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TECHNICAL PUBLICATION

EEDI & EEXI

Explanatory guidance

August 2022

REVISION HISTORY

Rev. No	Date	Amendments
1	August 2022	The publication has been amended to include only EEDI/EEXI-related Guidelines along with the 2021 guidance on the treatment of innovative energy efficiency technologies as per MEPC.1/Circ.896, and 2022 guidelines on survey and certification of the attained energy efficiency existing ship index (EEXI)
Initial	September 2021	Initial issue

CONTENT

BACKGROUND

The International Maritime Organization (IMO) has agreed a set of guidelines to support mandatory measures to cut the carbon intensity of all ships. These have been approved by IMO's Marine Environment Protection Committee (MEPC) and have been adopted on the MEPC 76th session on 10-17 June, 2021.

The amendments to the MARPOL Convention require ships to combine a technical and operational approach to reduce their carbon intensity. This is in line with the ambition of the Initial IMO GHG Strategy, which aims to reduce carbon intensity of international shipping and was agreed in 2018. Two of the targets set in the Initial Strategy were:

1. reduce CO_2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008; and
2. total annual GHG emissions from international shipping should be reduced by at least 50% by 2050, compared to 2008.

The following measures have been introduced:

1. The Energy Efficiency Design Index (EEDI), applicable for New* and Existing ship that has undergone a major conversion which is so extensive that the ship is regarded by the Administration as a newly constructed ship Ships, must be calculated according to 2018 guidelines on method for EEDI calculations for new ships MEPC.308(73). The attained EEDI shall be specific to each ship and shall indicate the estimated performance of the ship in terms of energy efficiency, and be accompanied by the EEDI technical file that contains the information necessary for the calculation of the attained EEDI and that shows the process of calculation. The attained EEDI shall be verified, based on the EEDI technical file, either by the Administration or by any organization duly authorized by it.

The above approach aims to address both technical (how the ship is equipped and retrofitted) and operational measures (how the ship operates).

The amendments require IMO to review the effectiveness of the implementation of the CII and EEXI requirements, by 1 January 2026 at the latest, and, if necessary, develop and adopt further amendments. IMO's Initial GHG Strategy is to be revised by 2023.

*New ship means a ship: for which the building contract is placed on or after 1 January 2013; or in the absence of a building contract, the keel of which is laid or which is at a similar stage of construction on or after 1 July 2013; or the delivery of which is on or after 1 July 2015.
**Existing ship means a ship which is not a new ship

THE ENERGY EFFICIENCY DESIGN INDEX (EEDI)

The Energy Efficiency Design Index (EEDI)[1] was made mandatory for new ships and the Ship Energy Efficiency Management Plan (SEEMP) for all ships at MEPC 62 (July 2011) with the adoption of amendments to MARPOL Annex VI (resolution MEPC.203(62)), by Parties to MARPOL Annex VI. This was the first legally binding climate change treaty to be adopted since the Kyoto Protocol.

The EEDI for new ships is the most important technical measure and aims at promoting the use of more energy efficient (less polluting) equipment and engines. The EEDI requires a minimum energy efficiency level per capacity mile (e.g. tonne mile) for different ship type and size segments. Since 1 January 2013, following an initial two-year phase zero, new ship design needs to meet the reference level for their ship type. The level is to be tightened incrementally every five years, and so the EEDI is expected to stimulate continued innovation and technical development of all the components influencing the fuel efficiency of a ship from its design phase. The EEDI is a non-prescriptive, performance-based mechanism that leaves the choice of technologies to use in a specific ship design to the industry. As long as the required energy efficiency level is attained, ship designers and builders are free to use the most cost-efficient solutions for the ship to comply with the regulations.

The EEDI provides a specific figure for an individual ship design, expressed in grams of carbon dioxide (CO2) per ship's capacity-mile (the smaller the EEDI the more energy efficient ship design) and is calculated as per 2018 guidelines on method for EEDI calculations for new ships MEPC.308(73) by a formula based on the technical design parameters for a given ship.

The CO2 reduction level (grams of CO2 per tonne mile) for the first phase is set to 10% and will be tightened every five years to keep pace with technological developments of new efficiency and reduction measures. Reduction rates have been established until the period 2025 and onwards when a 30% reduction is mandated for applicable ship types calculated from a reference line representing the average efficiency for ships built between 2000 and 2010. The EEDI is developed for the largest and most energy intensive segments of the world merchant fleet and embraces emissions from new ships covering the following ship types: tankers, bulk carriers, gas carriers, general cargo ships, container ships, refrigerated cargo carriers and combination carriers. In 2014, MEPC adopted amendments to the EEDI regulations to extend the scope of EEDI to: LNG carriers,

[1] EEDI: Energy Efficiency design index for new ship for which the building contract is placed on or after 01 January 2023.
EEXI: Energy Efficiency design index for existing ship for which the building contract is placed on or before 01 January 2023.

ro-ro cargo ships (vehicle carriers), ro-ro cargo ships; ro-ro passenger ships and cruise passenger ships having non-conventional propulsion. These amendments mean that ship types responsible for approximately 85% of the CO2 emissions from international shipping are incorporated under the international regulatory regime.

For the calculation of EEDI ships are divided into different types based on their cargo and size as in IMO Resolution MEPC.324(75). Each ship's attained EEXI is to be below the required EEXI to comply with the EEXI requirements.

Existing table 1 - Reduction factors in Regulation 21 for the required EEDI has been amended, as shown below. The EEDI relative to the EEDI reference line and the associated footnotes have been replaced by the following:

Ship Type	Size	Phase 0 01/01/2013 – 31/12/2014	Phase 1 01/01/2015 – 31/12/2019	Phase 2 01/01/2020 – 31/03/2022	Phase 2 01/01/2020 – 31/12/2024	Phase 3 01/04/2022 and onwards	Phase 3 01/01/2022 and onwards
Bulk carrier	20,000 DWT and above	0	0-10*		0-20*		0-30*
	10,000 and above but less than 20,000 DWT	n/a	0-10*	20		30	
Gas carrier	15,000 DWT and above	0	10	20		30	
	10,000 and above but less than 15,000 DWT	0	10		20		30
	2,000 and above but less than 10,000 DWT	n/a	0-10*		0-20*		0-30*
Tanker	20,000 DWT and above	0	10		20		30
	4,000 and above but less than 20,000 DWT	n/a	0-10*		0-20*		0-30*
Containership	200,000 DWT and above	0	10	20		50	
	120,000 and above but less than 200,000 DWT	0	10	20		45	
	80,000 and above but less than 120,000 DWT	0	10	20		40	

Ship Type	Size	Phase 0 01/01/2013 – 31/12/2014	Phase 1 01/01/2015 – 31/12/2019	Phase 2 01/01/2020 – 31/03/2022	Phase 2 01/01/2020 – 31/12/2024	Phase 3 01/04/2022 and onwards	Phase 3 01/01/2022 and onwards
	40,000 and above but less than 80,000 DWT	0	10	20		35	
	15,000 and above but less than 40,000 DWT	0	10	20		30	
	10,000 and above but less than 15,000 DWT	n/a	0-10*	0-20*		15-30*	
General Cargo ships	15,000 DWT and above	0	10	15		30	
	3,000 and above but less than 15,000 DWT	n/a	0-10*	0-15*		0-30*	
Refrigerated cargo carrier	5,000 DWT and above	0	10		15		30
	3,000 and above but less than 5,000 DWT	n/a	0-10*		0-15*		0-15*
Combination carrier	20,000 DWT and above	0	10		20		30
	4,000 and above but less than 20,000 DWT	n/a	0-10*		0-20*		0-30*
LNG carrier***	10,000 DWT and above	n/a	10**	20		30	
Roro cargo ship (vehicle carrier)***	10,000 DWT and above	n/a	5**		15		30
Roro cargo ship***	2,000 DWT and above	n/a	5**		20		30
	1,000 and above but less than 2,000 DWT	n/a	0-5*,**		0-20*		0-30*
Roro passenger ship***	1,000 DWT and above	n/a	5**		20		30
	250 and above but less than 1,000 DWT	n/a	0-5*,**		0-20*		0-30*
Cruise passenger	85,000 GT and above	n/a	5**	20		30	

Ship Type	Size	Phase 0 01/01/2013 – 31/12/2014	Phase 1 01/01/2015 – 31/12/2019	Phase 2 01/01/2020 – 31/03/2022	Phase 2 01/01/2020 – 31/12/2024	Phase 3 01/04/2022 and onwards	Phase 3 01/01/2022 and onwards
ship*** having nonconventional propulsion	25,000 and above but less than 85,000 GT	n/a	0-5*.**	0-20*		0-30*	
* Reduction factor to be linearly interpolated between the two values dependent upon ship size. The lower value of the reduction factor is to be applied to the smaller ship size. ** Phase 1 commences for those ships on 1 September 2015. *** Reduction factor applies to those ships delivered on or after 1 September 2019, as defined in paragraph 43 of regulation 2. Note: n/a means that no required EEDI applies.							

Table 1 - Reduction factors

EEDI TECHNICAL FILE

As of January 1st, 2023 an **EEXI technical file** needs to exist on board for vessels satisfying the Required EEXI.

The EEXI technical file need to include the EEXI calculation with supporting documentation and must be summitted to Dromon Head Office prior the International Energy Efficiency (IEE) survey takes place or an the first scheduled annual, intermediate or renewal surveys on or after 01/01/2023.

A sample of the EEXI Technical file is included in Annex 1 of this document.

THE CALCULATION FORMULA

The calculation of the EEDI is to be performed in accordance with IMO “2018 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships, as amended”.

The general formula for EEDI calculation is indicated below:

$$EEDI = CO_2 \text{ Emissions/Transport Work}$$

that can be also expressed as:

$$EEDI = \text{Engine Power}.SFC.C_F/\text{dwt}.\text{Speed (g } CO_2\text{/ tonmile)}$$

where,

- SPF (Specific Fuel Consumption) (g/KWH): an amount of fuel used for engines in an hour;
- C_F (Carbon Factor): the amount of CO2 generated per mass fuel burned; and
- DWT (DeadWeight Tonnage): the capacity of the vessel that carries full load.

The EEDI is provided by the following formula:

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

C_F is a non-dimensional conversion factor between fuel consumption measured in g and CO_2 emission also measured in g based on carbon content. The subscripts ME(i) and AE(i) refer to the main and auxiliary engine(s) respectively. CF corresponds to the fuel used when determining SFC listed in the applicable test report included in a Technical File. The value of C_F is as follows:

	Type of fuel	Reference	Lower calorific value (Kj/Kg)	Carbon content	Cf (t-CO_2/ t-Fuel)
1	Diesel/ Gas Oil	ISO 8217 Grades DMX through DMB	42.700	0.8744	0.3206
2	Light Fuel Oil (LFO)	ISO 8217 Grades RMA through RMD	41.200	0.8594	3.151
3	Heavy fuel Oil (HFO)	ISO 8217 Grades RME through RMK	40.200	0.8493	3.114
4	Liquefied Petroleum Gas	PROPANE	46.300	0.8182	3
		BUTANE	46.700	0.8264	3.03
5	Liquefied Natural Gas (LNG)		48.800	0.75	2.75
6	Methanol		19.900	0.375	1.375
7	Ethanol		26.800	0.5217	1.913

Table 2 – Conversion factor

In case the attained EEDI meets the required EEDI, then an Energy Efficiency Certificate can be issued but in the case that the above term is not met, then energy efficiency improvement is required. At the design stage it must be ensured that the EEDI requirements as well as the minimum required power demand for maneuverability of the ship in adverse weather conditions are fulfilled.

The energy efficiency improvement can be achieved with the below actions:

- Shaft/engine power limit (power optimization/with safety reserve);
- Fuel change and/or energy saving devices;
- Replacement with new ships; and
- Other verifiable options.

The required EEDI is the maximum allowable value of the attained EEDI as defined in table reference line values. The required EEDI is calculated for all ship types using 100% of the deadweight at summer load draft, except for passenger ships where GT is used.
The required EEDI will be reduced by X% each five years based on the initial value in phase 0 and depending on the vessel size. Below a certain size no reduction applies. Above a certain ship size, the reduction is in general 10% for each reduction phase. In between of those sizes the reduction is linear interpolated.

$$\text{Attained EEDI} \leqq \text{Required EEDI} = (1\text{-}X/100) * \text{Reference line value}$$

where,
X= Reduction factor in percentage (table reduction rates)
The reference Line value shall be calculated as follows (table reference line values)

$$\text{Reference EEDI} = a \times b^{-c}$$

While the EEDI reference line or baseline for each ship type is defined as a curve representing an average index value fitted on a set of individual index values for a defined group of ships.

For each new and existing ship that has undergone a major conversion which is so extensive that the ship is regarded by the Administration as a newly constructed ship, the attained EEDI shall be calculated with the reduction factor applicable corresponding to the ship type and size of the converted ship at the date of the contract of the conversion, or in the absence of a contract, the commencement date of the conversion.

Ship Types	a	b	c
Bulk Carrier	961.79	DWT of the ship	0.477
Gas Carrier	1120		0.456
Tanker	1218.8		0.488
Container ship	174.22		0.201
General Cargo ship	107.48		0.216
Refrigerated Cargo Ship	227.01		0.244
Combination Carrier	1219		0.488

Ro-Ro Cargo ship (Vehicle carrier)	(DWT/GT)^(-0.7)* 780.36 where DWT/GT<0.3 1812.63 where DWT/GT≥0.3		0.471
Ro-Ro Cargo ship	1405.15		0.498
Ro-Ro passenger ship	752.16		0.381
LNG Carrier	2253.16		0.474
Cruise Passenger ship having non-conventional propulsion	170.84		0.214

Table 3 – Reference Line Values

If the design of a ship allows it to fall into more than one of the above ship type definitions, the required EEDI for the ship shall be the most stringent (the lowest) required EEDI.

For each ship to which the regulation applies, the installed propulsion power shall not be less than the propulsion power needed to maintain the maneuverability of the ship under adverse conditions.

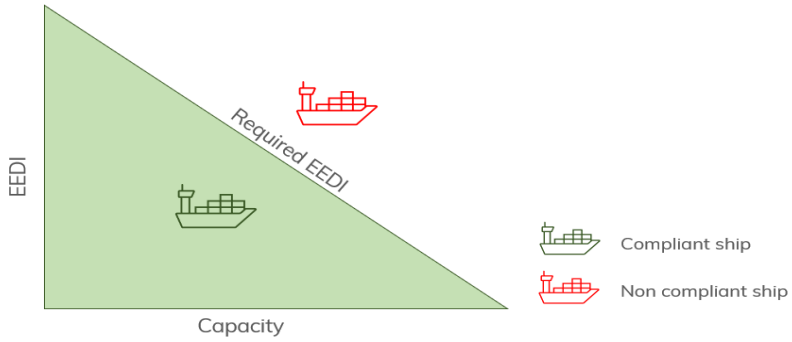


Figure 1 – Required EEDI compliance

EEXI TECHNICAL FILE

EEXI formula

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

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

* If part of the Normal Maximum Sea Load is provided by shaft generators, SFCME and CFME may

– for that part of the power – be used instead of SFCAE and CFAE

** In case of PPTI(i) > 0, the average weighted value of (SFCME · CFME) and (SFCAE · CFAE) to be used for calculation of Peff

PME(i), PAE(i), Vref, SFC, CF, fjRoRo, fcVEHICLE, fi, fc, fl, fw, fm, Capacity, as specified in MEPC 350 (78), MEPC 308 (73), IACS Procedures PR38 rev. 3, IACS EEXI Implementation Guidelines No. 172

Attained EEXI ≦ Required EEXI = (1-Y/100) * Reference line value

The reference Line value shall be calculated same as EEDI reference line calculation.

Table 4. Reduction factors (in percentage) for the EEDI relative to the EEDI Reference line:

Ship type	Size	Reduction factor
Bulk carrier	200,000 DWT and above	15
	20,000 and above but less than 200,000 DWT	20
	10,000 and above but less than 20,000 DWT	0-20*
Gas carrier	15,000 DWT and above	30
	10,000 and above but less than 15,000 DWT	20
	2,000 and above but less than 10,000 DWT	0-20*
Tanker	200,000 DWT and above	15
	20,000 and above but less than 200,000 DWT	20
	4,000 and above but less than 20,000 DWT	0-20*
Containership	200,000 DWT and above	50
	120,000 and above but less than 200,000 DWT	45
	80,000 and above but less than 120,000 DWT	35
	40,000 and above but less than 80,000 DWT	30
	15,000 and above but less than 40,000 DWT	20

	10,000 and above but less than 15,000 DWT	0-20*
General cargo ship	15,000 DWT and above	30
	3,000 and above but less than 15,000 DWT	0-30*
Refrigerated cargo carrier	5,000 DWT and above	15
	3,000 and above but less than 5,000 DWT	0-15*
Combination carrier	20,000 DWT and above	20
	4,000 and above but less than 20,000 DWT	0-20*
LNG carrier	10,000 DWT and above	30
Ro-ro cargo ship (vehicle carrier)	10,000 DWT and above	15
Ro-ro cargo ship	2,000 DWT and above	5
	1,000 and above but less than 2,000 DWT	0-5*
Ro-ro passenger ship	1,000 DWT and above	5
	250 and above but less than 1,000 DWT	0-5*
Cruise passenger ship having non-conventional propulsion	85,000 GT and above	30
	25,000 and above but less than 85,000 GT	0-30*

Table 4 – Reduction Factors

* For those ships outside the threshold identified by Table 4, the Required EEXI has not to be calculated and compared with the Attained EEXI. In this case, the Attained EEXI value only will be included in the EEXI technical file.

2021 GUIDELINES ON THE SHAFT / ENGINE POWER LIMITATION SYSTEM TO COMPLY WITH THE EEXI REQUIREMENTS AND USE OF A POWER RESERVE

The purpose of the IMO Resolution MEPC.335(76) is to provide technical and operational conditions that the SHaPoLi / EPL system should satisfy in complying with the EEXI requirements and in using a power reserve for existing ships.

However, noting that guidelines on the SHaPoLi / EPL system under EEDI framework on new ships are currently considered at the MEPC, the guidelines under EEXI and EEDI may be consolidated into one set of guidelines as appropriate upon consideration by the MEPC, taking into account circumstances and technical limitation of existing ships.

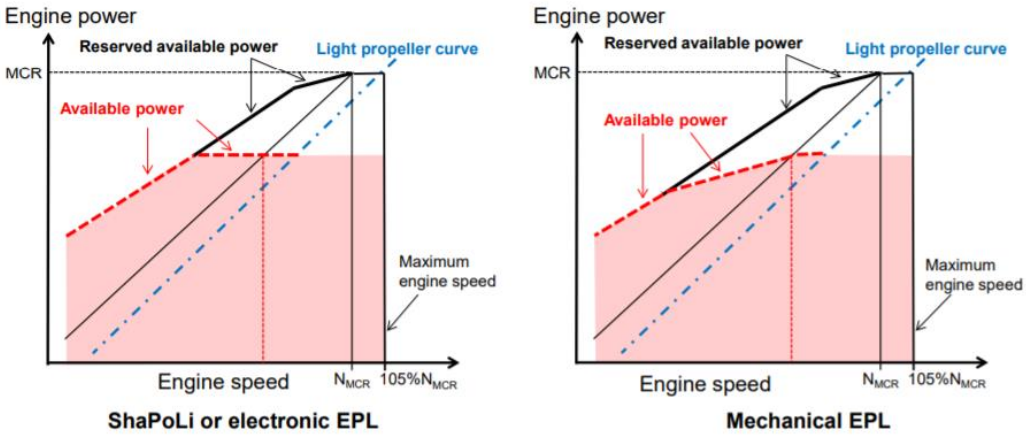


Figure 2: Engine load diagram on Shaft/Engine Power Limitation

The SHaPoLi / EPL system should consist of the following main arrangements:

1. SHaPoLi:
   - sensors for measuring the torque and rotational speed delivered to the propeller(s) of the ship. The system includes the amplifier and the analogue to the digital converter;
   - a data recording and processing device for tracking and calculation of the data as given in paragraph 2.2.5.1 of these Guidelines; and
   - a control unit for calculation and limitation of the power transmitted by the shaft to the propeller(s);
2. EPL:
   - for the mechanically controlled engine, a sealing device which can physically lock the fuel index by using a mechanical stop screw sealed by wire or an equivalent device with governor limit setting so that the ship's crew cannot release the EPL without permission from the ship's master or OICNW, as shown in figure 2; or
   - for the electronically controlled engine, fuel index limiter which can electronically lock the fuel index or direct limitation of the power in the engine's control system so that the ship's crew cannot release the EPL without permission from the ship's master or OICNW; and
   - where technically possible and feasible, the Sha/PoLi/EPL system should be controlled from the ships' bridge and not require attendance in the machinery space by ship's personnel.

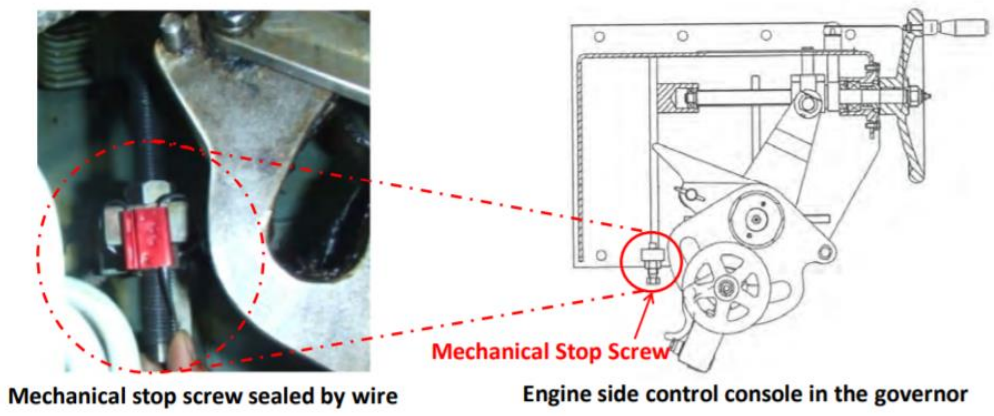


Figure 2: Sealing of mechanical stop screw

The SHaPoLi / EPL system should be non-permanent but should require the deliberate action of the ship's master or OICNW to enable the use of unlimited shaft / engine power (power reserve) of the ship. For systems that use a Password/PIN to control access to the power reserve override, attention should be paid to ensure that the necessary Password/PIN is always available when override is required.

For SHaPoLi / EPL system for the electronically controlled engine, the control unit should inform the ship's master or OICNW clearly and conspicuously when the ship's shaft / engine power exceeds the limited shaft / engine power as stated in the Onboard Management Manual (OMM) for SHaPoLi / EPL or in any case of system malfunction.

For EPL for the mechanically controlled engine, the sealing device should either:

1. visibly indicate removal of the sealing when the ship's engine power exceeds the limited engine power as stated in the OMM for EPL or in any case of system malfunction; or
2. be equipped with other systems such as an alert-monitoring system which can indicate when the ship's engine power exceeds the limited engine power, as stated in the OMM for EPL or in any case of system malfunction and recording the use of unlimited mode, verified by the Administration or the RO.

The SHaPoLi / EPL system (or each subsystem) should be tamper-proof.

The SHaPoLi / EPL system for the electronically controlled engine should indicate the following data during operation:

1. for SHaPoLi, shaft rotational speed, shaft torque and shaft power (and total shaft power in case of multiple shaft arrangements) to be recorded constantly in unlimiting mode; or
2. for EPL, a fuel index sealing system or power limitation system which can indicate and record the use of unlimited mode.

The procedure for SHaPoLi / EPL depends on the propulsion system and should be described in the OMM for SHaPoLi / EPL.

The use of a power reserve 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 (e.g. operating in adverse weather and ice-infested waters, participation in search and rescue operations, avoidance of pirates and engine maintenance). Use of a power reserve should not have adverse impact on the propeller, shaft and related systems. It is important that the ship master and OICNW are not restricted from exercising judgement to override the SHaPoLi / EPL when required for safety purposes. The authority for this should be clearly set out in the OMM and/or the Safety Management System manual, as appropriate.

Any use of a power reserve should be recorded in the record page of the OMM for SHaPoLi / EPL, signed by the master and should be kept on board. The record should include:

1. ship type;
2. IMO number;
3. ship size in DWT and/or GT, as applicable;
4. ship's limited shaft / engine power and ship's maximum unlimited shaft / engine power;
5. position of the ship and timestamp when the power reserve was used;
6. reason for using the power reserve;
7. Beaufort number and wave height or ice condition in case of using the power reserve under adverse weather condition;
8. supporting evidence (e.g. expected weather condition) in case of using the power reserve for avoidance action;
9. records from the SHaPoLi / EPL system for the electronically controlled engine during the power reserve was used; and
10. position of the ship and timestamp when the power limit was reactivated or replaced.

Where an EPL/ShaPoLi override is activated but the power reserve is not subsequently used, this event should be recorded in the bridge and engine-room logbooks.

The engine-room logbook should record power used during the period when the override was activated. The EPL/ShaPoLi should be reset as soon as possible, and details of the reset should also be recorded in the bridge and engine-room logbooks.

In case of having used a power reserve, the ship should without delay notify Dromon and the

competent authority of the relevant port of destination with the information recorded.

Once the risks have been mitigated, the ship should be operated below the certified level of engine power under the SHaPoLi / EPL. The SHaPoLi / EPL system should be reactivated or replaced by the crew immediately after the risks have been prevented and the ship can be safely operated with the limited shaft / engine power. The reactivation or replacement of the SHaPoLi / EPL system should be confirmed (e.g. validation of mechanical sealing) with supporting evidence (e.g. engine power log, photo taken at the occasion of resetting the mechanical sealing) by Dromon at the earliest opportunity.

ONBOARD MANAGEMENT MANUAL (OMM) FOR SHAPOLI / EPL

The SHaPoLi / EPL system should be accompanied by the OMM for SHaPoLi / EPL that should be permanently on board the ship for inspection.

The OMM for SHaPoLi / EPL should be verified by Dromon after a survey verifying the ship's attained EEXI, as required by regulation 5.4 of MARPOL Annex VI.

The OMM for SHaPoLi / EPL should, as a minimum, include:

1. SHaPoLi:
    - a technical description of the main system as specified in section 2 of these guidelines as well as relevant auxiliary systems;
    - identification of key components of the system by manufacturer, model/type, serial number and other details as necessary;
    - description of a verification procedure demonstrating that the system is in compliance with the technical description in accordance with items .1 and .2;
    - the maximum shaft power for which the unit is designed;
    - service, maintenance and calibration requirements of sensors according to sensor manufacturer and a description how to monitor the appropriateness of the calibration intervals, if applicable;
    - the SHaPoLi record book for the recording of service, maintenance and calibration of the system;
    - the description how the shaft power can be limited and unlimited and how this is displayed by the control unit as required by paragraph 2.2.5 of these Guidelines;
    - the description of how the controller limits the power delivered to the propeller shaft;

- the identification of responsibilities;
- procedures for notification of the use of power reserve and the detections of malfunctions of the system in accordance with paragraphs 3.4 and 3.5 of these Guidelines;
- time required for un-limiting the SHaPoLi; and
- procedures for survey of the SHaPoLi system by thew Administration/RO.

2. EPL:
   - rated installed power (MCR) or motor output (MPP) and engine speed (NMCR);
   - limited installed power (MCRlim) or motor output (MPPlim) and engine speed (NMCR,lim);
   - technical description of the EPL system;
   - method for sealing the EPL (mechanically controlled engine);
   - method for locking and monitoring the EPL (electronically controlled engine);
   - procedures and methods for releasing the EPL;
   - time required for unlimiting the EPL;
   - procedures for survey of the EPL system by the Administration/RO;
   - procedure for the report on release of the EPL; and
   - administrator of the EPL system.

In cases where the SHaPoLi / EPL system is applied and no changes are made to NOX critical settings and/or components outside what is allowed by the engine technical file as defined in the 2008 NOX Technical Code (NTC 2008), engine re-certification is not needed.

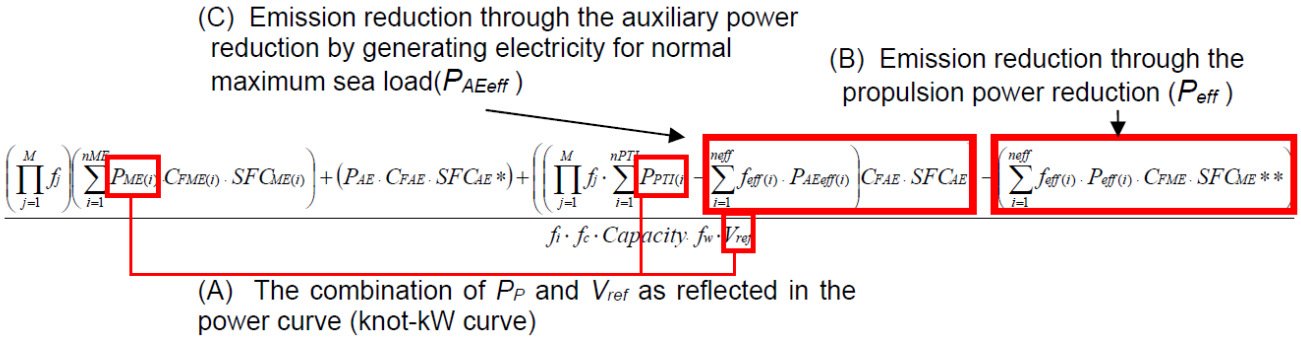
In cases where the SHaPoLi / EPL system is applied and the NOX critical settings and/or components are altered beyond what is allowed by the engine technical file as defined in NTC 2008, the engine needs to be re-certified. In such a case, for an EEDI-certified ship where the SHaPoLi / EPL system is applied at a power below that required by regulation 24.5 of MARPOL Annex VI (minimum power requirement), the certified engine power should be at the power satisfying that requirement.

2021 GUIDANCE ON TREATMENT OF INNOVATIVE ENERGY EFFICIENCY TECHNOLOGIES FOR CALCULATION AND VERIFICATION OF THE ATTAINED EEDI AND EEXI

Categorizing of Innovative Energy Efficiency Technologies

Innovative energy efficiency technologies are allocated to categories (A), (B) and (C), depending on their characteristics and effects to the EEDI formula. Furthermore, innovative energy efficiency technologies of category (B) and (C) are categorized to two sub-categories (category (B-1) and (B-2), and (C-1) and (C-2), respectively).

- **Category (A)**: Technologies that shift the power curve, which results in the change of combination of PP and Vref: e.g. when Vref is kept constant, PP will be reduced and when PP is kept constant, Vref will be increased.
- **Category (B)**: Technologies that reduce the propulsion power, PP, at Vref, but do not generate electricity. The saved energy is counted as Peff.
- **Category (B-1)**: Technologies which can be used at any time during the operation and thus the availability factor (feff) should be treated as 1.00.
- **Category (B-2)**: Technologies which can be used at their full output only under limited condition. The setting of availability factor (feff) should be less than 1.00.
- **Category (C)**: Technologies that generate electricity. The saved energy is counted as PAEeff.
- **Category (C-1)**: Technologies which can be used at any time during the operation and thus the availability factor (feff) should be treated as 1.00.
- **Category (C-2)**: Technologies which can be used at their full output only under limited condition. The setting of availability factor (feff) should be less than 1.00.



Innovative Energy Efficiency Technologies				
Reduction of Main Engine Power			Reduction of Auxiliary Power	
Category A	Category B-1	Category B-2	Category C-1	Category C-2
Cannot be separated from overall performance of the vessel	Can be treated separately from the overall performance of the vessel		Effective at all times	Depending on ambient environment
	$f_{eff} = 1$	$f_{eff} < 1$	$f_{eff} = 1$	$f_{eff} < 1$
▪ low friction coating ▪ bare optimization ▪ rudder resistance ▪ propeller design	▪ hull air lubrication system (air cavity via air injection to reduce ship resistance) (can be switched off)	▪ wind assistance (sails, Flettner-Rotors, kites)	▪ waste heat recovery system (exhaust gas heat recovery and conversion to electric power)	▪ photovoltaic cells

Table 4 – Categorization of innovative energy efficiency technologies

CALCULATION AND VERIFICATION OF EFFECTS OF INNOVATIVE ENERGY EFFICIENCY TECHNOLOGIES

The evaluation of the benefit of any innovative technology is to be carried out in conjunction with the hull form and propulsion system with which it is intended to be used. Results of model tests or sea trials of the innovative technology in conjunction with different hull forms or propulsion systems may not be applicable.

CATEGORY (A) TECHNOLOGY

Innovative energy efficiency technologies in category (A) affect PP and/or Vref and their effects cannot be measured in isolation. Therefore, these effects should not be calculated nor certified in isolation in this guidance but should be treated as a part of vessel in EEDI Calculation Guidelines and EEDI Survey Guidelines.

CATEGORY (B) TECHNOLOGY [2]

The effects of innovative energy technologies in category (B) are expressed as Peff which would be multiplied by CFME and SFCME (in the case of PPTI(i) >0, the average weighted value of (SFCME . CFME) and (SFCAE . CFAE)) and feff, and then be deducted from the EEDI formula. In the case of category (B-1) technology, feff is 1.00.

[2] Guidance on calculation and verification of effects of Category (B) innovative technologies is given in Annex 1 of MEPC.1/Circ.896.

Category B-1 – Air Lubrication System

An air lubrication system is one of the innovative energy efficiency technologies. Ship frictional resistance can be reduced by covering the ship surface with air bubbles, which is injected from the fore part of the ship bottom by using blowers, etc.

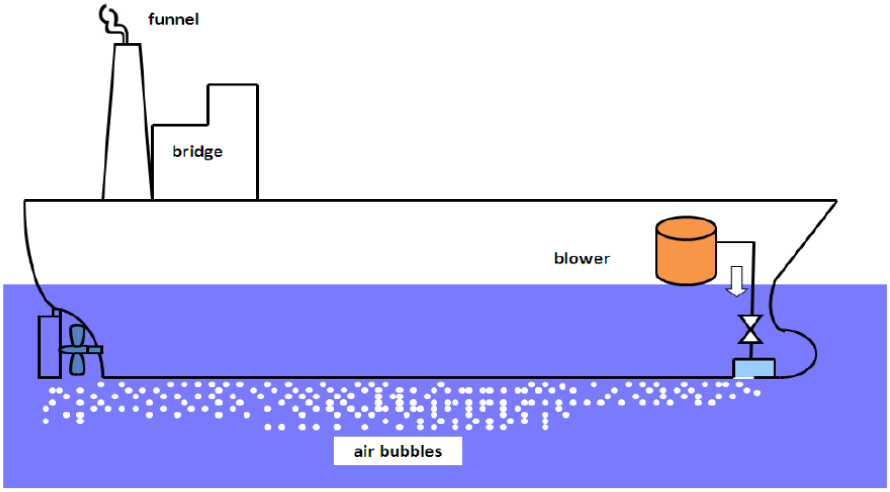


Figure 3 – Schematic illustration of an air lubrication system

Category B-2 – Wind Assisted Propulsion System

Wind-assisted propulsion systems (WAPS) belong to innovative mechanical energy-efficient technologies which reduce the CO2 emissions of ships. There are different types of wind propulsion technologies (sails, wings, kites, etc.) which generate forces dependent on wind conditions. This technical guidance defines the available effective power of WAPS as the product of the reference speed and the sum of the wind-assisted propulsion system force and the global wind probability distribution.

Secondary effects when applying the wind-assisted propulsion system which might increase the ship resistance are ignored for the purpose of these guidelines. With this simplification effects as for instance, additional drag due to leeway, rudder angle, and heel or reduced propeller efficiency in light running condition are ignored without significant loss of accuracy. Nonetheless, the corresponding forces are considered to rule out conditions that do not allow a safe operation of the ship, for instance, due to exceeding heel angles.

CATEGORY (C) TECHNOLOGY 3

[3] Guidance on calculation and verification of effects of Category (C) innovative technologies is given in Annex 2 of MEPC.1/Circ.896.

The effects of innovative energy technologies in category (C) are expressed as PAEeff which would be multiplied by CFAE, SFCAE and feff, and then be deducted from the EEDI formula. In the case of category (C-1) technology, feff is 1.00.

Category C-1: Waste Heat Recovery System For Generation Of Electricity
Waste heat energy technologies increase the efficiency utilization of the energy generated from fuel combustion in the engine through recovery of the thermal energy of exhaust gas, cooling water, etc. thereby generating electricity.

These are the following two methods of generating electricity by the waste heat energy technologies (electric generation type):

1. (A) method to recover thermal energy by a heat exchanger and to drive the thermal engine which drives an electric generator; and
2. (B) method to drive directly an electric generator using power turbine, etc. Furthermore, there is a waste heat recovery system which combines both of the above methods.

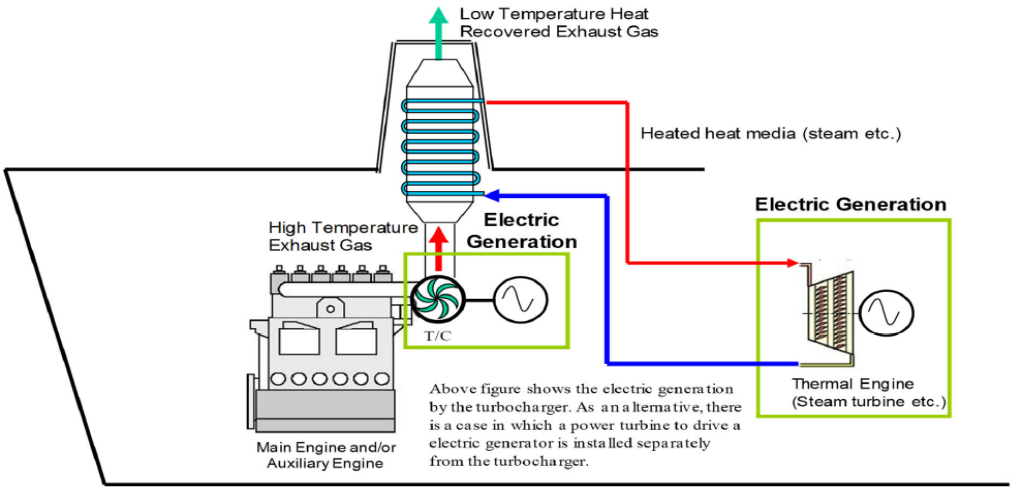


Figure 4 – Schematic illustration of Exhaust Heat Recovery

CATEGORY C-2 – PHOTOVOLTAIC POWER GENERATON SYSTEM

Photovoltaic (PV) power generation system set on a ship will provide part of the electric power either for propelling the ship or for use inboard. PV power generation system consists of PV modules and other electric equipment. Figure 1 shows a schematic diagram of PV power generation system. The PV module consists of combining solar cells and there are some types of solar cell such as "Crystalline silicon terrestrial photovoltaic" and "Thin-film terrestrial photovoltaic", etc.

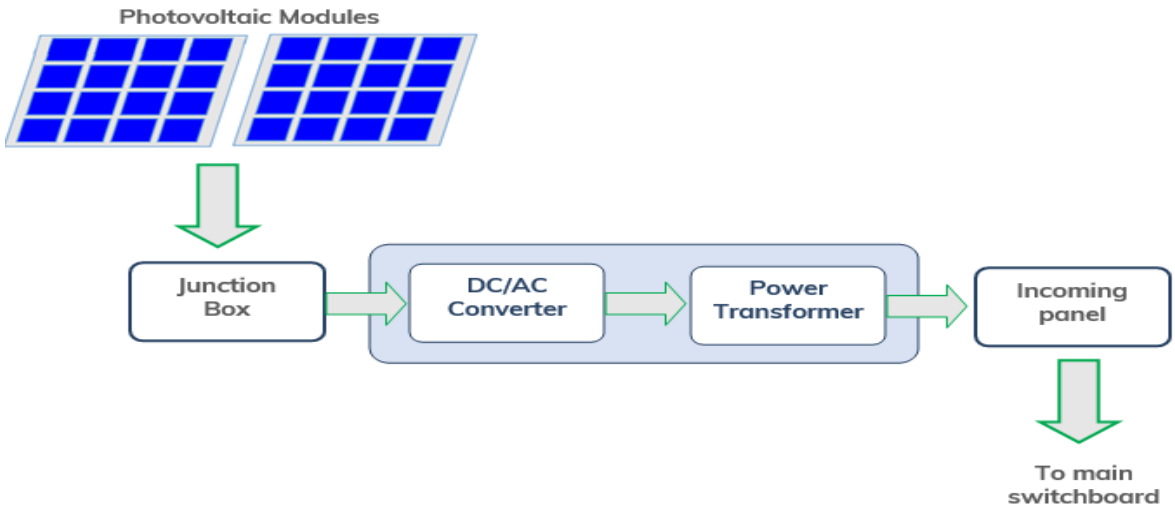


Figure 5 – Schematic diagram of a photovoltaic power generation system

2022 GUIDELINES ON SURVEY AND CERTIFICATION OF THE ATTAINED ENERGY EFFICIENCY EXISTING SHIP INDEX

The attained EEXI should be calculated in accordance with regulation 23 of MARPOL Annex VI and the 2022 Guidelines on the method of calculation of the attained Energy Efficiency Existing Ship Index (EEXI) (resolution MEPC.350(78)) (EEXI Calculation Guidelines).

The 2021 Guidance on treatment of innovative energy efficiency technologies for calculation and verification of the attained EEDI and EEXI (MEPC.1/Circ.896) should be applied for calculation of the attained EEXI, if applicable.

VERIFICATION OF THE ATTAINED EEXI

For verification of the attained EEXI, an application for a survey and an EEXI Technical File containing the necessary information for the verification and other relevant background documents should be submitted to Dromon Head Office, unless the attained EEDI of the ship satisfies the required EEXI.

The EEXI Technical File should be written at least in English. The EEXI Technical File should include, but not be limited to:

1. deadweight (DWT) or gross tonnage (GT) for ro-ro passenger ship and cruise passenger ship having non-conventional propulsion;
2. the rated installed power (MCR) of the main and auxiliary engines;
3. the limited installed power (MCRlim) in cases where the overridable Shaft/Engine Power Limitation system is installed;

4. the ship speed (Vref);
5. the approximate ship speed (Vref,app) for pre-EEDI ships in cases where the speed-power curve is not available, as specified in paragraph 2.2.3.5 of the EEXI Calculation Guidelines;
6. an approved speed-power curve under the EEDI condition as specified in paragraph 2.2 of the EEDI Calculation Guidelines, which is described in the EEDI Technical File, in cases where regulation 22 of MARPOL Annex VI (Attained EEDI) is applied;
7. an estimated speed-power curve under the EEDI condition, or under a different load draught to be calibrated to the EEDI condition, obtained from tank test and/or numerical calculations, if available;
8. estimation process and methodology of the power curves, as necessary, including documentation on consistency with the defined quality standards (e.g. ITTC 7.5-03-01-02 and ITTC 7.5-03-01-04 in their latest revisions) and the verification of the numerical set-up with parent hull or the reference set of comparable ships in case of using numerical calculations;
9. a sea trial report including sea trial results, which may have been calibrated by the tank test, under the sea condition as specified in paragraph 2.2.2 of the EEDI Calculation Guidelines, if available;
10. an in-service performance measurement report, where applicable, as specified in paragraphs 2.2.3.5 and 2.2.3.7.2 of the EEXI Calculation Guidelines;
11. calculation process of Vref,app for pre-EEDI ships in cases where the speed-power curve is not available, as specified in paragraph 2.2.3.6 of the EEXI Calculation Guidelines;
12. type of fuel;
13. the specific fuel consumption (SFC) of the main and auxiliary engines, as specified in paragraph 2.2.4 of the EEXI Calculation Guidelines;
14. the electric power table2 for certain ship types, as necessary, as defined in the EEDI Calculation Guidelines;
15. the documented record of annual average figure of the auxiliary engine load at sea obtained prior to the date of application for a survey for verification of the ship's EEXI, as specified in paragraph 2.2.2.3 of the EEXI Calculation Guidelines, if applicable;
16. calculation process of PAE,app, as specified in paragraph 2.2.2.3 of the EEXI Calculation Guidelines, if applicable;
17. principal particulars, ship type and the relevant information to classify the ship as such a ship type, classification notations and an overview of the propulsion system and electricity supply system on board;
18. description of energy-saving equipment, if available;

19. calculated value of the attained EEXI, including the calculation summary, which should contain, at a minimum, each value of the calculation parameters and the calculation process used to determine the attained EEXI; and
20. for LNG carriers:
    - type and outline of propulsion systems (such as direct drive diesel, diesel electric, steam turbine);
    - LNG cargo tank capacity in m3 and BOR as defined in paragraph 2.2.5.6.3 of the EEDI Calculation Guidelines;
    - shaft power of the propeller shaft after transmission gear at 100% of the rated output of motor (MPPMotor) and $\eta(i)$ for diesel electric;
    - shaft power of the propeller shaft after transmission gear at the de-rated output of motor (MPPMotor,lim) in cases where the overridable Shaft / Engine Power Limitation is installed;
    - maximum continuous rated power (MCRSteamTurbine) for steam turbine;
    - limited maximum continuous rated power (MCRSteamTurbine,lim) for steam turbine in cases where the overridable Shaft / Engine Power Limitation is installed; and SFCSteamTurbine for steam turbine, as specified in paragraph 2.2.7.2 of the EEDI Calculation Guidelines. If the calculation is not available from the manufacturer, SFCSteamTurbine may be calculated by the submitter.

The SFC should be corrected to the value corresponding to the ISO standard reference conditions using the standard lower calorific value of the fuel oil, referring to ISO 15550:2002 and ISO 3046-1:2002. For the confirmation of the SFC, a copy of the approved NOx Technical File and documented summary of the correction calculations should be submitted to the verifier.

For ships equipped with dual-fuel engine(s) using LNG and fuel oil, the CF-factor for gas (LNG) and the specific fuel consumption (SFC) of gas fuel should be used by applying the criteria specified in paragraph 4.2.3 of the 2014 Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI), as amended, as a basis for the guidance of the Administration.

In cases where overridable Shaft/Engine Power Limitation is installed, or in cases where engines do not have a test report included in the NOx Technical File, SFC should be calculated in accordance with paragraph 2.2.4 of the EEXI Calculation Guidelines. For this purpose, actual performance records of the engine may be used if satisfactory and acceptable to the verifier.

The verifier may request further information from the submitter, as specified in paragraph 4.2.7 of the EEDI Survey and Certification Guidelines, in addition to that contained in the EEXI Technical File, as necessary, to examine the calculation process of the attained EEXI.

VERIFICATION OF THE ATTAINED EEXI in case of major conversion

In cases of a major conversion of a ship taking place at or after the completion date of the survey for EEXI verification specified in regulation 5.4.7 of MARPOL Annex VI, the shipowner should submit to DBS Head Office an application for a general or partial survey with the EEXI Technical File duly revised, based on the conversion made and other relevant background documents.

The background documents should include as a minimum, but are not limited to:

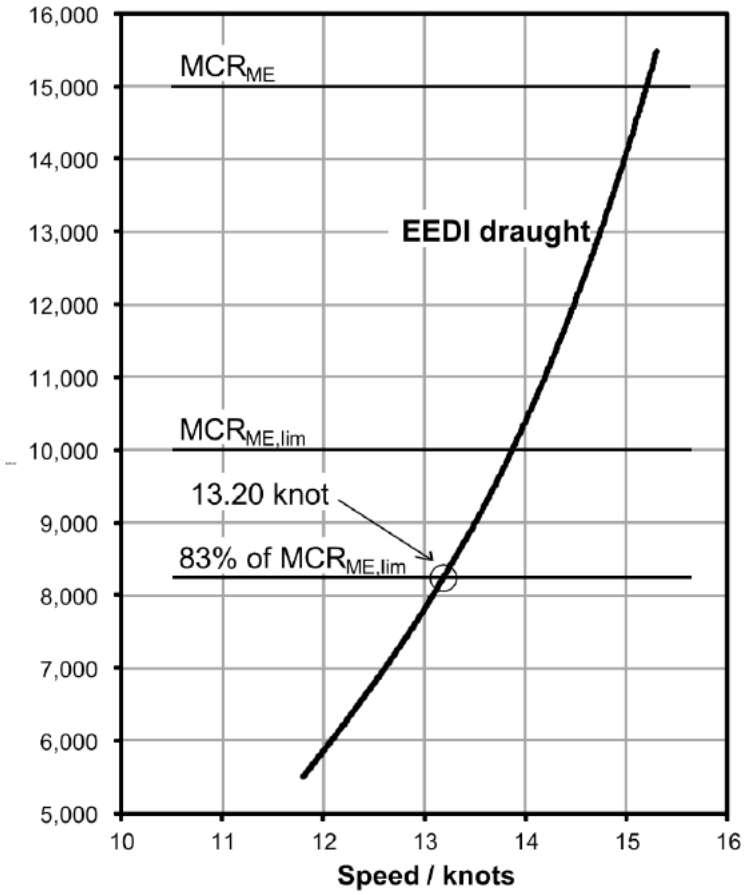
1. details of the conversion;
2. EEXI parameters changed after the conversion and the technical justifications for each respective parameter;
3. reasons for other changes made in the EEXI Technical File, if any; and
4. calculated value of the attained EEXI with the calculation summary, which should contain, as a minimum, each value of the calculation parameters and the calculation process used to determine the attained EEXI after the conversion.

DBS shall review the revised EEXI Technical File and other documents submitted and verify the calculation process of the attained EEXI to ensure that it is technically sound and reasonable and follows regulation 23 of MARPOL Annex VI and the EEXI Calculation Guidelines.

For verification of the attained EEXI after the major conversion, speed trials of the ship may be conducted, as necessary.

ANNEX 1- SAMPLE OF EEDI TECHNICAL FILE

1	**Data**	
1.1	General Information	
	Shipowner	XXX Shipping Line
	Shipbuilder:	XXX Shipbuilding Company
	Hull No.:	12345
	IMO No.:	94111XX
	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):	15,000 kW x 80 rpm
	SFC at 75% MCR:	165.0 g/kWh
	Number of sets:	1
	Fuel type:	Diesel Oil
1.4	Auxiliary engine:	
	Manufacturer:	XXX Industries
	Type:	5J-200
	Maximum continuous rating (MCR):	600 kW x 900 rpm
	SFC at 50% MCR:	220.0 g/kWh
	Number of sets:	3
	Fuel type:	Diesel Oil
1.5	Ship speed	
	Ship speed in deep water at summer load line draught at 75% of MCR:	14.25 knots
2	**Power curves**	
2.1	An approved speed-power curve contained in the EEDI Technical File is shown in figure 2.1	

2.2	An estimated speed-power curve obtained from the tank test and/or numerical calculations, if available, is also shown in figure 2.1
	 **Figure 2.1: Power curve**
2.3	An estimated speed-power curve under a ballast draught calibrayed to the design load draught, obtained from the tank test and/ or numerical calculations, if available, is shown in figure 2.2

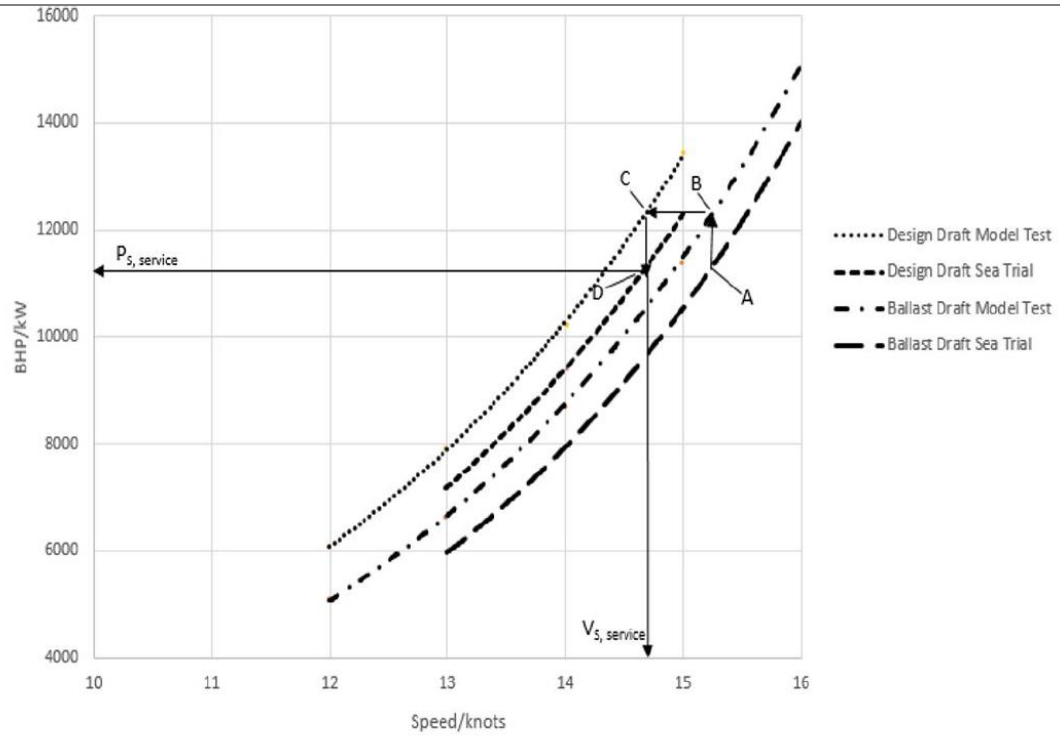


Figure 2.2: Power curve

3	**Overview of propulsion system and electric power supply system**	
3.1	Propulsion system	
3.1.1	Main engine	
	Refer to paragraph 1.3	
3.1.2	Propeller	
	Type	Fixed pitch propeller
	Diameter	7.0 m
	Number of blades	4
	Number of sets	1
3.2	Electric power supply system	
3.2.1	Auxiliary engines	
	Refer to paragraph 1.4	
3.2.2	Main generators	
	Manufacturer	XXX Electric
	Rated output	560 kW (700 kVA) x 900 rpm
	Voltage	AC 450 V
	Number of sets	3

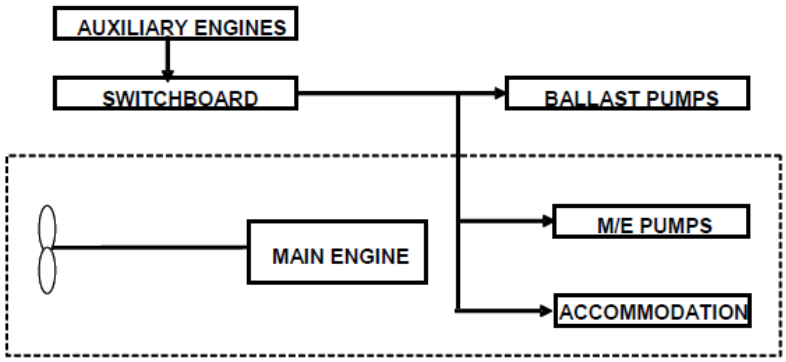


Figure 3.1: Schematic figure of propulsion and electric power supply system

4 Estimation process of power curves at design stage

Power curves are estimated based on model test results. The flow of the estimation process is shown below.

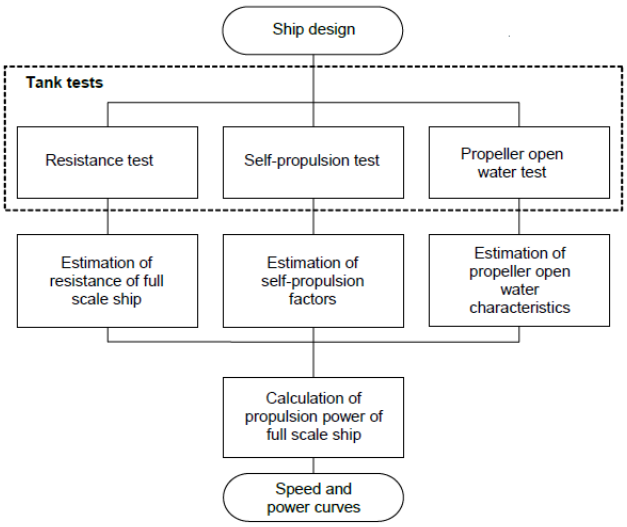


Figure 4.1: Flow-chart of process for estimating power curves

5 Description of energy saving equipment

5.1 Energy saving equipment the effects of which are expressed as PAEeff(i) and/or Peff(i) in the EEDI calculation formula

N/A

5.2 Other energy saving equipment

(Example)

5.2.1 Rudder fins

5.2.2 Propeller boss cap fins

(Specifications, schematic figures and/or photos, etc. for each piece of equipment or device should be indicated. Alternatively, attachment of a commercial catalogue may be acceptable.)

6 Calculated value of attained EEDI

6.1 Basic data

Type of ship	Capacity DWT	Speed V_{ref} (knots)
Bulk Carrier	150,000	13.20

6.2 Main engine

MCR_{ME} (kW)	$MCR_{ME,lim}$(kW)	P_{ME} (kW)	Type of fuel	C_{FME}	SFC_{ME} (g/kWh)

	15,000	9,940	8,250	Diesel Oil	3.206	166.5

6.3 Auxiliary engines

P_{AE} (kW)	Type of fuel	C_{FAE}	SFC_{AE} (g/kWh)
625	Diesel Oil	3.206	220.0

6.4 Ice class

N/A

6.5 Innovative electrical energy efficient technology

N/A

6.6 Innovative mechanical energy efficient technology

N/A

6.7 Cubic capacity correction factor

N/A

6.8 Calculated value of attained EEDI

$$EEXI = \frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + (P_{AE} \cdot C_{FAE} \cdot SFC_{AE})}{f_i \cdot f_c \cdot f_l \cdot Capacity \cdot f_w \cdot V_{ref} \cdot f_m}$$

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

$$- \frac{\left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}\right)}{f_i \cdot f_c \cdot f_l \cdot Capacity \cdot f_w \cdot V_{ref} \cdot f_m}$$

$$= \frac{1 \times (8250 \times 3.206 \times 166.5) + (625 \times 3.206 \times 220.0) + 0 - 0}{1 \times 1 \times 1 \times 150000 \times 1 \times 13.20 \times 1}$$

$$= 2.45\ (g - CO_2/ton \cdot mile)$$

attained EEDI: 2.45 g-CO_2/ton mile

7 Calculated value of attained $EEDI_{weather}$

7.1 Representative sea conditions

	Mean wind speed	Mean wind direction	Significant wave height	Mean wave period	Mean wave direction
BF6	12.6 (m/s)	0 (deg.)*	3.0 (m)	6.7 (s)	0 (deg.)*

* Heading direction of wind/wave in relation to the ship's heading, i.e. 0 (deg.) means the ship is heading directly into the wind.

7.2 Calculated weather factor, f_w

f_w	0.900

7.3 Calculated value of attained $EEDI_{weather}$

attained EEDIweather: 3.32 g-CO_2/ton mile

DBS EEXI CALCULATOR

As a part of DBS digital strategy, we have a free self-tool made available through our website that calculates the attained EEXI with precision and taking into account all the latest MEPC Resolutions and Guidelines.

After providing all necessary information in the appropriate inputs, an official email with the EEXI attained value will be sent to the user.

The EEXI attained value shall already be calculated and included in the Technical File, which must be submitted to Dromon Head Office for review and approval, prior the International Energy Efficiency (IEE) survey takes place or at the first scheduled annual, intermediate or renewal surveys on or after January 01, 2023.

Ship Owners / Managers / Operators are encouraged to use our EEXI Calculator to ensure compliance with the latest requirements regarding energy efficiency and have all the necessary documentation ready for review and approval by DBS before the effective date January 01, 2023.

DBS Marine Division may assist you comply with EEXI requirements.

Visit **eexi.dromon.com** for more.

REFERENCES

1. International Maritime Organization (IMO) (www.imo.org)
2. MARPOL Annex VI Chapter 4
3. IMO Resolution MEPC.214(63), Guidelines on Survey and Certification Of The Energy Efficiency Design Index (EEDI).
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7. IMO Resolution MEPC.308(73), 2018 Guidelines on The Method of Calculation of The Attained Energy Efficiency Design Index (EEDI) For New Ships
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9. IMO Resolution MEPC.324(75), Procedures for Sampling and Verification of The Sulphur Content of Fuel Oil and The Energy Efficiency Design Index (EEDI)
10. IMO Resolution MEPC.335(76), 2021 Guidelines on The Shaft / Engine Power Limitation System to Comply with The EEXI Requirements And Use Of A Power Reserve
11. IMO Resolution MEPC.1/Circ.855/Rev.2, 2014 Guidelines on Survey and Certification of The Energy Efficiency Design Index (EEDI).
12. IMO Resolution MEPC.1/Circ.896, 2021 Guidance on Treatment of Innovative Energy Efficiency Technologies for Calculation And Verification Of The Attained EEDI And EEXI.
13. IMO Resolution MEPC.351(78), 2022 Guidelines on Survey and Certification of the Attained Energy Efficiency Existing Ship Index (EEXI).
14. IMO Resolution MEPC.351(78) (adopted on 10 June 2022), 2022 GUIDELINES ON THE METHOD OF CALCULATION OF THE ATTAINED ENERGY EFFICIENCY EXISTING SHIP INDEX (EEXI)
15. IACS Procedure for calculation and verification of the Energy Efficiency Design Index (EEDI) Pr No. 38 rev. 3
16. IACS EEXI Implementation Guidelines No. 172
17. IMO RESOLUTION MEPC.328(76), 2021 Revised MARPOL Annex VI

For more information, please send an email to marine@dromon.com