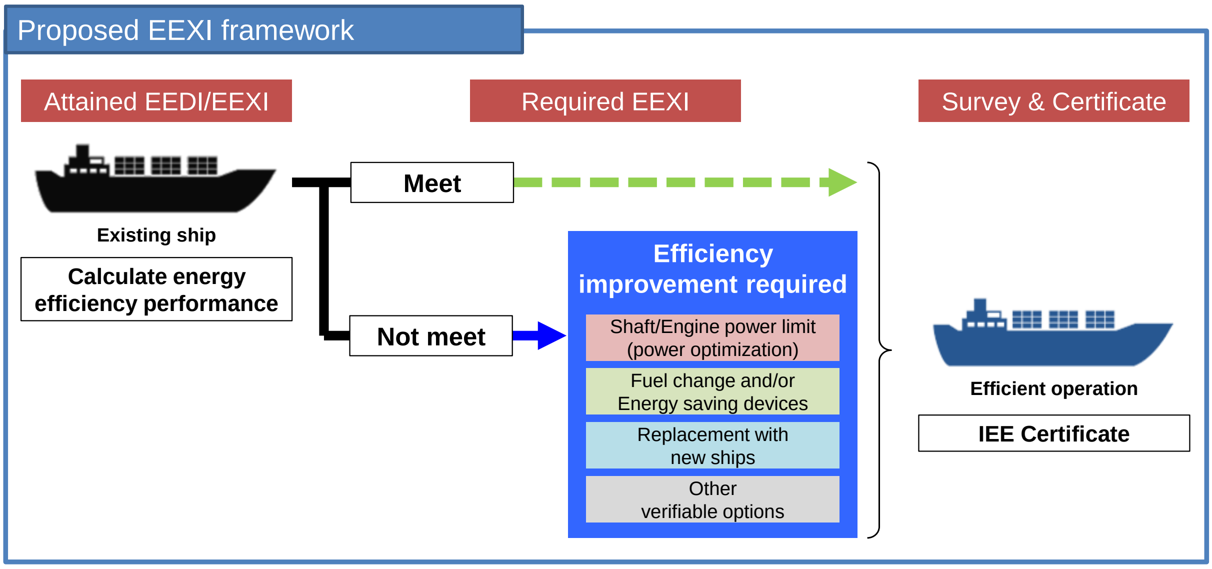

Figure 5: Structure of EEXI

Legal framework

20 EEXI is to be developed under the existing legal framework of MARPOL Annex VI, namely chapter 4 (Regulations on energy efficiency for ships) and chapter 2 (Survey, certification and means of control). Draft amendments to MARPOL Annex VI are set out in annex 1 to this document. Associated guidelines may be further developed as necessary.

Scope of application

21 Since EEXI is to be established based on the existing legal framework of MARPOL Annex VI, the scope of application in terms of ship type and ship size should be basically the same as that of the current EEDI requirement on new ships. That is, new and existing ships falling into one or more of the categories in regulations 2.25 to 2.35, 2.38 and 2.39 within the ship sizes listed in table 1 of regulation 21 of MARPOL Annex VI, should be subject to the proposed EEXI framework.

Attained EEDI/EEXI

22 First, ships specified in paragraph 21 shall calculate their energy efficiency performance (attained EEXI), in accordance with a formula to be set out in guidelines developed by the Organization. Following the EEXI formula, the attained EEXI can be calculated, documented in an EEXI Technical File and verified by the Administration or the recognized organizations on a document basis. The detailed description of the EEXI formula is set out in annex 2 to this document.

23 The EEXI formula follows the basic structure of the EEDI formula and includes the same correction factors. Therefore, the metric of EEXI is compatible with that of EEDI, and thus ships falling into the scope of EEDI requirement can use their attained EEDI as an alternative to the attained EEXI without re-calculation or re-certification, if the attained EEDI meets the required EEXI.

Required EEXI

24 Attained EEXI of each ship shall meet the mandatory requirement (required EEXI). For ships not meeting the requirement, the ship shall improve its attained EEXI by choosing and implementing the most cost-effective measures for itself, such as shaft/engine power limit to the optimum level, fuel change, energy saving device and/or any other verifiable options.

25 The level of the required EEXI will be decided by the Organization for each category (ship type and ship size), taking into account sufficient data on technical feasibility and future projection of entire fleet and seaborne trade as of 2030 in order to contribute to the 2030 target set out in the *Initial IMO Strategy on reduction of GHG from ships*.

26 At this stage, the co-sponsors propose the levels of required EEXI to be the same as those of the required EEDI for new ships as of 2022 (see table 1). Based on case studies on different types and sizes of existing ships (see paragraphs 43 to 45), the co-sponsors consider that it is technically feasible for those existing ships to achieve the proposed levels of required EEXI set out in table 1.

27 Furthermore, by equalizing the required EEXI on existing ships with the required EEDI on new ships, EEXI can stimulate fleet replacement with new innovative ships, which is essential to achieve mid- and long-term GHG emissions reduction targets.

Table 1: Proposed level of the required EEXI

Ship type	Required EEXI (Δ% from EEDI ref.line)
Bulk carrier	Δ20% (= EEDI phase 2)
Tanker	Δ20% (= EEDI phase 2)
Containership	Δ30-50% by size (= EEDI phase 3)
General cargo	Δ30% (= EEDI phase 3)
Gas carrier	Below 14,999 DWT: Δ20% (= EEDI phase 2) Above 15,000 DWT: Δ30% (= EEDI phase 3)
LNG carrier	Δ30% (= EEDI phase 3)
Refrigerated cargo carrier	Δ15% (= EEDI phase 2)
Combination carrier	Δ20% (= EEDI phase 2)
Ro-ro vehicle/cargo/passenger	Δ20% (= EEDI phase 2)
Cruise passenger ship	Δ30% (= EEDI phase 3)

Survey and certification (IEE Certificate)

28 The improved energy efficiency performance meeting the required EEXI shall be verified by the Administration or a recognized organization. Similarly to EEDI on new ships, EEXI is enforced within the system of survey and certification under MARPOL Annex VI. This prevents non-compliant ships being operated in advance under the scheme of survey and certification.

29 Under regulation 5.5 of MARPOL Annex VI, ships shall maintain the equipment, systems, fittings, arrangements or material as certified in the International Energy Efficiency (IEE) Certificate. For example, ships installing EPL as a measure to comply with EEXI shall not exceed EPL except for the use of "safety power reserve" in an emergency situation. Therefore, clear guidelines to prevent improper use of "safety power reserve" should be developed in accordance with documents MEPC 74/5/5 (France et al.) and/or MEPC 74/INF.23 (Japan). Such guidelines could require recording and reporting to the Administration in the case of releasing "safety power reserve".

30 Ships are subject to port State control (PSC) in accordance with regulation 10 of MARPOL Annex VI. If non-compliance to EEXI (e.g. improperly exceeding EPL) was detected by PSC, the ship would be subject to detention or penalty by the Administration or the port State.

Contribution to the 2030 level of ambition

31 Improvement in the EEXI results in operational efficiency improvements and reduction of GHG emissions. For example, if a ship chooses EPL to improve the attained EEXI, the ship should limit its maximum engine power for normal operation. Consequently, the ship will be operated in the range of lower engine power with less GHG emissions (see figure 6).

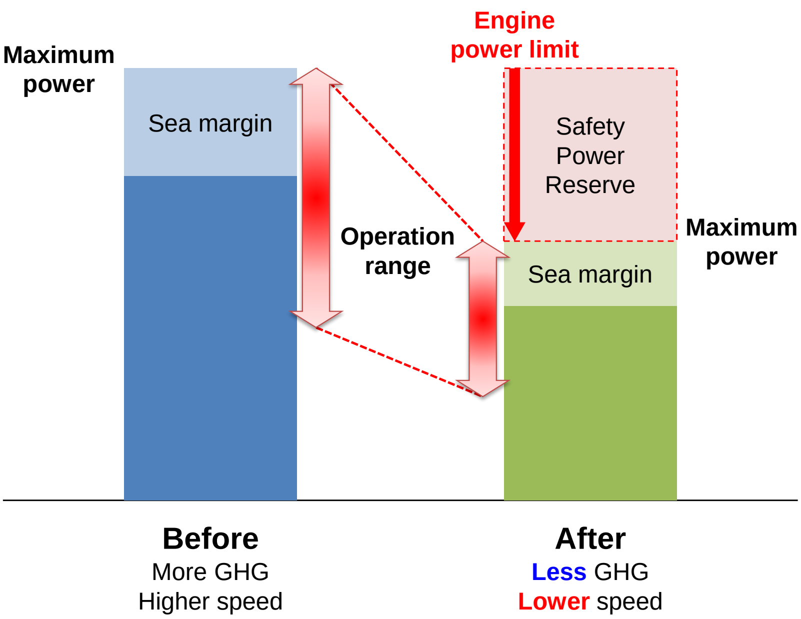

Figure 6: Effect of EEXI (in case of Engine Power Limit)

32 At MEPC 74, a question was raised that EEXI might bring "rebound effect". The rebound effect is a potential adverse effect of technical energy efficiency improvements on GHG reduction. For example, if a ship installs an energy saving device (ESD), the ship may speed up emitting no less GHGs than before.

33 However, EEXI clearly prevents such rebound effect through its verification mechanism. Similarly to EEDI on new ships, the attained EEXI is calculated and certified using the main engine power (P_{ME}) and ship speed (V_{ref}). If an ESD is installed on a ship to improve energy efficiency while maintaining the same speed, then, P_{ME} must be limited at a lower level ("ESD+EPL" in figure 7). In this case, certified P_{ME} and the attained EEXI prevents a potential rebound effect. On the other hand, if the ship prefers higher speed and keeps its P_{ME} at the original level without limitation, then, V_{ref} will become higher but improvement in the attained EEXI will be limited ("ESD only" in figure 7). In either case, EPL will result in better EEXI and there will be no case of a rebound effect.

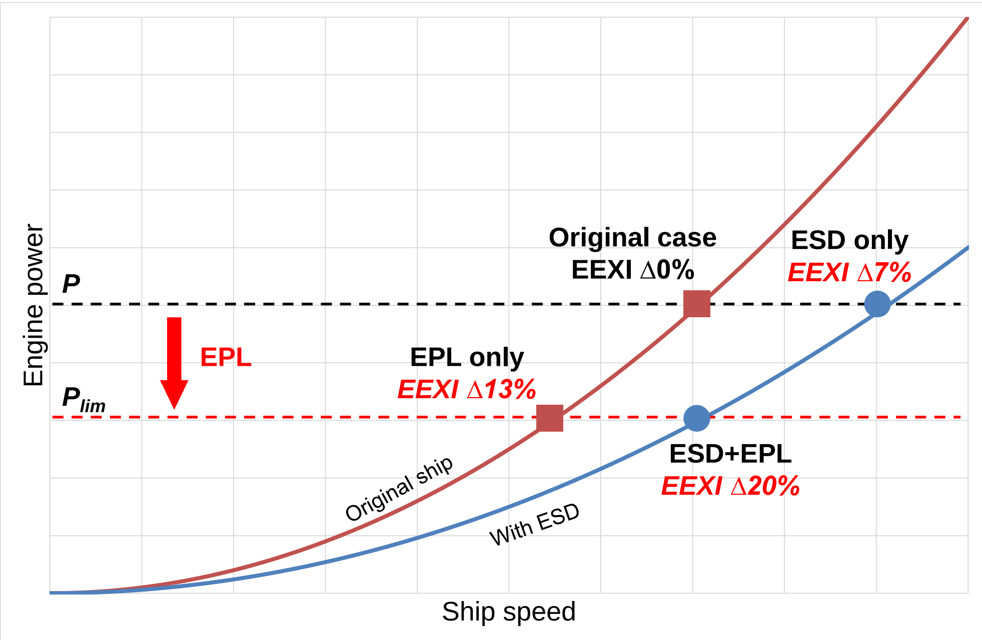

Figure 7: Effect of EEXI (in case of Energy Saving Device)

34 A relation between design efficiency and operational efficiency can be found from an analysis of publicly available data[1]. The results of the analysis show that a ship with an efficient design will on average also have lower carbon intensity in operation. A detailed description of the data and method can be found in annex 3 to this document.

35 The Technical Efficiency (TE) of the design is measured using EEDI or the Estimated Index Value (EIV) indicator while the operational carbon intensity is calculated using the Annual Efficiency Ratio (AER) indicator. All indicators use the same denominator – grams CO_2 per deadweight-mile – enabling a direct comparison. In order to compare across ships of difference types and sizes, EEDI/EIV and AER are related to the EEDI reference line value for each ship, as defined in regulation 21 of MARPOL Annex VI.

[1] Publicly available data from the EU Monitoring, Reporting and Verification scheme (EU-MRV).

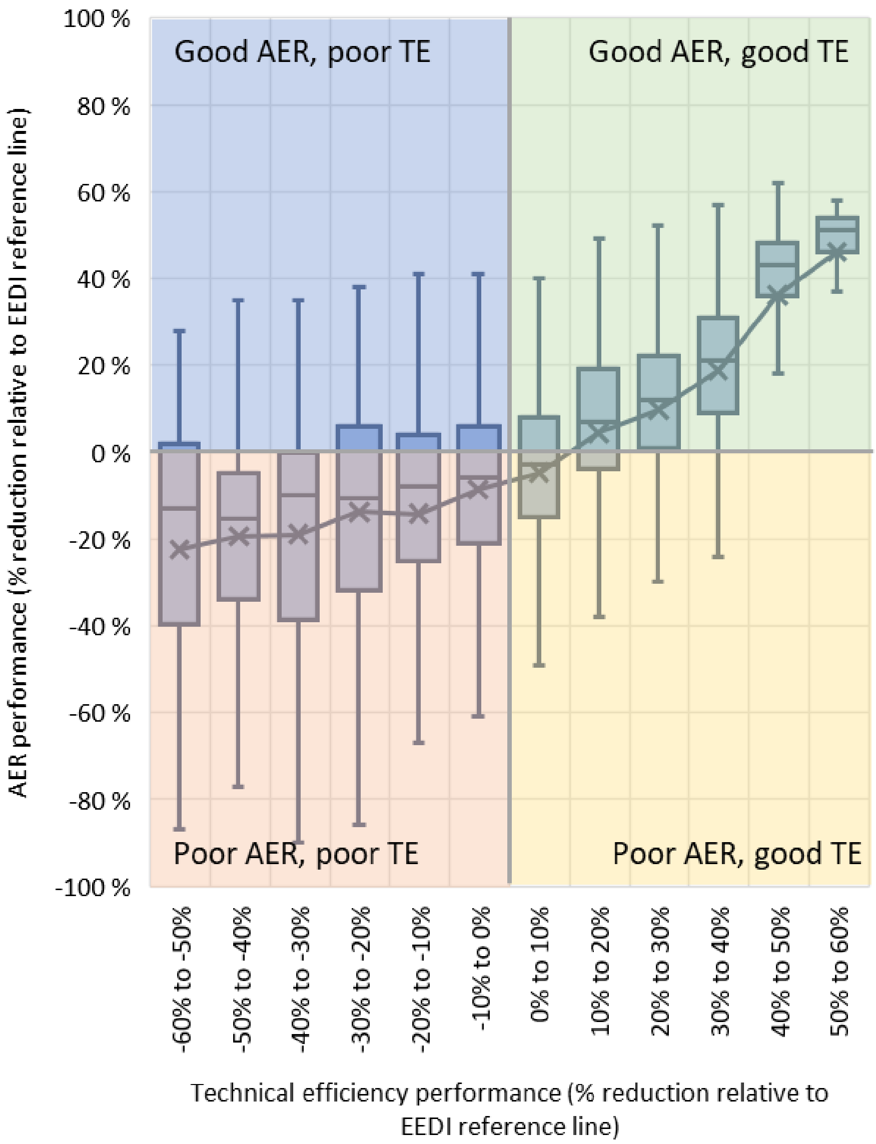

Figure 8: Operational carbon intensity (AER) relative to Technical Efficiency (EEDI/EIV)

36 Figure 8 shows a box and whisker plot of AER relative to the Technical Efficiency. A positive performance value means that the indicator is lower and better than the EEDI reference line for the ship (blue area for AER, yellow area for TE and green area for both). A negative value means a higher TE or AER than the EEDI reference line (yellow area for AER, blue area for TE and red area for both). The cross in the boxes indicates the average; the line in the boxes indicate the median; the top and bottom of the box is the first and third quartiles; and the top and bottom whiskers indicate 1.5 times the IQR (interquartile range).

37 For ships with poor Technical Efficiency (TE) performance (ships with TE above the EEDI reference line), there is little variation and the average AER is from 10% to 20% above the EEDI reference line. For ships with a TE below the EEDI reference line, AER improves with better designs, although it is not linear.

38 Ships with TE between 20% and 30% below the EEDI reference line have an AER performance of between 0% to 20% below the EEDI reference line, while ships with a TE of 40% to 60% below the EEDI reference line have a similar operational performance. These two categories consist almost exclusively of general cargo and container ships. It should be

noted that ships with TE on the EEDI reference line have AER performance of approximately 6% to 7% above the EEDI reference line. Therefore, if TE improves, improvement in AER performance will be 6 to 7 percentage points higher than the aforementioned values relative to TE on the EEDI reference line.

39 An efficient design can be operated badly, or it can encounter bad weather conditions and currents, increasing the emissions per dwt-mile (see figure 4 above). However, when looking at the minimum, maximum and average of AER performance, it indicates that an efficient design has both a potential for better performance and also are less prone to bad performance. The results show that there is a clear effect of mandating efficient designs.

40 EEXI can sufficiently contribute to the 2030 level of ambition (at least 40% carbon intensity reduction), if the required EEXI proposed in paragraph 26 (table 1) of this document is met.

Table 2: Estimated fleet-average EEXI

Ship type	2008 average		*EEXI reduction rate*	2030 average	
	EEXI	*AER*	*Δ%*	EEXI	Δ%
Bulk carrier	4.24	*5.56*	*Δ20%*	3.29	Δ22.5%
Tanker and Combination carrier	4.63	*5.04*	*Δ20%*	3.39	Δ26.6%
Containership	19.53	*18.50*	*Δ30-50%*	10.01	Δ48.7%
General cargo	15.66	*17.83*	*Δ30%*	10.11	Δ35.4%
Gas/LNG carrier	9.92	*10.84*	*Δ30%*	6.52	Δ34.3%
Refrigerated cargo carrier	23.02	*58.07*	*Δ15%*	17.43	Δ24.3%
Ro-ro vehicle	19.47		*Δ20%*	14.97	Δ23.1%
Ro-ro cargo	15.13	*31.53*	*Δ20%*	10.34	Δ31.7%
Ro-ro passenger	30.60		*Δ20%*	28.12	Δ8.1%
Cruise ships	NA	*NA*	*Δ30%*	NA	NA
Average	**8.04**	***9.93***	→	**4.59**	**Δ43.0%**

- Cruise ships are excluded from EEXI/AER calculation due to lack of data.
- 2030 fleet capacity is estimated from Scenario 16 (BAU) of the Third IMO GHG Study.
- 2030 fleet composition (ratio of each type and size) is fixed to average of 2011-2018. (Further ship size increase is not assumed.)

41 Based on IHS Seaweb database, carbon intensity (CO_2 emissions per transport work) of international shipping in terms of the fleet-average EEXI[2] in 2008 is estimated to be 8.04 [g-CO_2/DWT-mile]. Since then, average ship size has been continuously increasing, which contributes to reducing the carbon intensity.

2 "Fleet-average EEXI" is a weighted average of each ship's EEXI in each category by transport work in terms of the product of capacity (DWT) and design speed (V_{ref}).

42 Then, by assuming the following conditions, the carbon intensity in terms of the fleet-average EEXI in 2030 is estimated to be 4.59, which is 43.0% improvement from the 2008 level of carbon intensity (see table 2). If average ship sizes keep increasing even after 2018, the estimated fleet-average EEXI in 2030 will be further improved. The conditions assumed for this estimation are as follows:

.1 the world seaborne trade and fleet capacity will increase in accordance with Scenario 16 (BAU) of the *Third IMO GHG Study 2014*;

.2 fleet composition (percentage of different ship type/size categories) is fixed to that of 2018;

.3 the EEDI phase 0 to 3 requirements are applied and implemented to new ships contracted on or after 1 January 2013; and

.4 the proposed EEXI is applied to pre-EEDI existing ships and EEDI phase 0 to 2 ships with the level of requirement set out in table 2 of this document.

Case study

43 In order to examine technical feasibility of pre-EEDI existing ships in complying with the proposed EEXI requirements, the co-sponsors conducted a case study on different types and sizes of existing ships. In the case study, several samples are taken from typical categories of ship type and ship size as listed below:

.1 bulk carriers: Capesize (200,000 DWT), Panamax (81,000 DWT), Handymax (60,000 DWT) and Handy (33,000 DWT);

.2 tankers: VLCC (300,000 DWT), Aframax (105,000 DWT), Product (50,000 DWT) and Small chemical (20,000 DWT); and

.3 containerships: 20,000 TEU (200,000 DWT), 14,000 TEU (140,000 DWT), 8,000 TEU (90,000 DWT) and 3,000 TEU (37,000 DWT).

44 In the case study, the following three different options to comply with the EEXI requirements are assumed:

.1 option 1 (EPL only): the ship is installed with EPL which limits the ship's main engine power (P_{ME}) to the optimum level where its attained EEXI achieves the required EEXI;

.2 option 2 (Energy saving device and EPL): the ship is retrofitted with energy saving device (e.g. waste heat recovery system) improving the ship's design efficiency by 10%. EPL is further installed to meet the required EEXI; and

.3 option 3 (replacement with a new ship): the ship is replaced with a new ship complying with the EEDI phase 3 requirement with better hull design, propulsion system and engine performance.

45 Results of the case study, as summarized in tables 3 to 5 respectively for each ship type, show that the proposed EEXI requirements can be feasibly complied with by pre-EEDI ships utilizing currently available technologies and measures.

Table 3: Result of the case study (bulk carriers)

		2008 base level	EPL (with safety reserve)	Energy saving device* with EPL	Retrofit or replacement with new ship
Handy (33,000 DWT)	P_{ME}	5,067 kW	3,626 kW	3,822 kW	4,410 kW
	V_{REF}	14.2 knot	12.7 knot	13.4 knot	14.2 knot
	EEXI	6.73	**5.38 (Δ20%)**		
Handymax (60,000 DWT)	P_{ME}	7,222 kW	5,168 kW	5,448 kW	6,467 kW
	V_{REF}	14.6 knot	13.1 knot	13.8 knot	14.6 knot
	EEXI	5.06	**4.05 (Δ20%)**		
Panamax (81,000 DWT)	P_{ME}	8,228 kW	5,860 kW	6,177 kW	7,343 kW
	V_{REF}	14.2 knot	12.7 knot	13.4 knot	14.2 knot
	EEXI	4.38	**3.51 (Δ20%)**		
Capesize (200,000 DWT)	P_{ME}	13,837 kW	9,780 kW	10,333 kW	12,372 kW
	V_{REF}	14.7 knot	13.1 knot	13.8 knot	14.7 knot
	EEXI	2.85	**2.28 (Δ20%)**		

Table 4: Result of the case study (tankers)

		2008 base level	EPL (with safety reserve)	Energy saving device with EPL	Retrofit or replacement with new ship
Small Chemical (20,000 DWT)	P_{ME}	4,588 kW	3,283 kW	3,461 kW	4,206 kW
	V_{REF}	14.5 knot	13.0 knot	13.7 knot	14.5 knot
	EEXI	9.71	**7.76 (Δ20%)**		
Product (50,000 DWT)	P_{ME}	7,702 kW	5,504 kW	5,801 kW	7,257 kW
	V_{REF}	15.0 knot	13.4 knot	14.1 knot	15.0 knot
	EEXI	6.21	**4.97 (Δ20%)**		
Aframax (105,000 DWT)	P_{ME}	10,291 kW	7,259 kW	7,660 kW	9,697 kW
	V_{REF}	14.5 knot	12.9 knot	13.6 knot	14.5 knot
	EEXI	4.32	**3.46 (Δ20%)**		
VLCC (300,000 DWT)	P_{ME}	19,372 kW	13,745 kW	14,511 kW	18,291 kW
	V_{REF}	15.8 knot	14.1 knot	14.9 knot	15.8 knot
	EEXI	2.59	**2.07 (Δ20%)**		

Table 5: Result of the case study (containerships)

		2008 base level	EPL (with safety reserve)	Energy saving device with EPL	Retrofit or replacement with new ship
3,000 TEU (37,000 DWT)	P_{ME}	18,686 kW	10,773 kW	11,379 kW	14,556 kW
	V_{REF}	22.0 knot	18.3 knot	19.3 knot	20.8 knot
	EEXI	21.0	**14.7 (Δ30%)**		
8,000 TEU (90,000 DWT)	P_{ME}	45,311 kW	20,840 kW	21,989 kW	29,601 kW
	V_{REF}	26.0 knot	20.1 knot	21.2 knot	24.0 knot
	EEXI	17.6	**10.6 (Δ40%)**		
14,000 TEU (140,000 DWT)	P_{ME}	67,105 kW	27,131 kW	28,621 kW	38,495 kW
	V_{REF}	27.0 knot	20.0 knot	21.1 knot	23.9 knot
	EEXI	16.1	**8.85 (Δ45%)**		
20,000 TEU (200,000 DWT) *Phase 1 ship	P_{ME}	87,888 kW	36,211 kW	37,101 kW	45,147 kW
	V_{REF}	28.0 knot	20.8 knot	21.4 knot	23.2 knot
	EEXI	13.50 (Δ10%)	**7.49 (Δ50%)**		

Impact of the measure

46 The result of initial impact assessment of the proposed EEXI conducted by the co-sponsors is provided in document ISWG-GHG 6/2.

47 In summary, the co-sponsors are of the view that the proposed EEXI has positive impacts on reduction of GHG emissions and voyage cost, and that the overall transport cost could be reduced.

48 Furthermore, the initial impact assessment states that, in order to avoid any potential disproportionately negative impacts, it is essential to set the required EEXI at an appropriate level for each category of ship type and ship size, rather than applying a fixed/the same reduction rate to all ships. The required EEXI should satisfy both i) contribution to at least 40% carbon intensity reduction target by 2030 and ii) feasibility to be achieved without substantial increase in cost or major technical challenges. The level of required EEXI as proposed in paragraph 26 (table 1 above) satisfies these conditions.

Timelines

49 In order to develop and adopt EEXI with a view of entry into force before 2023 in accordance with the Programme of follow-up actions of the Initial Strategy approved at MEPC 73 and the *Procedure for assessing impacts on States of candidate measures* (MEPC.1/Circ.885) approved at MEPC 74, the Working Group should consider the proposed EEXI in the timeline as set out in table 6.

Table 6: Timeline for development of EEXI (entry into force before 2023)

Year	sessions	Development of EEXI	Impact assessment
2019	ISWG-GHG 6 Step 1: Data collecitоn	• Proposal and consideration on draft amendment to MARPOL VI	• Initial assessment • [Additional information]
2020	MEPC 75 MEPC 76	• Further consider the proposal • Approve MARPOL VI 4th GHG Study report Further refine draft texts	• Commenting document • Comprehensive response [Comprehensive assessment]
2021	MEPC 77 Step 2: Data analysis	• Adopt MARPOL VI and guidelines	• [Finalize comprehensive assessment]
2022	MEPC 78 MEPC 79 Step 3: Decision	• Acceptance • Entry into force (GHG starts declining)	
2023			
2024			
2030		• Achieving the Δ40% target	

50 In this timeline, the Working Group is invited to consider the draft amendments to MARPOL Annex VI to introduce EEXI as set out in annex 1 to this document. Then, the Committee will further consider the proposal, in parallel with impact assessment. Reflecting any findings from the report of the Fourth IMO GHG Study, the Ship Fuel Oil Consumption Database from the IMO data collection system (DCS) and any feedback from the impact

assessment, the Committee may adopt the amendment to MARPOL Annex VI and associated guidelines at MEPC 77 in 2021. Accordingly, following acceptance by the Member States in the beginning of 2022, EEXI may enter into force in the end of 2022.

51 If EEXI was considered to be subject to more detailed data analysis and aforementioned timelines could not be met, then, following the timeline as set out in table 7 should be referred as an alternative case.

Table 7: Timelines for development of EEXI (subject to more detailed analysis)

Year	sessions	Development of EEXI	Impact assessment
2019	ISWG-GHG 6 Step 1: Data colleciton	• Proposal and consideration on draft amendment to MARPOL VI	• Initial assessment • [Additional information]
2020	MEPC 75 MEPC 76	• Further consider the proposal • Continue developing draft texts	• Commenting document • Comprehensive response
2021	MEPC 77 Step 2: Data analysis	4th GHG Study report Further refine draft texts	[Comprehensive assessment]
2022	MEPC 78 MEPC 79 Step 3: Decision	• Approve MARPOL VI • Adopt MARPOL VI, guidelines and early implementation resolution	• [Finalize comprehensive assessment]
2023		• Acceptance and early implementation (GHG starts declining)	
2024		• Entry into force	
2030		• Achieving the ∆40% target	

52 In this timeline, the Committee may take more sessions to consider the proposal, in parallel with impact assessment. Following detailed data analysis based on the Fourth IMO GHG Study, the Ship Fuel Consumption Database from the DCS and any feedback from the impact assessment, the Committee should adopt the amendment to MARPOL Annex VI and associated guidelines at MEPC 79 in 2022. Accordingly, following acceptance by the Member States in 2023, EEXI may enter into force in 2024.

53 In this case, in order to accelerate early action to reduce GHG from existing ships well before 2023, the Committee may adopt a resolution on early implementation, urging Member States and existing ships to improve EEXI and have it verified before entry into force of EEXI under MARPOL Annex VI.

Expected workload for the Organization

54 The legal framework and the supporting guidelines for EEXI will build upon the existing framework provided in chapter 4 of MARPOL Annex VI on Regulations on energy efficiency for ships – specifically regulations 19, 20 and 21 that relates to the Energy Efficiency Design Index (EEDI) – and in regulation 5 on Surveys. Building upon an existing and proven framework will facilitate the development of the measure and accelerate the effective date of entry into force of the measure. The co-sponsors expect that the following work needs to be finalized before the measure can be implemented:

.1 there should be a consideration of possible technical solutions for reducing/meeting EEXI for existing ships, and particular attention should be given to shaft/engine power limit. The co-sponsors suggest that these discussions should run in parallel with the development of the overall measure;

.2 the *Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships* should be used as a basis for the development of *Guidelines on the method of calculation of the attained Energy Efficiency Existing Ship Index (EEXI)*;

.3 the *Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI)* should be used as a basis for the development of *Guidelines on survey and certification of the Energy Efficiency Existing Ship Index (EEXI)*; and

.4 the amendments to MARPOL Annex VI, as set out in annex 1 to this document, are needed.

Proposal

55 The co-sponsors propose the Working Group to consider the proposed EEXI, along with draft amendments to MARPOL Annex VI as set out in annex 1 to this document in line with the timeline set out in table 6, recognizing that the timeline set out in table 7 could be referred as an alternative case where more detailed data analysis is needed.

Actions requested of the Working Group

56 The Group is invited to consider the proposals set out in this document and take action as appropriate.

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ANNEX 1

DRAFT AMENDMENTS TO MARPOL ANNEX VI
(Energy efficiency improvement measure on existing ships)
(shown as additions/~~deletions~~)

Regulation 2
Definitions

24 Major conversion means in relation to chapter 4 of this Annex a conversion of a ship:

.5 which substantially alters the energy efficiency of the ship and includes any modifications that could cause the ship to exceed the applicable required EEDI as set out in regulation 21 or required EEXI as set out in regulation 21A of this Annex.

36A Attained EEXI is the EEXI value achieved by an individual ship in accordance with regulation 20A of chapter 4.

37A Required EEXI is the maximum value of attained EEXI that is allowed by regulation 21A of chapter 4 for the specific ship type and size.

Regulation 5
Surveys

4 Ships to which chapter 4 of this Annex applies shall also be subject to the surveys specified below, taking into account Guidelines adopted by the Organization**:

.6 For ships for which the building contract is placed before [1 January 2022], the verification of the ship's EEXI according to regulation 20A shall take place at the first intermediate or renewal survey identified in paragraph 1 of this regulation, whichever is the first, on or after 1 January [20XX]; and

.7 Notwithstanding paragraph 4.6 of this regulation, a general or partial survey, according to the circumstances, after a major conversion of a ship to which regulation 20A applies. The survey shall ensure that the ship's EEXI is recalculated as necessary and meets the requirement of regulation 21A.

Regulation 9
Duration and Validity of Certificates

International Energy Efficiency Certificate

11 An International Energy Efficiency Certificate issued under this Annex shall cease to be valid in any of the following cases:

.3 if the ship's equipment, systems, fittings, arrangements, or material covered by the survey was changed without the express approval of the Administration in accordance with regulation 5.5 of this Annex.

** Refer to the 2014 Guidelines on survey and certification of the Energy Efficiency Design Index, as may be amended.

Regulation 19
Application

3 Regulations 20, 20A, ~~and~~ 21 and 21A of this Annex shall not apply to ships which have non-conventional propulsion, except that regulations 20 and 21 shall apply to cruise passenger ships having non-conventional propulsion and LNG carriers having conventional or non-conventional propulsion~~, delivered on or after 1 September 2019, as defined in paragraph 43 of regulation 2~~. Regulations 20, 20A, ~~and~~ 21 and 21A shall not apply to cargo ships having ice-breaking capability.

Regulation 20A
Energy Efficiency Existing Ship Index (EEXI)

1 EEXI shall be calculated for:

.1 each ship for which the building contract is placed before [1 January 2022]; and

.2 each ship for which the building contract is placed before [1 January 2022], which has undergone a major conversion,

which falls into one or more of the categories in regulations 2.25 to 2.35, 2.38 and 2.39 of this Annex. EEXI shall be specific to each ship and shall indicate the estimated performance of the ship in terms of energy efficiency. EEXI shall be verified either by the Administration or by any organization duly authorized by it*.

2 EEXI shall be calculated taking into account guidelines** developed by the Organization.

3 For each ship to which regulation 20 of this annex applies, the attained EEDI may be used as an alternative to EEXI.

Regulation 21A
Required EEXI

1 For each:

.1 ship for which the building contract is placed before [1 January 2022]; and

.2 ship for which the building contract is placed before [1 January 2022], which has undergone a major conversion,

which falls into one of the categories in regulations 2.25 to 2.31, 2.33 to 2.35, 2.38 and 2.39 and to which this chapter is applicable, the attained EEXI shall be as follows:

Attained EEXI ≤ Required EEXI = (1-Y/100) × Reference line value as defined in regulation 21 of this Annex where Y is the reduction factor specified in table 3 for the required EEXI compared to the EEDI Reference line.

* Refer to Code for Recognized Organizations (RO Code), adopted by the MEPC by resolution MEPC.237(65), as may be amended.

** Guidelines on the method of calculation of the Energy Efficiency Existing Ship Index to be developed by the Organization.

Table 3. Reduction factors (in percentage) for EEXI relative to the EEDI Reference line

Ship type	Size	Reduction factor
Bulk carrier	20,000 DWT and Above	[20]
	10,000 and above but less than 20,000 DWT	[0-20*]
Gas carrier	15,000 DWT and Above	[30]
	10,000 and above but less than 15,000 DWT	[20]
	2,000 and above but less than 10,000 DWT	[0-20*]
Tanker	20,000 DWT and above	[20]
	4,000 and above but less than 20,000 DWT	[0-20*]
Container ship	200,000 DWT and above	[50]
	120,000 and above but less than 200,000 DWT	[45]
	80,000 and above but less than 120,000 DWT	[40]
	40,000 and above but less than 80,000 DWT	[35]
	15,000 and above but less than 40,000 DWT	[30]
	10,000 and above but less than 15,000 DWT	[15-30*]
General cargo ship	15,000 DWT and Above	[30]
	3,000 and above but less than 15,000 DWT	[0-30*]
Refrigerated cargo carrier	5,000 DWT and Above	[15]
	3,000 and above but less than 5,000 DWT	[0-15*]
Combination carrier	20,000 DWT and Above	[20]
	4,000 and above but less than 20,000 DWT	[0-20*]
LNG carrier	10,000 DWT and Above	[30]
Ro-ro cargo ship (vehicle carrier)	10,000 DWT and Above	[15]
Ro-ro cargo ship	2,000 DWT and Above	[20]
	1,000 and above but less than 2,000 DWT	[0-20*]
Ro-ro passenger ship	1,000 DWT and Above	[20]
	250 and above but less than 1,000 DWT	[0-20*]
Cruise passenger ship having nonconventional propulsion	85,000 GT and above	[30]
	25,000 and above but less than 85,000 GT	[0-30*]

* Reduction factor to be linearly interpolated between the two values dependent upon ship size. The lower value of the reduction factor is to be applied to the smaller ship size.

[to be developed: Amendments to Appendix VIII – Form of International Energy Efficiency (IEE) Certificate – to include the EEXI value]

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ANNEX 2

METHOD OF CALCULATION OF THE ATTAINED ENERGY EFFICIENCY EXISTING SHIP INDEX (EEXI)

1 The attained Energy Efficiency Existing Ship Index (EEXI) is a measure of ship's energy efficiency (g/t*nm) and calculated by the following formula:

$$\frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE}\right) + \left\{\left(\prod_{j=1}^{M} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) \cdot C_{FAE} \cdot SFC_{AE}\right\} - \left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}\right)}{f_i \cdot f_c \cdot f_l \cdot Capacity \cdot V_{ref} \cdot f_w}$$

2 In calculating the attained EEXI, parameters under the *2018 Guidelines on the method of calculation of the attained EEDI for new ships* (resolution MEPC.308(73) amended by resolution MEPC.322(74)) should be applied. The attained EEXI shall be verified by the Administration or the recognized organizations on a document basis in accordance with the guidelines developed by the Organization.

3 Ships falling into the scope of EEDI requirement can use their attained EEDI calculated in accordance with resolution MEPC.308(73) amended as an alternative to attained EEXI without re-calculation or re-certification.

4 If the attained EEXI/EEDI cannot meet the required EEXI, the ship shall improve the attained EEXI by choosing and implementing the most cost-effective measures for itself, such as shaft/engine power limit (EPL) to the optimum level, fuel blending/change, installation of energy saving device, retrofitting and/or any other verifiable options. In case of EPL, the limited engine power shall be sealed, in accordance with the guidelines developed by the Organization, so that the ship's crews cannot release it without permission.

5 The ship speed V_{ref} shall be calculated based on speed-power curve obtained from sea trial or tank test. For containerships, if the tank test has not been conducted at 70 % DWT condition, the ship speed V_{ref} at the condition shall be properly corrected based on tank test results at full load and ballast conditions.

6 For some pre-EEDI existing ships, some of the values in the EEXI formula, namely ship speed V_{ref} and engine fuel consumption *SFC*, may not be available in existing documents. In such cases, notwithstanding paragraph 2 of this annex, the following approximation can be applied:

.1 Approximate ship speed $V_{ref,app}$

Sea trial or tank test is needed to obtain absolute value of the ship speed V_{ref}. If sea trial or tank test has not been conducted, the following approximation can be applied:

$$V_{ref,app} = V_{ref,avg} - 2\sigma \text{ [knot]} \qquad (1)$$

where,

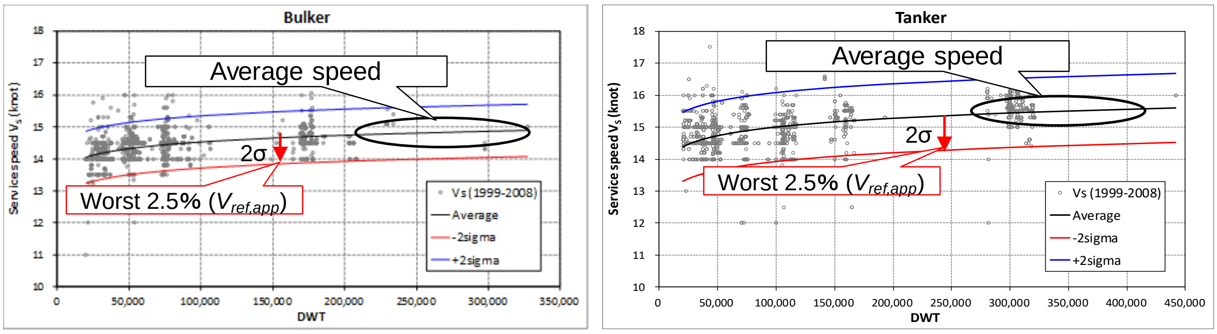
$V_{ref,avg}$ is a statistical mean of distribution of ship speed in given ship type and ship size, to be calculated in accordance with the guidelines developed by the Organization, based on IHS Seaweb database; and

σ is a standard deviation of distribution of ship speed in given ship type and ship size, to be calculated in accordance with the guidelines developed by the Organization, based on IHS Seaweb database.

Statistically, $V_{ref,app}$ refers to the worst 2.5% performer in terms of ship speed based on IHS Seaweb database. Therefore, this approximation will secure the EEXI value not overestimating the ship's energy efficiency performance.

Figure 1 illustrates the value of $V_{ref,app}$ (in the case of bulk carrier and tanker as an example).

Figure 1: The value of approximate ship speed $V_{ref,app}$



.2 Limited maximum engine power MCR_{lim}

If the attained EEXI calculated by using $V_{ref,app}$ cannot meet the required EEXI, the main engine power shall be limited by using shaft/engine power limit in order to improve the attained EEXI. In such a case, the limited maximum engine power MCR_{lim} to comply with the required EEXI can be calculated as follows:

$$MCR_{lim} = \left[\frac{\text{Required EEXI}}{\text{Attained EEXI with } V_{ref,app}}\right]^{\frac{3}{2}} \times MCR_{ME} \qquad (2)$$

where,

Attained EEXI with $V_{ref,app}$ is the attained EEXI calculated by using $V_{ref,app}$; and

MCR_{ME} is maximum continuous rating of main engine (Registered power).

Note: equation (2) is derived from a relationship that EEXI is proportional to the 2/3 power of engine power as shown below.

$$\text{Engine power} \propto (\text{Ship speed})^3 \rightarrow \text{Ship speed} \propto (\text{Engine power})^{\frac{1}{3}}$$

$$\begin{aligned}\text{Attained EEXI} &\cong \frac{C_F \cdot \text{SFC} \cdot \text{Engine power}}{\text{Capacity} \cdot \text{Ship speed}} \\ &\cong \frac{C_F \cdot \text{SFC} \cdot (\text{Engine power})^{\frac{2}{3}}}{\text{Capacity}} \\ &\propto (\text{Engine power})^{\frac{2}{3}} \qquad (3)\end{aligned}$$

From equation (3),

$$\frac{\text{Required EEXI}}{\text{Attained EEXI with } V_{ref.app}} = \left(\frac{MCR_{lim}}{MCR_{ME}}\right)^{\frac{2}{3}} \qquad (4)$$

.3 Engine specific fuel consumption *SFC*

Data for SFC should be used as described in section 2.7 of resolutions MEPC.308(73) and MEPC.322(74). For those engines which do not have a test report included in a NOx technical file, the SFC specified by the manufacturer and endorsed by a competent authority should be used.

For those engines which do not have a test report included in a NOx technical file and which do not have the SFC specified by the manufacturer, the following approximation can be applied:

$$SFC_{ME,app} = 190\ [g/kWh]$$

$$SFC_{AE,app} = 215\ [g/kWh]$$

The above fixed values are the same as those calculated for EEDI reference line (EIV: Estimated Index Value for existing ships).

7 Notwithstanding paragraph 6 of this annex, the limited maximum engine power MCR_{lim} to comply with the required EEXI can also be calculated by using the EEDI reference line value, instead of using using $V_{ref,app}$. The process is described as follows:

.1 Average value of MCRs corresponding to the EEDI reference line MCR_{avg} :

For $\Sigma MCR_{ME} \geq 10{,}000\ \text{kW}$

$$MCR_{avg} = \frac{\frac{EIV_{avg} \times \text{Capacity} \times V_{ref,avg}}{3.1144} - 215 \times 250}{190 \times 0.75 + 215 \times 0.025} \qquad (5)$$

For $\Sigma MCR_{ME} < 10{,}000\ \text{kW}$

$$MCR_{avg} = \frac{EIV_{avg} \times \text{Capacity} \times V_{ref,avg}}{3.1144 \times (190 \times 0.75 + 215 \times 0.05)} \qquad (6)$$

where EIV_{avg} is the reference line value of the required EEDI as defined in regulation 21.3 of MARPOL Annex VI.

Note: equations (5) and (6) are derived from the following relationships:

$$EIV = \frac{3.1144 \times (190 \sum P_{ME} + 215 P_{AE})}{\text{Capacity} \times V_{ref}} \qquad (7)$$

$$P_{ME} = 0.75 \times \Sigma MCR_{ME} \qquad (8)$$

$$P_{AE} = \begin{cases} 0.025 \times \Sigma MCR_{ME} + 250 & \text{For } \Sigma MCR_{ME} \geq 10{,}000 \text{ kW} \\ 0.05 \times \Sigma MCR_{ME} & \text{For } \Sigma MCR_{ME} < 10{,}000 \text{ kW} \end{cases} \qquad (9)$$

.2 Limited maximum engine power based on the EEDI reference line *MCR_{lim}*

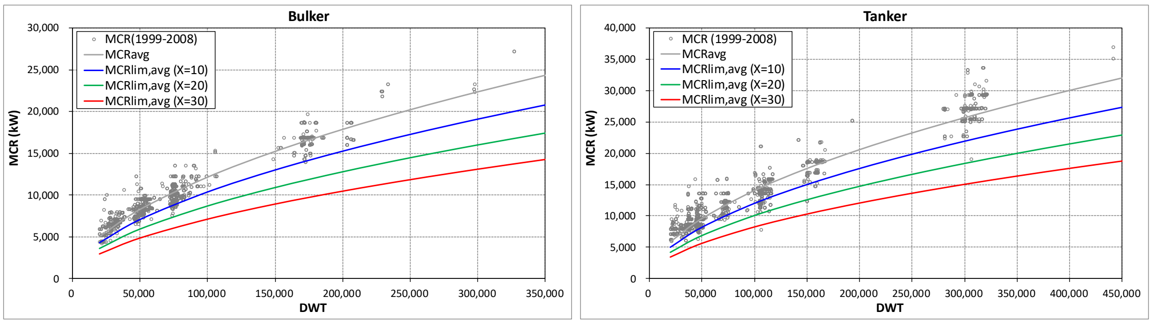
From the relationship between EEXI and MCR as shown in equation (4), MCR_{lim} can be calculated as follows:

$$MCR_{lim} = \left(1 - \frac{X}{100}\right)^{\frac{3}{2}} \times MCR_{avg} \qquad (10)$$

where *X* is reduction factor of the required EEXI as proposed in table 3 of annex 1 of this document.

Figure 2 illustrates the value of MCR_{lim} (in the case of bulk carrier and tanker as an example).

Figure 2: The value of approximate limited maximum engine power MCR_{lim} corresponding to different reduction late (X = 10, 20 and 30)



8 The above method of calculation of the attained EEXI, along with further approximation or adjustment for existing ships if any, should be incorporated in guidelines to be developed by the Organization. The guidelines could take form of either i) amendment to the 2018 EEDI guidelines (resolution MEPC.308(73) amended), ii) annex to the 2018 guidelines or iii) a set of new standalone guidelines.

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ANNEX 3

DESCRIPTION OF DATA AND METHOD COMPARING TECHNICAL AND OPERATIONAL EFFICIENCY USING EU-MRV DATA

1 The following is a detailed description of the analysis. The EU-MRV dataset contains reports from 11,506 ships* and includes reported fuel consumption, distance sailed and the Technical Efficiency of the ship. The Technical Efficiency is either EEDI, or, if not applicable, EIV (Estimated Index Value) of the vessel.

2 The operational carbon efficiency is calculated using the Annual Efficiency Ratio (AER) indicator, which is measured in grams CO_2 per DWT-mile. The CO_2 emissions and distance sailed are taken from the MRV data, while deadweight is taken from the IHS fleet database.

3 The Technical Efficiency and AER are related to the EEDI reference line value for the ships, as defined in MARPOL Annex VI. The EEDI reference line value is calculated based on ship type, deadweight and other relevant parameters, from the IHS fleet database.

4 The Technical Efficiency (TE) and Annual Efficiency Ratio (AER) performances are calculated as follows:

$$TE\ performance = 1 - \frac{TE}{EEDI_{reference}}$$

$$AER\ performance = 1 - \frac{AER}{EEDI_{reference}}$$

5 The following ship type specific correction factors used in the EEDI calculation guidelines are applied for the calculation of the AER:

.1 containerships: capacity is calculated as 70% of deadweight;

.2 general cargo ships: power correction factor f_j; and

.3 chemical tankers: cubic capacity correction factor f_c.

6 The MRV reports only cover voyages to, from and within the EU, and many ships only sail for a limited time on such voyages. In order to have long enough periods for the AER calculation, only ships that have sailed 10,000 nautical miles or more are included.

7 Ro-ro cargo, ro-ro passenger, cruise and LNG vessels are also excluded, due to the complexity of the EEDI calculation making it difficult to compare the AER with the EEDI reference line without applying ship specific correction factors. Passenger vessels are excluded due to the lack of an EEDI reference line.

8 When filtering out the excluded ship types (i.e. ships that have sailed less than 10,000 nm and those that do not contain a Technical Efficiency value), 5,509 ships are left for the analysis.

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* https://mrv.emsa.europa.eu/#public/emission-report, v24 retrieved 24 August 2019.