

Outlines of EEXI regulation



EEDI Section of Hull Department, ClassNK
June 2021

1. Initial IMO Strategy on Reduction of GHG emissions from ships
2. Outlines of the EEXI regulation
3. Preparation for the EEXI regulation



Initial IMO Strategy on Reduction of GHG emissions from ships (adopted on April 2018)

- ✓ The Initial IMO GHG Strategy including goals of reduction of GHG emissions from ships was adopted. It shall be reviewed every 5 years.
- ✓ First effort aimed at the GHG zero emissions from global sector without distinction between developed countries and developing countries.

Levels of ambition of the Initial Strategy

1. Vision (Final target)

- Final target: **GHG zero emissions** at earliest in this century

2. Levels of ambition

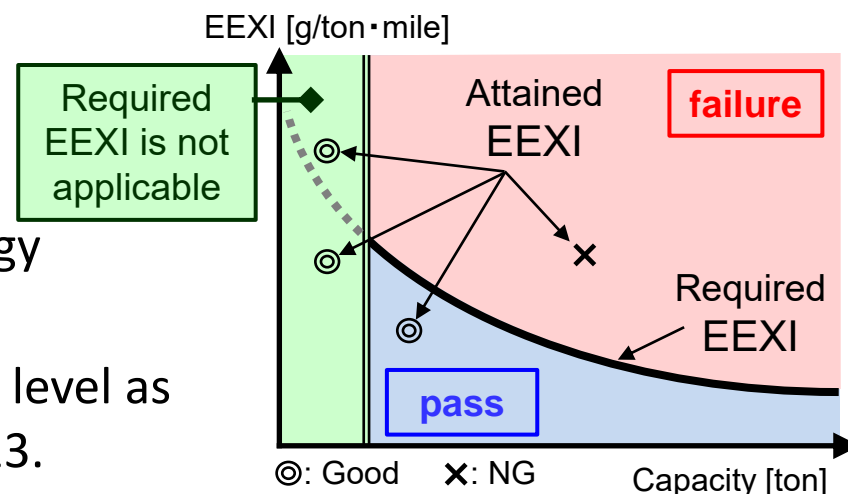
- Target of transportation efficiency (CO₂ emissions per transport work) compared to 2008;
At least 40% improvement by 2030, 70% improvement by 2050
- Target of total annual GHG emissions compared to 2008;
At least 50% reduction by 2050, effort for zero emissions at earliest in this century

■ MEPC 76 (June 2021)

The amendments to MARPOL Annex VI (MEPC.328(76)) were adopted at MEPC 76.

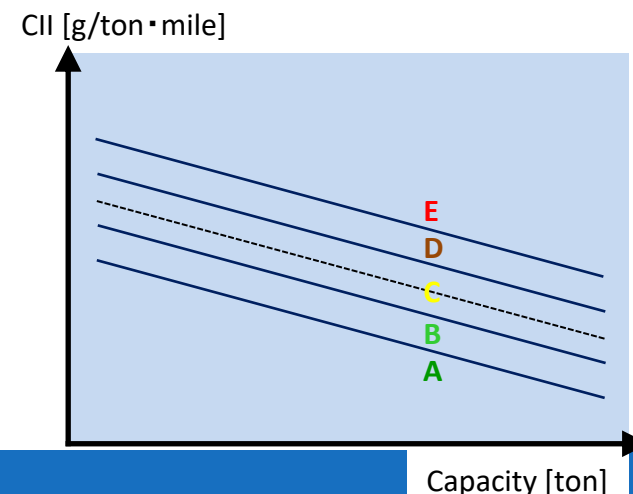
➤ Technical approach (EEXI)

- Introduce the Energy Efficiency Existing Ship Index (EEXI) as the energy efficiency index for existing ship.
- The required EEXI is almost the same level as required EEDI for new ships as of 2023.



➤ Operational approach (CII rating)

- Ship is rated on a scale of A to E based on the annual operational carbon intensity indicator (CII).
- A ship rated D for three consecutive years, or E, would have to submit a corrective action plan.



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Outlines of the EEXI regulation

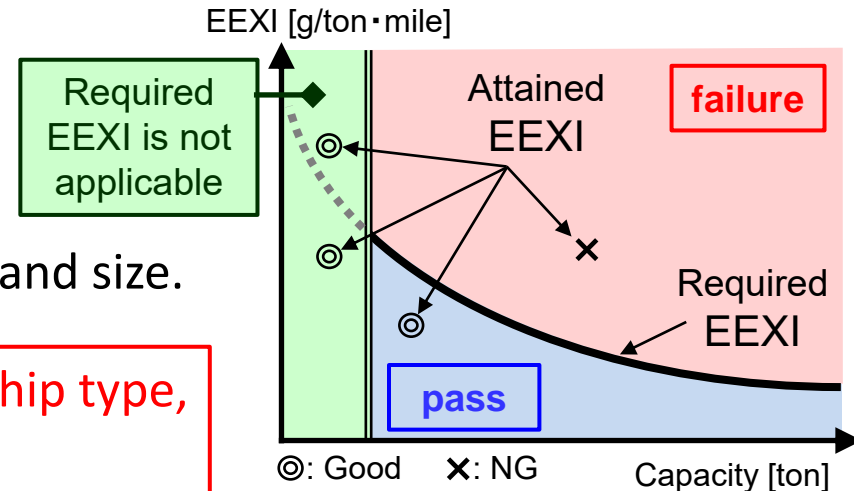
■ Attained EEXI

EEXI value is calculated by an individual ship.

■ Required EEXI

Required EEXI is specified for each ship type and size.

➔ For ships with a certain size of specified ship type,
 $\text{Attained EEXI} \leq \text{Required EEXI}$



EEXI requirements shall apply to all ships of 400 GT and above which are engaged in the international voyages **regardless of ship's delivery date**, except the following ships as with the case of EEDI.

- Ships not propelled by mechanical means
- Platforms including FPSOs and FSUs and Drilling rigs, regardless of their propulsion
- Category A ships as defined in the Polar code
- Ships which have non-conventional propulsion such as diesel electric, turbine or hybrid propulsion system (except LNG carrier and cruise passenger ship)

■ EEXI is calculated by the same formula as EEDI.

EEXI [g/ton·mile]=

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



Concept formula

$$\text{EEXI [g/ton·mile]} = \frac{\text{CO}_2 \text{ Conversion factor} \times \text{SFC [g/kW·h]} \times \text{Engine Power [kW]}}{\text{Capacity [ton]} \times \text{EEXI Speed [knots]}}$$

CO₂ emissions (gram) from a ship when ship sail transport 1 (ton) cargo for 1 (nautical mile)

CO ₂ Conversion factor (C _F)	C _F corresponds to the fuel used when determining SFC (DM grade: 3.206)
SFC	Fuel consumption at 75%MCR (M/E), at 50%MCR (A/E)
Engine Power	75% of the rated installed power (MCR) (In case of EPL, 83%MCR _{lim})
Capacity	Deadweight (For containerhips, 70% of the deadweight)
EEXI Speed (V _{ref})	Ship speed at 75%MCR under the draught condition corresponding to the capacity

Calculation formula of EEXI (Differences from EEDI) ClassNK

■ The formula of EEXI is the same as EEDI, but some parameters' definitions are different.

Concept formula

$$\text{EEXI [g/ton} \cdot \text{mile]} = \frac{\text{CO2 Conversion factor} \times \text{SFC [g/kW} \cdot \text{h]} \times \text{Engine Power [kW]}}{\text{Capacity [ton]} \times \text{EEXI Speed (Vref) [knot]}}$$

SFC

Fuel consumption at 75%MCR (M/E), at 50%MCR (A/E) specified in NOx technical file

- In cases where the installed engines don't have NOx technical file, approximated default values including margin, SFC_{app} (i.e. M/E: 190 g/kW·h, A/E: 215 g/kW·h), are available.
- In cases where the NOx regulation doesn't apply to the propulsion system (e.g. steam turbine, etc.), SFC specified by the manufacturer or confirmed by the verifier is available.

Engine Power
(P_{ME})

75% of the rated installed power (MCR) (In cases where the propulsion system is diesel electric or steam turbine, P_{ME} is 83% of MPP or MCR.)

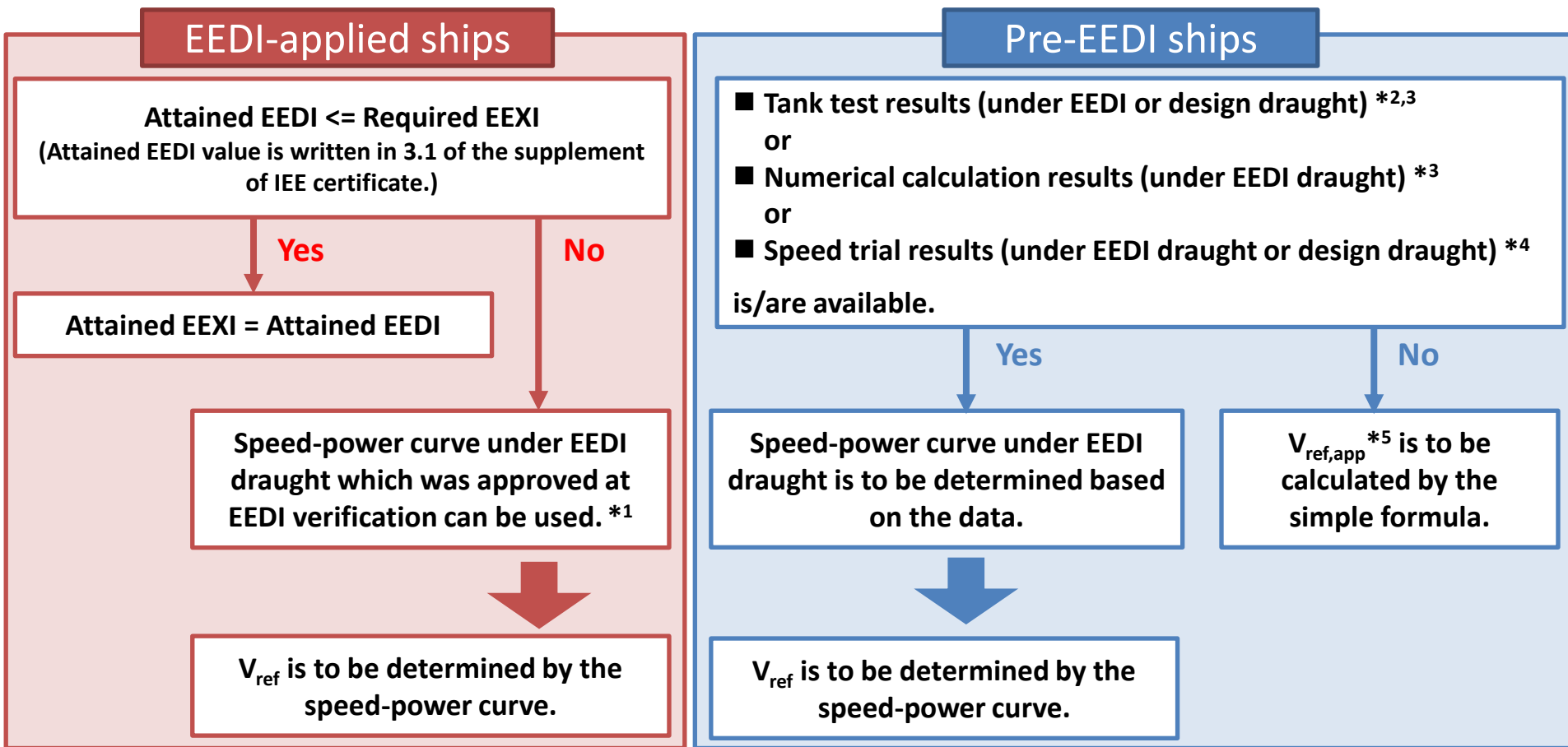
- In cases where EPL is installed, P_{ME} is 83% of the limited installed power (MCR_{lim}).

V_{ref}

Ship speed at P_{ME} and under the maximum summer load draught (for container ships, under 70%DWT draught.)

- In cases where both of tank test results and speed trial results are not available, an approximated ship speed including margin, $V_{\text{ref,app}}$ is to be calculated by the simple formula. The parameters of this formula are ship type, DWT, and MCR.

Methods for obtaining V_{ref}



*1 The approved speed-power curve is available without any corrections.

*2 The tank test results can be corrected/calibrated by numerical calculation such as CFD, etc.

*3 In case of using numerical calculations, estimation process and methodology of the power curves are to be submitted. (It should include documentation on consistency with the defined quality standards and the verification of the numerical setup with parent hull or the reference set of comparable ships.)

*4 The sea conditions and ship speed should have been measured in accordance with ISO 15016:2002 or the equivalent and the measured ship speed was calibrated, if necessary, by taking into account the effects of wind, tide, waves, etc. If the speed trial was carried out under design draught, the ship speed shall be calibrated under EEDI draught by using Admiralty Coefficient, etc.

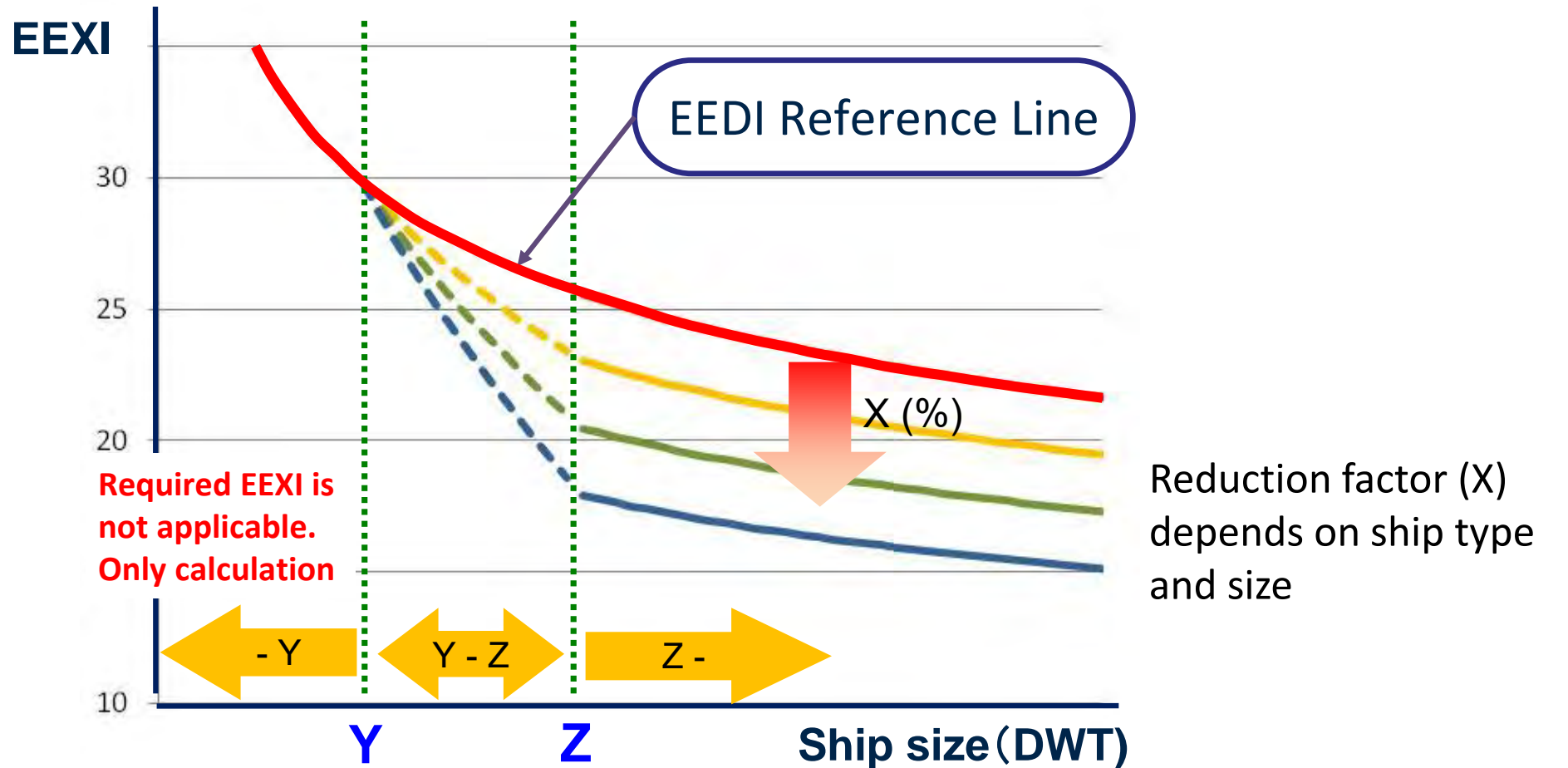
*5 $V_{ref,app}$ is an approximated ship speed obtained by a certain correction applies to the average ship speed of each ship type and size (including margin).

Application of EEXI

The “**calculation of EEXI (Attained EEXI)**” and “**conformity to required value (Required EEXI)**” shall apply to the following ship type and size as with the case of EEDI.

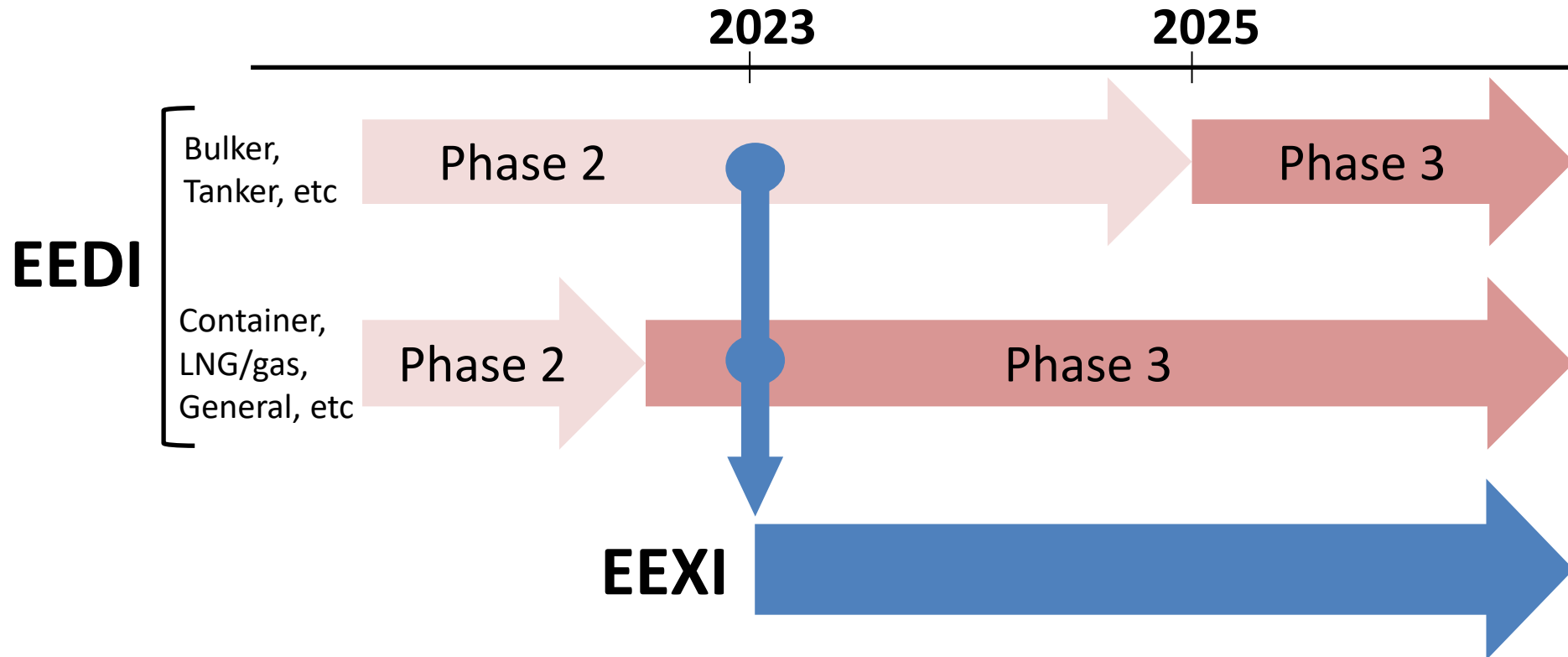
Type of ship	Calculation of Attained EEXI	Conformity to Required EEXI
Bulk carrier	400 GT and above	10,000 DWT and above
Gas carrier	400 GT and above	2,000 DWT and above
Tanker	400 GT and above	4,000 DWT and above
Containership	400 GT and above	10,000 DWT and above
General cargo ship	400 GT and above	3,000 DWT and above
Refrigerated cargo carrier	400 GT and above	3,000 DWT and above
Combination carrier	400 GT and above	4,000 DWT and above
Ro-ro cargo ship (Vehicle carrier)	400 GT and above	10,000 DWT and above
Ro-ro cargo ship	400 GT and above	1,000 DWT and above
Ro-ro passenger ship	400 GT and above	250 DWT and above
LNG carrier	400 GT and above	10,000 DWT and above
Cruise passenger ship (non-conventional)	400 GT and above	25,000 GT and above

$$\text{Required EEXI} = \left(1 - \frac{X}{100} \right) \times \text{EEDI Reference Line}$$



Y, Z value depends on ship type

Almost the same level as **required EEDI for new ships as of 2023***



*However, very large tanker and bulk carrier, small and middle containership, Ro-ro cargo ship and Ro-ro passenger ship are relaxed for technical difficulty to improve the efficiency.

Required EEXI (3/5)

EEDI Reference Line

✓ Required EEXI is set based on the EEDI reference line

Type of ship		Reference Line
Bulk carrier	DWT ≤ 279,000	$961.79 \times \text{DWT}^{-0.477}$
	DWT > 279,000	$961.79 \times 279,000^{-0.477}$
Gas carrier		$1120.00 \times \text{DWT}^{-0.456}$
Tanker		$1218.80 \times \text{DWT}^{-0.488}$
Containership		$174.22 \times \text{DWT}^{-0.201}$
General cargo ship		$107.48 \times \text{DWT}^{-0.216}$
Refrigerated cargo carrier		$227.01 \times \text{DWT}^{-0.244}$
Combination carrier		$1219.00 \times \text{DWT}^{-0.488}$
Ro-ro cargo ship (vehicle carrier)	DWT/GT < 0.3	$(\text{DWT/GT})^{-0.7} \times 780.36 \times \text{DWT}^{-0.471}$
	DWT/GT ≥ 0.3	$1812.63 \times \text{DWT}^{-0.471}$
Ro-ro cargo ship	DWT ≤ 17,000	$1686.17 \times \text{DWT}^{-0.498}$
	DWT > 17,000	$1686.17 \times 17,000^{-0.498}$
Ro-ro passenger ship	DWT ≤ 10,000	$902.59 \times \text{DWT}^{-0.381}$
	DWT > 10,000	$902.59 \times 10,000^{-0.381}$
LNG carrier		$2253.7 \times \text{DWT}^{-0.474}$
Cruise passenger ship having non-conventional propulsion		$170.84 \times \text{GT}^{-0.214}$

Required EEXI (4/5)

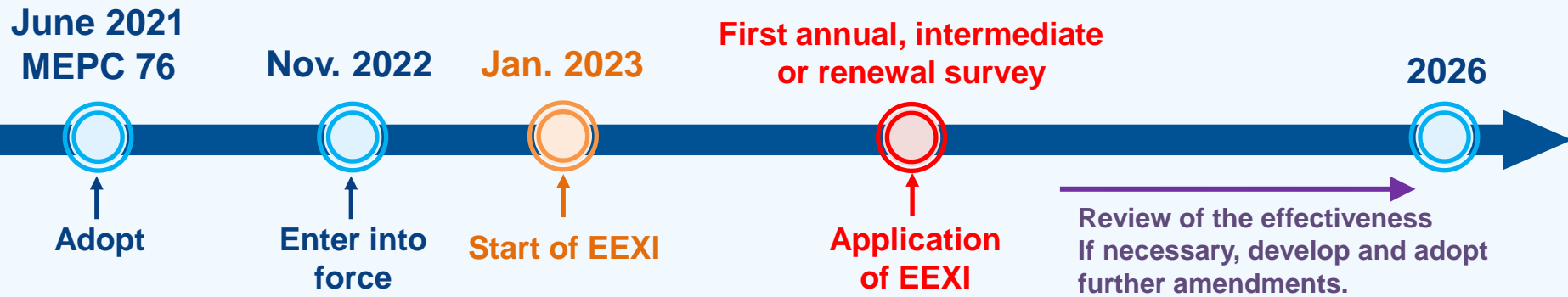
Type of ship	Size	Reduction factor (X) %
Bulk carrier	200,000 DWT and above	15
	20,000 - 200,000 DWT	20
	10,000 - 20,000 DWT	0 - 20 *
Gas carrier	15,000 DWT and above	30
	10,000 - 15,000 DWT	20
	2,000 - 10,000 DWT	0 - 20 *
Tanker	200,000 DWT and above	15
	20,000 - 200,000 DWT	20
	4,000 - 20,000 DWT	0 - 20 *
Containership	200,000 DWT and above	50
	120,000 - 200,000 DWT	45
	80,000 - 120,000 DWT	35
	40,000 - 80,000 DWT	30
	15,000 - 40,000 DWT	20
	10,000 - 15,000 DWT	0 - 20 *

* Reduction factor to be linearly interpolated between the two values dependent upon ship size.

Required EEXI (5/5)

Type of ship	Size	Reduction factor (X) %
General cargo ship	15,000 DWT and above	30
	3,000 - 15,000 DWT	0 - 30 *
Refrigerated cargo carrier	5,000 DWT and above	15
	3,000 - 5,000 DWT	0 - 15 *
Combination carrier	20,000 DWT and above	20
	4,000 - 20,000 DWT	0 - 20 *
Ro-ro cargo ship (vehicle carrier)	10,000 DWT and above	15
Ro-ro cargo ship	2,000 DWT and above	5
	1,000 - 2,000 DWT	0 - 5 *
Ro-ro passenger ship	1,000 DWT and above	5
	250 - 1,000 DWT	0 - 5 *
LNG carrier	10,000 DWT and above	30
Cruise passenger ship having non-conventional propulsion	85,000 GT and above	30
	25,000 - 85,000 GT	0 - 30 *

* Reduction factor to be linearly interpolated between the two values dependent upon ship size.



■ Timing of EEXI application

- ✓ The amendments to MARPOL ANNEX VI will enter into force on 1 November 2022.
- ✓ EEXI requirements will start from **1st January 2023**.
- ✓ The EEXI verification shall take place at the following timing.

Ships delivered **before**
1 January 2023

First annual, intermediate or renewal survey of the International Air Pollution Certificate (IAPP Certificate), whichever is the first, **on or after 1 January 2023**

Ships delivered **on or after**
1 January 2023

Initial survey of the International Energy Efficiency Certificate (IEE Certificate)

- The relevant guidelines of EEXI were adopted at MEPC 76 (June 2021)

**GUIDELINES ON THE
METHOD OF CALCULATION
OF THE ATTAINED EEXI
(MEPC.333(76))**

- The **detailed calculation method** of the attained EEXI is provided.
- Only parameters different from the EEDI Calculation Guidelines are prescribed.

**GUIDELINES ON SURVEY
AND CERTIFICATION OF THE
ATTAINED EEXI
(MEPC.334(76))**

- The **details of survey and certification** of the attained EEXI is provided.
- The content of EEXI Technical File and additional information for EEXI verification are prescribed.

**GUIDELINES ON THE SHAFT /
ENGINE POWER LIMITATION
SYSTEM AND USE OF A
POWER RESERVE
(MEPC.335(76))**

- **Technical and operational conditions** that the SHaPoLi / EPL system should satisfy in complying with the EEXI requirements and in using a power reserve are provided.
- The contents to be included in the **Onboard Management Manual (OMM)** are prescribed.

1.1 General information

Shipowner	XXX Shipping Line
Shipbuilder	XXX Shipbuilding Company
Hull no.	12345
IMO no.	94112XX
Ship type	Bulk carrier

1.2 Principal particulars

Length overall	250.0 m
Length between perpendiculars	240.0 m
Breadth, moulded	40.0 m
Depth, moulded	20.0 m
Summer load line draught, moulded	14.0 m
Deadweight at summer load line draught	150,000 tons

1.3 Main engine

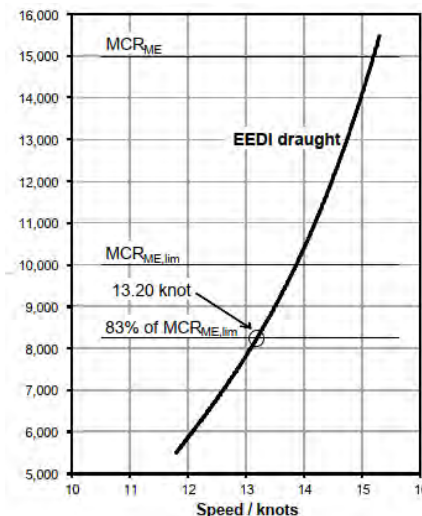
Manufacturer	XXX Industries
Type	6J70A
Maximum continuous rating (MCR _{ME})	15,000 kW x 80 rpm
Limited maximum continuous rating with the Engine Power Limitation installed (MCR _{ME,lim})	9,940 kW x 72 rpm
SFC at 75% of MCR _{ME} or 83% of MCR _{ME,lim}	166.5 g/kWh
Number of sets	1
Fuel type	Diesel Oil

1.4 Auxiliary engine

Manufacturer	XXX Industries
Type	5J-200
Maximum continuous rating (MCR _{AE})	600 kW x 900 rpm
SFC at 50% MCR _{AE}	220.0 g/kWh
Number of sets	3
Fuel type	Diesel Oil

1.5 Ship speed

Ship speed (V _{ref}) (with the Engine Power Limitation installed)	13.20 knots
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6.8 Calculated value of attained EEXI

$$\begin{aligned}
 EEXI = & \frac{(\prod_{j=1}^M f_j) (\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}) + (P_{AE} \cdot C_{FAE} \cdot SFC_{AE})}{f_i \cdot f_c \cdot f_l \cdot Capacity \cdot f_w \cdot V_{ref} \cdot f_m} \\
 & + \frac{\{(\prod_{j=1}^M f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEff(i)}) \cdot C_{FAE} \cdot SFC_{AE}\}}{f_i \cdot f_c \cdot f_l \cdot Capacity \cdot f_w \cdot V_{ref} \cdot f_m} \\
 & - \frac{(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME})}{f_i \cdot f_c \cdot f_l \cdot Capacity \cdot f_w \cdot V_{ref} \cdot f_m} \\
 = & \frac{1 \times (8250 \times 3.206 \times 166.5) + (625 \times 3.206 \times 220.0) + 0 - 0}{1 \times 1 \times 1 \times 150000 \times 1 \times 13.20 \times 1} \\
 = & 2.41 \text{ (g - CO}_2\text{/ton} \cdot \text{mile)}
 \end{aligned}$$

attained EEXI: 2.41 g-CO₂/ton mile

Contents of EEXI Technical File

DWT/GT, Principal particulars of M/E and A/E (e.g. type, MCR, SFC, etc.), MCR_{lim} in case of installing EPL, Ship Speed (i.e. V_{ref}), Estimated speed-power curve(s), Principal particulars and schematic figure of propulsion system and electric power supply system, Estimation process of speed-power curve(s), Description of energy saving equipment(s), Calculation of attained EEXI, (For LNG carrier, relevant information of propulsion system, LNG cargo tank, etc.)

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Flow chart of EEXI application

Check whether a ship has the attained EEDI or not.

Attained EEDI was calculated for ship for which building contract is placed on or after 1 January 2013 or the delivery of which is on or after 1 July 2015^{Note}.

Yes

- Check the attained EEDI from the IEE Certificate or EEDI Technical File.
- The attained EEDI can be used as an alternative to the attained EEXI.

No

Calculate the current attained EEXI.

Attained EEXI \leq Required EEXI ?

Yes

The ship complies with the EEXI requirements.

No

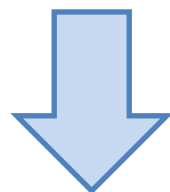
The ship's energy efficiency **needs to be improved** by any of the following measures.

- Shaft / **Engine power limitation** (SHaPoLi / **EPL**)
- Installation of energy-saving devices
- Fuel conversion to the low-carbon fuel

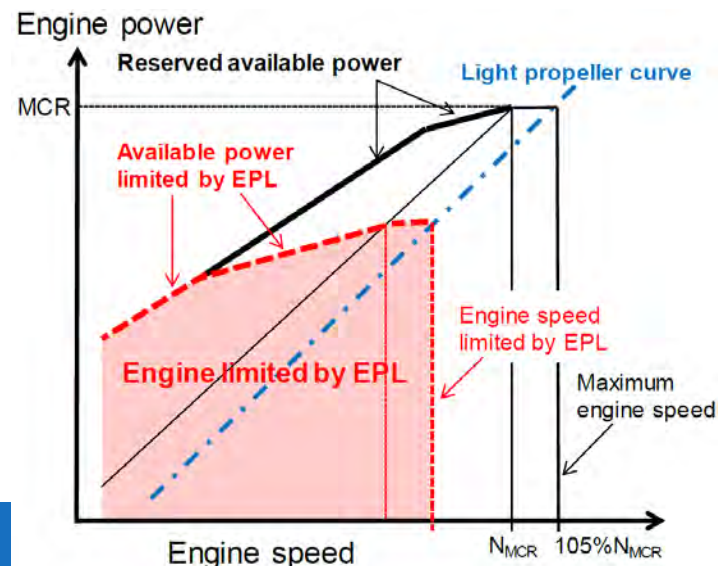
Note : In case of LNG carrier and Cruise passenger ship, building contract is placed on or after 1 September 2015 or the delivery of which is on or after 1 September 2019.

■ What is Engine Power Limitation (EPL) ?

- ✓ Engine Power Limitation (EPL) is a system to improve a ship's energy efficiency by limiting the ship's engine power within the optimum engine setting. As a result, the ship speed will be limited.
- ✓ EPL consists of a simple device which can easily limit the maximum engine power by **adjusting a fuel index limiter** on the engine control system without retrofitting a complicated system within the current regulatory framework.
- ✓ EPL can be easily installed in a short time during a port without updating EIAPP certificate and the NOx technical file.
- ✓ EPL can be released in the adverse weather conditions. Therefore, the limited engine power does not have to meet the minimum power requirement.



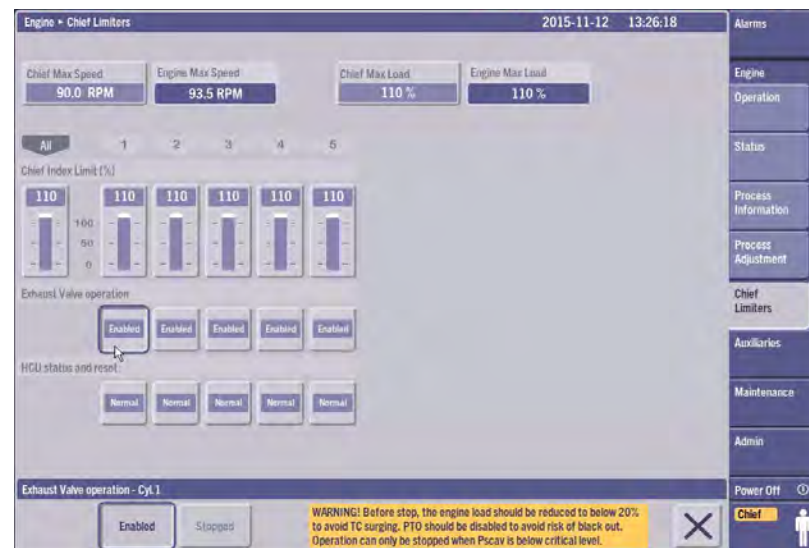
EPL can be utilized as **one of the effective measures** to improve energy efficiency of existing ships in terms of EEXI.



■ Electronically controlled type engine such as new engine type

1. Changing a set of governor's fuel index limiter

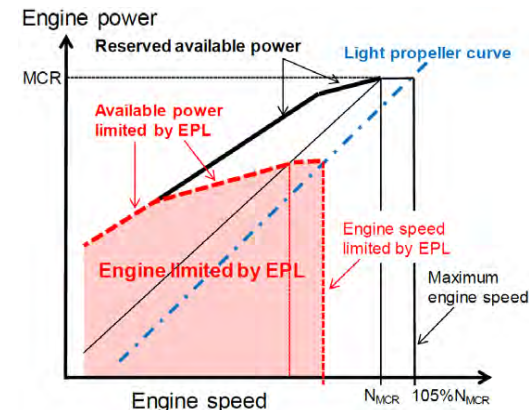
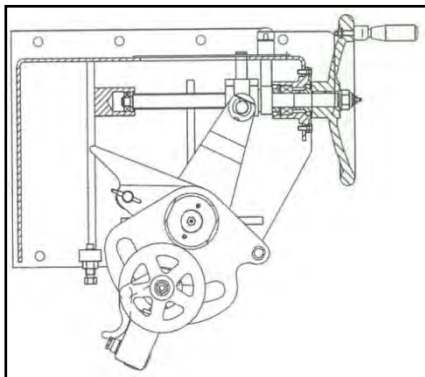
(In case of MAN B&W engines, setting the fuel index limit in Chief Limiters)



Source: MAN Energy Solutions

Since the electronically controlled type engine is not physically sealed unlike the mechanical driven type engine, it is confirmed that the EPL had not been released without permission since the last confirmation by **checking the data recorded in the data logging program.**

Principal requirements of EPL



Principal requirements

- The available power is to be limited by locking fuel index.
- EPL cannot be released without permission from the ship master or the officer in charge of navigational watch (OICNW).
- If EPL is un-limited due to the purpose of securing the safety of a ship or saving life at sea, the reason and relevant information are to be recorded in Onboard Management Manual (OMM).
- EPL system (or each sub system) should be tamper-proof.
- EPL system should be accompanied by OMM for EPL that should be on board the ship for inspection.

Contents of OMM

Original MCR (kW x rpm), MCR after installing EPL: MCR_{lim} (kW x rpm), Technical description of EPL system, Sealing method (mechanically controlled engine), Locking and monitoring method (electronically controlled engine), Procedures and methods for releasing EPL, Time required for un-limiting EPL, Procedures for survey by the Administration/RO, Procedure for the report on release of EPL, Administrator of the EPL system, etc.

The un-limiting EPL is only allowed for the purpose of securing the safety of a ship or saving life at sea, consistent with regulation 3.1 of MARPOL Annex VI.

Examples)

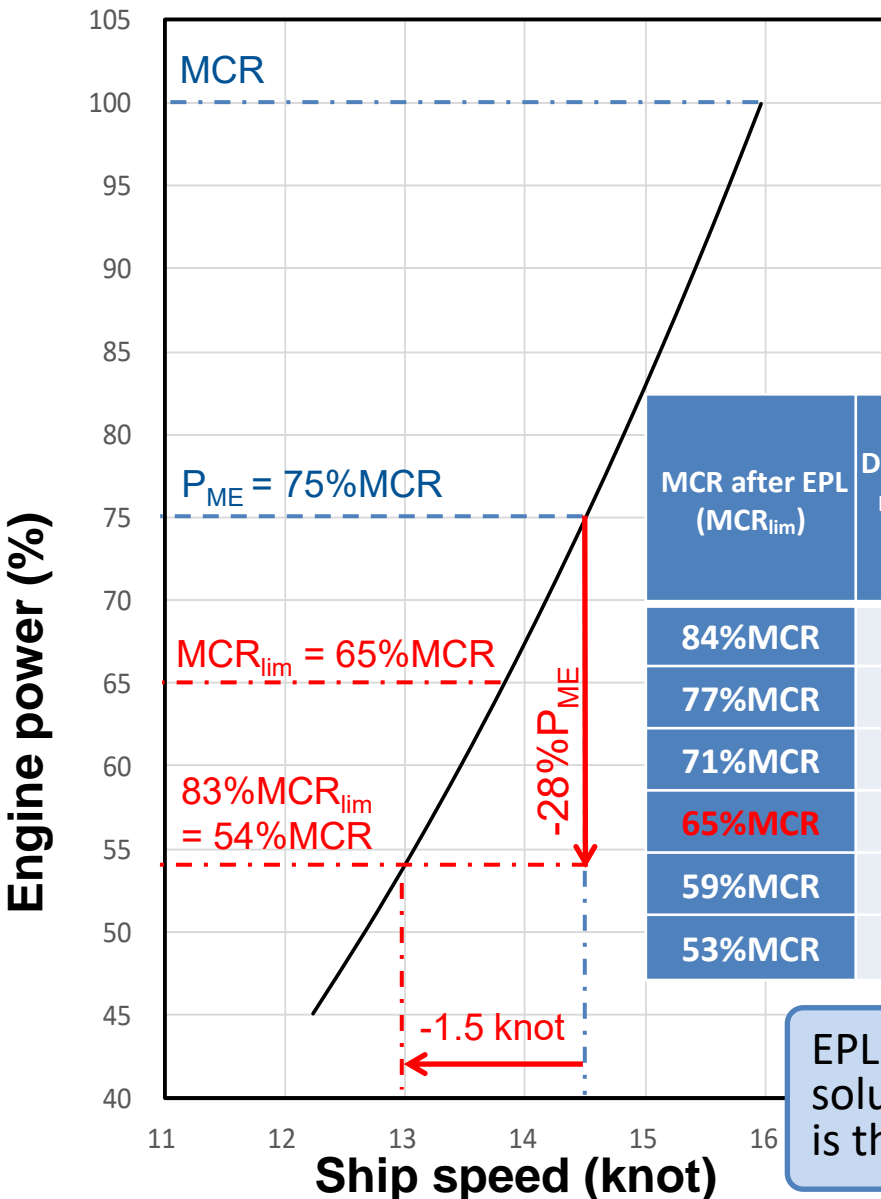
- Operating in adverse weather and ice-infested waters, or avoidance voyaging in such areas
- Participation in search and rescue operations
- Avoidance of pirates
- Engine maintenance (e.g. removing soot, etc.)



■ Necessary procedures in cases where EPL is un-limited

- Recording the status in OMM (e.g. reason of the un-limiting, ship speed, maximum un-limited power, beaufort number and wave height, position and timestamp, etc.)
- Notifying Administration or RO
- Reactivating/Replacing EPL system immediately after the risks have been prevented
- Confirmation of the reactivated/replaced EPL system by Administration or RO (Remote confirmation may be acceptable.)

Example of improvement of EEXI by EPL



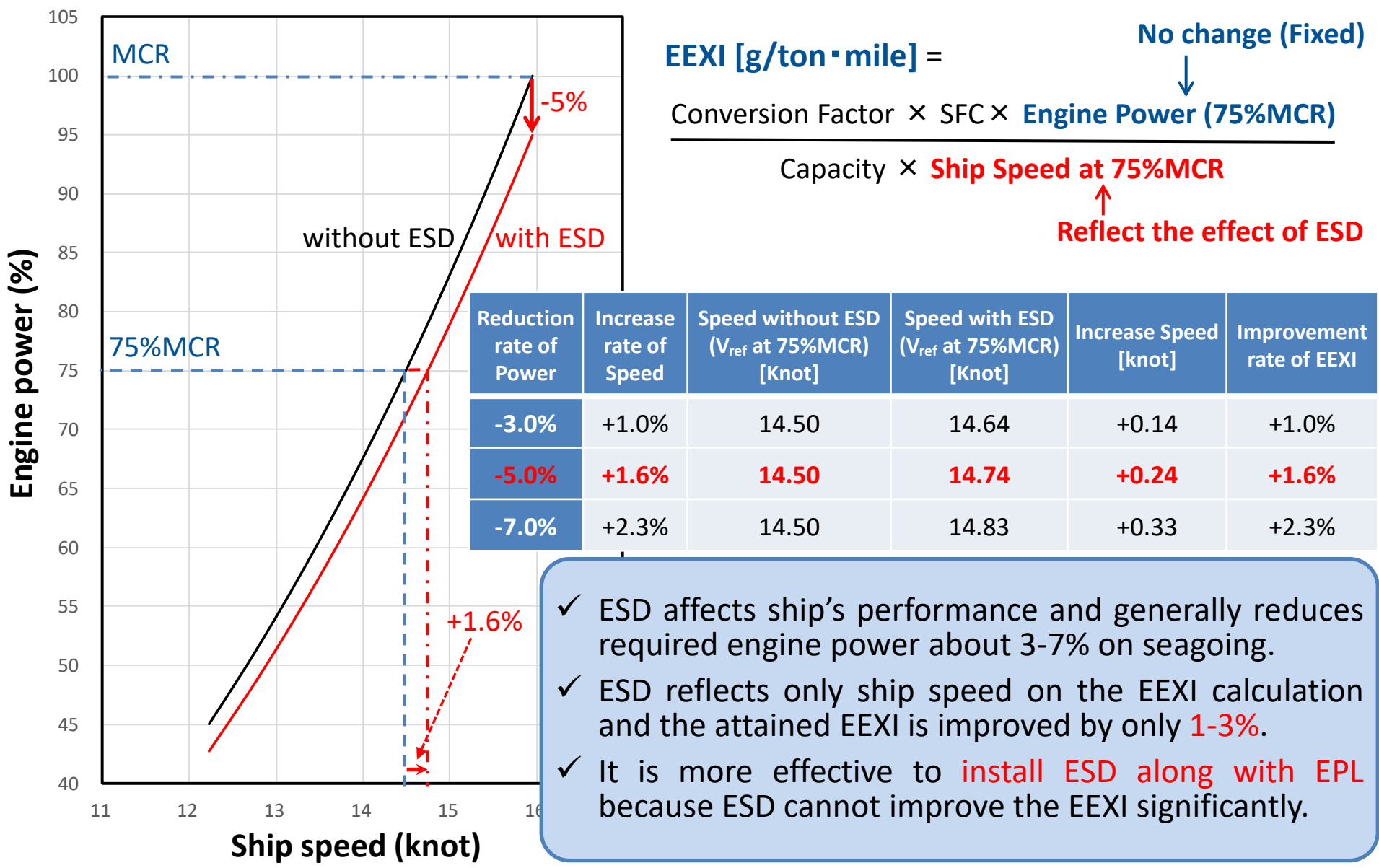
EEXI after EPL [g/ton • mile] =

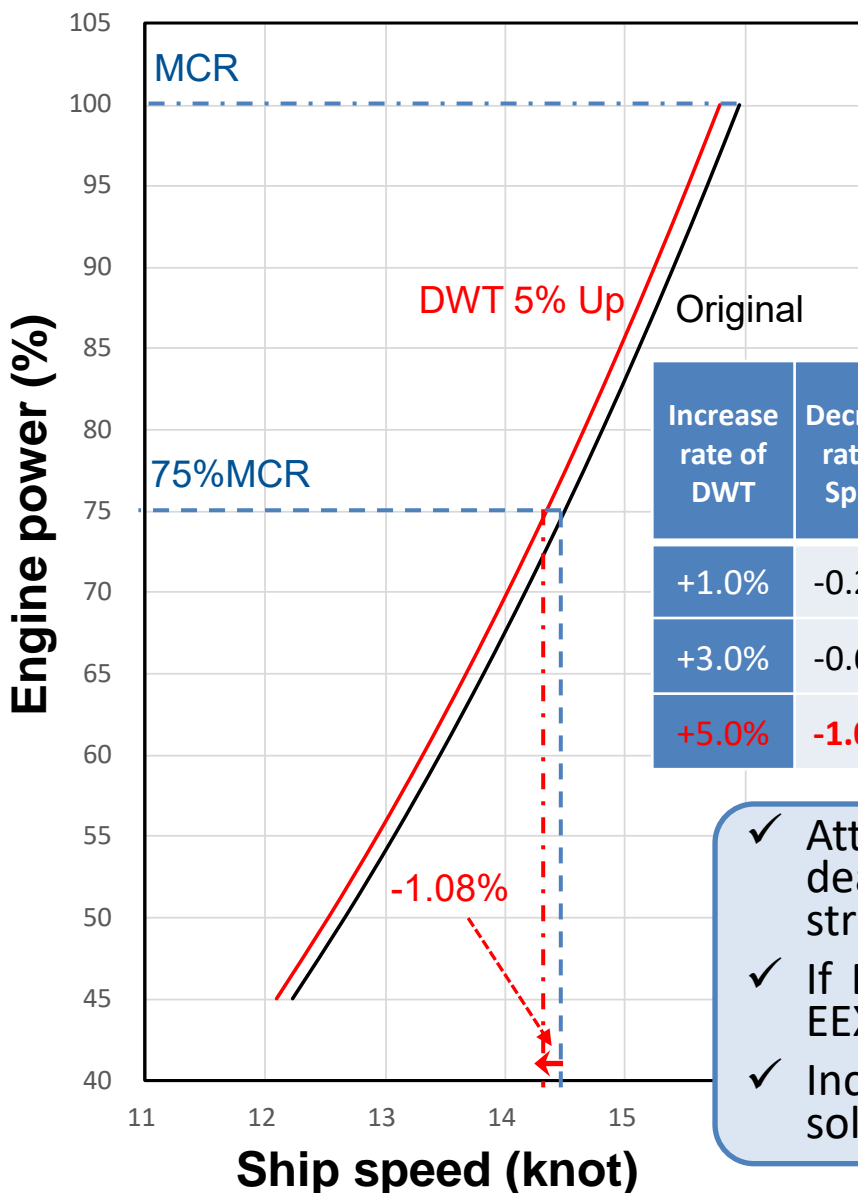
$$\frac{\text{Conversion Factor} \times \text{SFC} \times \text{Engine Power (83\% MCR}_{\text{lim}})}}{\text{Capacity} \times \text{Ship Speed at 83\%MCR}_{\text{lim}}}$$

$$\left(\begin{array}{ll} \text{Power} \propto \text{Speed}^3 & \Rightarrow \text{EEXI} \propto \text{Speed}^2 \\ \text{Speed} \propto \text{Power}^{1/3} & \Rightarrow \text{EEXI} \propto \text{Power}^{2/3} \end{array} \right)$$

MCR after EPL (MCR _{lim})	Decrease rate of P _{ME}	Decrease rate of Speed	Original Speed (V _{ref} at 75%MCR) [knot]	Speed after EPL (V _{ref} at 83%MCR _{lim}) [knot]	Decrease of Speed (ΔV) [knot]	Improvement rate of EEXI
84%MCR	-7%	-3%	14.5	14.1	-0.4	+5%
77%MCR	-15%	-5%	14.5	13.8	-0.7	+10%
71%MCR	-22%	-8%	14.5	13.4	-1.1	+15%
65%MCR	-28%	-11%	14.5	13.0	-1.5	+20%
59%MCR	-35%	-13%	14.5	12.6	-1.9	+25%
53%MCR	-41%	-16%	14.5	12.1	-2.4	+30%

EPL is a highly effective measure and a cost-effective solution to improve the ship's attained EEXI. Thus, EPL is the **most effective measure** for EEXI improvement.





EEXI [g/ton·mile] =

Conversion Factor × SFC × **Engine Power (75%MCR)**

Capacity (DWT) × Ship Speed at 75%MCR

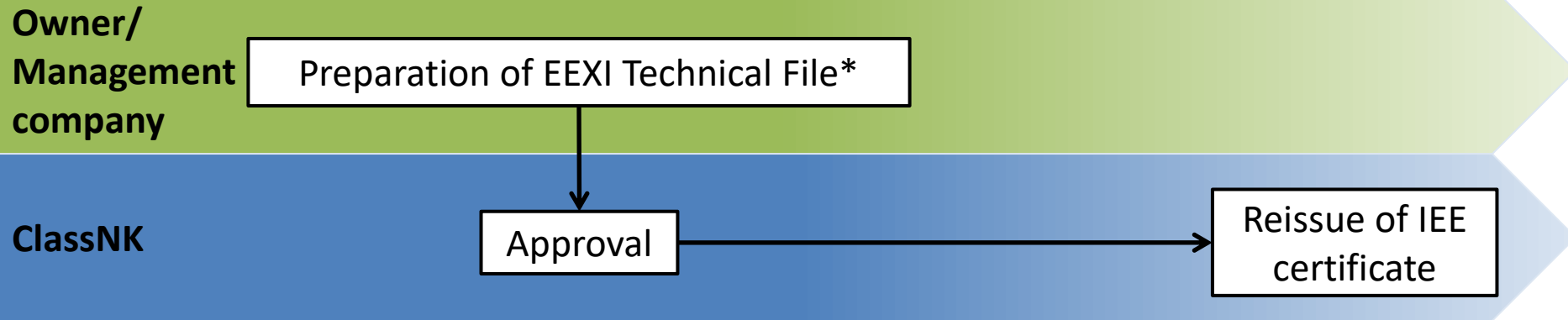
Speed ∝ DWT^{-2/9}

Increase rate of DWT	Decrease rate of Speed	Improvement rate of attained EEXI	Decrease rate of required EEXI (Bulk carrier)	Decrease rate of required EEXI (Tanker)	Actual improvement rate (Bulk carrier)	Actual improvement rate (Tanker)
+1.0%	-0.22%	+0.77%	-0.47%	-0.48%	+0.30%	+0.29%
+3.0%	-0.65%	+2.27%	-1.40%	-1.43%	+0.87%	+0.84%
+5.0%	-1.08%	+3.72%	-2.30%	-2.35%	+1.42%	+1.37%

- ✓ Attained EEXI can be improved by increasing deadweight. However, Required EEXI becomes more stricter simultaneously.
- ✓ If Deadweight is increased by 5%, the actual gain of EEXI becomes about **1.4%**.
- ✓ Increasing deadweight may not be a cost-effective solution to improve the ship's attained EEXI.

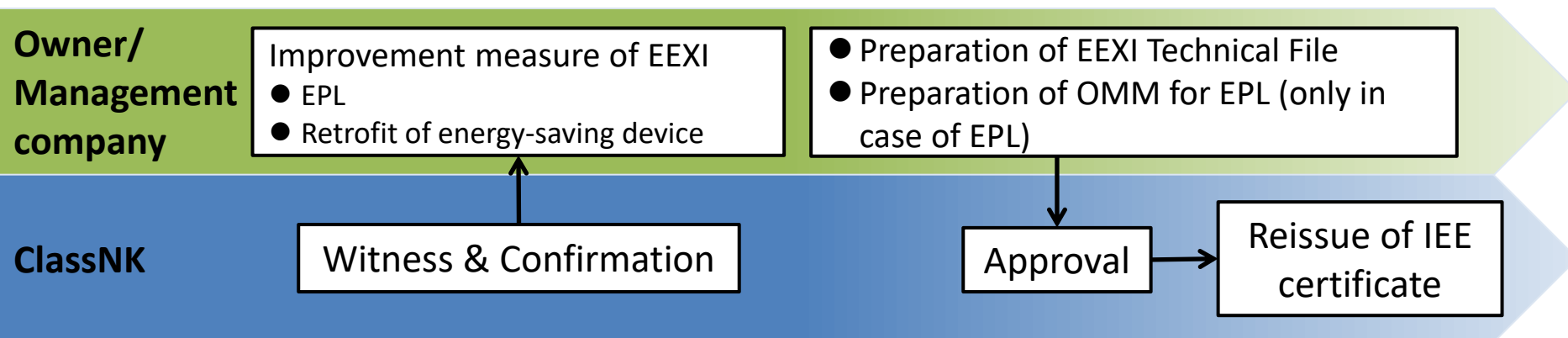
Flow of EEXI verification

Improvement of energy efficiency (EEXI) is **not needed**. (only non EEDI ship)



* Document including the information necessary for the calculation of the attained EEXI

Improvement of energy efficiency (EEXI) is **needed**.



Status of compliance with EEXI on NK classed ship

■ Number of ships subjected to EEXI

7,200 ships

✓ Non EEDI ship

5,300 ships

✓ EEDI ship (not comply with EEXI)

750 ships

✓ EEDI ship (comply with EEXI)

1,150 ships

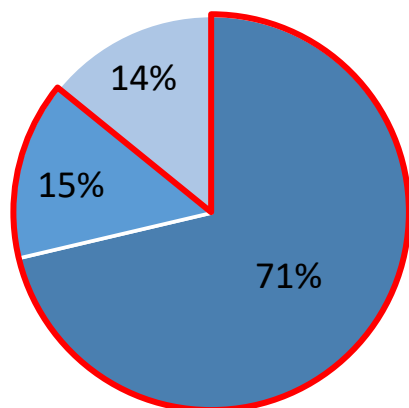


Action needed:
6,050 ships (84%)



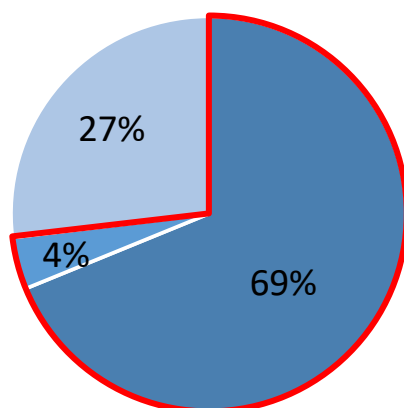
No action needed:
1,150 ships (16%)

Bulk carrier



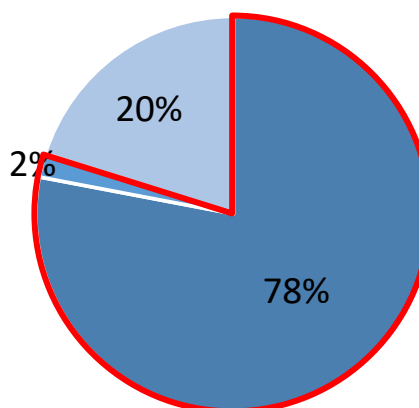
Action needed: 86%

Tanker



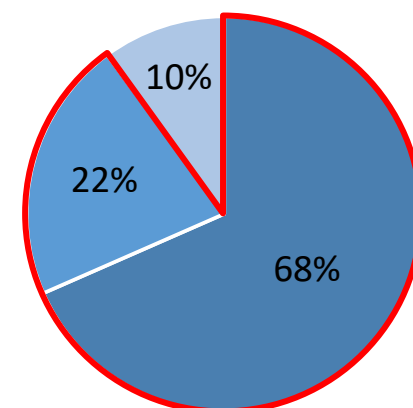
Action needed: 73%

Containership



Action needed: 80%

Gas carrier



Action needed: 90%

- Non EEDI ship
- EEDI ship (not comply with EEXI)
- EEDI ship (comply with EEXI)

Inquiry contact

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THANK YOU

for your kind attention

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