



Shipping Decarbonisation: Regulations, Best Practice and Compliance

Topic 2 – IMO Ship Energy Efficiency Regulations

19-20 Marzo 2025

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Learning objectives

By the end of this lecture you will be able to:

- Explain the full scope of IMO MARPOL Annex VI.
- Discuss Chapter 4 of MARPOL Annex VI and how IMO intends to decarbonise shipping.
- Talk about details of EEDI, EEXI, DCS, SEEMP and CII.
- Do simplified calculation of EEDI, EEXI and CII.

*Acknowledgement: Some of the diagrams in this presentation are taken from public domain and for training purposes only. This is gratefully acknowledged.

Content

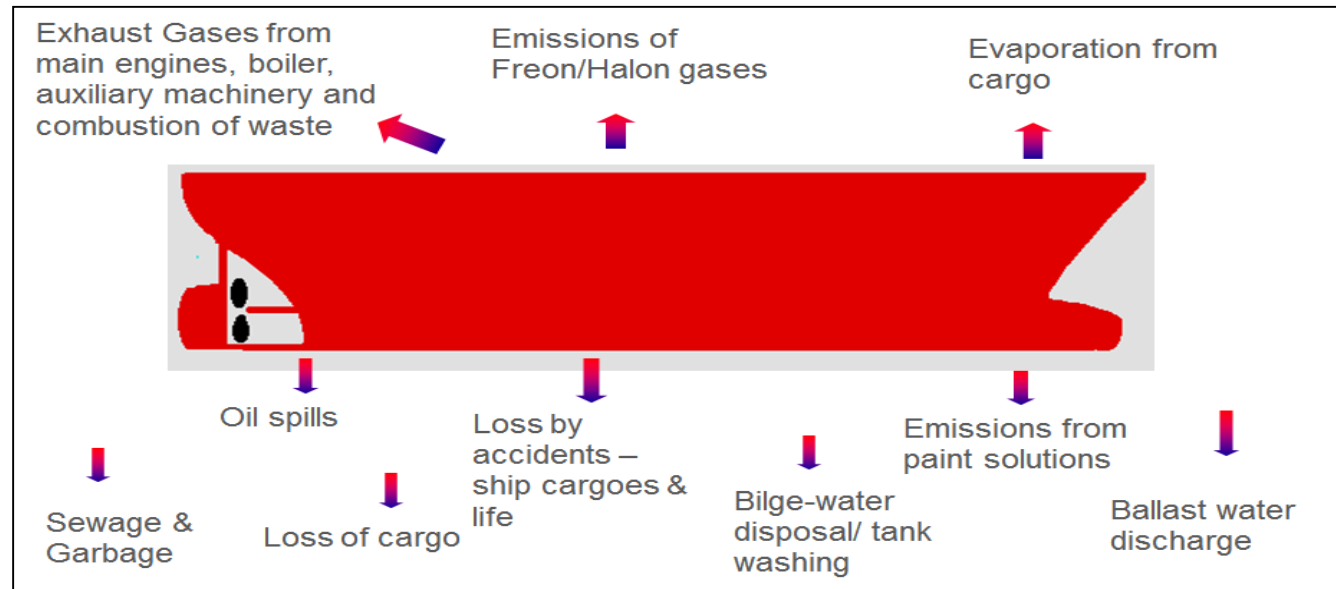
- Introduction to MARPOL Annex VI
- Attained and Required EEDI
- Attained and Required EEXI
- SEEMP and DCS
- Attained and Required CII and CII rating
- Exercises and discussion

Introduction to MARPOL Annex VI



MARPOL

MARPOL includes 6 independent annexes; each dealing with specific types of ship pollutions



Annex I	Annex II	Annex III	Annex IV	Annex V	Annex VI
Oil (1983)	Noxious Liquid Substances Carried in Bulk (1987)	Harmful Substances Carried in Packaged Form (1992)	Sewage (2003)	Garbage (1988)	Air Pollution & Energy Efficiency (2005)

MARPOL Annex VI Chapters and Regulations

Chapter 1 – General

- Regulation 1 – Application
- Regulation 2 – Definitions
- Regulation 3 – Exceptions and exemptions
- Regulation 4 – Equivalents

Chapter 2 – Survey, certification and means of control

- Regulation 5 – Surveys
- Regulation 6 – Issue of endorsement of certificate
- Regulation 7 – Issue of a certificate by another party
- Regulation 8 – Form of certificates
- Regulation 9 – Duration and validity of certificates
- Regulation 10 – Port State control and operational requirement
- Regulation 11 – Detection of violation and enforcement.

Chapter 3 – Requirements for control of emissions from ships

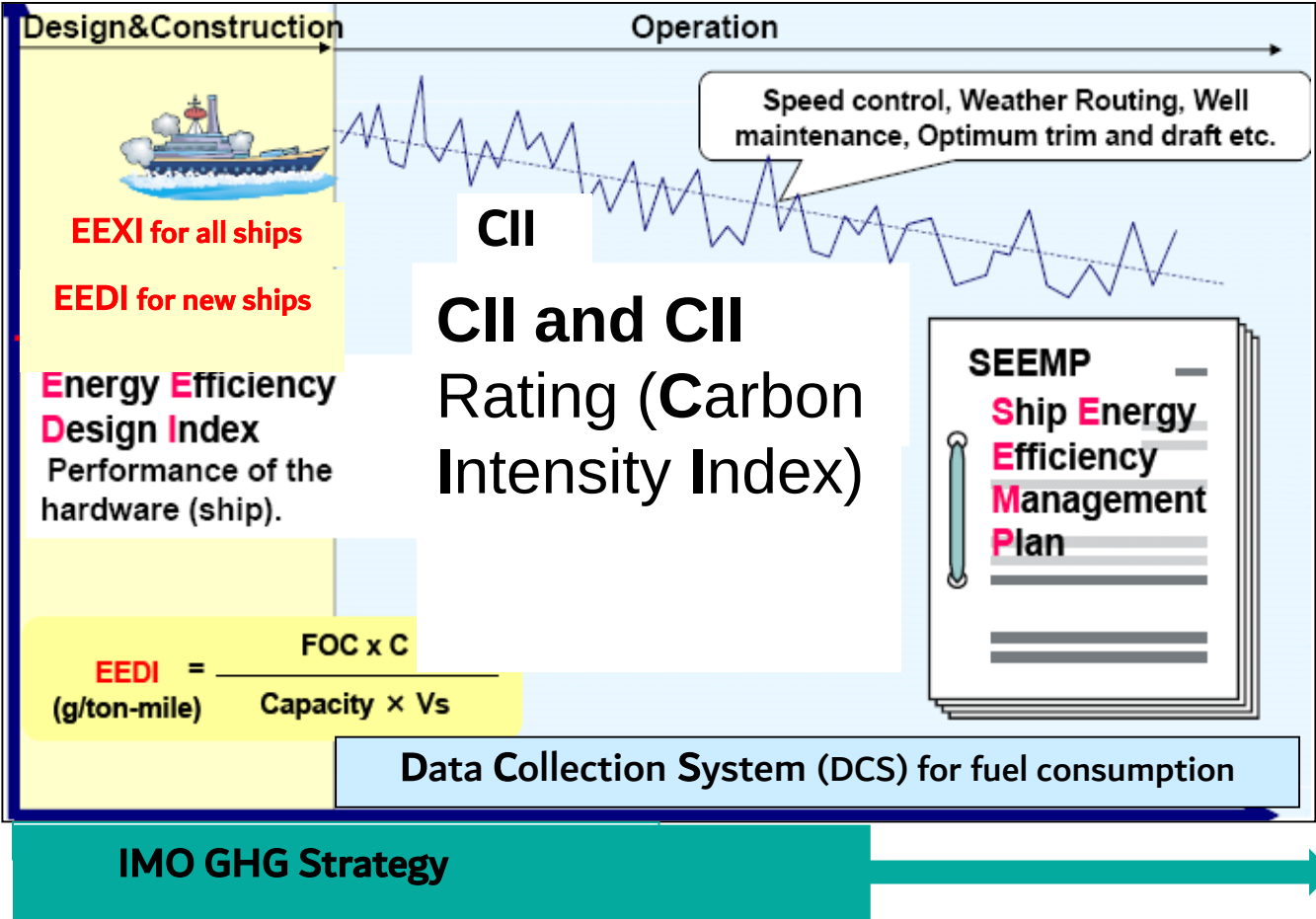
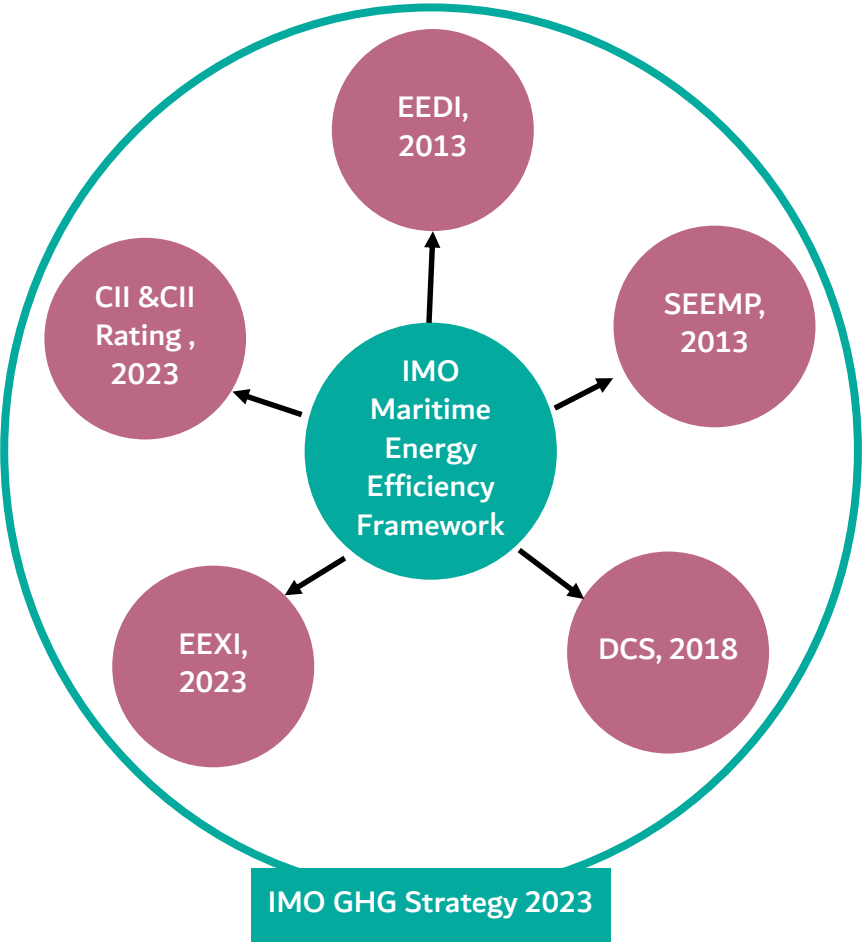
- Regulation 12 – Ozone Depleting Substances (ODSs)
- Regulation 13 – Nitrogen oxides (NO_x)
- Regulation 14 – Sulphur oxides (SO_x)
- Regulation 15 – Volatile Organic Compounds (VOCs)
- Regulation 16 – Shipboard incineration
- Regulation 17 – Reception facilities
- Regulation 18 – Fuel oil availability and quality

MARPOL Annex VI Chapters and Regulations

Chapter 4 – Regulations on the carbon intensity of international shipping

- Regulation 19 – Application
- Regulation 20 – Goals
- Regulation 21 – Functional requirements
- Regulation 22 – Attained EEDI
- Regulation 23 – Attained EEXI
- Regulation 24 – Required EEDI
- Regulation 25 – Required EEXI
- Regulation 26 – SEEMP
- Regulation 27 – DCS
- Regulation 28 – Carbon Intensity Index (CII) and rating
- Regulation 29 - Technical cooperation and technology transfer

Chapter 4 of MARPOL Annex VI

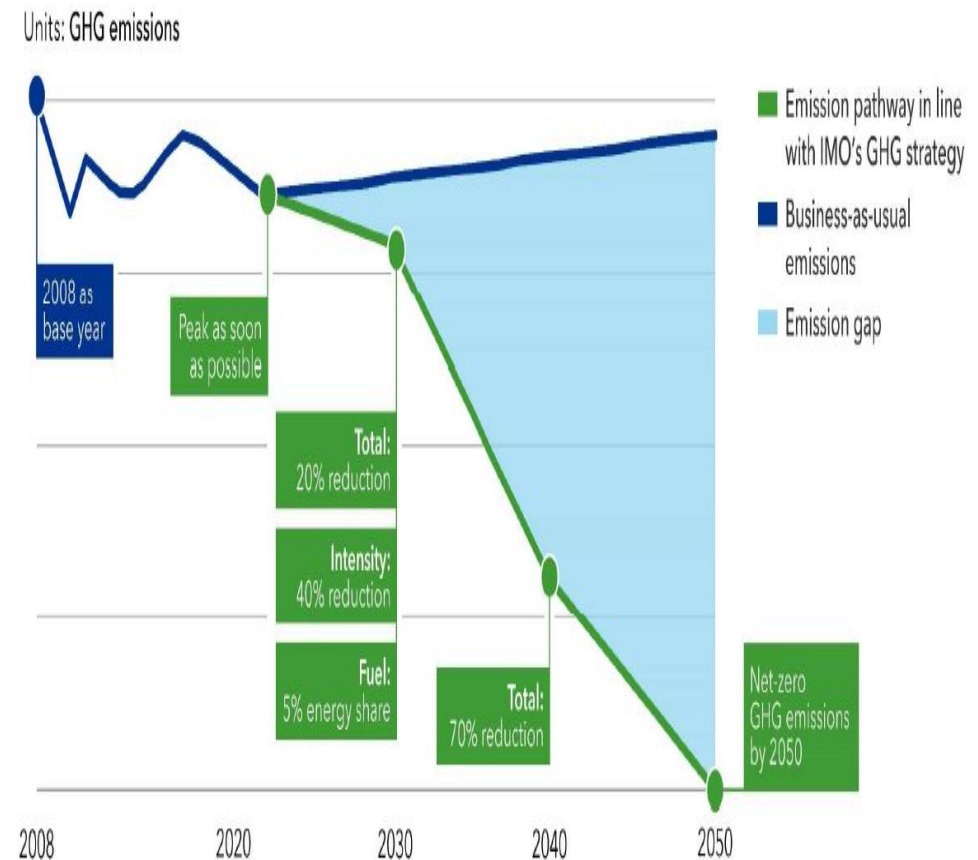


Regulation 19 - Applications

- Applicable to all ships of 400 gross tonnage and above; except otherwise specified under each regulation.
- The provisions of this chapter shall not apply to ships solely engaged in national waters.

Regulation 20 - Goals

- Under this regulation, the goals are set at those specified under **IMO GHG Strategy**.
- This regulation basically **formalises the targets** of IMO GHG Strategy



Total: Well-to-wake GHG emissions; Intensity: CO₂ emitted per transport work; Fuel: Uptake of zero or near-zero GHG technologies, fuels and/or energy sources

Source: DNV

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Regulation 21 - Functional requirements

This regulation affirms that the targets will be achieved through:

- Technical measures as currently regulated under Regulations 22-25.
- Operational measures as currently regulated under Regulations 26-28.

Attained EEDI and Attained EEXI



Regulation 22 – Attained EEDI (Energy Efficiency Design Index)

- The Attained EEDI is the **actual EEDI** of a ship.
- Applicable to **new ships** (also when a ship undergoes a **major conversion**).
- The attained EEDI shall be **specific** to each ship and be accompanied by an **EEDI Technical File**
- The attained EEDI shall be **calculated** taking into account the relevant **IMO guidelines**.
- The attained EEDI shall be **verified**, taking into account the relevant **IMO guidelines**.

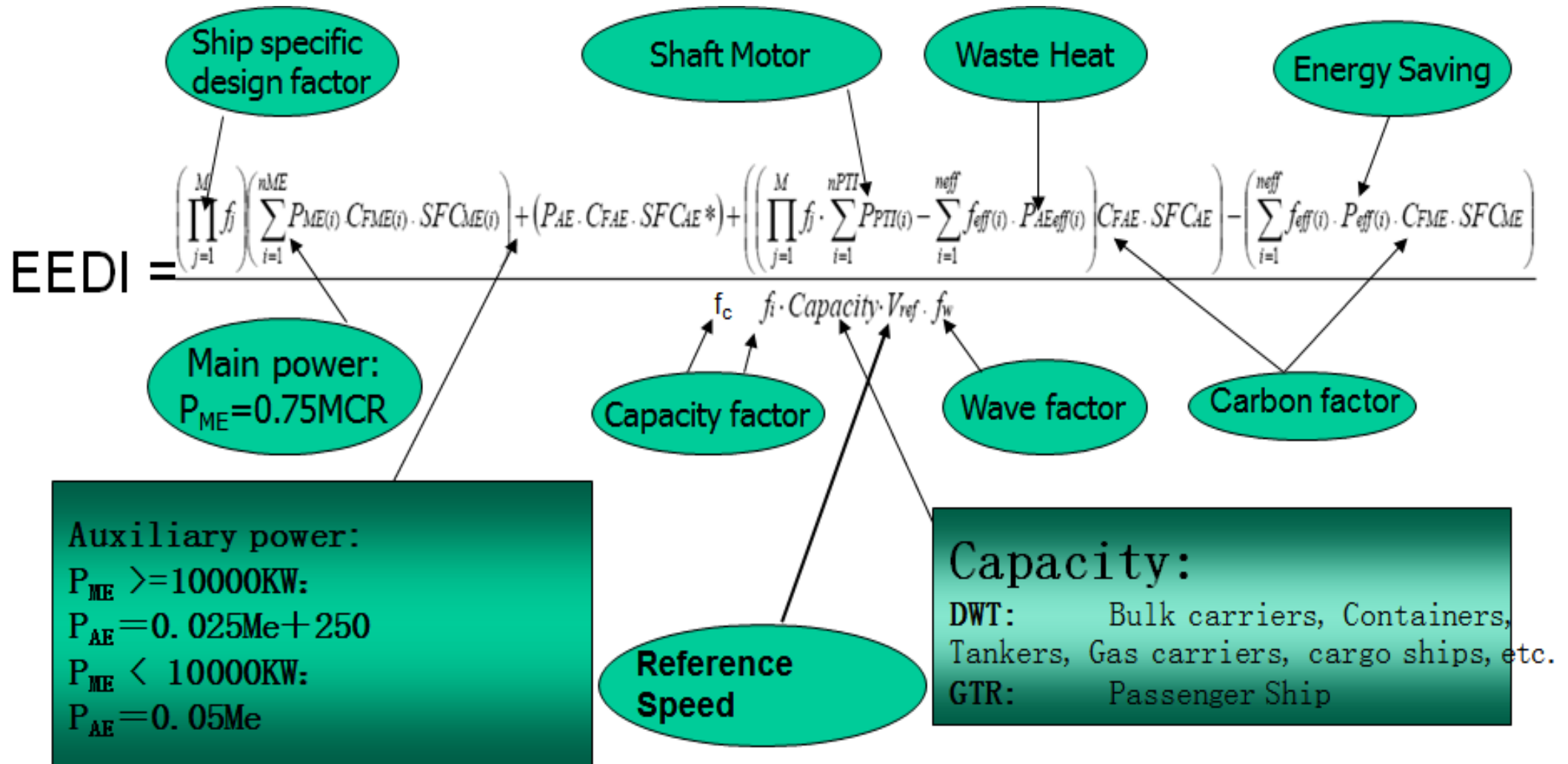
$$EEDI = \frac{CO_2 \text{ emission}}{\text{Transport work}}$$

EEDI Unit: gCO₂ / tonne. nmile



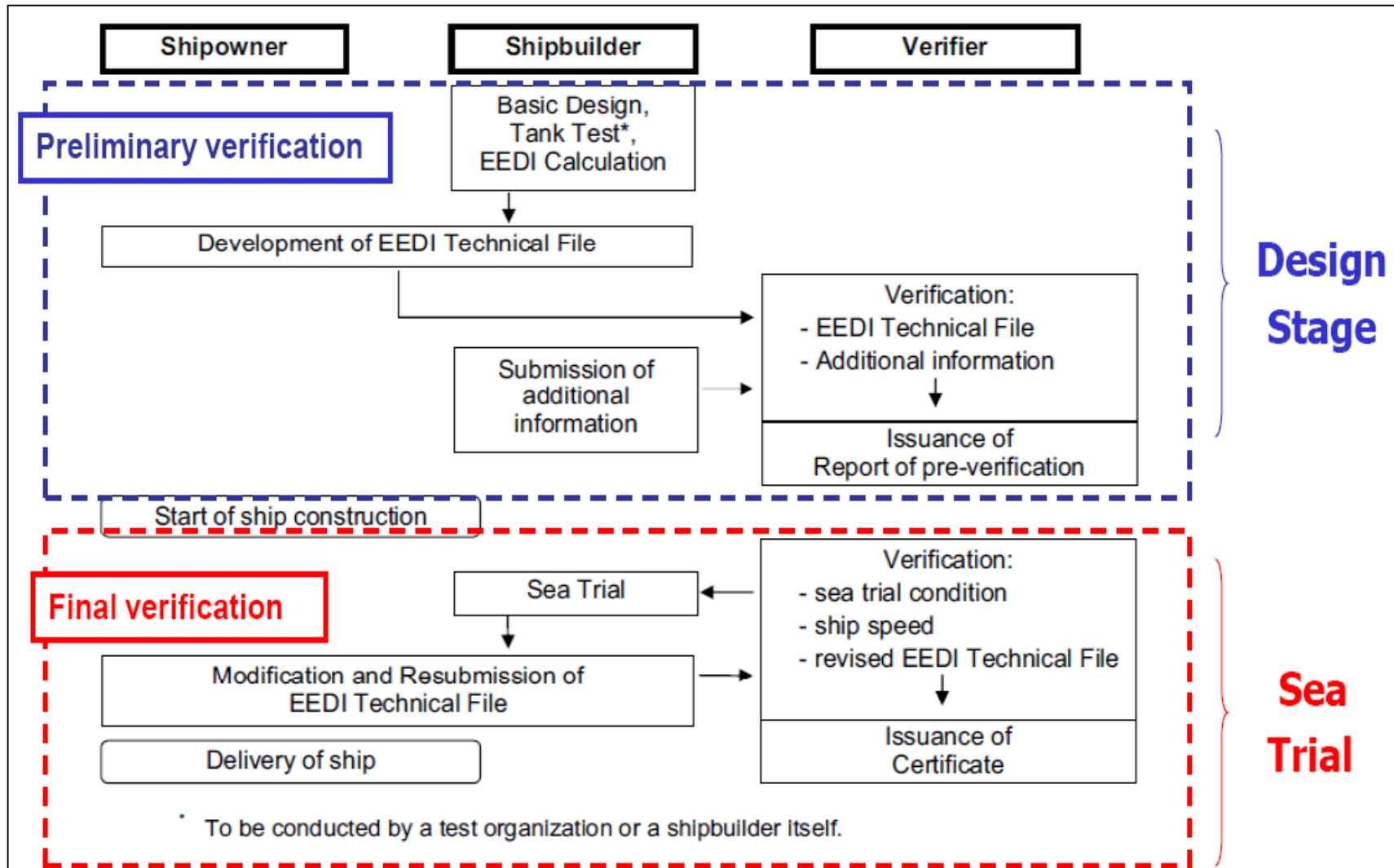
Source: IRIclass

Attained EEDI: Calculation formula and parameters



Full details can be found in the IMO EEDI calculation guidelines

Attained EEDI: Verification process



Full details can be found in the IMO EEDI verification guidelines

Regulation 23 – Attained EEXI (Energy Efficiency eXisting ship Index)

- The attained EEXI shall be **calculated** for each ship.
- The attained EEXI shall be **specific** to each ship and be accompanied by an **EEXI Technical File**.
- The attained EEXI shall be **calculated** taking into account the relevant **IMO guidelines** (largely similar to Attained EEDI formula).
- The attained EEXI shall be **verified**, based on **EEXI Technical File**.

EEXI Unit: gCO₂ / tonne. nmile



Condition where Attained EEXI does not need to be calculated:
For ships with EEDI, the Attained EEDI will be accepted as Attained EEXI; if it is equal or less than the Required EEXI.

Required EEDI and Required EEXI



Regulation 24 – Required EEDI

- Required EEDI represents the **regulatory limit** of the EEDI
- Required EEDI shall be calculated for each **new ship** (also when new ship undergoes a major conversion).
- Calculation method:

$$\text{Required EEDI} = (1 - X/100) * \text{Reference Line Value}$$

- Where:
 - “**Reference line value**” is a baseline value specified by the regulation for each ship type.
 - X is the “**reduction factor**” specified by the regulation for each ship type

Reference line value: Method of calculation

$$\text{Reference line value} = a * b^{-c}$$

Ship type	a	b	c
2.25 Bulk carrier	961.79	DWT of the ship	0.477
2.26 Gas carrier	1120.00	DWT of the ship	0.456
2.27 Tanker	1218.80	DWT of the ship	0.488
2.28 Container ship	174.22	DWT of the ship	0.201
2.29 General cargo ship	107.48	DWT of the ship	0.216
2.30 Refrigerated cargo carrier	227.01	DWT of the ship	0.244
2.31 Combination carrier	1219.00	DWT of the ship	0.488
2.33 Ro-Ro cargo ship (vehicle carrier)	$(\text{DWT/GT})^{0.7} \cdot 780.36$ where $\text{DWT/GT} < 0.3$	DWT of the ship	0.471
	1812.63 where $\text{DWT/GT} \geq 0.3$		
2.34 Ro-Ro cargo ship	1405.15	DWT of the ship	0.498
2.35 Ro-Ro passenger ship	752.16	DWT of the ship	0.381
2.38 LNG carrier	2253.7	DWT of the ship	0.474
2.39 Cruise passenger ship having non-conventional propulsion	170.84	GT of the ship	0.214

Reduction factors (part of regulation)

Ship Type	Size	Phase 0 1 Jan 2013 – 31 Dec 2014	Phase 1 1 Jan 2015 – 31 Dec 2019	Phase 2 1 Jan 2020 – 31 Mar 2022	Phase 2 1 Jan 2020 – 31 Dec 2024	Phase 3 1 Apr 2022 and onwards	Phase 3 1 Jan 2025 and onwards
Bulk carrier	20,000 DWT and above	0	10		20		30
	10,000 and above but less than 20,000 DWT	n/a	0-10*		0-20*		0-30*
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*
Cruise passenger ship*** having non- conventional propulsion	85,000 GT and above	n/a	5**	20		30	
	25,000 and above but less than 85,000 GT	n/a	0-5*, **	0-20*		0-30*	

Regulation 25 – Required EEXI

- Applies to all ships as per size in the Table.
- Required EEXI refers to the **regulatory limit** of EEXI.
- Required EEXI shall be calculated for all existing ships according to ship size and ship type.
- The Required EEXI is calculated using **EEDI “reference line value”** and **EEXI “reduction factor” Y**.
- Calculation formula is:

$$\text{Required EEXI} = (1 - Y/100) * \text{Reference Line Value}$$

Type of ship	Size	Reduction factor Y %
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*
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*

Ship compliance to EEDI and EEXI regulations

EEDI:

- All **new ships** with contract date of 1 January 2013 and later.
- Required EEDI must be less than or equal to Required EEDI:

$$\text{Attained EEDI} \leq \text{Required EEDI}$$

EEXI:

- All **existing ships (new and old)** should comply.
- Attained EEXI must be less than or equal to Required EEXI.

$$\text{Attained EEXI} \leq \text{Required EEXI}$$

- For ships with EEDI, the **Attained EEDI** will be accepted as Attained EEXI; if it is equal or less than the **Required EEXI**.

SEEMP and Data Collection System (DCS)



Regulation 26 - SEEMP

Regulation 26

Ship Energy Efficiency Management Plan (SEEMP)

1 Each ship shall keep on board a ship specific Ship Energy Efficiency Management Plan (SEEMP). This may form part of the ship's Safety Management System (SMS). The SEEMP shall be developed and reviewed, taking into account the guidelines adopted by the Organization.⁴⁰

2 In the case of a ship of 5,000 gross tonnage and above, the SEEMP shall include a description of the methodology that will be used to collect the data required by regulation 27.1 of this Annex and the processes that will be used to report the data to the ship's Administration.

3 In the case of a ship of 5,000 gross tonnage and above, which falls into one or more of the categories in regulations 2.2.5, 2.2.7, 2.2.9, 2.2.11, 2.2.14 to 2.2.16, 2.2.22, and 2.2.26 to 2.2.29 of this Annex:

- .1 On or before 1 January 2023 the SEEMP shall include:
 - .1 a description of the methodology that will be used to calculate the ship's attained annual operational CII required by regulation 28 of this Annex and the processes that will be used to report this value to the ship's Administration;
 - .2 the required annual operational CII, as specified in regulation 28 of this Annex, for the next three years;
 - .3 an implementation plan documenting how the required annual operational CII will be achieved during the next three years; and
 - .4 a procedure for self-evaluation and improvement.
- .2 For a ship rated as D for three consecutive years or rated as E in accordance with regulation 28 of this Annex, the SEEMP shall be reviewed in accordance with regulation 28.8 of this Annex to include a plan of corrective actions to achieve the required annual operational CII.
- .3 The SEEMP shall be subject to verification and company audits taking into account the guidelines to be developed by the Organization.

Part I
(Energy
Management
Plan)

Part II
(Data
Collection
Plan)

Part III
(CII Plan)

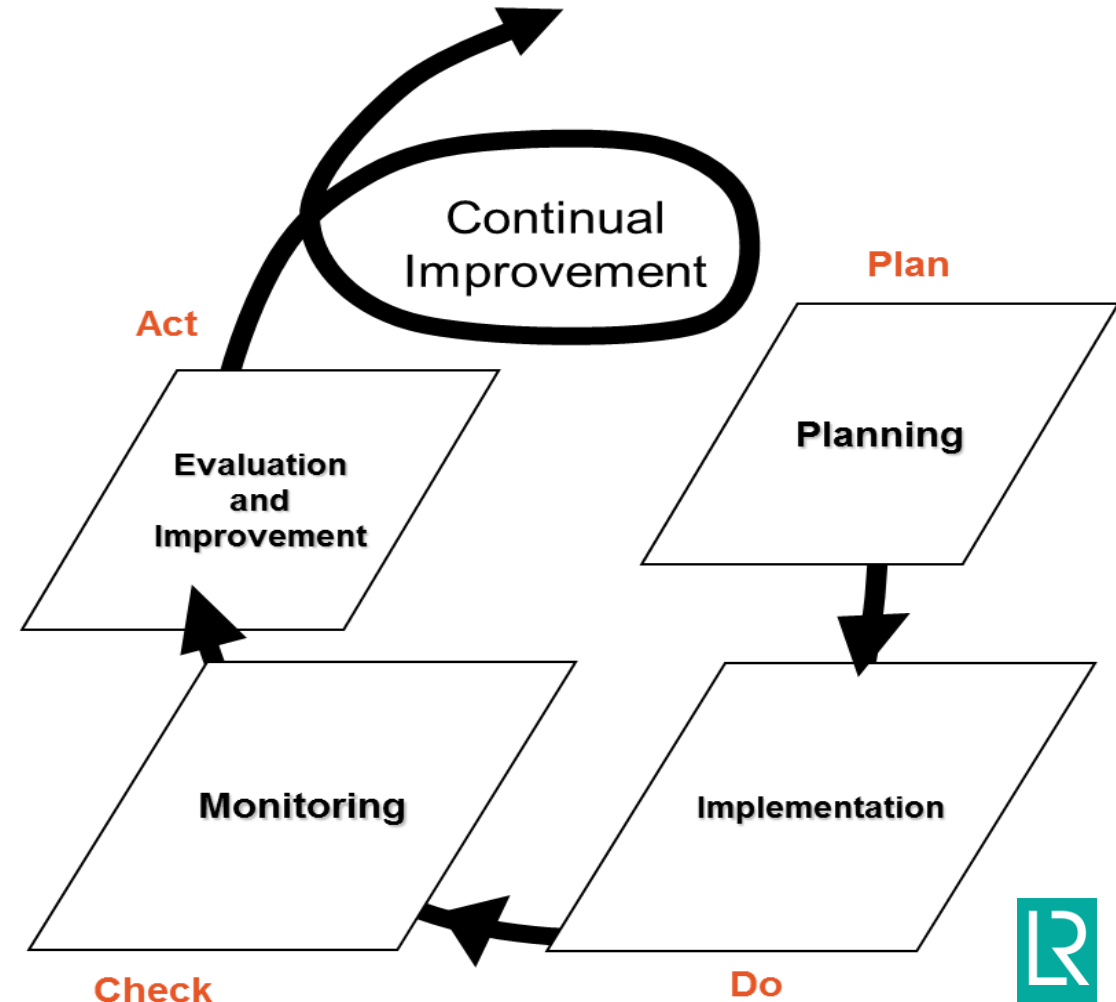


Confirmation of
Compliance

SEEMP Part I – Energy Management Plan

There is a complete IMO Guideline for development of SEEMP.

- Based on **PDCA** continuous improvement principle.
- SEEMP works through four steps: (1) **Planning**; (2) **Implementation**; (3) **Monitoring**; and (4) **Self-evaluation**
- The core of the SEEMP is an **Action Plan** that specifies a set of **Energy Efficiency Measures** together with how to do them and by who.
- Methods of **implementation**, **monitoring** and **evaluation** should also be specified in the SEEMP.



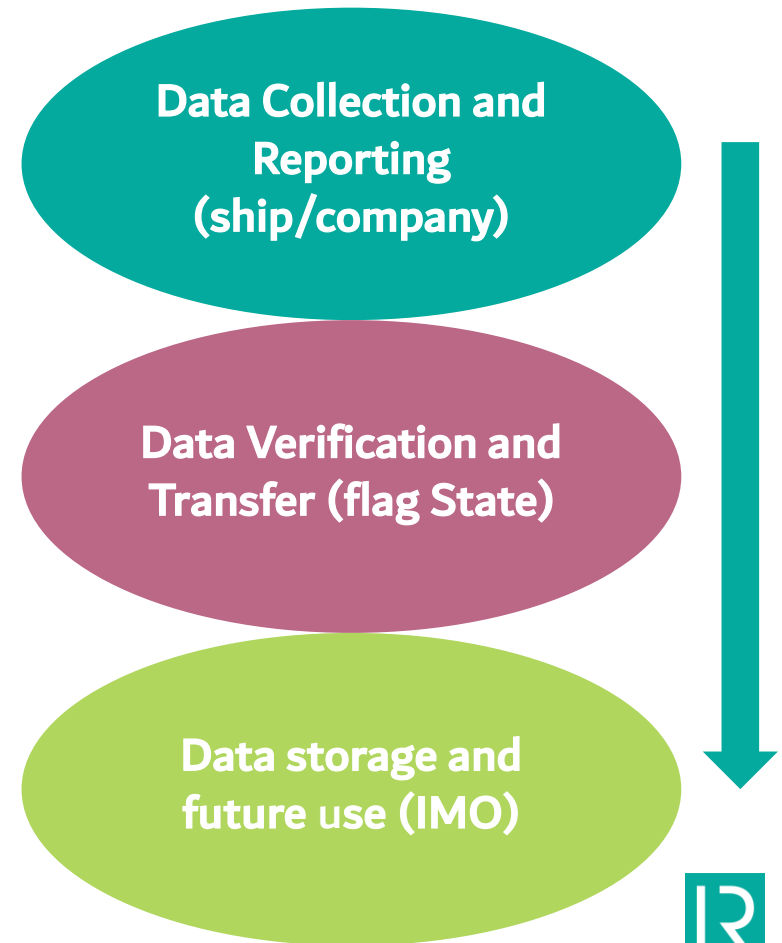
Regulation 27 – Data Collection System (DCS)

Mandatory requirements for ship fuel consumption measurement and reporting

This refers to the IMO regulations that mandate the measurement and reporting of the ship's annual fuel consumption (plus some other data).

The system have three main elements:

1. Data collection by ships /company and reporting to Flag State.
2. Data verification by Flag State and reporting to IMO
3. Data storage by the IMO and reporting to MEPC.



IMO DCS: Main features

- Applicable to ships greater than 5000 GT.
- Annual reporting with no need for voyage data.
- Company responsible for submission of data.
- Flag Administration responsible for data verification.
- Compliance through having a Statement of Compliance (SOC) issued annually.
- Calculated and verified data should be submitted and stored in an IMO database.

IMO DCS: Types of data to be reported

- Ship IMO number
- Technical characteristics of the ship including ship type, Gross Tonnage, Deadweight at summer load line, etc.
- Total annual fuel consumption by fuel type
- Distance travelled
- Hours underway

SEEMP Part II - Data Collection Plan

Part II of SEEMP provides guidance on a variety of topics

- Fuel consumption measurement methods.
- Carbon factor values (fuel emissions factors).
- Method of determination of distance travelled.
- Method of determination of hours underway.
- Data quality and general aspects.
- IMO has included a template for Data Collection Plan in its Guidelines.

Data Verification

- Data verification is the responsibility of **Flag States** (they may delegate).
- Timely submission of data to Flag is the responsibility of the **company**.
- Resolution MEPC.348(78) **2022 Guidelines for Administration Verification of Ship Fuel Oil Consumption Data and Operational Carbon Intensity**, June 2022.
- The above Guidelines stipulates that **additional information** as per Flag requirements must be provided.
- Example of additional info could be SEEMP Part II (**Data Collection Plan**), **dis-aggregated fuel consumption data**, etc.

Data storage by IMO and reporting to member states

- Data storage and data management is the responsibility of IMO.
- Relevant IMO Guidelines provides further details such as access and reporting:
 - **Data anonymization:** Data would remain anonymous.
 - **Data submission and access:** Flags will be responsible for submission and will have access to own data.
 - Guidance on how to ensure the **completeness of the database**
 - **Annual reporting to MEPC by** the IMO Secretariat inclusive of general aspects of data, the issues and shortcomings.

Attained CII, Required CII and CII Rating



Regulation 28 – Operational Carbon Intensity Indicator (CII)

- This regulation deals with all aspects of annual **calculation, reporting, verification and certification** of a ship's CII values and CII Rating.
- It is applicable to ships of **5000 GT** and above (similar to DCS).
- All **reporting, verification and certification** will be part of the same process as DCS.
- Similar to DCS, it would require to have a **CII Plan** as Part III of SEEMP that would give all details of CII, CII Rating and ship-board related activities.
- The regulation specifically covers:
 - **Attained CII**: Actual CII of a ship.
 - **Required CII**: Regulatory value of a ship's CII.
 - **CII rating**: A-E rating via comparison of Actual CII and Required CII.
 - **Implementation plan** for CII realisation for the next 3 years.
 - **Corrective actions**: If the rating does not meet the requirements.

Regulation 28 – Attained CII calculation method

- Attained CII is the CII calculated using the data collected under IMO DCS.

Calculation of annual CII:

$$\text{CII} = \frac{\text{Annual fuel consumption} \cdot \text{CO}_2 \text{ factor}}{\text{Annual distance travelled} \cdot \text{Capacity}}$$

- The above calculated value is **corrected** based on ship's specific **design/operation** features.
- The formula for this purpose is:

$$\frac{\sum_j C_{Fj} \cdot \left\{ FC_j - \left(FC_{voyage,j} + TF_j + (0.75 - 0.03y_i) \cdot (FC_{electrical,j} + FC_{boiler,j} + FC_{others,j}) \right) \right\}}{f_i \cdot f_m \cdot f_c \cdot f_{ivse} \cdot \text{Capacity} \cdot (D_t - D_x)}$$

- All **design correction factors** (f_i, f_m, f_c, f_{ivse}) would come from **EEDI / EEXI Technical File**.
- All **operational correction factors** is explained in the next slide.

Regulation 28 – CII Operational correction factors

$$\frac{\sum_j C_{Fj} \cdot \left\{ FC_j - \left(FC_{voyage,j} + TF_j + (0.75 - 0.03y_i) \cdot (FC_{electrical,j} + FC_{boiler,j} + FC_{others,j}) \right) \right\}}{f_i \cdot f_m \cdot f_c \cdot f_{IVSE} \cdot Capacity \cdot (D_t - D_x)}$$

- $FC_{voyage,j}$ for **voyage adjustment** (safety and some ice related voyages should be excluded)
- TF_j is a factor to account for fuel removed due to STS or shuttle tanker operation.
- $FC_{electrical,j}$ for corrections relating to fuel used for **electrical power** for all **Cargo related electricity** (e.g. refrigerated containers, cargo discharge pumps, etc.)
- $FC_{Boiler,j}$ for corrections relating to boiler fuel consumption for **cargo heating and discharge**.
- $FC_{others,j}$ for corrections relating to other related fuel consumption devices (**cargo related machines**)
- y_i is a consecutive numbering system starting at $y_{2023} = 0$, $y_{2024} = 1$, $y_{2025} = 2$, etc. **Gradually eliminating** cargo related correction
- D_x **represents distance travelled** for voyages which may be deducted from CII calculation (e.g. safety related voyages)

Regulation 28 - Required CII calculation method

- **Required CII** is calculated using the **CII for 2019** (CII_R as reference) and a **reduction factor (Z)**.
- Calculation formula is:

$$\text{Required annual operational CII} = \left(1 - \frac{Z}{100}\right) \cdot CII_R$$

- Reduction factor Z is set by the regulation as:

Year	Reduction from 2019 reference (mid-point of C-rating ban)
2023	5%
2024	7%
2025	9%
2026	11%
2027-2030	To be decided

Regulation 28 - CII Rating

- **CII Rating of A to E** shall be assigned to each ship according to IMO Guidelines.
- The rating is assigned using diagram below via calculation of d_1 , d_2 , d_3 and d_4 .
- Ships with rating of **E (one year)** and **D (for 3 years)** shall develop a corrective action plan in SEEMP and implement to improve.

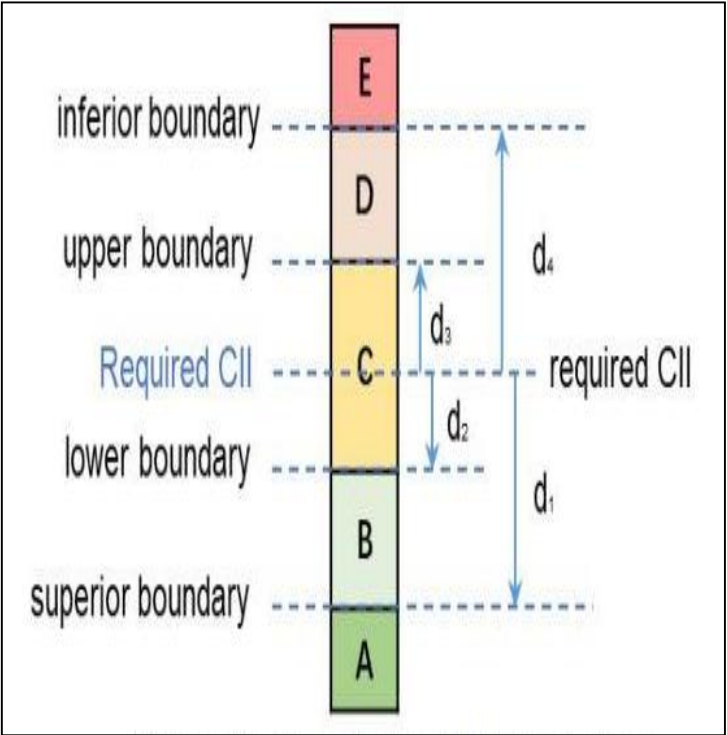


Table 1: dd vectors for determining the rating boundaries of ship types

Ship type		Capacity in CII calculation	dd vectors (after exponential transformation)			
			exp(d1)	exp(d2)	exp(d3)	exp(d4)
Bulk carrier		DWT	0.86	0.94	1.06	1.18
Gas carrier	65,000 DWT and above	DWT	0.81	0.91	1.12	1.44
	less than 65,000 DWT	DWT	0.85	0.95	1.06	1.25
Tanker		DWT	0.82	0.93	1.08	1.28
Container ship		DWT	0.83	0.94	1.07	1.19
General cargo ship		DWT	0.83	0.94	1.06	1.19
Refrigerated cargo carrier		DWT	0.78	0.91	1.07	1.20
Combination carrier		DWT	0.87	0.96	1.06	1.14
LNG carrier	100,000 DWT and above	DWT	0.89	0.98	1.06	1.13
	less than 100,000 DWT		0.78	0.92	1.10	1.37
Ro-ro cargo ship (vehicle carrier)		GT	0.86	0.94	1.06	1.16
Ro-ro cargo ship		GT	0.76	0.89	1.08	1.27
Ro-ro passenger ship		GT	0.76	0.92	1.14	1.30
Cruise passenger ship		GT	0.87	0.95	1.06	1.16

IMO Guidelines on assigning the rating (G4)

- $d_1 = \text{Req. CII} * \exp(d1)$
- $d_2 = \text{Req. CII} * \exp(d2)$
- $d_3 = \text{Req. CII} * \exp(d3)$
- $d_4 = \text{Req. CII} * \exp(d4)$

Content of Part III of SEEMP on CII – Should include:

- The ship's **CII methodologies** for the ship detailing the calculation method used, etc.
- **Attained CII** calculation methodology; data collection plan and data quality
- **Required CII** for the reporting year and the next three years
- An **implementation plan** on how to achieve the CII for next 3 years.
- Process for **self-evaluation** and **improvement**
- **Review and update** of part III of the SEEMP
- **Plan** of corrective actions (ships rated E or three years with D).

Template of the Ship Operational **CII Plan** (Part III of SEEMP) is provided in the relevant SEEMP Guidelines.

RESOLUTION MEPC.346(78)
(adopted on 10 June 2022)

2022 GUIDELINES FOR THE DEVELOPMENT OF A SHIP ENERGY EFFICIENCY
MANAGEMENT PLAN (SEEMP)

Summary of Learning Points and Discussion



Summary of learning points

You are now familiar with the following to pics:

- MARPOL Annex VI in general
- The chapter 4 of MARPOL Annex VI on:
 - Attained and Required EEDI
 - Attained and Required EEXI
 - SEEMP and its three parts
 - DCS for ship fuel consumption measurement, verification and reporting.
 - Attained and Required CII + CII Rating and its implication.
- General understanding of calculation methods for the above indices/indicators.

Summary of learning points

Regulations



- ☐ EEDI
- ☐ SEEMP
- ☐ EEXI
- ☐ DCS
- ☐ CII and CII Rating

Status / domain



- ☐ New ships - mandatory
- ☐ Existing (and new) ships - mandatory
- ☐ Existing (and new) ships - mandatory
- ☐ Annual fuel consumption reporting to IMO - mandatory
- ☐ Annual CII calculation, reporting and action plan - mandatory

Compliance



- ☐ Technical survey and verification, EEDI
Technical File on-board
- ☐ Approval by Flag needed, SEEMP on-board
- ☐ Calculation, verification and EEXI Technical
File on-board
- ☐ Flag verification and Statement of
Compliance on-board, Part II of SEEMP
- ☐ Flag verification and SOC as DCS,
Part III of SEEMP

Ship **IEE Certificate** is the top level certificate that together with its **Ship Record of Construction on Energy Efficiency** would include a summary of all the above.

True or False?

- Required EEDI is different from the Required EEXI?
- To show compliance, Attained EEDI must be less than or equal to Required EEXI?
- Ships' fuel consumption data, for applicable ships, must be reported to IMO on a six-monthly basis?
- Under DCS, there is no need to document the way a ship's fuel consumption is measured?
- Calculation of CII is based on data collected under DCS regulation?
- The calculation of a ship's Attained CII and Required CII is mandated from 2025?
- Attained CII must always be less than the Required CII?
- A ship with a CII rating of D for 3 years or E (for one year) must have a Corrective Action Plan in its Part III of SEEMP?

True or False?

- All applicable existing ships must have an EEXI Technical File on-board?
- All applicable new ships must have an EEDI Technical File on-board?
- All applicable existing ships must have a Statement of Compliance indicating compliance to fuel consumption data collection regulations.
- A ship with EEDI certification will automatically pass the EEXI regulations?
- The Attained CII of a ship must always be less than or equal to its Required CII?
- One would expect to see details of ship compliance to Chapter 4 of MARPOL Annex VI in its Ship Record of Construction on Energy Efficiency that must be on-board the ship?

Exercise 2.1

Calculation of Required EEDI and EEXI



Exercises 2.1 – Calculation of Required EEDI and Required EEXI

- We have a cruise passenger ship (of non-conventional propulsion type, i.e. electric propulsion) with a GT of 170,000 and an Attained EEDI of 9.50 [gCO₂/tonne.mile].
- This ship is built in 2021 (consider contract date). Calculate the Required EEDI for this ship.
- Also calculate the Required EEXI for this ship. Would this ship require any action to comply with EEXI requirements?

Exercises 2.1 – Worksheet

Exercise 2.2

Calculation of CII and CII Rating



Exercises 2.2 – Calculation of CII and CII Rating

- A cruise ship with a GT of 150,000 tonnes, shows the following set of data according to IMO DCS database:

Year	2019	2020	2021
Fuel consumption [MT]	45,500	46,200	45,200
Distance travel [nmile]	3700	3800	3800
Hours underway [hr]	5800	6000	6200

- Calculate the Attained CII for 2019 and 2021. Assume that the CF (carbon factor) of fuel is 3.1140 for all cases. Also assume that no design or operation correction factors are applicable. (NB: Unit should be gCO₂ / tonne.nmile).
- Calculate the Required CII for this ship for years 2024, 2025 and 2026.
- Assign the CII Rating to this ship for year 2025 Assume that the Attained CII of the ship in 2025 will be 245 gCO₂/tonne.nmile.

Exercises 2.2 – Worksheet

Questions

