JUNE, 2021

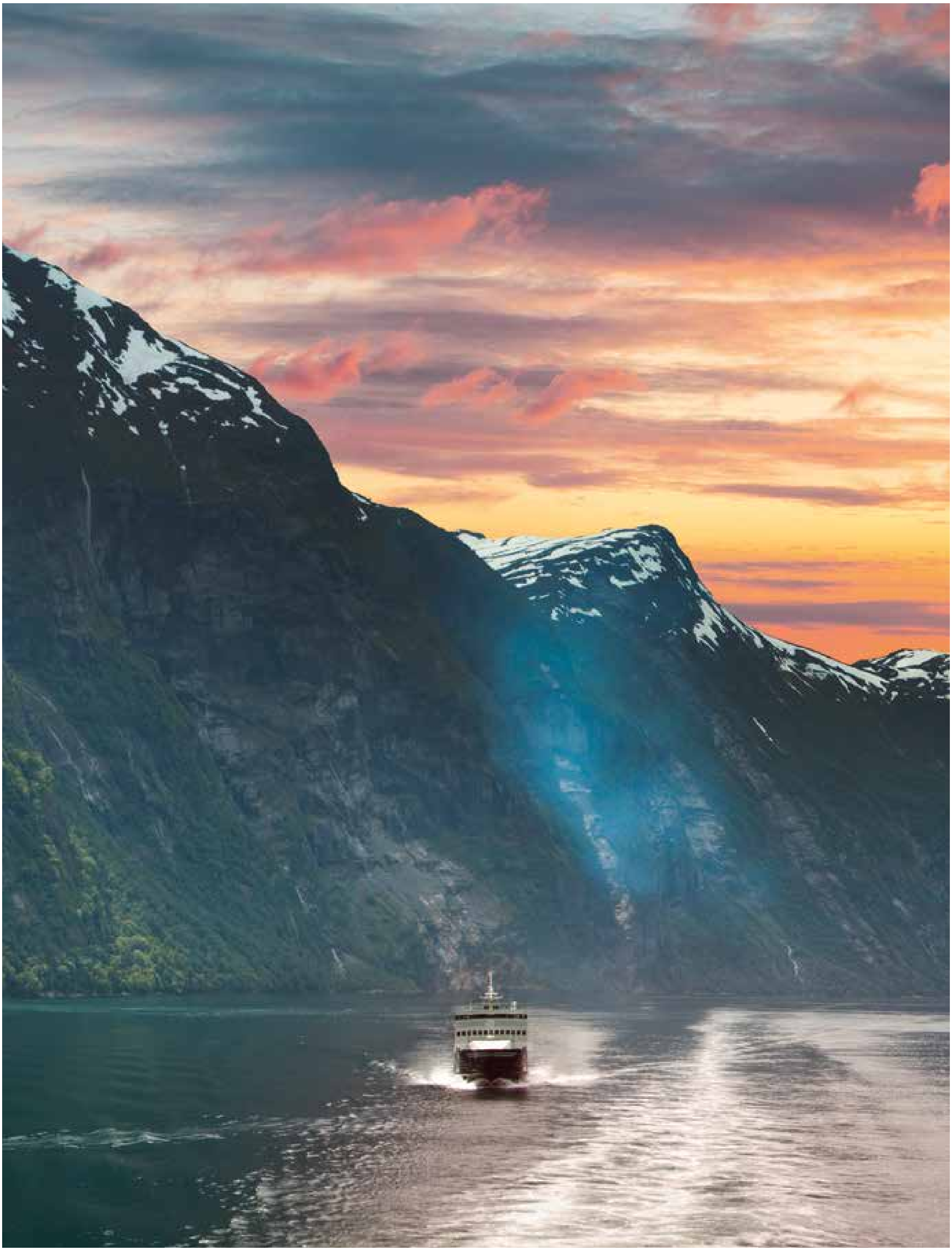
REDUCING SHIP EMISSIONS

IMO EEXI & CII / SEEMP

WHITE PAPER

BUREAU VERITAS

CONTENT



1. INTRODUCTION: UNDERSTANDING THE EMISSIONS CHALLENGE

The shipping industry is engaged in a considerable challenge to decarbonize operations significantly within the next decade as part of the global energy transformation that will enable us to preserve our world for future generations.

An important part of the global response to the threat of climate change is the Paris Agreement. This agreement, within the United Nations Framework Convention on Climate Change (UNFCCC), was signed in 2016 following a conference held in 2015. Its goal is to keep the increase in average global temperature to (well) below 2°C above pre-industrial levels, and to continue efforts to limit the increase to 1.5°C.

THE SCALE OF THE EMISSIONS CHALLENGE IN SHIPPING

This goal will, of course, impact shipping. According to the International Energy Agency (IEA), in 2019, the transport sector as a whole was responsible for 24% of world carbon dioxide (CO_2) emissions. The agency also concluded that in the same year, shipping was responsible for 11% of the transport sector's CO_2 emissions, and noted that the share of shipping emissions in global anthropogenic emissions increased from 2.76% in 2012 to 2.89% in 2018. In other words, although shipping is known as the most efficient means of transport in terms of CO_2 emissions per metric ton-mile, there is still work to be done.

The main source of ships' emissions is exhaust gas from internal combustion engines. These emissions are the "tank to wake" emissions. However, in a lifecycle assessment, it is also necessary to include emissions generated in the production of the fuel ("well to tank" emissions). Among the exhaust gases, CO_2 directly affects the global climate, while carbon monoxide (CO), sulfur oxides (SOx), nitrogen oxides (NOx), methane (CH_4), and particulate matters including black carbon (BC) impact both global climate and local environment with consequences for both human health and nature.

The International Maritime Organization (IMO) has set ambitious goals to reduce emissions, including a headline goal of a minimum 50% reduction in total annual GHG emissions by 2050 compared to 2008. To reach – and perhaps even exceed – these goals, the shipping industry will need to find the optimal mix of technical, operational measures and innovative solutions. This is a major challenge, but one which can be overcome if we leverage and combine the industry's talent and the determination of all shipping stakeholders. After all, shipping was originally a zero-emissions activity: until around 1840, sails were our primary means of propulsion!

BUREAU VERITAS' ROLE IN EMISSIONS REDUCTION

Bureau Veritas has a central role to play in helping the shipping industry understand and reduce emissions as part of our wider societal commitment. Our mission is to shape a world of trust by reducing clients' risks, improving their performance, and helping them innovate to meet the challenges of quality, health and safety, environmental protection, and social responsibility.

As a Business to Business to Society company, Bureau Veritas is contributing to transforming the world we live in; both externally through our support for our clients' corporate social responsibility (CSR) commitments, and internally, through our own CSR strategy.

TO REACH IMO'S EMISSIONS REDUCTION GOALS, THE SHIPPING INDUSTRY WILL NEED TO FIND THE OPTIMAL MIX OF TECHNICAL, OPERATIONAL MEASURES AND INNOVATIVE SOLUTIONS.

Internally, our scope of action is composed of three pillars, each with single or multiple references in the Sustainable Development Goals (SDGs) adopted by United Nations (UN) in 2015: a better workplace (goals 3, 5 and 8), a better environment (goals 13 and 14), and better business practices (goal 16).

Externally, our CSR performance is constantly subject to independent rating, the results of which are posted regularly on our corporate webpage.

Since 1828, Bureau Veritas has offered classification and value-added services for the marine industry, in the belief that the safety of the ship, its crew and the environment is of the utmost importance. Ship owners and operators need to ensure safety and compliance, while also managing other important priorities to remain competitive. These priorities include optimizing environmental performance to meet stricter industry-wide environmental regulations.

ABOUT THIS WHITE PAPER

This paper offers an overview of the application of selected IMO amendments to the MARPOL convention Annex VI, which requires ships to take both a technical and operational approach to reducing their carbon intensity.

While requirements for newly designed ships within the Energy Efficient Design Index (EEDI) have been in force for a while, new requirements for existing vessels (Efficiency Existing Ship Index - EEXI) are sure to impact their operations and may even shorten the expected service life due to costs incurred to reduce their GHG emissions. This paper will address the EEDI requirement as it is the foundation for the later EEXI requirements.

The Bureau Veritas team is, of course, available to clarify technical details and discussion the new requirements. We remain our clients' trusted partner and look forward to helping you ensure compliance and developing the future together.

2. WHAT IS THE OBJECTIVE OF THIS PAPER?

This white paper is designed to offer a concise overview of the latest IMO requirements regarding the reduction of GHG emissions from new and existing ships, including defined formulae and the initial consequences of their application. It is not our intention to list all the formulae and their parameters, but to give the reader an overview either as a starting point for discussions with Bureau Veritas experts or a way into more detailed IMO documents.

We explore the latest IMO Rules for existing vessels, and the ratio that is currently expected to comply with the EEXI including most relevant outcome of decisions from recent Marine Environmental Protection Committee (MEPC) 76 in June 2021. We also look at differences in this compliance ratio between different ship types.

Ahead of the CII Rules to be finalized shortly, the paper also discusses the impact of new criteria for Operational Carbon Intensity.

Bureau Veritas has drawn on data from more than 600 vessels available on our register and this combined with available data from external sources. The data has not been verified with the owners or operators, and certain assumptions have been made. As a result, our conclusions are to be considered as estimations more than accurate and precise results for given ship types.

IMO requirements are still being developed and fine-tuned due to the nature of international regulations and their development. This white paper uses information available as of June 2021. Examples of EEXI calculations, given in Appendix 1, have not been updated according to decisions at MEPC 76 as we do not expect significant impact on the results. Regular updates will be issued following outcome from future MEPC meetings.

3. IMO REGULATIONS GENERAL CONTEXT

3.1. OBJECTIVES

In 1973, IMO adopted the MARPOL convention, which is the main tool for preventing pollution of the marine environment by ships through operations or accidents. Over the years, this convention has been enriched with annexes, covering additional requirements to address specific topics. The MARPOL convention has be ratified by 99 states, which represent around 97% of the world tonnage.

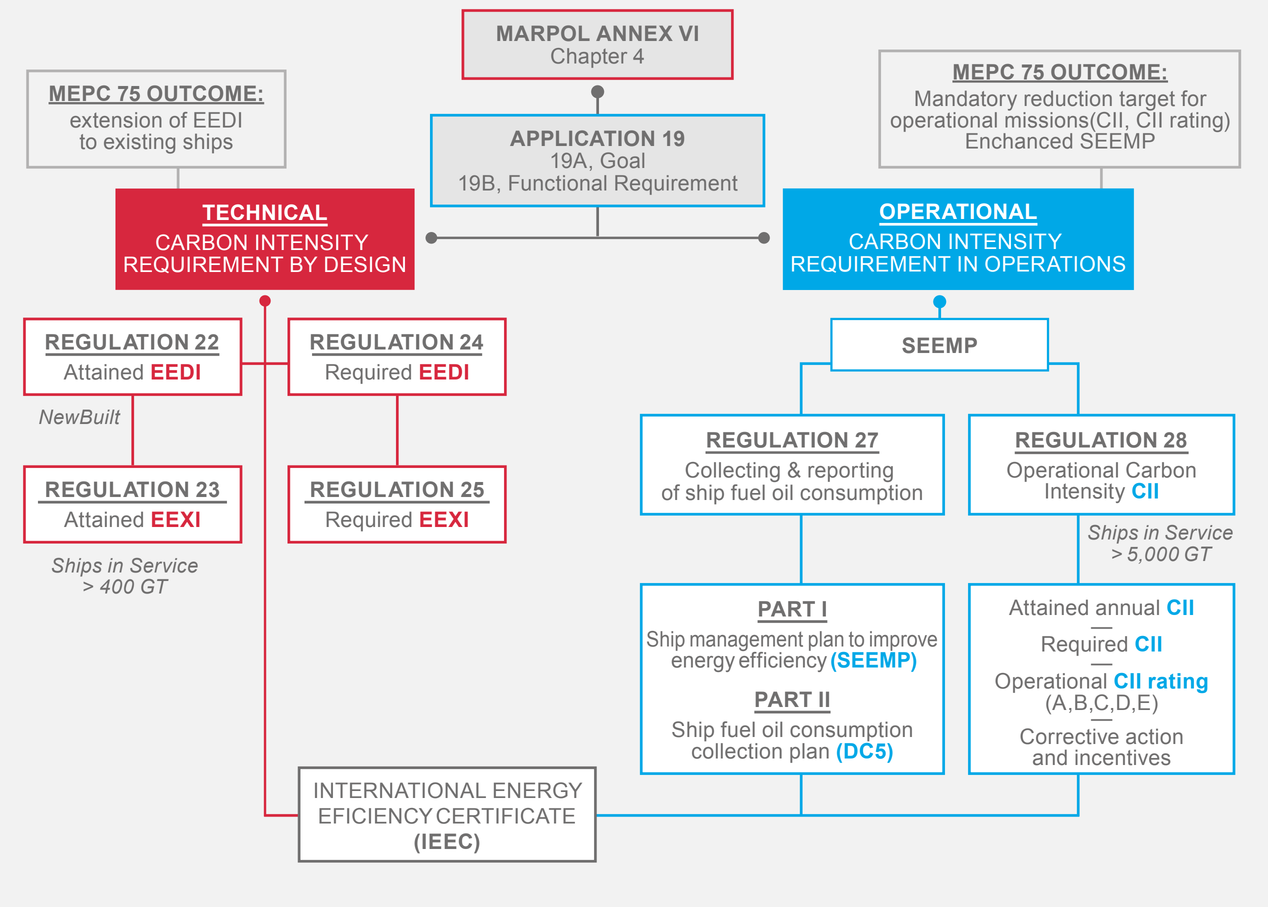
Annex VI, for the Prevention of Air Pollution from Ships, came into force in May 2005. It sets limits on sulfur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances. The annex has been revised many times to reflect the increased focus on reducing greenhouse gas (GHG) emissions from ships by introducing mandatory technical and operational energy efficiency measures.

Technical support for strategy development by the MEPC is given by an IMO Intersessional Working Group on GHG emissions (ISWG GHG) which reports to MEPC. The MEPC makes the final decision regarding implementation in MARPOL Annex IV.

The initial IMO GHG Strategy aims to reduce the carbon intensity of international shipping by 40% by 2030 (compared to 2008) and pursue efforts to achieve a 70% reduction by 2050. It also aims to reduce total annual GHG emissions from international shipping by at least 50% by 2050 compared to 2008. The strategy will be revised in 2023 following the latest acquired data from fuel consumption of ships over 5,000 GT initiated in 2019.

To achieve the goal of reducing carbon intensity by 70% compared with 2008, a mix of design, technical, operational measures and innovative measures (such as with fuel and technologies) is required.

REGULATORY FRAMEWORK



3.2. OVERVIEW OF THE REGULATORY FRAMEWORK AND TIMETABLE

Based on the IMO GHG Strategy, the shipping energy efficiency regulatory framework is set out in chapter 4 of the MARPOL ANNEX VI. It includes the following main components:

In summary, the latest changes include technical requirements for existing vessels and operational requirements for all vessels with the aim of reducing their carbon intensity.

The latest update and modification of chapter 4 took place following the last MEPC 76 meeting in June 2021. Recent developments are as follows:

- **MEPC 76, June 2021**
  Mandatory goal-based technical and operational measures to reduce carbon intensity (EEXI & CII). Calculation guidelines for attained EEXI. Survey and Certification guidelines for EEXI. Guidelines on shaft/engine power limitation system (EEXI). Guidelines for CII calculation, reference lines, reduction factors and rating of ships;
- **MEPC 75, November 2020**
  Extension of EEDI to existing ships: EEXI regulations will establish required EEXI for specified ship types and an attained EEXI to be calculated for each ship. Calculation of Required EEXI based on existing EEDI Phase 0 reference lines with reduction factors. Annual Efficiency Ratio AER and Carbon Intensity Index CII. Ship energy Efficiency Management Plan (SEEMP);
- **MEPC 74, May 2019**
  Acceleration of EEDI Phase 3 in 2022 (from 2025) for selected ship types and increase of reduction factor for specific ship types (gas carrier of 15,000 DWT and above, containership, general cargo ship, LNG carrier and cruise passenger ship with non-conventional propulsion);
- **MEPC 73, October 2018**
  Adoption of the initial strategy on the reduction of greenhouse gas (GHG) emissions.

What happens next?

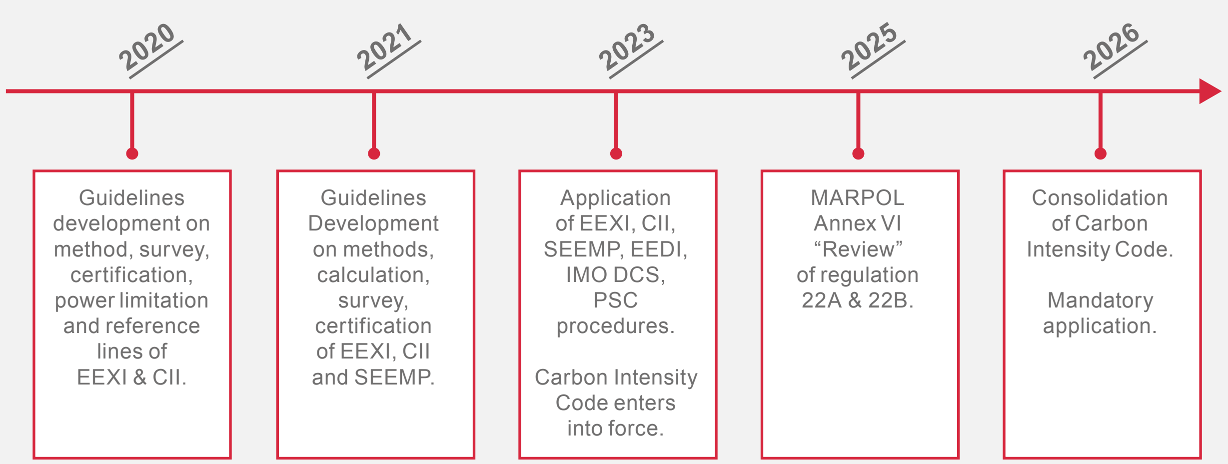
Based on ongoing discussions, we expect to see a number of steps taken by IMO in the near future, which will contribute to achievement of the overall timetable for the Carbon Intensity Code (see below). In the short term, it is expected that IMO will revise its initial strategy and complete the following measures:

- EEXI retroactive requirements applied to existing ships;
- improved Ship Energy Efficiency Management Plan (SEEMP) with mandatory reduction targets for operational emissions;
- both items mentioned above to enter into force by end of 2022.

The following are IMO's intentions as medium-term measures to reduce the carbon intensity of the fleet by at least 40%:

- establishment of an International Maritime Research and Development Board (IMRB), a non-governmental research and development (R&D) organization to be overseen by IMO member states;

ANTICIPATED IMO CARBON INTENSITY CODE TIMETABLE



- GHG and carbon emission factors for fuels in units of carbon dioxide equivalent (CO_2e). Gasses will be “converted” to CO_2e by multiplying with a factor for their global warming potential (GWP);
- new methane emission regulations;
- possible phase 4 of EEDI requirements.

The following updated guidelines are therefore expected to be released shortly by IMO:

- guidelines adopted at MEPC 76 for the EEXI calculation, associated survey, certification, and shaft-engine power limitation;
- guidelines adopted at the MEPC 76 for the calculation and certification of the Carbon Intensity Indicator (CII).

3.3. INDICES AND TOOLS

IMO’s first step was to introduce a standard for new vessels to immediately push the industry towards innovating and developing energy-efficient solutions. The result was the Energy Efficiency Design Index (EEDI), mandatory for all new ships of more than 400 GT (MEPC 62, July 2011) ref. MARPOL Annex IV. The formula offers the possibility of allowing for more stringent criteria over the years to come, taking into account the fact that ambitions will certainly grow over the coming years in order to meet overall objectives.

With the outcome of the MEPC 75, and as previously mentioned, the requirement for new vessels was extended to include the existing fleet. Using the same formula as for new vessels, with some adjustments, the industry can easily proceed with the application of the new requirements.

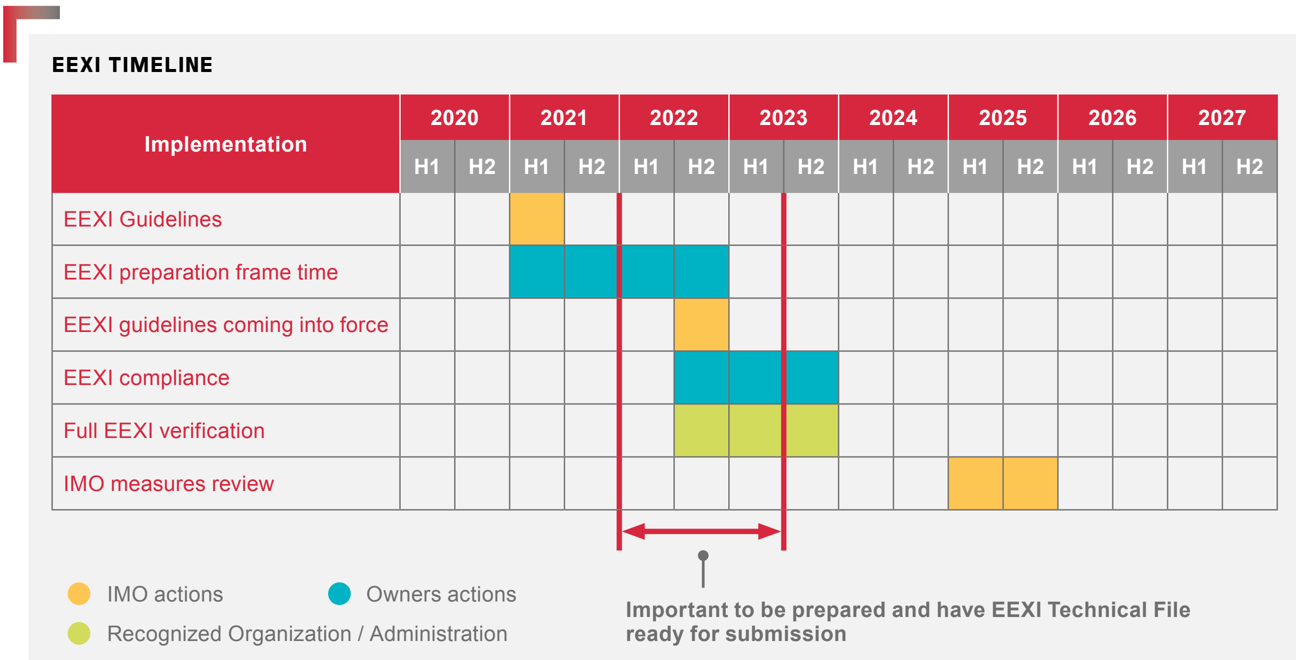
For owners and operators, it is now time to prepare the EEXI technical file, applicable to existing ships, and get ready to submit it. The application timeline allows for preparation in 2021-22, with final verification in 2023.

Bureau Veritas is introducing, VeriSTAR Green, a calculation tool available on our website to estimate the EEXI value for a given vessel in addition to all the decarbonization services our Group companies are offering. We want to offer the industry a free tool to enable stakeholders to test different assumptions and strategies to ensure compliance with the new standards.

Bureau Veritas is introducing, VeriSTAR Green, a calculation tool available on our website to estimate the EEXI value for a given.

New vessels: timeline for compliance with EEXI

The following chart gives an overview of key milestones for compliance with the EEXI requirements.



4. NEW SHIPS – THE ENERGY EFFICIENCY DESIGN INDEX (EEDI)

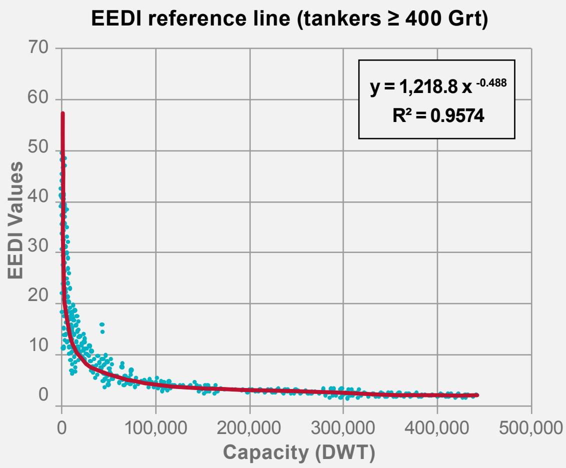
4.1. EEDI OVERVIEW

The Energy Efficiency Design Index (EEDI) is now a well-known parameter for all maritime operators and recognized as the most important technical measure for energy efficiency in new ships.

Aiming to ensure that new ships are designed to be energy efficient, it indicates the number of grams of CO_2 emissions per capacity mile (e.g., tonne mile), or the ratio between the impact on the environment and the benefits for society. This index represents only technical design aspects such as the optimization of engines, hull and propeller or the use of non-fossil fuels; it does not cover operational or commercial aspects. The calculation takes into account different ship types and size segments. The EEDI has a constant value, which will only be changed in the event of ship modification.

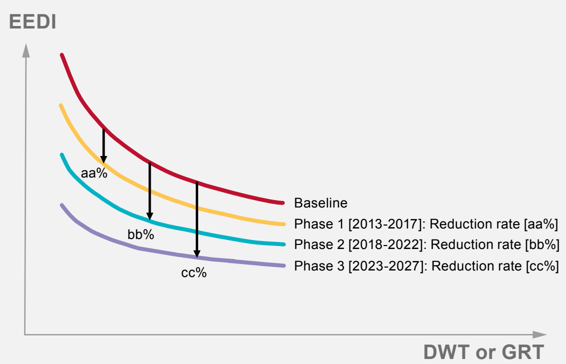
For each new ship, the EEDI attained must be equal to or lower than the required EEDI. Introduced in 2013 initially for a two-year phase zero, the required level is reduced every five years, which forces the marine industry to invest in new technologies to become more energy efficient.

DEFINITION OF THE EEDI BASELINE



Source: Fairplay

DEFINED REDUCTION RATES



The **EEDI baseline** is defined for selected group of ships representing an average index value calculated as the mean value for ships concerned.

Reduction rates have been established up to beginning of 2025.

EEDI FORMULA – PARAMETERS EXPLAINED

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

Parameter	Description	Source
CF	Non-dimensional conversion factor between fuel consumption and CO_2 emission	MEPC 245(66) "2014 Guidelines on the calculation of the Attained EEDI for new ships"
V_{ref}	Ship speed in nautical miles per hour (knot)	At design stage Speed-Power curves obtained from model testing; at final stage Sea Trial Report
$Capacity$	Computed as a function of Deadweight as indicated in 2.3 and 2.4 of MEPC 245(66) "2014 Guidelines on the calculation of the Attained EEDI for new ships"	Stability Booklet
P_{ME}	75% of the Main Engine MCR in kW	NOx Technical File
P_{AE}	Auxiliary Engine Power	MEPC 245(66) "2014 Guidelines on the calculation of the Attained EEDI for new ships"
P_{PTI}	75% of rated power consumption of shaft motor	
P_{eff}	Output of innovation mechanical energy efficient technology for propulsion at 75% main engine power	
P_{AEeff}	Auxiliary power reduction due to innovative electrical energy efficient technology	
SFC	Certified Specific Fuel Consumption in g/kWh	NOx Technical File
f_j	Correction factor to account for ship specific design elements (for e.g. ice classed ships, shuttle tankers)	MEPC 245(66) "2014 Guidelines on the calculation of the Attained EEDI for new ships"
f_W	Non-dimensional coefficient indicating the decrease of speed in representative sea conditions of wave height, wave frequency and wind speed	
f_I	Capacity factor for any technical / regulatory limitation on capacity	
f_c	Cubic capacity correction factor (for chemical tankers and gas carriers)	
f_ℓ	Factor for general cargo ships equipped with cranes and other cargo-related gear to compensate in a loss of deadweight of the ship	
f_{eff}	Availability factor of innovative energy efficiency technology	MEPC.1/Circ.815

4.2. IMPROVEMENT OF THE EEDI

As the threshold criteria for EEDI decreases over the coming years, designers will have to optimize energy consumption to bring attained EEDI below the required level.

For a new design there are obviously multiple solutions to improve the EEDI, although they must be economically feasible. Designers have a broad portfolio of possible technical solutions and can chose freely from the available options:

- propulsion optimization (CFD optimized hull shape, bulbous shapes, trim options, etc.);
- engine optimization / tuning / derating (lower energy consumption in main and auxiliary engines);
- alternative fuels;
- energy-saving devices (such as sails and air lubrication systems - ALS);
- paint and any other feature which has the purpose of reducing energy consumption.

We will come back to some of these options in the following chapter as we explore ways to upgrade existing vessels.

4.3. CERTIFICATION OF THE EEDI

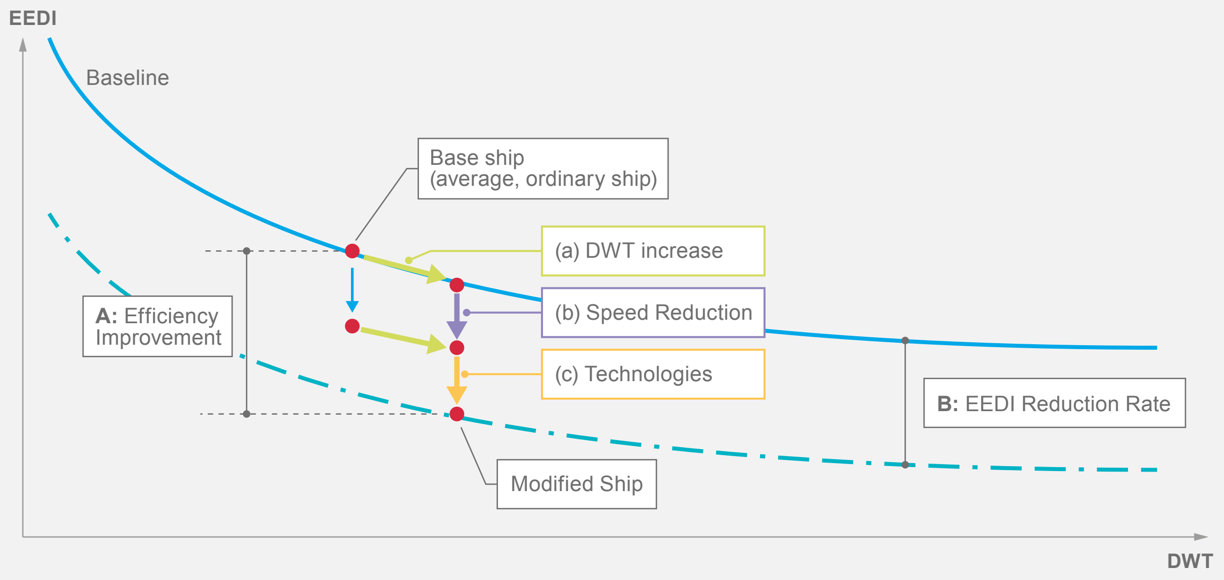
Following the amended requirements outlined in MEPC 254 (67), the EEDI calculation and associated technical documentation must be approved during the design stage and confirmed during sea trials through the completion of the initial survey. The ship's International Energy Efficiency Certificate (IEEC) can then be issued.

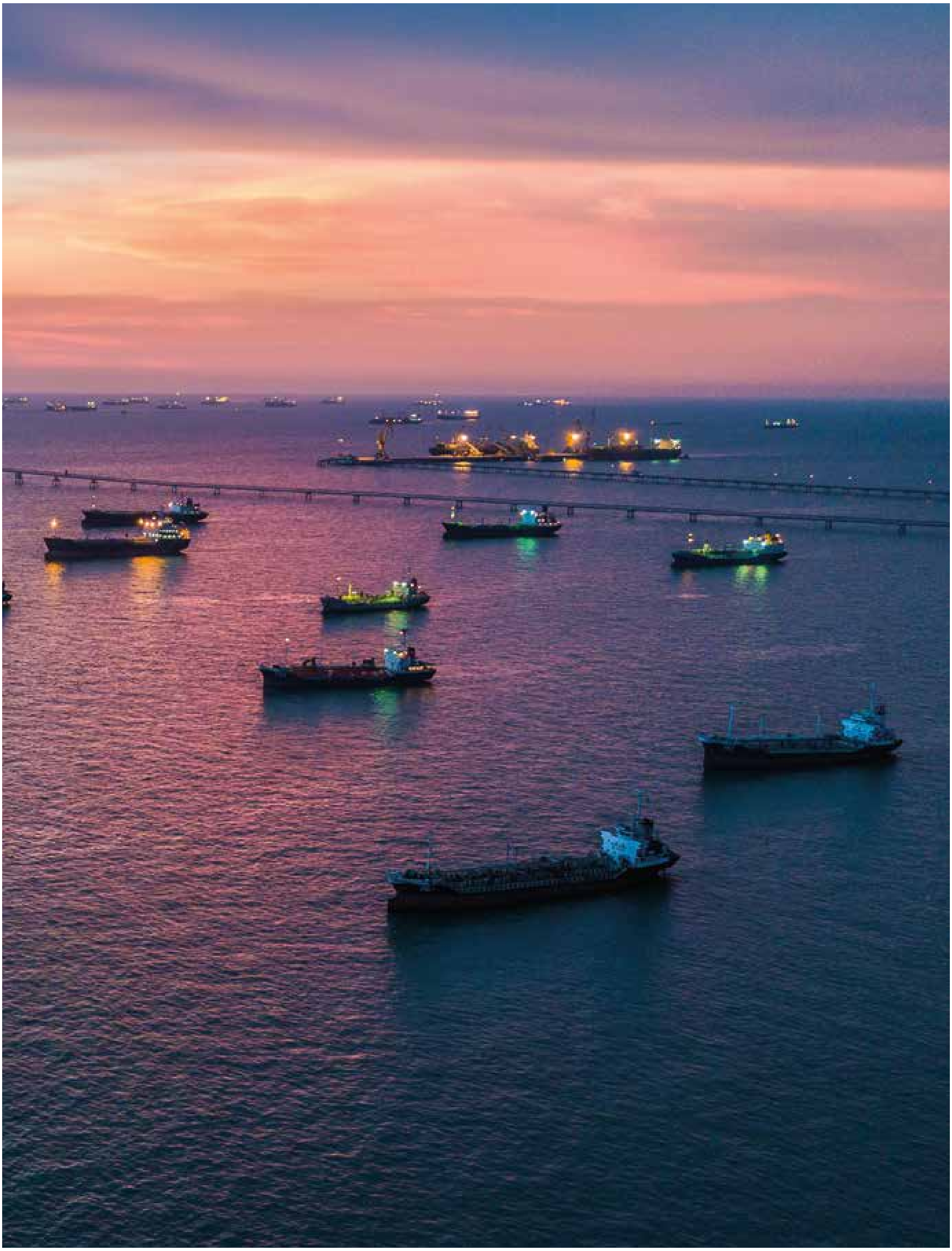
The EEDI calculation must be performed in accordance with requirements and following the building schedule, yard contract date, and delivery date as stipulated in EEDI scheme regulations 20 and 21, Phase 2, 3 and the upcoming Phase 4.

An IEEC is issued for all ships of 400 GT and over that undertake international voyages.

If a ship is equipped with innovative energy-efficiency technologies (e.g., an air lubrication system, a waste heat recovery system), relevant verification must be carried out in accordance with the 2013 guidance on treatment of innovative energy-efficiency technologies for calculation and verification of the attained EEDI (IMO MEPC.1/Circ.815).

POSSIBILITIES TO IMPROVE EEDI





5. ALL SHIPS – IMO DATA COLLECTION AND REPORTING FRAMEWORK

During the MEPC 70, held in October 2016, the IMO adopted a mandatory Fuel Oil Data Collection System (DCS) for international shipping, requiring ships of 5,000 GT and over to collect and report data to an IMO database as of 2019. This process is stipulated in Regulation 22A of chapter 4, Annex VI of MARPOL. Aggregated data is to be reported to Flag Authorities at the end of each calendar year. Flag Authorities will then submit aggregated data to the IMO for anonymized publication.

The Ship Fuel Oil Consumption Data Collection Plan (DCP), SEEMP Part II, describes the particulars of the ship as well as procedures, systems and responsibilities to monitor fuel consumption, distance traveled and hours sailed. The Data Collection System (DCS) is required within Part II of the SEEMP and a statement of compliance must be available on board the vessel.

The European Union (EU) has also introduced new regulations on monitoring, reporting and verifying fuel consumption (MRV shipping) for all merchant vessels above 5,000 GT calling at European ports. While the IMO DCS is an anonymous public database, the EU MRV is a distinctive public database.

THE SHIP FUEL OIL CONSUMPTION DATA COLLECTION PLAN (DCP), SEEMP PART II DESCRIBES THE PARTICULARS OF THE SHIP AS WELL AS PROCEDURES, SYSTEMS AND RESPONSIBILITIES TO MONITOR FUEL CONSUMPTION, DISTANCE TRAVELLED AND HOURS UNDERWAY.

6. INTRODUCTION TO REQUIREMENTS FOR EXISTING SHIPS (EEXI AND CII SCHEMES)

6.1. TECHNICAL AND OPERATING MEASURES

In line with the IMO's ambitious goals for reducing GHG emissions from ships, the existing fleet is also now impacted by new regulations to improve ships' energy efficiency. At the MEPC 75, the Committee introduced the following two-part approach:

- technical requirements are given in the establishment of an EEXI – retroactive EEDI requirements applied to existing ships. The EEXI is to be applied for the same type of vessels as the EEDI (400 GT and above);
- in addition, a new operational carbon intensity indicator has been introduced to address operational measures with a rating from A to E. Each ship's performance level is to be recorded in its Ship Energy Efficiency Management Plan.

The amendments to MARPOL Annex VI chapter 4 also require an improved SEEMP, which was initially introduced by MEPC 62, July 2011. This must now include targets for operational emissions.

6.2. ENERGY EFFICIENCY EXISTING SHIP INDEX

6.2.1. EEXI overview

Like the EEDI, the EEXI is a mandatory measure with a goal-based objective. It offers a number of options to improve energy efficiency and address this issue on all vessels regardless of differences in design, function, and size.

The EEXI is applicable to ships in service with a GT of 400 or more. The EEXI requirement is applicable as of January 2023 for ships' first annual, intermediate or renewal survey conducted after January 1 of that year. Ships that fall within the scope of EEDI requirements can use the attained EEDI calculated in accordance with the 2018 guidelines on the method of calculation of the attained EEDI for new ships (resolution MEPC 308 (73), the "EEDI Calculation Guidelines") as an alternative to attained EEXI without recalculation or recertification, unless the attained EEDI for the vessel does not satisfy the required EEXI.

The attained EEXI should be calculated in accordance with regulation 20A of MARPOL Annex VI (renumbered 23 as per MEPC 76) and the guidelines on the method of calculation of the attained EEXI has recently been decided and issued at the MEPC 76.

The EEXI scheme is based on the same type, size and category of ships used for the EEDI requirements.

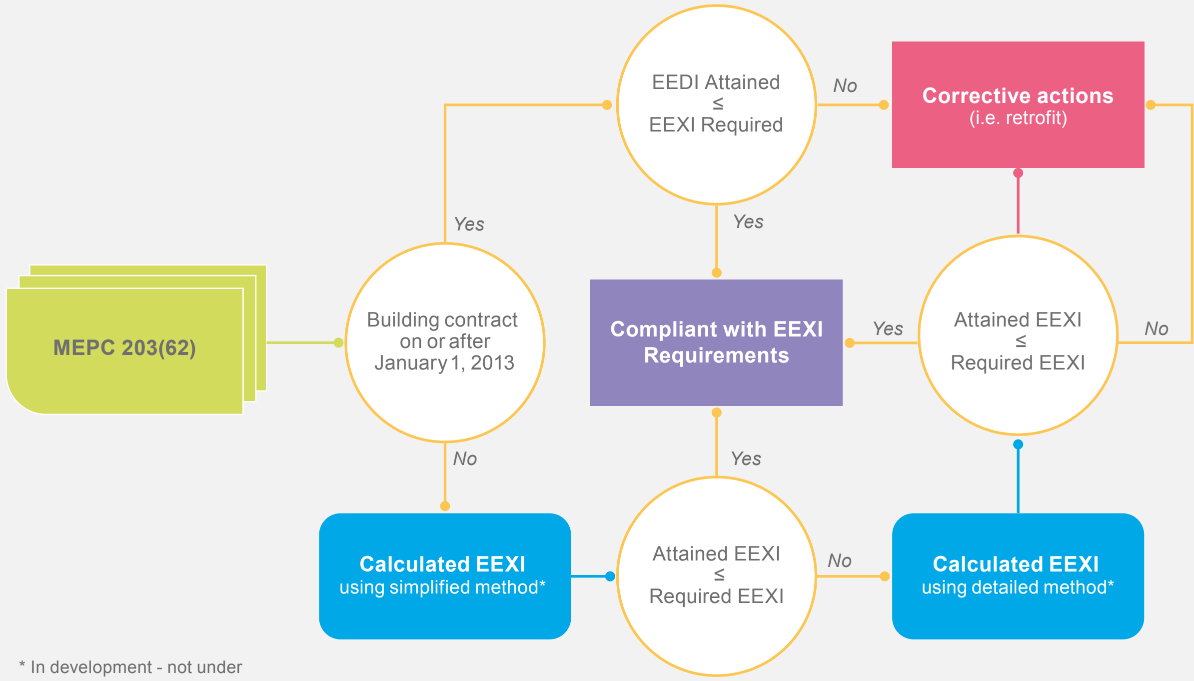
The requirement is that attained EEXI be less than the required EEXI. The final EEXI technical file and SEEMP are to be submitted to Bureau Veritas for review, and a verification survey must be carried out prior to issuance of a new IEE certificate. If the attained EEXI does not comply with the requirement, a solution must be found to raise the efficiency index to the required level.

It should be noted that yachts, fishing vessels, dredgers and tugs are not subject to these requirements.

Existing ships: timeline for compliance with EEXI

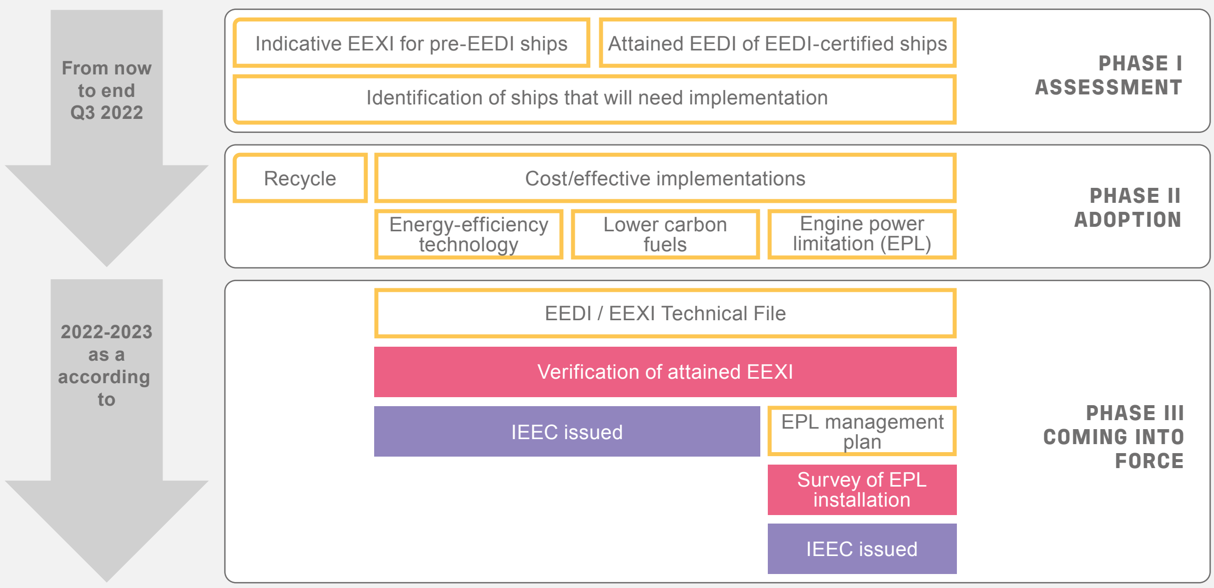
The table EEXI Application Timeline (next page) shows the timeline for the introduction of the EEXI and its application following possible amendments.

APPLICATION OF EEXI



* In development - not under

EEXI APPLICATION TIMELINE



6.2.2. EEXI calculation formula

The EEXI is calculated using the following formula.

EEXI CALCULATION FORMULA

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

Impact of propulsion
Impact of auxiliary services
Impact of PTI reduced with electrical innovations
Impact reduction due to mechanical innovations
Correction factors
Ship's work

f Correction factors
CF CO_2 emissions factor (fuel type)
SFC Specific Fuel Consumption (g/kWh)
P Power (kW)
$Capacity$ Weight (t)
V_{ref} Speed (knot)
ME Subscript for parameters related to Main Engine(s)
AE Subscript for parameters related to Auxiliary Engine(s)

EEXI Unit
g CO_2 / (tonnes * nautical miles)

6.2.3. EEXI vs EEDI

Calculation of the required EEXI will be based on the existing EEDI reference lines, with a table of reduction factors specific to the EEXI calculation. These reduction factors (in percentage) are relative to the EEDI reference line per ship type and size, and are similar to the EEDI values for 2022 (EEDI Phases 2 or 3).

The attained EEXI must be equal to or less than the required EEXI.

It should be noted that the Vref should be obtained from an approved "speed-power" curve. If this curve is not available, the ship speed Vref can be approximated from a statistical mean of distribution of ship speed and engine power, as per the formula introduced in the Marpol Annex VI guideline.

Standard values for the specific fuel oil consumption of main and auxiliary engines are defined within the EEXI calculation guideline. These standard values are conservative, so it is advisable to provide evidence and documentation for measured shop test data from NOx technical files as these could improve the attained EEXI.

Ship types impacted by the requirement for EEXI calculation, and their reduction factor "Y" is given in Regulation 21A, table 3.

EEDI VS EEXI

MARPOL ANNEX VI Chapter 4			
	EEDI	Versus	EEXI
Ship's type, category and size	New ships Regulation 21	=	New ships Regulation 21
Attained Index Formula	New ships Regulation 20 MEPC 322(74), MEPC 75 draft amendment	=	Regulation 20A Guideline in development
Required Index Formula	Regulation 21	=	Regulation 21A
Reduction factor	X=Regulation 21 table 1	<	Y=Regulation 21A table 3
	Phase 0-1	Adjusted =	
	Phase 2-3	=	
Reference Line Value	Regulation 21.3	=	Regulation 21A.1.2

SEEMP Regulation			
	Regulation 22A (DCS)	Versus	Regulation 22B (CII)*
Ships more than 5,000 GT	Applicable	+	Applicable

* Regulations 20.A.1 and 22.B.1: applicable to all ships that fall into one or more of the categories in regulations 2.25 to 2.31, 2.33 to 2.35, 2.38, and 2.39 of Annex VI.

REGULATION 21A TABLE 3

Ship Type	Size	Reduction Factor
Bulk Carrier	200,000 DWT and above	15
	20,000 DWT and above but less than 200,000	20
	10,000 DWT and above but less than 20,000	0-20*
Gas Carrier	15,000 DWT and above	30
	10,000 DWT and above but less than 15,000	20
	2,000 DWT and above but less than 10,000	0-20*
Tanker	200,000 DWT and above	15
	20,000 DWT and above but less than 200,000	20
	4,000 DWT and above but less than 20,000	0-20*

Ship Type	Size	Reduction Factor
Container Ship	200,000 DWT and above	50
	120,000 DWT and above but less than 200,000	45
	80,000 DWT and above but less than 120,000	35
	40,000 DWT and above but less than 80,000	30
	15,000 DWT and above but less than 40,000	20
	10,000 DWT and above but less than 15,000	0-20*

Ship Type	Size	Reduction Factor
General Cargo Ship	15,000 DWT and above	30
	3,000 DWT and above but less than 15,000	0-30*
Refrigerated Cargo Carrier	5,000 DWT and above	15
	3,000 DWT and above but less than 5,000	0-15*
Combination Carrier	20,000 DWT and above	20
	4,000 DWT and above but less than 20,000	0-20*
LNG Carrier	10,000 DWT and above	30
Ro-ro Cargo Ship (vehicle carrier)	10,000 DWT and above	15

Ship Type	Size	Reduction Factor
Ro-ro Cargo Ship	2,000 DWT and above	5
	1,000 DWT and above but less than 2,000	0-5*
Ro-ro Passenger Ship	1,000 DWT and above	5
	250 DWT and above but less than 1,000	0-5*
Cruise Passenger Ship with non-conventional propulsion	85,000 DWT and above	30
	25,000 DWT and above but less than 85,000	0-30*

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

6.2.4. EEXI – Sensitive parameters and derived consequences

When the calculated EEXI is close to or beyond the allowed threshold, it is necessary to make adjustments for the given vessel to achieve compliance with the new requirement. It is therefore important to clarify which parameters are sensitive for the calculation.

As a corrective approach, the immediate action to improve the calculated EEXI should be to replace the conservative approximated reference speed with values derived from "speed power curves" and the standard values of the specific fuel oil consumption with shop test data.

Main Engine Power

The most important parameter for the determination of attained EEXI is the power of the main engine (PME). For the EEDI and EEXI calculation, this value takes into account the propulsion power and a fixed part of the auxiliary power, measured at the output of the crankshaft of the main or auxiliary engine.

The power PME is generally defined as 75% MCR of all main engines. However, for LNG carriers with diesel electric propulsion systems, the power PME is 83% of the rated output of the electrical propulsion motor(s) divided by the electrical chain efficiency from the output of the auxiliary engines to the output of the propulsion motor(s).

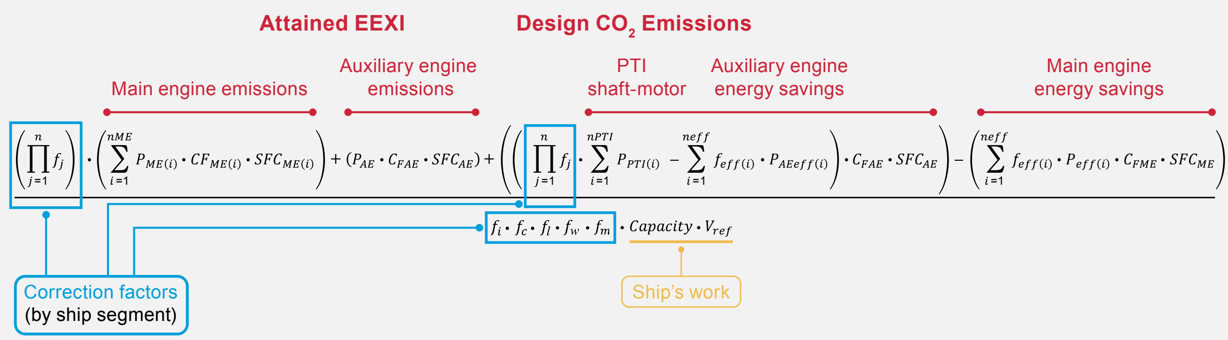
For LNG carriers with steam turbines, the power PME is 83% of the rated installed power of steam turbines.

At the recent MEPC it was decided to set main engine power at 83% of the limited installed power (MCRim), if lower than 75% of the original installed power (MCR), as mentioned above.

Please consult the 2015 industry guidelines for the calculation and verification of EEDI for further details on how to determine the PME.

One possible solution to improve the attained EEXI is to reduce engine power by fitting an overridable Engine Power Limitation (EPL) or Shaft Power Limitation (ShaPoLi). This will have an immediate effect on the result of the EEXI calculation.

EEXI IMPORTANT PARAMETERS



Auxiliary Power

The auxiliary power (PAE) is also included in the formula and needs particular attention. This power demand is largely dependent on loading and trading patterns and also incorporates a safety aspect. The auxiliary power can generally be considered as a fixed proportion of the main engine power. Details are given in the IMO calculation guidelines.

Fuel consumption

We have mentioned that the standard values for the specific fuel oil consumption of main and auxiliary engines as defined within the EEXI calculation guideline are conservative. This affects pre-EEDI ships and LNG carriers with steam turbines. Specific fuel consumption (SFC) can be determined from results recorded in the parent engine NOx Technical File as defined in the NOx Technical Code 2008. SFC is the corrected specific fuel consumption of the engines, measured in g/kWh. The subscripts ME(i) and AE(i) refer to the main and auxiliary engines respectively. SFCae is the power-weighted average among SFCae of the respective engines.

When gas fuel is the primary fuel for one or more of the main and auxiliary engines, the Cf factor and the SFC for gas (LNG) and pilot fuel should be combined at the relevant EEDI load point, as described in the IMO guidelines.

For LNG carriers with steam turbine propulsion, the SFC of the steam turbine should be determined during the running test of the main boilers and steam turbines on board and under load during sea trials.

Reference speed V_{ref}

Another important piece of data is the reference speed, V_{ref}. This should be obtained from an approved "speed-power curve" for the maximum scantling draft, obtained from sea trials. For EEDI-certified ships, V_{ref} should be obtained from an approved "speed-power curve".

IMO has evaluated what to do when the value cannot be determined from past sea trials. It was decided at the MEPC 76 to accept CFD calculations (ship-specific) to determine power-speed curve for a vessel.

Ship Capacity

Ship capacity is also an important parameter and is calculated as a function of the gross tonnage for cruise passenger ships and of the deadweight for other types of ships as indicated in the IMO guidelines. An exception is made for containerships for which 70% of the deadweight is to be used for capacity.

6.2.5. EEXI calculations for various ship types and sizes

Post-EEDI ships

Based on data from more than 600 vessels on our register, Bureau Veritas has estimated the EEXI index giving us the following indications:

- 70% of post-EEDI ships are expected to be compliant without any alterations;
- for non-compliant ships, the EPL (Engine Power Limitation) option is likely to be the most convenient way to achieve an acceptable EEXI.

For details, please refer to Annex 1.

Compared to all other ship types, the containerships we looked at have a rather high ratio of vessels with feeder size engaged in Europe, and due to their relatively high power considering the deadweight, the outlook for this group of vessels is somewhat pessimistic.

The group of LNG carriers we considered, none of which have steam turbines, look set to achieve compliance.

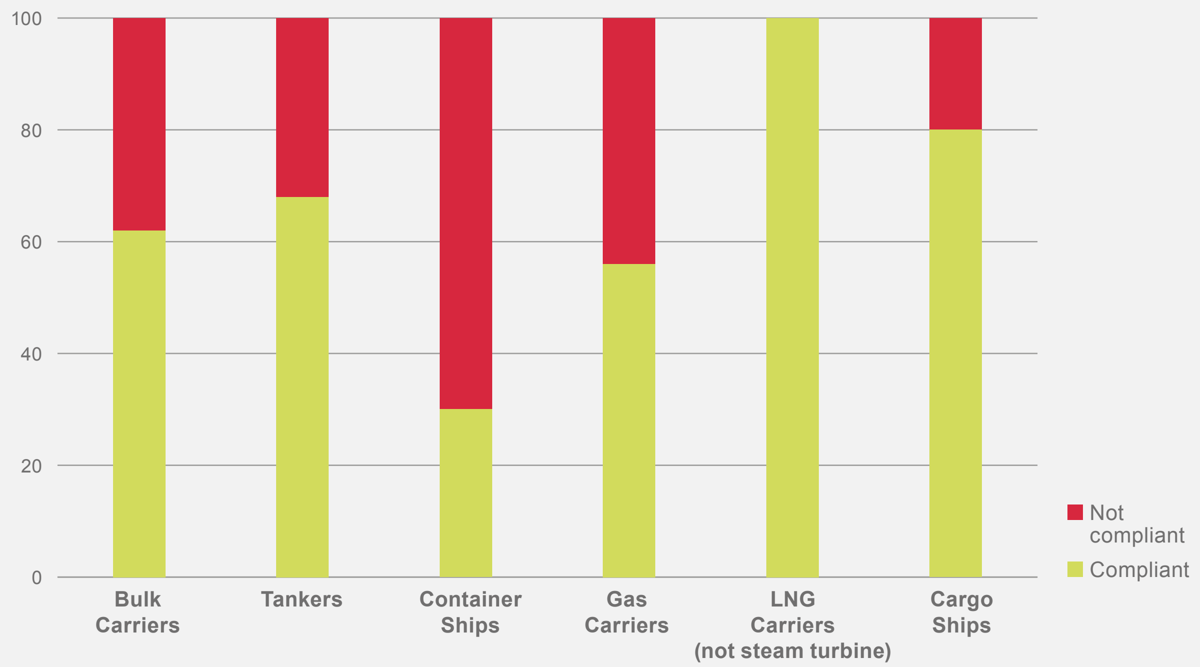
The overall results are satisfactory, as it seems likely that by using EPL, power could be reduced by 10-40% in order to ensure compliance with EEXI criteria. Currently, the average use of power varies between vessels but generally falls between 50% and 60%. As a result, impact will probably be limited for post-EEDI ships. Please see chapter 6.2.6 for use of EPL.

Bulk carriers

Bureau Veritas has analyzed the available data for more than 150 bulk carriers built after 2002 to estimate the impact of EPL on the EEXI obtained value in order to comply with relevant EEXI criteria. On average, we see that a 18% reduction of power is enough achieve compliance. This will result in a reduction of reference speed of 6.5%. There is different from the estimated value for the size category of bulk carriers.

Unsurprisingly, applied EPL depends on the size of vessels as well as the date of construction.

EEXI EXPECTED COMPLIANCE

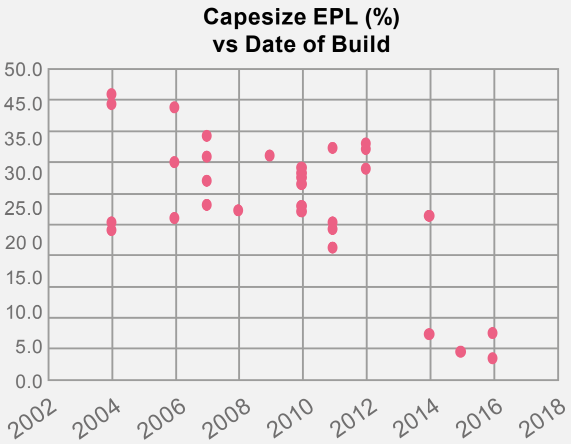


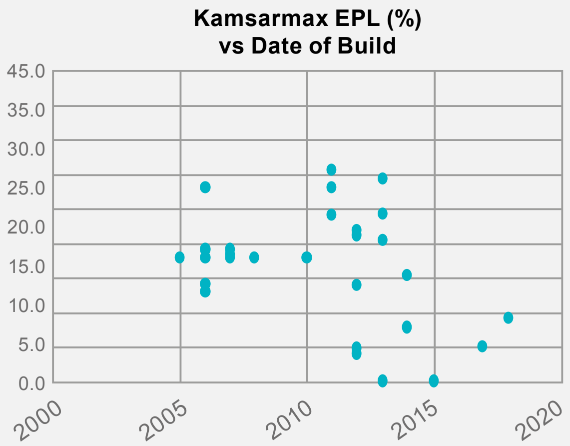
Source: BV EEDI data – Scope: post-EEDI ships

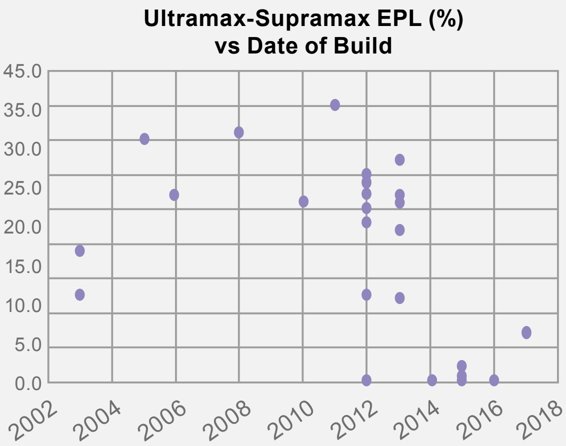
EEXI EFFECT BASED ON BV CALCULATIONS ON OVER 150 VESSELS BUILT AFTER 2002

Type	Required EPL Range	Average Required EPL	V_{ref} (75% MCR) before EPL (knots)	V_{ref} (75% MCR) after EPL (knots)	V_{ref} Reduction
Newcastlemax	0% - 6%	1%	14.4	14.4	0%
Capesize	7% - 46%	28%	14.8	13.0	11.6%
Minicapes	24% - 38%	32%	14.7	13.0	11.4%
Kamsarmax-Panamax	0% - 30%	13%	13.8	13.2	4.2%
Ultramax-Supramax	0% - 40%	14%	14.0	13.3	5.0%
Average		18%			6.5%

APPLICATION OF EPL FOLLOWING SHIP TYPE AND SIZE







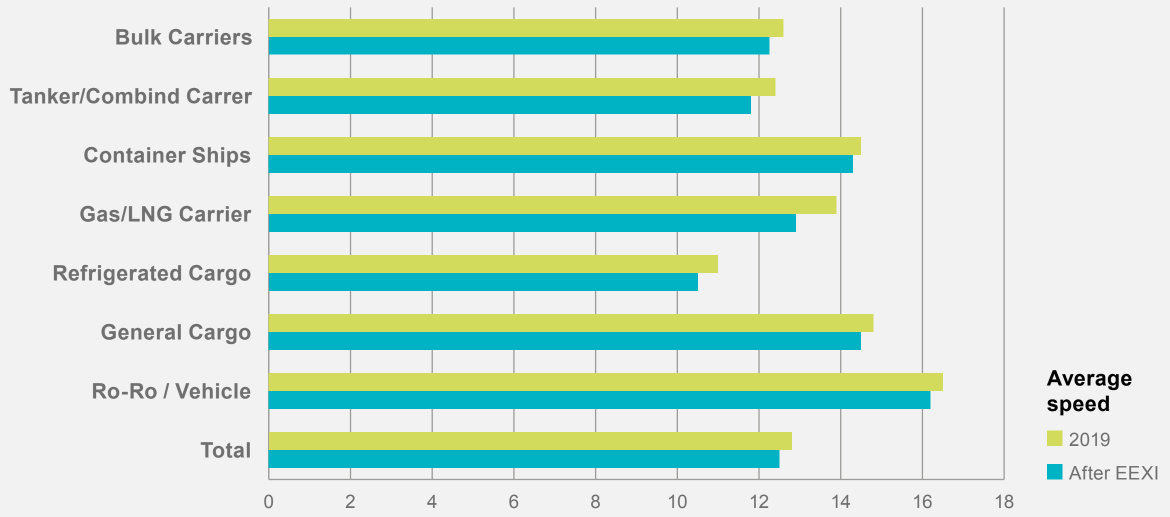
IMO Study on EEXI effect following EPL

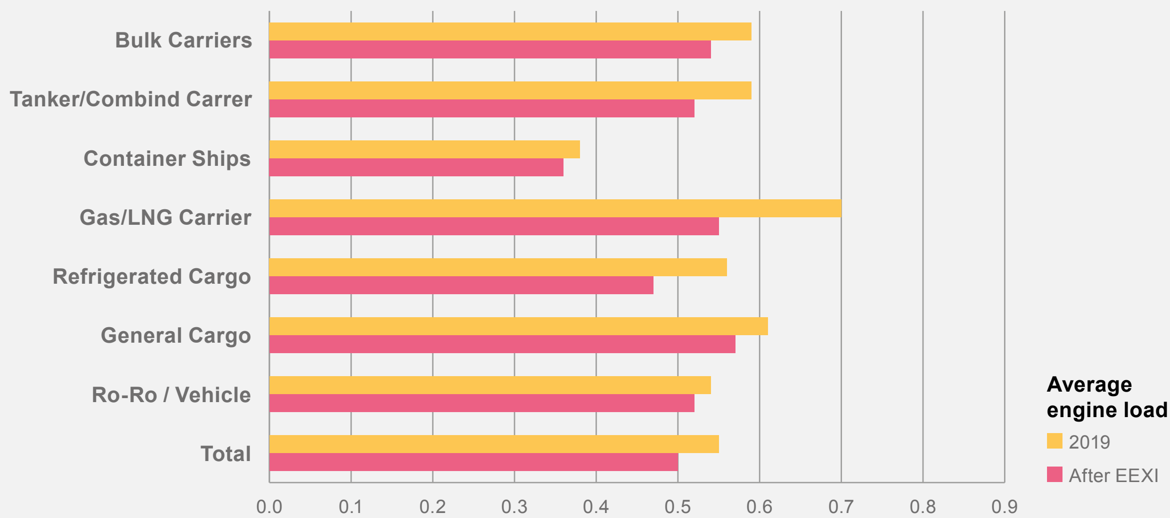
Following fuel consumption reported in 2019, IMO has conducted a study to estimate reductions in speed as a consequence of applying EPL. It concluded that overall speed will not be reduced by more than 5%. As mentioned previously, the speed and engine load are already reduced due to market conditions and fuel prices. The introduction of EEXI criteria will not affect average operation speed but will reduce time spent during high engine loads.

Ice class vessels

Our calculations have shown that even when applying the ice class correction factor in attained EEXI, required EPL will be remarkably high for ice-classed vessels compared to conventional ones. The situation is even worse for smaller vessels where the engine power needs to be disproportionally increased to cover the ice class minimum power. However, the large EPL figures derived from our calculation (between 38% and 51%) will not affect operations as the power reserve in ice-classed vessels is not normally needed and EPL can be released when operating in ice. Operations of most ice-class vessels will not therefore be impacted by the EEXI requirement.

EEXI EFFECT ON SHIP SPEED





Source: IMO ISWG-GHG 7/2/15 7 February 2020 – Study on world fleet operations for 2019

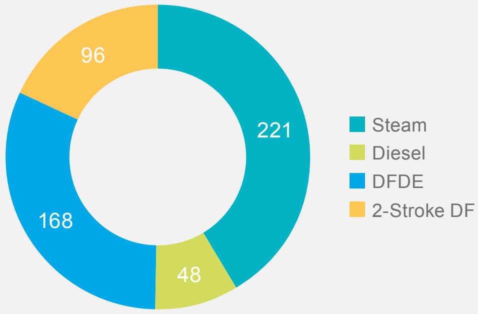
LNG carriers with steam turbines

It appears that the vast majority of steam turbine driven LNG carriers will be non-compliant due to the low efficiency of the propulsion system. Application of Shaft Power Limitation (ShaPoLi) to comply with EEXI could lead to consumption levels below the natural boil-off rate. In principle, the EEXI guidelines allow that "excessive boil-off gas" can be burned in engines or boilers to avoid releasing to the atmosphere or unnecessary oxidization in GCUs or steam dumping. Pending further clarifications by IMO on this provision, it seems that the boil-off rate operating point will be the maximum limit for these vessels, which corresponds roughly to 60% of their MCR. Significant reduction of speed is expected as a result. More than one third of the world's LNG Carrier fleet will need to operate at reduced speeds and inefficient turbine settings to comply with EEXI. The latter is also making compliance with CII an important challenge as there will be few options left to further reduce the emissions and keep up with a CII reduction rate of 2%.

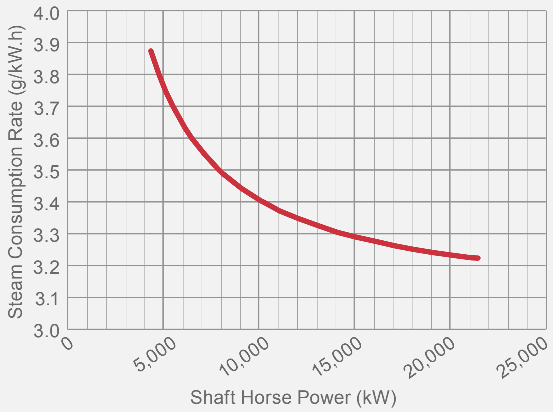
EEXI related to RoPax ships

Applying the proposed EEXI index on RoPax and Ro-Ro ships (vehicle carriers) is a challenge as a reduction of speed / power could artificially increase the EEXI and impact the EEDI value. The correction factor for Ro-Ro vessels has been adjusted to avoid discrepancy.

PROPULSION FLEET (> 40,000 m³) BY NUMBER WITHOUT FSU, FSRU OR LAID-UP SHIPS



TYPICAL SPECIFIC STEAM CONSUMPTION OF MHI STEAM TURBINE FOR 135,000 m³ LNG CARRIER



SUMMARY OF BV CALCULATIONS FOR DIFFERENT LNG CARRIER TYPES

Type	DF 2-Stroke	DF Diesel Electric	Steam Turbine
Date of Build (year)	2017-2020	2007-2019	1977-2014
Capacity 100% (m³)	174,000 – 180,000	155,000 – 174,000	125,000 – 150,000
SGC (g/kWh)	145 – 160	170 – 190	240 – 300
Daily Gas Consumption (t/day)	96 – 104	120 – 125	130 – 170
Natural BOG (t/day)	67 – 69	70 – 78	85 – 102
EEXI attained	4.0 – 4.1	7.4 – 8.0	9.0 – 11.0
EEXI required	6.9 – 7.1	7.2 – 7.4	7.1 – 7.8
Shaft Power Limitation	N/A	0% - 10%	25% – 45%
Daily Gas Consumption (t/day) after ShaPoLi	N/A	Not affected	90 – 76
Reduction of Speed	N/A	Not affected	From 19.5 kn to 16.5 kn

MEPC 76-7-X1 (TOR 1): For LNG carriers, the power from combustion of the excessive natural boil-off gas in the engines or boilers to avoid releasing to the atmosphere or unnecessary thermal oxidation, should be deducted from P ME(i) with the approval of the verifier.

6.2.6. ShaPoLi & EPL management

For non-compliant vessels, the ShaPoLi or EPL are likely to be the easiest options to achieve compliance as the required power limitation to meet the EEXI requirement is, in most cases, less than the reduction in load factors currently practiced.

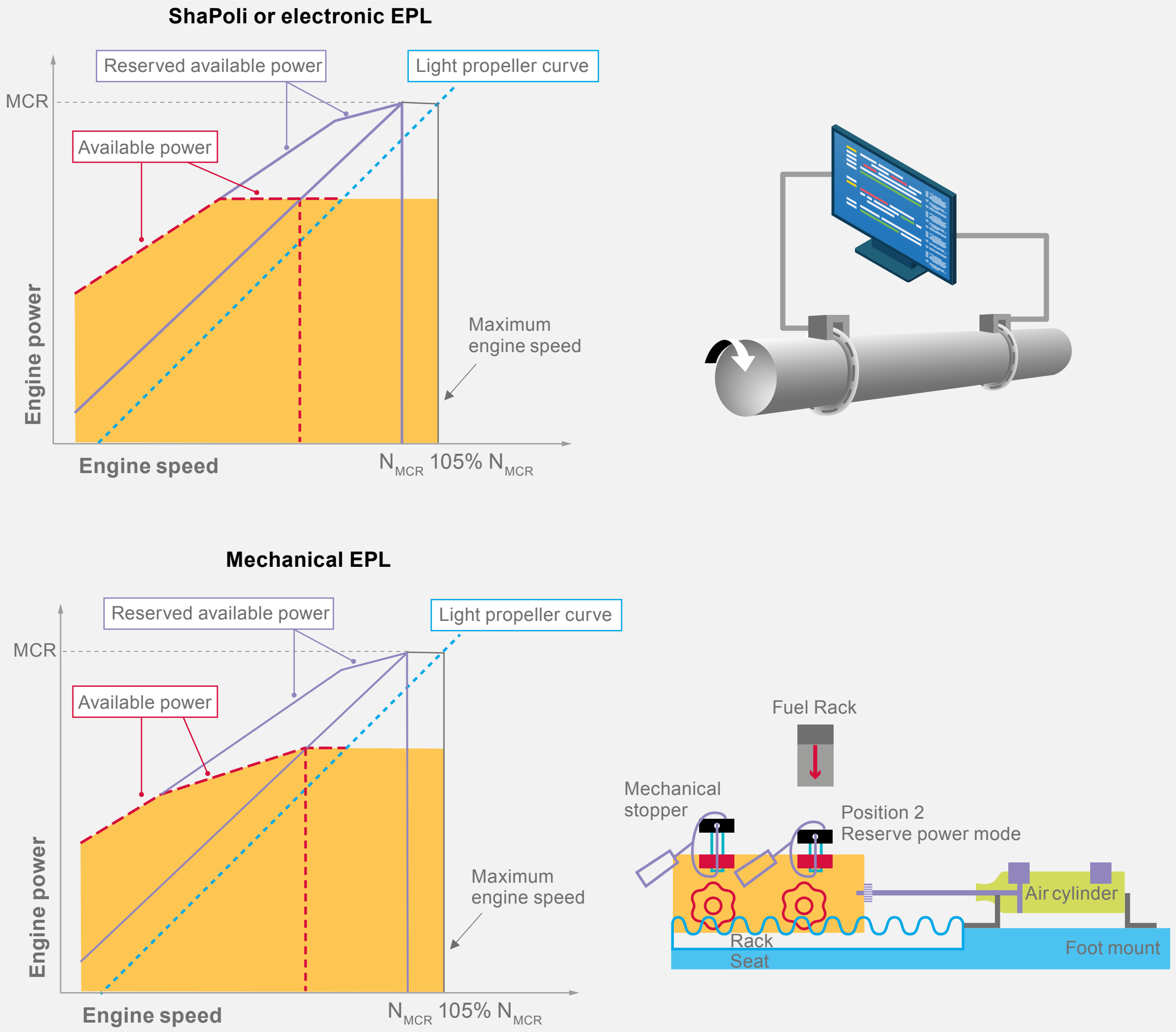
The principle of the ShaPoLi/EPL is that it is non-permanent but requires deliberate action by crew, following the master's authorization, to deactivate it. The ShaPoLi and EPL Onboard Management Manual (OMM) is to be verified by the RO. According to IMO regulations (Annex VI Regulation 3.1), the power reserve can be used in the following cases:

- adverse weather;
- ice-infested waters;
- search and rescue operations;
- avoidance of pirates;
- engine maintenance.

The use of the power reserve and related conditions are to be recorded in the OMM.

Guidelines on the Shaft/Engine Power Limitation system to comply with the EEXI requirements and use of a power reserve.

LIMITATION OF ENGINE POWER ELECTRONICALLY OR MECHANICALLY



6.2.7. Introduction of ESDs in EEXI compliance

One option to improve EEXI attained is to install energy-efficiency technologies to increase the reference speed for constant installed power. Energy-Saving Devices (ESDs) may be beneficial in cases where the EEXI is exceeded only slightly but more complex retrofits of hull/machinery may offer greater benefits. A CFD calculation can be used to document the ship-specific effect of an ESD in the EEXI calculation and the technical file.

Solutions may be based on:

Wind Assisted Propulsion (WAP)

Fitting of sails or other technology utilizing wind power on deck to assist in the propulsion of the vessel

Increased propeller efficiency

Various methods to enhance propeller efficiency by optimizing water flow around the propeller, etc.

Alternative fuel

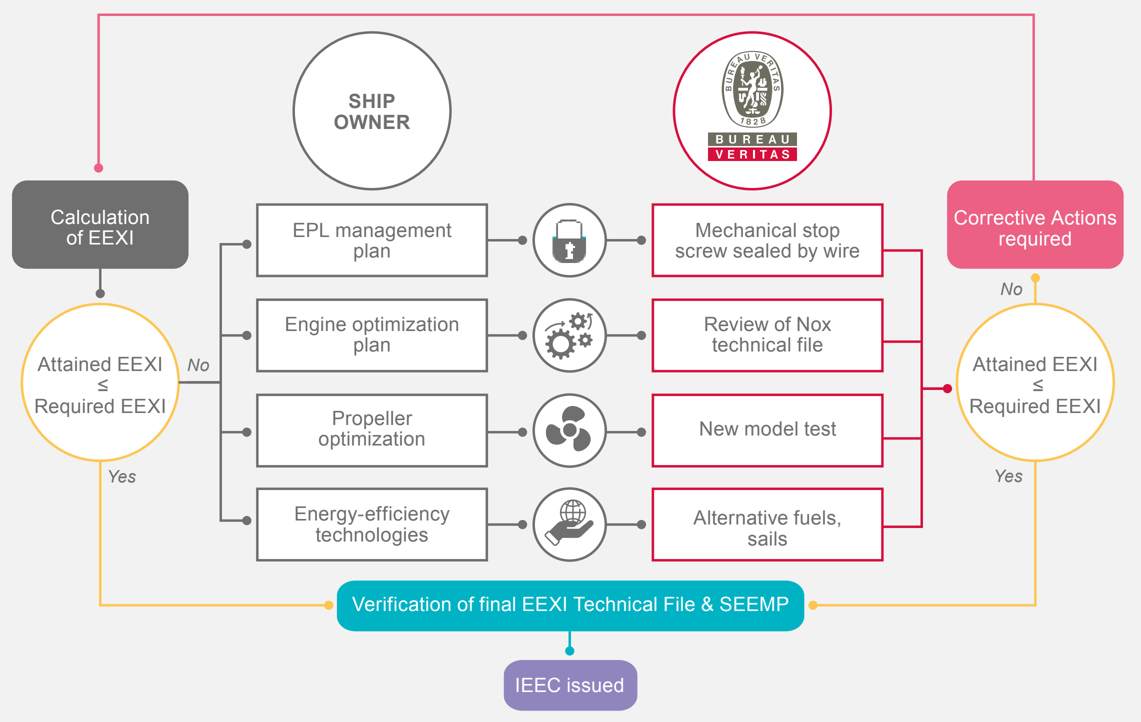
- switch to carbon-neutral or carbon-free fuel;
- LNG / CNG / LPG carbon capture;
- Bio-Methane;
- "Green" Methanol;
- "Green" Hydrogen.

However, the established criteria for EEXI calculation are today limited to the use of Diesel/Gas Oil, Light fuel Oil (LFO), Heavy Fuel Oil (HFO), Liquefied Petroleum Gas (LPG), Liquefied Natural Gas (LNG), Methanol and Ethanol.

It would be beyond the purpose of this paper to discuss the aforementioned options in detail. We would like to highlight that Bureau Veritas offers expertise in all the above areas. Please contact us to discuss these options in greater detail.

ENERGY-SAVING DEVICES CAN BE USED TO INCREASE THE REFERENCE SPEED FOR CONSTANT INSTALLED POWER

THE PATHS TO COMPLY WITH EEXI AND ISSUANCE OF IEE CERTIFICATE

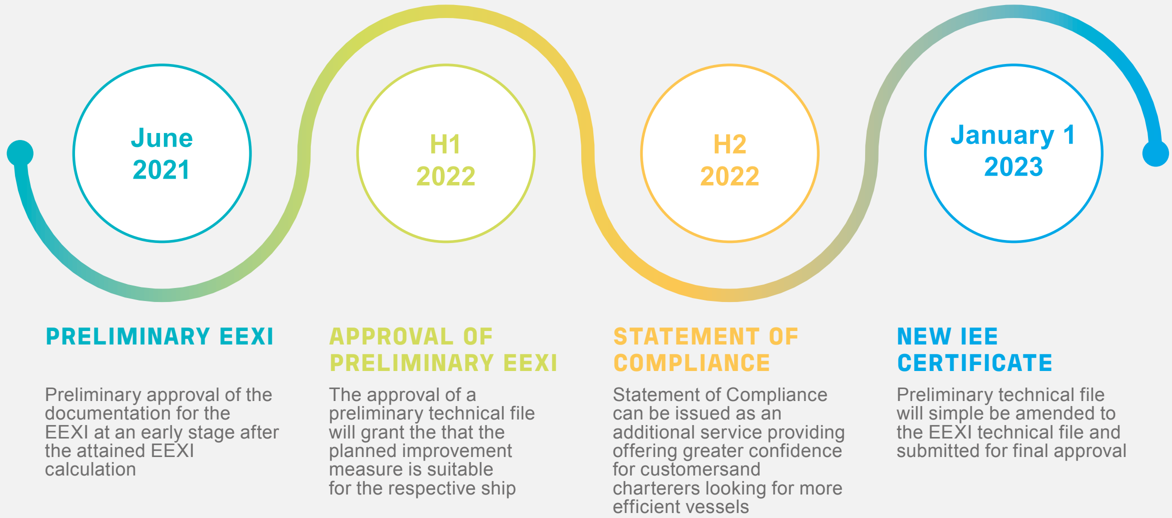


6.2.8. Composition of the EEXI technical file

The file to be submitted should document all calculations and give evidence for parameters used. In the event that corrective actions are required, all engineering calculations are to be made available, as shown in the diagram below.

The EEXI technical file must be prepared and validated before January 2023. However, Bureau Veritas can issue a statement of compliance prior to this date if a vessel already fulfills EEXI requirements. This enables the ship owner to show any concerned party that the ship is already compliant with IMO's GHG regulations.

THE EEXI TIMELINE



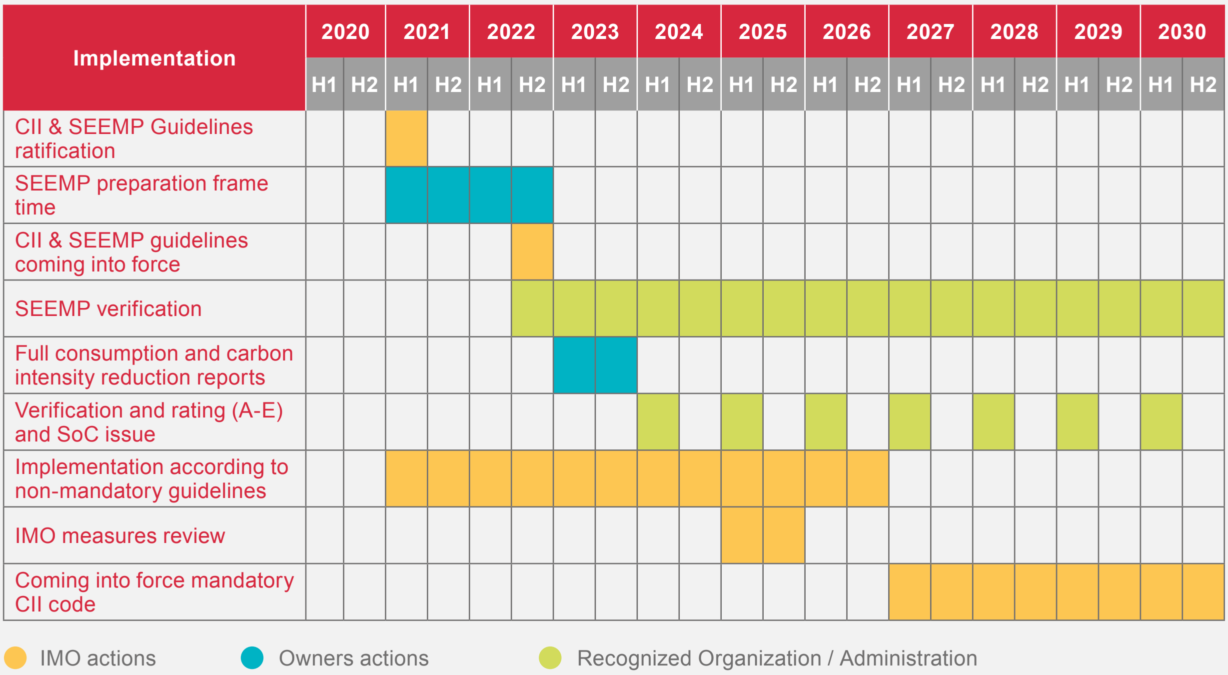
6.3. ANNUAL OPERATIONAL CARBON INTENSITY INDICATOR (CII) & SHIP ENERGY EFFICIENCY MANAGEMENT PLAN (SEEMP)

The marine industry is currently awaiting the outcome of the next MEPC meetings, during which guidelines for the application of CII and SEEMP will be finalized. These requirements currently in preparation will explain how to calculate the Carbon intensity Indicator CII (both attained and required) and the rating scheme. Calculations will be based on data in the Data Collection System (DCS) to rate each ship according to how its CII relates to an agreed CII reference value, and classify the ship annually in a category (A, B, C, D or E) according to its annual attained CII.

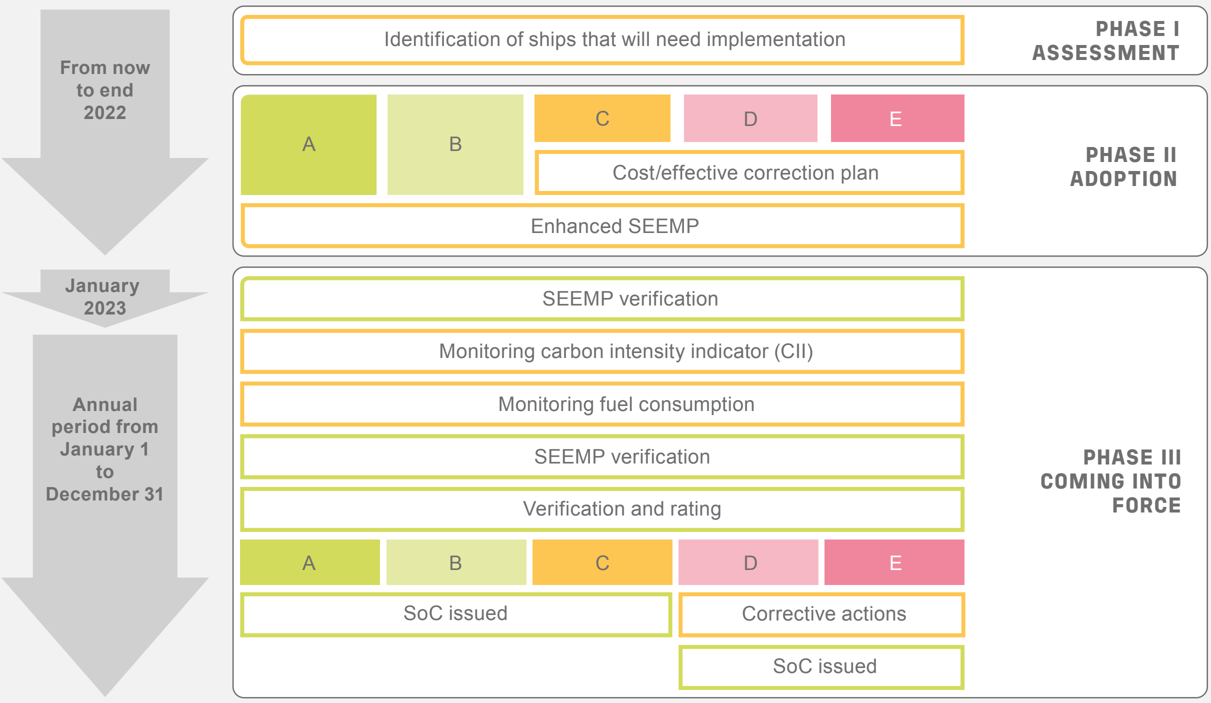
The SEEMP scheme is likely to become a tool for managing energy efficiency in a similar way to the International Safety Management (ISM) code, and ship owners may choose measures to reduce emissions from their vessels.

Based on information currently available (which will be confirmed later this year) the roadmap for development of this operational carbon intensity reduction measure has three phases, from assessment to coming into force. The chart below lays out this proposed timeline.

THE SEEMP TIMELINE



ROADMAP FOR DEVELOPMENT OF OPERATIONAL CARBON INTENSITY REDUCTION MEASURE



6.3.1. Attained CII – Definition and methodology

Initially, it is important to mention that the following definitions and methodology have not yet been finalized. Discussions are still going on as this text is being drafted, and the outcome of the upcoming MEPC meetings will determine the requirements to be adopted.

For now, then, the attained annual operational CII of an individual ship (applicable to all ships above 5,000 GT) is calculated as the ratio of the total mass of CO_2 (M) emitted, to the total transport work (W), undertaken in a given calendar year.

Based on different understandings of "transport work", IMO is considering two calculation methods for the attained CII: either the Annual Efficiency Ratio (AER) based on IMO DCS data or the Energy Efficiency Operational Index (EEOI). The AER represents a supply-based approach while the EEOI represents a demand-based approach. IMO will take the high variability of EEOI data and the compatibility with IMO DCS into consideration in the decision process.

IMO DCS reported data enables the calculation of a carbon intensity metric known as the Annual Efficiency Ratio (AER), using the parameters of the annual total fuel consumption and distance travelled, plus deadweight tonnage (DWT). AER is reported in unit grams of CO_2 per tonne-mile (gCO_2/dwt-nm).

The Energy Efficiency Operational Indicator (EEOI) is a carbon intensity metric similar to the AER. The difference is that capacity is expressed as actual cargo carried for each voyage. To ensure they are completely defined, ballast voyages should be attached to related cargo voyages and EEOI calculated for the complete round trip.

In order to work as an annual indicator, EEOI has to be calculated for each round trip voyage and the rolling average for the year must be calculated and reported. The unit of EEOI depends on the measurement of cargo carried or the transport work done, e.g., tons CO_2/(tons/nautical miles), tons CO_2/(TEU/nautical miles) or tons CO_2/(person/nautical miles), etc. The EEOI is compatible with data collected and reported for the EU MRV regulation.

Following the discussions at the ISWG GHG8 it has been noted that in demand-based measurement, the carbon intensity of international shipping has improved by 31.8% in year 2018 relative to year 2008, while in supply-based measurement the improvement has been 22.0%.
To move forward in the decision process, IMO will further study the difference in using each solution. The ISWG GHG8 is proposing to continue monitoring the development in annual carbon intensity improvement using both the AER and EEOI in parallel to the annual analysis of fuel consumption data reported in the context of IMO DCS.

CALCULATION OF ATTAINED CII

Actual annual CO_2 Emissions

$$CH = f \cdot \frac{CO_2\ Emissions}{Capacity \times Distance}$$

Actual annual Transport work

$$AER = \frac{\Sigma CO_2\ Emissions}{DWT_{max} \times Distance}$$

Supply Based

$$EE01 = \frac{\Sigma CO_2\ Emissions}{Cargo_{actual} \times Distance}$$

Demand Based

6.3.2. Required CII calculation formula

The ships are to achieve a required operational energy efficiency (required CII) in accordance with the carbon intensity indicator (CII) reduction factor.

The required annual operational carbon intensity indicator is to be calculated according to the Guidelines adopted at MEPC 76.

The required annual operational CII = (1 – Z/100) x CII®
where:

- Z is the annual reduction factor to ensure the continuous improvement of a given ships' operational carbon intensity within a specific rating level;
- CII® is the reference value.

These two parameters must be defined according to guidelines currently being prepared by IMO.

The annual operational carbon intensity reduction factor denoted "Z" is a positive value. It stipulates the minimum percentage points of the required annual operational carbon intensity indicator of a ship for a given year that should be reduced from the reference value. This carbon intensity of a ship is to be monitored at every quarter.

The guidelines on the reference lines for each ship type has been adopted at MEPC 76.

For a defined group of ships, the reference line is formulated as follows:

$$CII_{ref} = aCapacity^{-c}$$

where CII_{ref} is the reference value of year 2019;

- capacity is identical with the one defined in the specific carbon intensity indicator (CII) for a ship type;
- a and c are parameters estimated through median regression fits, taking the attained CII and the capacity of individual ships collected through IMO DCS in year 2019 as the sample, see below table.

The values of the reduction factors for each ship type will then increase over time, or at least remain at a certain level so as to ensure that the reduction in CO_2 emissions per transport work will be at least 40% by 2030 (compared to 2008), as given by the IMO objective. The guidelines on the operational carbon intensity reduction factors has been adopted at MEPC 76.

REQUIRED ANNUAL CARBON OPERATIONAL INTENSITY CII

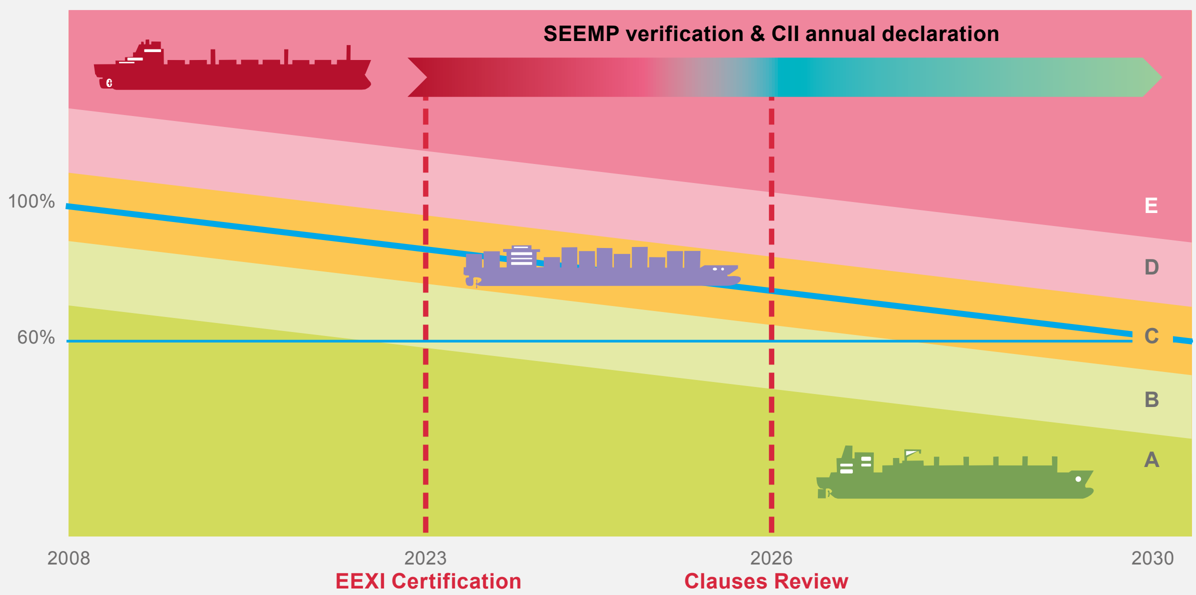


TABLE 1: PARAMETERS FOR DETERMINING THE 2019 SHIP TYPE SPECIFIC REFERENCE LINES

Ship type		Capacity	a	c
Bulk carrier	279,000 DWT and above	279,000	4977	0.626
	less than 279,000 DWT	DWT	4977	0.626
Gas carrier	65,000 DWT and above	DWT	2384E7	1.910
	less than 65,000 DWT	DWT	8032	0.638
Tanker		DWT	5118	0.607
Container ship		DWT	1963	0.487
General cargo ship	20,000 DWT and above	DWT	61293	0.854
	less than 20,000 DWT	DWT	361	0.336
Refrigerated cargo carrier		DWT	6736	0.599
Combination carrier		DWT	151991	0.930
LNG carrier	100,000 DWT and above	DWT	9.860	0
	65,000 DWT and above, but less than 100,000 DWT	DWT	1966E10	2.498
	less than 65,000 DWT	65,000	1966E10	2.498
Ro-ro cargo ship (vehicle carrier)		GT	5831	0.633
Ro-ro cargo ship		DWT	15958	0.677
Ro-ro passenger ship		GT	7691	0.586
Cruise passenger ship		GT	904	0.380

MEPC 76-7-X1 (TOR 1): For LNG carriers, the power from combustion of the excessive natural boil-off gas in the engines or boilers to avoid releasing to the atmosphere or unnecessary thermal oxidation, should be deducted from P ME(i) with the approval of the verifier.

6.3.3. Rating of ships

The guidelines on the operational carbon intensity rating of ships has been adopted at MEPC 76 (MEPC.338(76)).

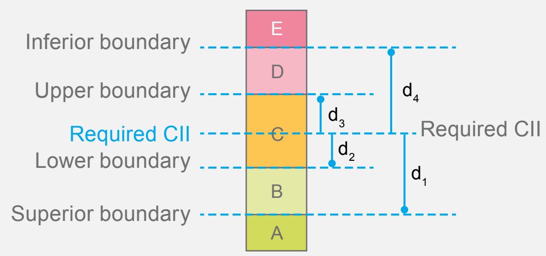
Operational carbon intensity rating is based on assigning a ranking label from among the five grades (A, B, C, D and E) to the ship based on the attained annual operational carbon intensity indicator, indicating a major superior, minor superior, moderate, minor inferior, or inferior performance level.

To facilitate the rating assignment, for each year from 2023 to 2030, four boundaries are defined for the five-grade rating mechanism, namely superior boundary, lower boundary, upper boundary, and inferior boundary.

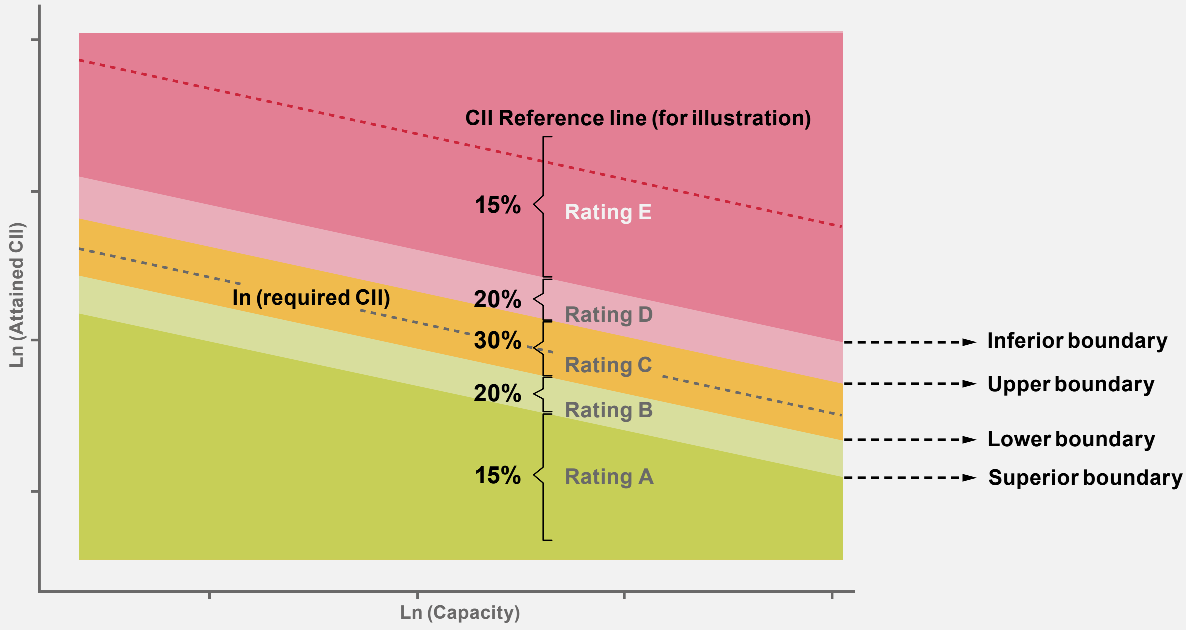
It was agreed at the MEPC 76 that given the incremental operational carbon intensity reduction factors over time, the boundaries for defining performance ratings should be synchronized accordingly, although the relative distance between the boundaries should not change. The rating of a ship would be determined by the attained CII and the predetermined rating boundaries, rather than the attained CII of other ships.

The middle point of rating level C is the value equivalent to the required annual operational CII set out in the regulations. Acting as a Recognized Organization of the Flag Administration, and using guidelines developed by IMO, Bureau Veritas will verify the attained annual operational CII, comparing it to the required annual operational CII to attribute the operational carbon intensity rating A, B, C, D or E.

RATING PRINCIPLE



OPERATIONAL ENERGY EFFICIENCY PERFORMANCE RATING SCALE



6.3.4. CII Exemptions

It is discussed that some conditions should not be reflected in the CII calculation, such as navigating ice conditions or sea states at Bf 7 or above.

6.3.5. Corrective actions and incentives

A ship rated E or rated D for three consecutive years must develop a plan with corrective actions to achieve the required annual operational CII. The SEEMP should include this plan along with corrective actions.

According to the available information from IMO, the revised SEEMP must be submitted to the Flag Administration for verification within one month after reporting the attained annual operational CII in accordance with the regulation.

In general, IMO is encouraging administrations, port authorities, and other stakeholders as appropriate to provide incentives to owners of ships rated A or B.

To obtain a correct and fair definition of both the attained and required CII, a certain number of parameters and principles are still to be fully explored at upcoming IMO meetings.

A certain number of ships will be rated D or E. IMO will therefore also have to provide guidance for acceptable contingency plans and corrective actions.

The corrective actions and incentives will be further detailed in the years to come and will be subject to discussion at each upcoming MEPC until 2026.

6.3.6. Improvement of CII

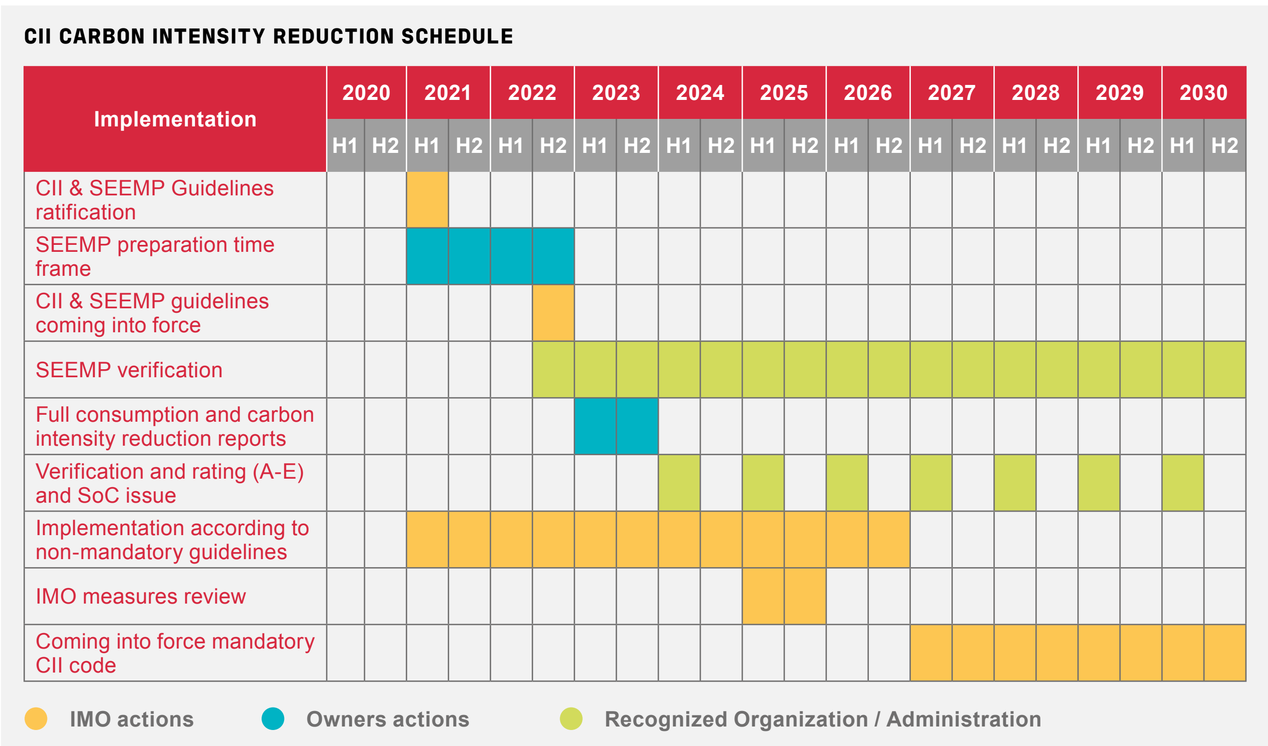
Several options exist to improve the CII, including changes to both design and operations. Naturally, some of them are easier to apply than others. For retrofit decisions, vessels and operational profile needs should be evaluated carefully to confirm suitability and financial feasibility.

Possible solutions include:

- waste heat recovery system;
- Air lubrication system (ALS);
- alternative fuels;
- improved logistics;
- Energy saving device (ESD);
- VFD control;
- weather routing;
- Wind assisted propulsion system (WAPS);
- LED lighting on board;
- hull cleaning and coating.

This white paper does not explore these options in detail, however Bureau Veritas has expertise in all of the solutions mentioned. Please contact a Bureau Veritas representative to discuss them further.

6.3.7. CII Carbon intensity reduction schedule



6.3.8. Summary of CII requirement

CII is required for all vessels over 5,000 GT.

For newbuildings and ships in service > 400 GT: SEEMP regulation 22.1.

For newbuildings and ships in service > 5,000 GT: SEEMP regulation 22.2 and 22A (IMO DCS).

For newbuildings and ships in service belonging to an EEDI/EEXI category and with a size of < 5,000 GT: SEEMP according to regulation 22.3, 22.4, and 22.5.

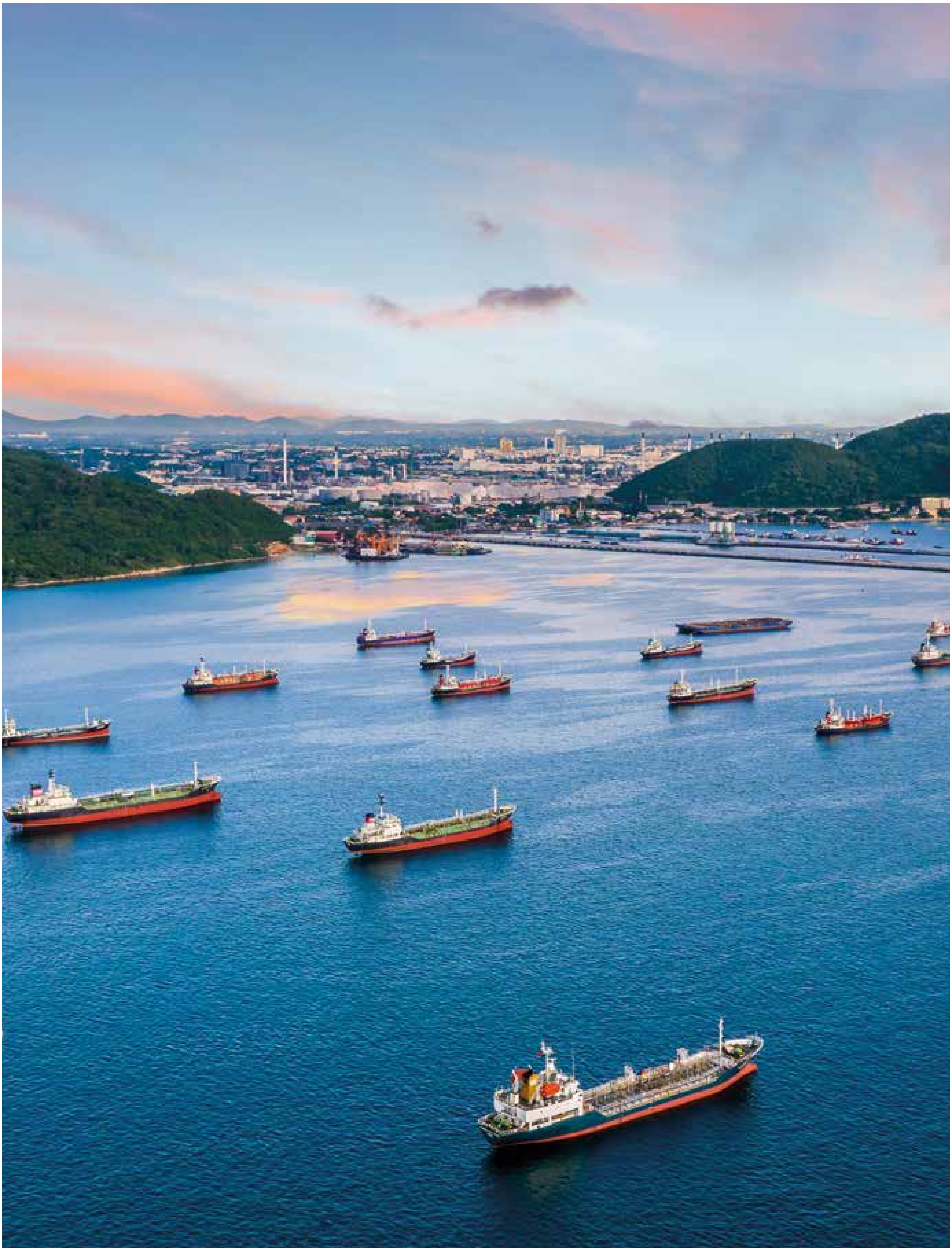
CII according to regulation 22B.

Further to MEPC 76, the regulation numbers will be modified as follows:

- Regulation 22 will be renumbered 26;
- Regulation 22A will be renumbered 27;
- Regulation 22B will be renumbered 28.

6.3.9. SEEMP

Part I of SEEMP should be developed as a ship-specific plan by the company and reflect efforts to improve the ship's energy efficiency. For ships subject to regulation 22B, part I of the SEEMP should also include calculations and descriptions of the ship's attained and required annual operational CII, and the operational rating, along with consequential corrective actions if needed. It is important to note that, for ships that are not subject to regulation 22B, goal-setting is voluntary and they are under no obligation to announce the goal or the result to the public. In addition, neither the company nor the ship is subject to external inspection. The purpose of goal-setting is to communicate with concerned stakeholders, create incentives for proper implementation, and increase commitment to improving energy efficiency.



7. CONCLUSION

The ambitions of the shipping community and IMO are set and will likely impose significant changes on our industry. IMO is now moving forward with the update of the International Convention for the Prevention of Pollution from Ships (MARPOL) which regulates various sources of operational pollution.
It has been ratified by 99 States, which represent around 97% of the world tonnage.

For new design, the marine industry has been used to the requirements given in the Energy Efficiency Design index (EEDI), which foresee gradual improvement in energy efficient ship design and building.
The principle has been extended to cover existing ships through the Energy Efficiency Existing ship Index (EEXI). It is now to be combined with an operational approach through the operational carbon intensity reduction factor (CII) and regulated through enhanced use and auditing of the Ship Energy Efficiency Management Plan (SEEMP).

The EEXI will address ships over 400 GT, representing around 55,000 ships worldwide.
The results of our internal analysis shows that approximately 70% of post EEDI ships are expected to be compliant with the new EEXI requirements without any alterations. For non-compliant ships, the EPL (Engine / Shaft Power Limitation) option is likely to be the most convenient feature to obtain an acceptable EEXI. The EEXI framework gives also the possibility for other efficiency improvements such as fuel change and/or energy saving devices.
The EEXI will enter into force by 2023, at which point the Statement of Compliance must have been issued.

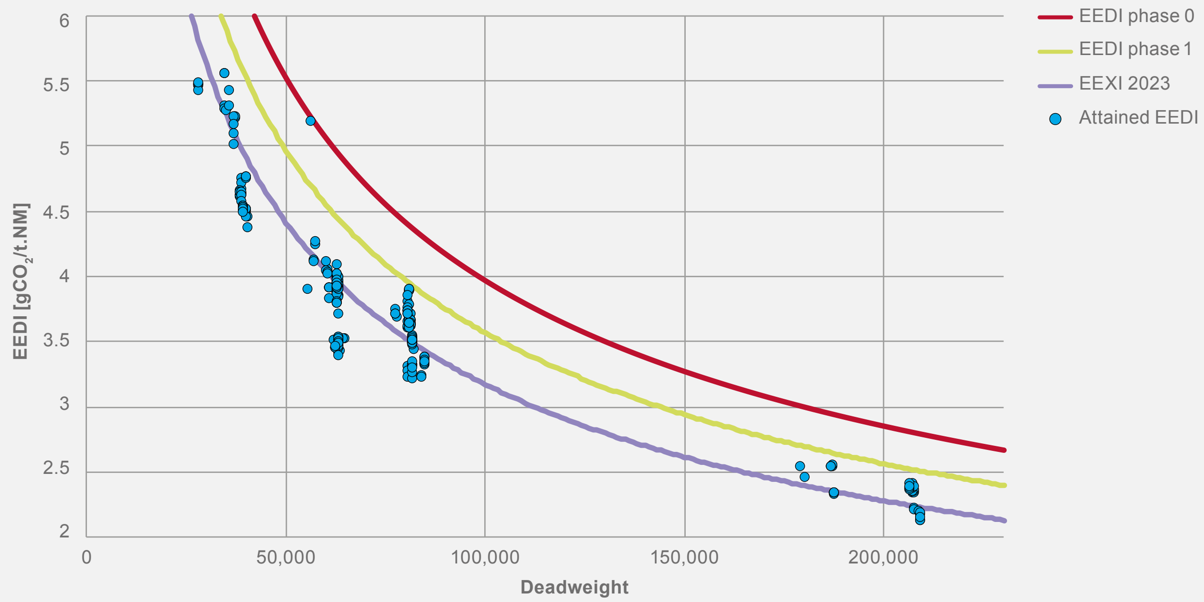
Regarding the ongoing development of the annual operational carbon intensity indicator CII, we have presented the principle and parameters which are still under discussion at international level and under consideration at the upcoming MEPCs.
The CII is combined with the enhanced use and auditing of the Ship Energy Efficiency Management Plan (SEEMP). The CII will concern approximately 32,000 ships, which have a tonnage of 5,000 GT and above. Based on the initial scenarios and publications issued by IMO, and the available data, we estimate that 60-90% of the concerned vessels will be compliant in 2023. All results are to be confirmed once the IMO regulations are adopted.

Bureau Veritas will update this document upon consideration of the requirements adopted at the MEPC 77 and beyond related to the MARPOL Annex VI.

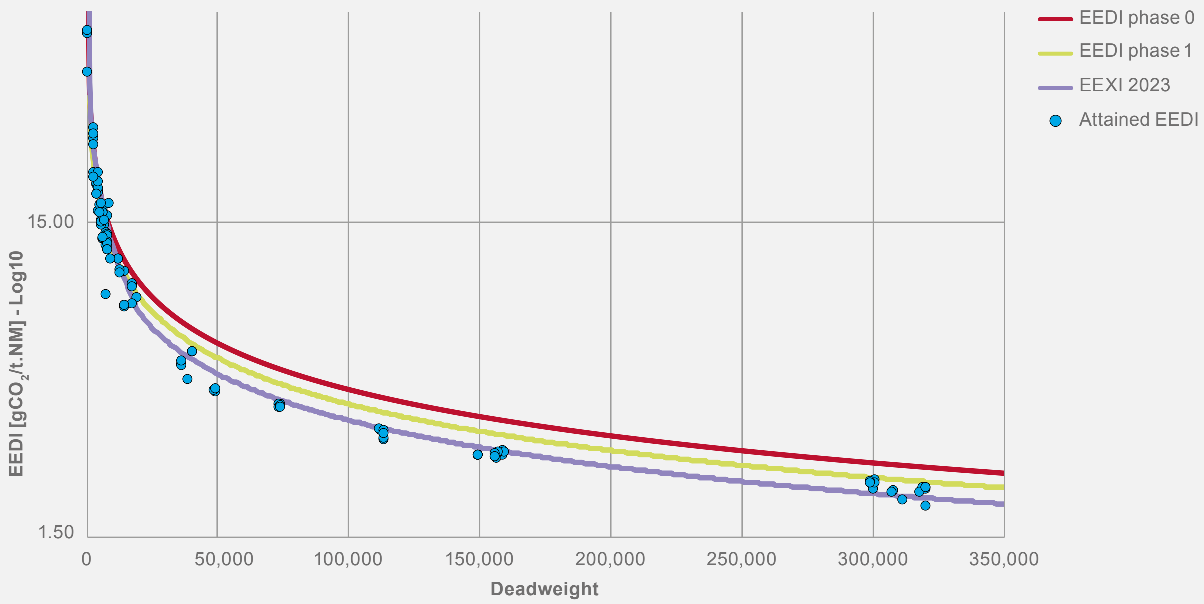
Bureau Veritas remains at your disposal for clarifications, technical discussions, and review of documentation.
We hope this white paper gives you a general overview of the latest IMO requirements and their ongoing development, enabling you to evaluate the technical challenges specific to your fleet or business.

ANNEX 1 - CERTIFIED EEDI SHIPS (PHASE 0-1) VS REQUIRED EEXI 2023

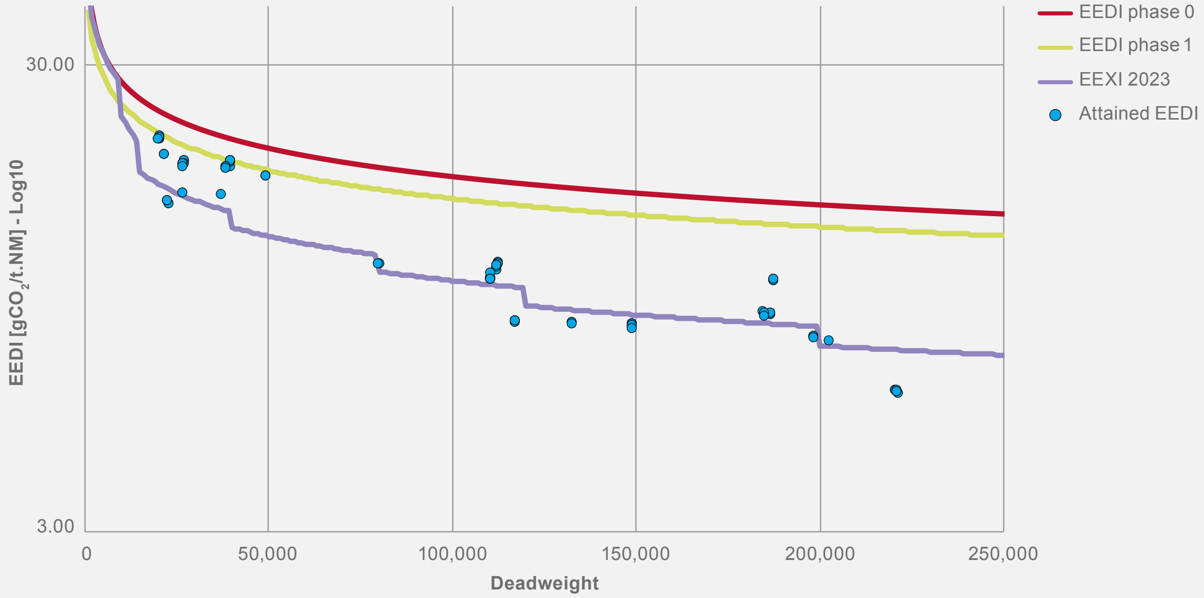
CERTIFIED EEDI SHIPS VS REQUIRED EEXI 2023 (BULK CARRIER-BV FLEET)
TOTAL 315 SHIPS - 60.6% MEET REQUIRED EEXI 2023



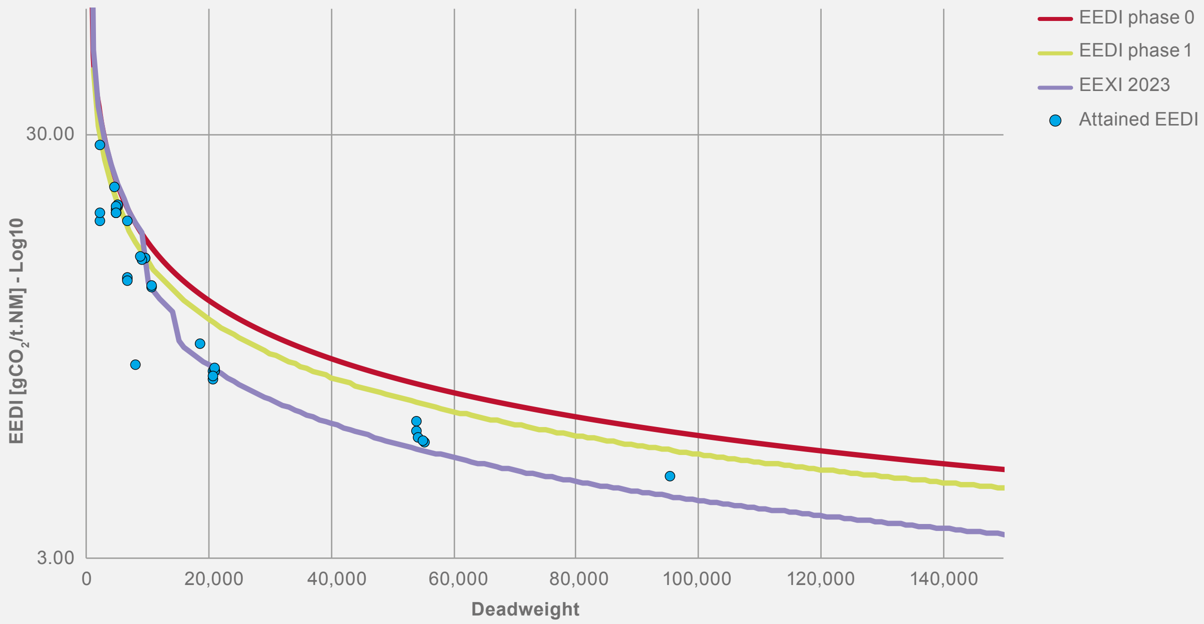
CERTIFIED EEDI SHIPS VS REQUIRED EEXI 2023 (TANKER-BV FLEET)
TOTAL 120 SHIPS - 68.3% MEET REQUIRED EEXI 2023



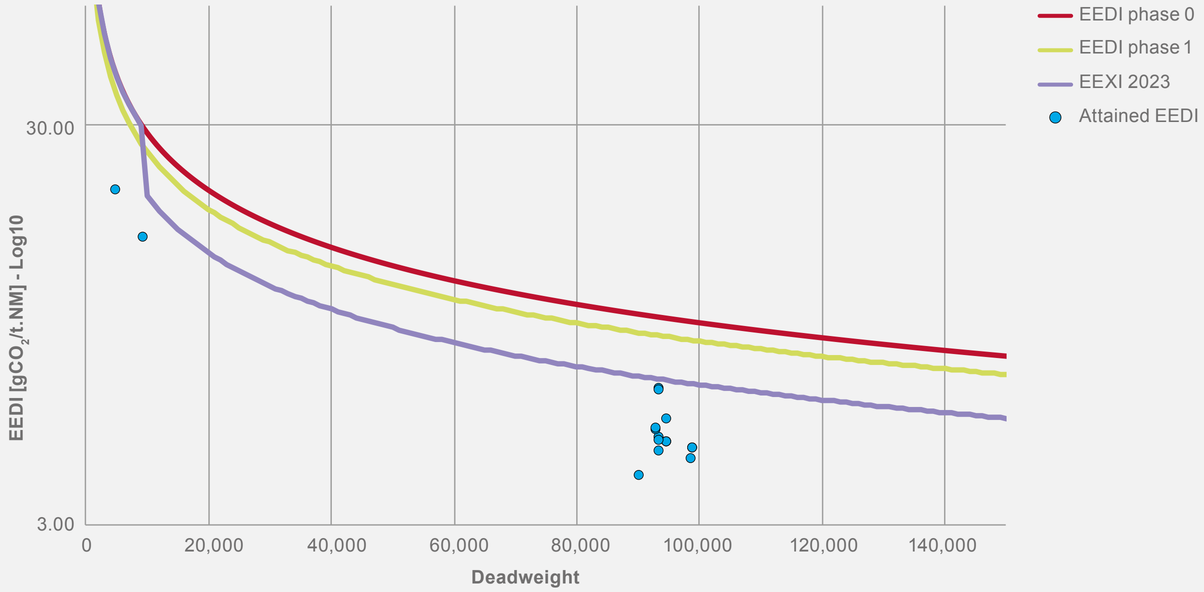
CERTIFIED EEDI SHIPS VS REQUIRED EEXI 2023 (CONTAINER SHIPS-BV FLEET)
TOTAL 79 SHIPS - 30.4% MEET REQUIRED EEXI 2023



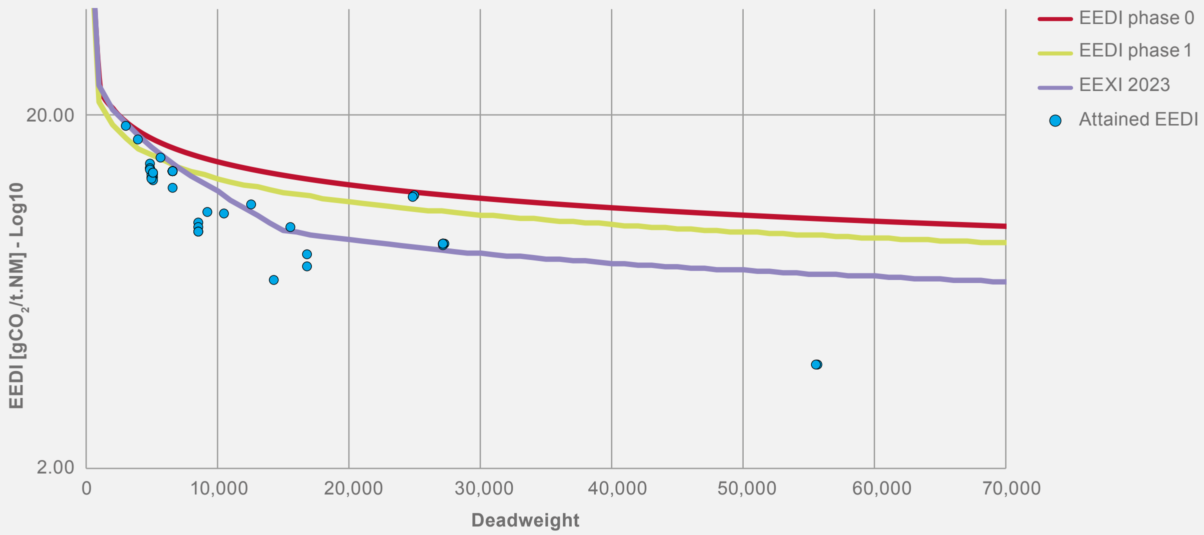
CERTIFIED EEDI SHIPS VS REQUIRED EEXI 2023 (GAS CARRIER-BV FLEET)
TOTAL 47 SHIPS - 57.4% MEET REQUIRED EEXI 2023



CERTIFIED EEDI SHIPS VS REQUIRED EEXI 2023 (LNG CARRIER-BV FLEET)
TOTAL 17 SHIPS - 100% MEET REQUIRED EEXI 2023 (EXCLUDED STEAM TURBINE SHIPS)



CERTIFIED EEDI SHIPS VS REQUIRED EEXI 2023 (CARGO SHIP-BV FLEET)
TOTAL 50 SHIPS - 80.0% MEET REQUIRED EEXI 2023



ABBREVIATIONS

ALS / ACS Air Lubrication System, air injection on the wetted hull surfaces to improve a ship's hydrodynamic characteristics. Air lubrication systems are recognized by IMO as a Category B-1 "Innovative Energy Efficiency Technology" (MEPC.1/Circ.815).

CII Operational Carbon Intensity Indicator.

CSR Corporate Social Responsibility.

DCS IMO created mandatory Fuel Oil Data Collection System (DCS) for international shipping, requiring ships of 5,000 gross tonnage or above to start collecting and reporting data to an IMO database from 2019.

EEDI The Energy Efficiency Design Index (EEDI) mandatory for all new ships (MEPC 62, July 2011) ref. MARPOL Annex VI (>400 GT).

EEOI Energy Efficiency Operational Indicator (MEPC 1 / Circ 684).

EEXI Energy Efficiency Existing Ship Index.

EPL Engine Shaft Power Limitation.

ESD Energy Saving Device.

GHG Greenhouse gases (GHG) are compound gases that trap heat or longwave radiation in the atmosphere. Their presence in the atmosphere makes the Earth's surface warmer as the gases are blocking for the heat and longwave radiation from the planet to leave the atmosphere.

GWP Global Warming Potential (GWP) – GHG and carbon emission factors for fuels in units of carbon dioxide equivalent (CO_2e). Gases will be "converted" to CO_2e by multiplying with a factor for their global warming potential (GWP).

IEA Internal Energy Agency.

IEEC International Energy Efficiency Certificate (IEEC) following Chapter 4 of Marpol Annex VI.

IMO International Maritime Organization (IMO) established by means of a convention adopted in Geneva in 1948. Entered into force in 1958 and first meetings in 1959. In September 2019, IMO had 173 member states as well as Non-Governmental Organizations (NGOs) and Intergovernmental Organizations (IGO) as representatives.

IMBR IMO proposed International Maritime Research and Development Board (IMRB) a non-governmental R&D organization to be overseen by the IMO member states.

ISWG IMO Intersessional Working Group (ISWG).

MEPC Marine Environment Protection Committee (MEPC) addresses environmental issues under IMOs remit. Each official session will have a unique number and which is used as reference in the official announcement listing the decisions made during the session.

OMM Onboard Management Manual (OMM) to give directions for the eventual use of EPL and ShaPoLi.

Principal GHG's Heat trapping gases; Caron dioxide (CO_2 – 64% of GHGs), Methane (CH_4), nitrous oxide (N_2O) and the fluorinated gases.

PSC IMO Port State Control (CSC).

SDG Suistainable Development Goals.

SEEMP Ship Energy Efficiency Management Plan (SEEMP) (MEPC 62, July 2011) (>400 GT).

ShaPoLi Shaft Power Limitation.

WAPS Wind Assisted Propulsion System.

REFERENCES

IMO publications regarding the new parts of the MARPOL convention Annex VI can be found on the IMO website: Index of MEPC Resolutions and Guidelines related to MARPOL Annex VI (imo.org)

BUREAU VERITAS PUBLICATIONS

NR 467 Rules for the Classification of Steel Ships

NR 206 Wind Propulsion Systems

NR 529 Gas-Fueled ships

NR 586 Additional Class Notation SEEMP (Ship Energy Efficiency Management Plan)

NI 525 Risk-based Qualification of New Technology - Methodological Guidelines

NI 547 Guidelines for Fuel Cell Systems Onboard Commercial Ships

NI 559 Guidelines for the Use of Low-Sulfur Fuel Oils (IMO 2020 compliance)

NI 618 Guidelines on LNG Bunkering

NI 647 LPG-Fueled Ships (Tentative Rules)

NI 654 Guidelines on Conversion to LNG as Fuel

All Bureau Veritas publications are available on:

- https://marine-offshore.bureauveritas.com/rules-guidelines
- https://marine-offshore.bureauveritas.com/newsroom/report-mepc-76-meeting-10-17-june-2021

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