

Calculation Master Guide

Every computation behind every page: the equations, every parameter and its source, the rules that change the result, and worked results.

Engine 2026.10.30 · built 31 October 2026 · CarbonKeel is not an accredited verifier; allowances are surrendered and FuelEU balances settled on the figures the ship's verifier accepts.

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1 How to read this guide

Every figure on carbonkeel.com, in the app, the allowance planner, the MOHA workspace, the compliance documents and the reports comes from one of the deterministic calculations below. Each section gives the equations (numbered on the right), a table defining every symbol with its unit and value or source, the rules and nuances of the regulation that change the result, and a worked example whose numbers were produced by the engines themselves when this guide was built. Engine version **2026.10.30**; register file **thetis_mrv_2025_v67.xlsx**; built 31 October 2026.

THREE KINDS OF FIGURE, NEVER MIXED

- **Public-data estimate:** rebuilt from the EU MRV register EMSA publishes (THETIS-MRV, Regulation (EU) 2015/757 Art. 21). Always labelled ESTIMATE.
- **Customer-data calculation:** the same rules applied to figures the customer supplies (fuel by type, distance, voyages, technical data).
- **Verified compliance:** done by the accredited verifier and the Administration. CarbonKeel prepares figures for them and never claims verification.

CONVENTIONS

- Masses in tonnes (t); energy in megajoules (MJ); distance in nautical miles (nm); intensities in grams per unit (g CO₂/t·nm, g CO₂e/MJ).
- Allowances (EUAs, UKAs) are whole units: where a document or a company total is due, the figure is rounded **up**. The ship page shows one decimal.
- Market inputs are assumptions the user can change, echoed in every result: EU allowance €85, UK allowance £40, €/£ 1.15, FuelEU pool price €110 per t CO₂e (checked 17 October 2026). The allowance planner uses EEX primary auction results instead (section 15).

2 Fuel properties and shared constants

One table per fuel, used by every scheme. Each scheme uses its own column: the EU and UK ETS use tank-to-wake CO₂ and the AR5 global-warming potentials; FuelEU uses Annex II well-to-wake values with AR4 potentials; the Poseidon Principles use their own well-to-wake factors with AR6 potentials. The regimes deliberately differ, so the same fuel gives different numbers in each.

Fuel	C _F CO ₂ , t/t (ETS, CII, EEXI)	CH ₄ , t/t	N ₂ O, t/t	LCV, MJ/t (FuelEU)	WtW, g CO ₂ e/MJ (FuelEU)	WtW, g CO ₂ e/g (Poseidon)
Heavy fuel oil (HFO)	3.114	5e-05	0.00018	40,500	91.74	3.84
Light fuel oil (LFO)	3.151	5e-05	0.00018	41,000	91.39	3.75
Diesel / gas oil (MDO, MGO)	3.206	5e-05	0.00018	42,700	90.77	4.01
LNG	2.750	0	0.00011	49,100	89.2	4.61
Methanol (fossil)	1.375	5e-05	0.00018	19,900	103.15	2
B24 biofuel blend	2.367	5e-05	0.00018	40,040	74.8	3.07
B100 biofuel	0.000	5e-05	0.00018	37,000	16.4	0.82

LNG engine (consumer class)	Methane slip, share of fuel mass (ETS)	FuelEU WtW, g CO ₂ e/MJ
otto medium speed	3.1%	89.2
otto slow speed	1.7%	82.87
diesel dual fuel	0.2%	76.08
lbsi	2.6%	86.94

SOURCES AND NUANCES

- C_f : 2018 IMO DCS guidelines and MEPC.364(79) (identical for oil fuels). CH_4 and N_2O factors and slip: Regulation (EU) 2015/757 Annex I Part A as amended by Delegated Regulation (EU) 2023/2776.
- Global-warming potentials: ETS (EU and UK) AR5 CH_4 28, N_2O 265 (Delegated Reg. 2020/1044; UK Order Table C1); FuelEU AR4 25 and 298 (Annex II); Poseidon AR6 29.8 and 273 (Technical Guidance v5.2 Table 8).
- FuelEU WtW is computed from Annex II as $WtT + (C_{f,CO_2} + 25 \cdot C_{f,CH_4} + 298 \cdot C_{f,N_2O}) \div LCV$; for LNG the slipped share counts as methane, which is why the four LNG engine classes differ.
- Biofuel: B100 is counted at zero tank-to-wake CO_2 only if certified (RED); its FuelEU WtW of 16.4 is the UCOME default pathway and must be replaced by the certificate's value (Art. 10). Methanol's CH_4/N_2O use the highest value of its class.

3 Rebuilding a ship-year from the public register

The EU MRV register publishes, for each ship and year, total CO_2 , total fuel mass, CO_2 per distance, the CO_2 (and from 2024 the CH_4 and N_2O) of each scope (voyages between EU/EEA ports, departing, arriving, at EU/EEA berths), the verifier's ETS-scope CO_2 and fuel per transport work. It does not publish fuel types, deadweight or distance. These equations turn the filing into the voyage legs every engine reads.

DISTANCE

$$D = \frac{CO_2 \text{ total} \times 1000}{CO_2/D} \quad (3.1)$$

WHERE

D	distance sailed in the year	nm	derived
$CO_2 \text{ total}$	total CO_2 in the filing	t	register
CO_2/D	CO_2 per distance in the filing	kg/nm	register

YEAR'S FUEL MIX

$$r = \frac{CO_2 \text{ total}}{M_{\text{total}}}, \quad x_{MGO} = \frac{r - 3.114}{3.206 - 3.114}, \quad x_{HFO} = 1 - x_{MGO} \quad (3.2)$$

WHERE

r	the ship's average CO_2 per tonne of fuel	t/t	derived
M_{total}	total fuel mass in the filing	t	register
x	share of fuel mass by fuel	–	derived

READING THE RATIO

- Within ± 0.0015 of a single fuel's C_F (3.114, 3.151, 3.206, 2.750) the ship is read as burning that fuel.
- Between 3.114 and 3.206: a blend of HFO and MGO by mass, as in (3.2). Between 2.750 and 3.114: a blend of LNG and HFO, $x_{LNG} = (3.114 - r) \div (3.114 - 2.750)$. Up to 0.05 above 3.206: MGO.
- Any other ratio, or no fuel figure: assumed HFO (LNG for an LNG carrier), stated on the result. The blend reproduces both published totals exactly.

EACH SCOPE'S OWN MIX

$$M_s = \frac{N_2O_s}{0.00018}, \quad r_s = \frac{CO_{2s}}{M_s} \quad (3.3)$$

WHERE

M_s	fuel burned in scope s	t	derived
N_2O_s	the scope's N_2O in the filing	t	register
0.00018	N_2O per tonne of HFO, LFO and MGO alike	t/t	Reg. 2015/757 Annex I
r_s	the scope's own CO_2 per tonne, read as in (3.2)	t/t	derived

WHEN THE SCOPE'S OWN MIX IS USED

- Only for a ship whose whole-year N_2O is the oil default within 1% (no LNG, default factors), and where the scope's N_2O is at least 0.0025 t (about 14 t of fuel). Otherwise the year's mix (3.2) is used.
- It matters because EU berths require 0.1% sulphur fuel, mostly gas oil: the berth scope usually reads as MGO even when the ship burns HFO at sea.
- Outside EU scope the fuel left over (M_{total} minus the fuel already placed in the EU scopes) gives the mix, so the year's fuel and CO_2 totals are still reproduced.

FUEL AND DISTANCE PER LEG

$$M_{s,f} = \frac{CO_{2s}}{\sum_f x_{s,f} C_{F,f}} x_{s,f}, \quad D_s = D \frac{CO_{2s}}{CO_{2sea}} (D_{berth} = 0) \quad (3.4)$$

WHERE

$M_{s,f}$	tonnes of fuel f placed in scope s	t	derived
$C_{F,f}$	carbon factor of fuel f	t/t	section 2
CO_{2sea}	CO_2 of the three sea scopes (all except berth)	t	register
D_s	distance given to scope s	nm	derived

CALIBRATION TO THE VERIFIER

$$k = \frac{CO_{2ETS, verifier}}{CO_{2between} + 0.5 (CO_{2leaving} + CO_{2arriving}) + CO_{2berth}} \quad (3.5)$$

WHERE

k	calibration of our rebuild to the verifier's ETS figure	–	derived
$CO_{2ETS, verifier}$	" CO_2 to be reported under Directive 2003/87/EC"	t	register

The EU ETS engine multiplies its rebuild by k (equation 4.4), so the bill uses the verifier's figure, which already reflects ports of call, transshipment stops, ship size and derogations the file does not show. $k = 0$ means the verifier reported no ETS-scope emissions (typically a ship below 5,000 GT, an offshore ship before 2027, or an exempt one): no allowances and no FuelEU result.

DEADWEIGHT ESTIMATE

$$\text{Cargo} = 1000 \frac{\text{fuel per distance}}{\text{fuel per transport work}}, \quad \text{DWT}_{est} = \frac{\text{Cargo}}{\lambda_{type}} \quad (3.6)$$

WHERE

Cargo	average cargo on board, laden voyages first	t	register ratio
λ_{type}	cargo as a share of deadweight on laden voyages	–	container ship 0.68, bulk carrier 0.85, oil tanker 0.85, chemical tanker 0.8, general cargo ship 0.7, refrigerated cargo carrier 0.55, gas carrier 0.6, lng carrier 0.6, combination carrier 0.85
DWT_{est}	first deadweight for the CII, rounded to 100 t	t	shown with a $\pm 15\%$ band; not offered below 3,000 t

WORKED EXAMPLE: PETER OLDENDORFF (IMO 9464663), 2025 FILING

Total CO ₂ ÷ total fuel	13,829.15 ÷ 4,426.56 = 3.124 t/t → 89% HFO 11% MGO by mass
Distance (3.1)	32,515 nm
Leg: intra eea	HFO 164.18 t, MDO_MGO 28.55 t; 1,458 nm
Leg: extra eea	HFO 3,756.04 t, MDO_MGO 356.85 t; 31,058 nm
Leg: at berth eea	HFO 16.82 t, MDO_MGO 104.07 t; 0 nm
Rebuilt ETS-scope CO ₂	602.76 + 0.5 × (5,346.68 + 7,493.68) + 386.02 = 7,408.97 t
Verifier's ETS-scope CO ₂	7,408.97 t, so $k = 1.0000$
Deadweight estimate (3.6)	cargo 57,443 t ÷ 0.85 = 67,600 t

The rebuild reproduces the verifier's figure exactly for this ship. Over the whole 2025 register: exact for 67.8% of ships, within 2% for 76.5%.

4 EU Emissions Trading System (shipping)

Directive 2003/87/EC as amended by Directive (EU) 2023/959; monitoring formula of Regulation (EU) 2015/757 Annex I Part A as amended by Delegated Regulation (EU) 2023/2776.

GASES, COMBUSTED MASS

$$\text{CO}_2 = \sum_i (M_i - M_{i,NC}) C_{F,i}, \quad \text{CH}_4 = \sum_i [(M_i - M_{i,NC}) EF_{CH_4,i} + M_{i,NC}], \quad \text{N}_2\text{O} = \sum_i$$

WHERE			
M_i	mass of fuel i used	t	customer data or section 3
$M_{i,NC}$	fuel released unburned (slip) = slip share $\times$ M_i ; LNG only	t	section 2
EF	CH ₄ and N ₂ O per tonne combusted	t/t	section 2

CO₂ EQUIVALENT

$$CO_2e = CO_2 + \delta_y (28 CH_4 + 265 N_2O), \quad \delta_y = \begin{cases} 0 & y < 2026 \\ 1 & y \geq 2026 \end{cases} \tag{4.2}$$

WHERE			
y	emissions year	–	
28, 265	AR5 global-warming potentials	–	Delegated Reg. 2020/1044

SCOPE

$$E_{scope} = \sum_{legs} \sigma_{leg} CO_{2e_{leg}}, \quad \sigma = \begin{cases} 1.0 & \text{between EU/EEA ports, at EU/EEA berth} \\ 0.5 & \text{into or out of the EU/EEA} \\ 0 & \text{otherwise} \end{cases} \tag{4.3}$$

WHERE			
σ	scope share	–	Directive Art. 3ga

VERIFIER BASIS

$$E_{ETS} = k \cdot E_{scope} \tag{4.4}$$

WHERE			
k	calibration to the verifier, (3.5); 1 for customer data	–	

ALLOWANCES AND COST

$$A = E_{ETS} \phi_y (1 - \rho) (1 - 0.05 \iota), \quad \text{Cost} = A \times P_{EUA} \tag{4.5}$$

WHERE			
ϕ_y	share to surrender: 2024 40%, 2025 70%, 2026 onwards 100%; 0 before 2024	–	Art. 3gb
ρ	share of in-scope emissions covered by a derogation (island, outermost-region, public-service routes)	0–1	Art. 12(3-b) to (3-d), to 31 Dec 2030; stated by the user
ι	1 for ice class IA or IA Super, else 0	–	Art. 12(3-e), to 31 Dec 2030
A	allowances due	EUA	
P_{EUA}	allowance price	€	input, default 85

EXCESS EMISSIONS PENALTY

$$\text{Penalty} = 100 \times (\text{allowances not surrendered by 30 September}) \tag{4.6}$$

WHERE			
100	excess emissions penalty per t CO ₂ e, indexed to EU consumer prices since 2013 (so at least €100)	€/t	Art. 16(3)

RULES AND NUANCES

- Surrender by 30 September of the following year (Art. 12(2a)); verified emissions by 31 March. The penalty does not replace the allowances: they are still owed, the company is named, and after two consecutive failures a ship can be refused entry (Art. 16(11a)).
- Scope: ships of 5,000 GT and above carrying cargo or passengers. Offshore ships of 5,000 GT and above join in 2027; cargo ships of 400–5,000 GT and offshore ships below 5,000 GT report under EU MRV but are outside the ETS.
- Only CO₂ is counted for 2024 and 2025; CH₄ and N₂O from 1 January 2026 (Annex I).
- A container ship's stop at a listed neighbouring transshipment port is not a port of call (Art. 3(z)); this is already in the verifier's figure, which is why the register path uses k.
- Certified sustainable biofuel (RED) can be zero-rated; uncertified biofuel uses the fossil factor.
- The shipping company may recover the cost from the charterer or operator (Art. 3gc); see sections 12 and 13.

WORKED EXAMPLE: 3,000 T HFO, ALL BETWEEN EU PORTS, 2026

CO ₂ (4.1)	$3,000 \times 3.114 = 9,342.0 \text{ t}$
CH ₄ as CO ₂ e	$3,000 \times 0.00005 \times 28 = 4.2 \text{ t}$
N ₂ O as CO ₂ e	$3,000 \times 0.00018 \times 265 = 143.1 \text{ t}$
E _{scope} (4.3), $\sigma = 1$	9,489.3 t CO ₂ e
Allowances (4.5), $\varphi = 100\%$	9,489.3
Cost at €85	€806,590
9,489.3 EUAs, €806,590	

WORKED EXAMPLE: PETER OLDENDORFF, REGISTER 2025

E _{ETS} (4.4), $k = 1.0000$	7,409.0 t CO ₂ (2025: CO ₂ only)
Allowances, $\varphi_{2025} = 70\%$	$7,409.0 \times 0.70 = 5,186.3$
Cost at €85	€440,834
Same activity on 2026 rules	100%, with CH ₄ and N ₂ O: 7,525.3 EUAs, €639,654
€440,834 for 2025; €639,654 if the same year were sailed under 2026 rules.	

5 UK Emissions Trading Scheme (shipping) and your own fuel by scope

The Greenhouse Gas Emissions Trading Scheme (Amendment) (Extension to Maritime Activities) Order 2026, SI 2026/392, Schedule 2A. Same gases, factors, GWPs and monitoring formula as (4.1)–(4.2).

UK ALLOWANCES

$$A_{UK} = \sum_{legs} u_{leg} \text{CO}_2 e_{leg}, \quad u = \begin{cases} 1.0 & \text{UK domestic voyages, UK berths} \\ 0.5 & \text{Great Britain} \leftrightarrow \text{Northern Ireland,} \\ 0 & \text{otherwise} \end{cases}$$

Cost\pounds

WHERE

<i>u</i>	UK share	–	Order para 15(1)
<i>P_{UKA}</i>	UK allowance price	£	input, default 40 (indicative)

EU AND UK TOGETHER

$$\text{Bill}_\epsilon = \text{Cost}_{EU} + \text{Cost}_{\pounds} \times FX$$

(5.2)

WHERE

<i>FX</i>	euros per pound	€/£	input, default 1.15
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YOUR OWN FUEL SPLIT BY SCOPE

$$M_{EU} = M(s_{between} + 0.5 s_{in/out} + s_{berth}), \quad M_{UK} = M(s_{UK} + 0.5 s_{GB-NI})$$

(5.3)

WHERE

<i>M</i>	the year's fuel of one type	t	customer data
<i>s</i>	share of the year's fuel burned on each kind of voyage, stated by the operator	–	

RULES AND NUANCES

- Ships of 5,000 GT and above; excluded: armed services, law enforcement, fishing, research and rescue, wooden and non-mechanical ships, ships operating a Scottish ferry service, offshore ships until 31 Dec 2026 (para 5).
- A voyage starts at the last berth in a UK port and ends at the first berth in a UK port without calling outside the UK (para 7): a voyage between the EU and the UK is EU ETS at 50% and **not** UK ETS. Northern Ireland ports are UK ports here and not EU ports. A leg is never counted in both schemes; the engine refuses one that would be.
- No phase-in. The first scheme year runs 1 July–31 December 2026 and is not pro-rated. Surrender 30 April of the following year, except 2026 emissions: 30 April 2028. Verified report by 31 March.
- The EU register cannot show UK voyages, so on public data the UK figure is reported as not observable rather than zero.

WORKED EXAMPLE: 4,300 T HFO IN 2026: 40% BETWEEN EU PORTS, 30% INTO OR OUT OF THE EU, 10% AT EU BERTHS, 5% UK DOMESTIC

EU fuel (5.3)	$4,300 \times (0.40 + 0.5 \times 0.30 + 0.10) = 2,795 \text{ t}$
EU CO ₂ e	$2,795 \times (3.114 + 0.00005 \times 28 + 0.00018 \times 265) = 8,840.86 \text{ t}$
EU cost at €85	€751,473
UK fuel and CO ₂ e	$4,300 \times 0.05 = 215 \text{ t}; \times 3.1631 = 680.07 \text{ t}$
UK cost at £40	£27,203, or €31,283 at 1.15
€782,756 for both schemes together	

6 FuelEU Maritime

Regulation (EU) 2023/1805: Art. 4 (limit), Annex I (intensity), Annex IV (compliance balance and penalty), Art. 20–21 (banking, borrowing, pooling), Art. 23 (penalties). From reporting period 2025.

ENERGY IN SCOPE

$$E_{MJ} = \sum_{legs} \sigma_{leg} \sum_f M_f LCV_f \quad (6.1)$$

WHERE

σ	scope share, as (4.3): 1, 0.5 or 0	–	Art. 2
LCV_f	lower calorific value	MJ/t	Annex II, section 2

GHG INTENSITY

$$I = \frac{\sum_{legs} \sigma \sum_f M_f LCV_f WtW_f}{E_{MJ}} \quad (6.2)$$

WHERE

I	GHG intensity of the energy used on board, well to wake	g CO ₂ e/MJ	
WtW_f	Annex II default, or the certified value (Art. 10), LNG by engine class	g CO ₂ e/MJ	section 2

LIMIT

$$I_{target}(y) = 91.16 (1 - r_y) \quad (6.3)$$

WHERE

91.16	2020 reference value	g CO ₂ e/MJ	Art. 4(2)
r_y	2025: 2%, 2030: 6%, 2035: 14.5%, 2040: 31%, 2045: 62%, 2050: 80% (each holds until the next)	–	Art. 4(2)

COMPLIANCE BALANCE

$$CB = (I_{target} - I) E_{MJ} \text{ [g CO}_2\text{e]}, \quad CB_t = CB/10^6 \quad (6.4)$$

WHERE			
CB	compliance balance: positive surplus, negative deficit	g CO ₂ e	Annex IV Part A

PENALTY

$$\text{Penalty} = \frac{|CB|}{I \times 41\,000} \times 2\,400 \times \left(1 + \frac{n-1}{10}\right) \quad (CB < 0) \quad (6.5)$$

WHERE			
41,000	energy of one tonne of VLSFO	MJ/t	Annex IV Part B
2,400	penalty per tonne of VLSFO-equivalent	€/t	Annex IV Part B
n	consecutive reporting periods with a FuelEU penalty, this one included	–	Art. 23(2); stated by the user

PENALTY PER TONNE, AND POOLING INSTEAD

$$p_t = \frac{10^6}{I \times 41\,000} \times 2\,400, \quad \text{Pooled} = |CB_t| \times P_{pool} \quad (6.6)$$

WHERE			
p_t	statutory cost of one tonne of deficit at this intensity (about €638 at HFO's 91.74)	€/t CO ₂ e	
P_{pool}	price of surplus bought from a pool	€/t CO ₂ e	input, default 110

RULES AND NUANCES

- Applies to ships above 5,000 GT carrying cargo or passengers (Art. 2), the same ships as the ETS. On public data a ship whose verifier reported no ETS-scope emissions ($k = 0$) is shown as outside FuelEU, so no phantom penalty appears.
- A surplus can be banked (Art. 20) or pooled (Art. 21); a deficit can be pooled, part-borrowed from the next year with 10% added (Art. 20), or paid. Pooled ships cannot borrow (Art. 21(7)); a ship can be in only one pool per year; pools are recorded by the verifier by 30 April.
- Surplus value: negotiated, and never above the penalty the other party avoids. The scorecard values it at half that ceiling (section 10).
- Not modelled: the RFNBO reward factor (2 until 2033), wind-assisted propulsion reward, on-shore power obligations from 2030, and the 2034 RFNBO sub-target. They need customer data the register does not have.

WORKED EXAMPLE: 3,000 T HFO BETWEEN EU PORTS, 2026

Energy (6.1)	$3,000 \times 40,500 = 121,500,000 \text{ MJ}$
Intensity (6.2)	$91.74 \text{ g CO}_2\text{e/MJ}$
Limit (6.3), 2026	$91.16 \times 0.98 = 89.34$
Compliance balance (6.4)	$(89.3368 - 91.74) \times 121.5 \times 10^6 = -292.0 \text{ t CO}_2\text{e}$
Penalty (6.5), $n = 1$	$292 \times 10^6 \div (91.74 \times 41,000) \times 2,400 = \text{€}186,309$
Third consecutive deficit, $n = 3$	$\times 1.2 = \text{€}223,571$
Pooled at €110 (6.6)	$291.99 \times 110 = \text{€}32,119$

€186,309 as a penalty, or **€32,119** bought from a pool

WORKED EXAMPLE: PETER OLDENDORFF, REGISTER 2025

Energy in scope	96,671,549 MJ (each scope with its own mix, section 3)
Intensity against the 2025 limit	91.61 against 89.34
Compliance balance	-219.4 t CO ₂ e

€140,221 penalty, or **€24,138** pooled at €110

7 Carbon Intensity Indicator (CII)

MARPOL Annex VI Regulation 28 and the guidelines G1 MEPC.352(78), G2 MEPC.353(78), G3 MEPC.338(76) as amended by MEPC.400(83), G4 MEPC.354(78), G5 MEPC.355(78).

ATTAINED (G1)

$$\text{CII}_{\text{attained}} = \frac{\sum_j M_j C_{F,j} \times 10^6}{\text{Capacity} \times D} \quad (7.1)$$

WHERE

M_j	fuel of type j in the calendar year (IMO DCS, all voyages)	t	
Capacity	DWT; GT for ro-ro, ro-pax, cruise and vehicle carriers; bulk capped at 279,000 DWT	t or GT	G1
D	distance sailed	nm	

REFERENCE LINE (G2)

$$\text{CII}_{\text{ref}} = a \times \text{Capacity}_{\text{ref}}^{-c} \quad (7.2)$$

WHERE

a, c	per ship type and size, Appendix table A1	–	G2
Capacity_{ref}	as (7.1), except vehicle carriers capped at 57,700 GT and LNG carriers below 65,000 DWT taken at 65,000		G2

REQUIRED (G3)

$$C\Pi_{required} = \left(1 - \frac{Z_y}{100}\right) C\Pi_{ref} \quad (7.3)$$

WHERE

Z_y	2023: 5%, 2024: 7%, 2025: 9%, 2026: 11%, 2027: 13.625%, 2028: 16.25%, 2029: 18.875%, 2030: 21.5%	%	G3, MEPC.400(83)
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RATING (G4)

$$\text{rating} = \begin{cases} A & R \leq d_1 \\ B & d_1 < R \leq d_2 \\ C & d_2 < R \leq d_3, \\ D & d_3 < R \leq d_4 \\ E & R > d_4 \end{cases} \quad R = \frac{C\Pi_{attained}}{C\Pi_{required}} \quad (7.4)$$

WHERE

$d_1 \dots d_4$	dd vector per ship type, Appendix table A1	–	G4
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WITH G5 CORRECTIONS

$$C\Pi_{G5} = \frac{\sum_j C_{F,j} \{M_j - (M_{voy,j} + TF_j + (0.75 - 0.03 y')(M_{el,j} + M_{boil,j} + M_{oth,j}))\}}{f_i f_m f_c f_{iVSE} \text{ Capacity } (D - D_x)} \times 10^6$$

WHERE

M_{voy}, D_x	fuel and distance of voyages endangering safe navigation (reg. 3.1) or within the ice edge	t, nm	G5 4.1
M_{el}	reefers (2.75 kW × 24 h × SFOC × reefer-days without a meter), cargo cooling on gas/LNG carriers, electric discharge pumps on tankers	t	G5 4.3, App. 1
M_{boil}, M_{oth}	cargo heating and steam pumps; standalone engine-driven cargo pumps (tankers)	t	G5 4.4–4.5
y'	years from 2023 (0.75 in 2023, 0.66 in 2026, 0.54 in 2030)	–	G5 4
TF_j	STS tankers: $(1 - 6.1742 \cdot DWT^{-0.246}) \times$ fuel on STS voyages; shuttle tankers with DP: $(1 - 5.6805 \cdot DWT^{-0.208}) \times$ all fuel	t	G5 2.8–2.9
f_i, f_m, f_c, f_{iVSE}	only if in the ship's EEDI/EEXI Technical File	–	G5 4.6

FUEL FROM SPEED (WHEN FUEL IS NOT KNOWN)

$$M_{ME} = M_{ref} \left(\frac{V}{V_{ref}} \right)^n t_{sea}, \quad D = 24 V t_{sea} \quad (7.6)$$

WHERE

M_{ref}	main-engine fuel per day at the reference speed	t/day	sea trial or charter party
n	speed exponent, 3 (cube law) by default, 2.6–3.5 typical	–	user
t_{sea}	days at sea; auxiliary and port fuel are added flat per day	days	

WORKED EXAMPLE: BULK CARRIER, 50,000 DWT, 3,000 T HFO, 50,000 NM, 2026

Attained (7.1)	$9,342 \times 10^6 \div (50,000 \times 50,000) = 3.737$
Reference (7.2)	$4,745 \times 50,000^{-0.622} = 5.669$
Required (7.3), Z = 11%	$5.669 \times 0.89 = 5.045$
Ratio	$3.737 \div 5.045 = 0.741$
Boundaries (dd × required)	$A \leq 4.339, B \leq 4.742, C \leq 5.348, D \leq 5.953$

Rating A**RULES AND NUANCES**

- The CII covers the ship's whole IMO DCS year. From the EU register only EU-related voyages are visible, so a CII from public data is an estimate, not offered below 1,000 nm in the year.
- Z rises every year to 2030, so the same ship drifts down a band without any change; the trajectory view recomputes every year, including the G5 deduction share.
- Rated D three years in a row, or E once: a corrective action plan in SEEMP Part III (section 18).
- G5 deductions are applied only from documented values; any deduction the guideline does not allow for the ship type, or larger than the fuel reported, is refused.

8 Energy Efficiency Existing Ship Index (EEXI)

MARPOL Annex VI Regulations 23 and 25 as revised by MEPC.328(76); calculation guidelines MEPC.350(78); survey and certification MEPC.351(78); capacity MEPC.364(79).

REQUIRED

$$EEXI_{required} = \left(1 - \frac{Y}{100}\right) a b^{-c} \quad (8.1)$$

WHERE

a, b, c	EEDI reference line, Appendix table A2; b = DWT (GT for cruise)	Reg. 24.3 Table 2
Y	reduction factor by type and size, linear inside the starred bands	% Reg. 25 Table 3

Y INSIDE A BAND

$$Y = Y_{lo} + (Y_{hi} - Y_{lo}) \frac{b - b_{lo}}{b_{hi} - b_{lo}} \quad (8.2)$$

WHERE

b_{lo}, b_{hi}	edges of the band the ship falls in	DWT or GT	Reg. 25 Table 3
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ATTAINED (TECHNICAL FILE)

$$EEXI_{attained} = \frac{f_j P_{ME} C_{F,ME} SFC_{ME} + P_{AE} C_{F,AE} SFC_{AE}}{f_i f_c f_l \text{ Capacity } f_w V_{ref} f_m} \quad (8.3)$$

WHERE			
P_{ME}	75% of MCR per engine; with a power limitation $\min(0.83 \times MCR_{lim}, 0.75 \times MCR)$	kW	MEPC.350(78) 2.2.1
P_{AE}	$0.025 \times \Sigma MCR + 250$ where $\Sigma MCR \geq 10,000$ kW, else $0.05 \times \Sigma MCR$	kW	EEDI guidelines 2.2.5.6
SFC	from the NOx Technical File; otherwise SFC_{app} 190 (ME) and 215 (AE) g/kWh with C_F 3.114	g/kWh	MEPC.350(78) 2.2.4–2.2.5
Capacity	DWT; 70% of DWT for container ships; GT for cruise		MEPC.364(79) 2.2.3
V_{ref}	speed at P_{ME} on the reference draught, deep water	kn	speed-power curve
$f_j, f_i, f_c, f_l, f_w, f_m$	correction factors from the Technical File; 1 when not applicable	–	MEPC.350(78)

RULES AND NUANCES

- Container ships: the attained index uses 70% of DWT, but the required value uses full DWT, because $a = 174.22$ and $c = 0.201$ were fitted on 100% DWT (MEPC.364(79) 2.2.3.3.3–4). Using 70% in both understates the requirement.
- Bulk carriers: b capped at 279,000 DWT. Ro-ro cargo and ro-pax use the phase-2 lines (Reg. 25.2): $a = 1,686.17$ with b capped at 17,000 DWT, and $a = 902.59$ with b capped at 10,000 DWT.
- Vehicle carriers: $a = (DWT/GT)^{-0.7} \times 780.36$ where $DWT/GT < 0.3$, and 1,812.63 where $DWT/GT \geq 0.3$; both DWT and GT are needed.
- The register may report EEXI, EEDI or EIV. EEDI and EIV are design or estimated indices: the verdict is then labelled INDICATIVE.
- Not included: power take-off/take-in, shaft generators and innovative technologies (their terms are zero). The usual remedy above the requirement is an engine or shaft power limitation documented in the Onboard Management Manual.

WORKED EXAMPLE: BULK CARRIER, 93,000 DWT, FILED EEXI 2.97

Reference	$961.79 \times 93,000^{-0.477} = 4.10$
Y	20% (20,000–200,000 DWT band)
Required (8.1)	$0.80 \times 4.10 = 3.28$
Margin	$(3.28 - 2.97) \div 3.28 = 9.5\%$

COMPLIANT

WORKED EXAMPLE: VEHICLE CARRIER, 22,500 DWT AND 60,868 GT, FILED EEXI 13.69

DWT/GT	$22,500 \div 60,868 = 0.370 \geq 0.3$, so $a = 1,812.63$
Reference	$1,812.63 \times 22,500^{-0.471} = 16.16$
Required, $Y = 15\%$	13.74

COMPLIANT ($13.69 \leq 13.74$)

WORKED EXAMPLE: TECHNICAL FILE, 150,000 DWT BULK CARRIER WITH A POWER LIMITATION (MEPC.351(78) SAMPLE)

P_{ME}	$\min(0.83 \times 9,940, 0.75 \times 15,000) = 8,250.2 \text{ kW}$
P_{AE}	$0.025 \times 15,000 + 250 = 625.0 \text{ kW}$
SFC and C_F	ME 166.5 g/kWh, AE 220 g/kWh, C_F 3.206 (diesel oil)
Attained (8.3)	$(8,250.2 \times 3.206 \times 166.5 + 625 \times 3.206 \times 220) \div (150,000 \times 13.2) = 2.45$
Required	2.61

2.45 against 2.61: COMPLIANT

Screening estimate on the EEXI page, when only MCR and V_{ref} are known: (8.3) with every $f = 1$, SFC 175 (ME) and 215 (AE) g/kWh and C_F of the main fuel. Example: 93,000 DWT, MCR 12,000 kW, 14 kn $\rightarrow$ 4.05. Always labelled INDICATIVE.

9 IMO Net-Zero Framework (scenario until adopted)

Draft MARPOL Annex VI Chapter 5, approved in principle at MEPC 83; adoption postponed in October 2025 and not adopted when this guide was built. Every output carries that note; all parameters are configurable.

GHG FUEL INTENSITY

$$GFI = \frac{\sum_{all\ legs} \sum_f M_f LCV_f WtW_f}{\sum_{all\ legs} \sum_f M_f LCV_f} \quad (9.1)$$

WHERE

GFI	GHG fuel intensity of all the ship's energy, international voyages and berths (not only EU)	g CO ₂ e/MJ
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TARGETS

$$T_{base} = 93.3 (1 - b_y), \quad T_{direct} = 93.3 (1 - d_y) \quad (9.2)$$

WHERE

93.3	2008 reference	g CO ₂ e/MJ	MEPC 83
b_y	2028: 4%, 2029: 6%, 2030: 8%, 2031: 12.4%, 2032: 16.8%, 2033: 21.2%, 2034: 25.6%, 2035: 30%	%	base target
d_y	2028: 17%, 2029: 19%, 2030: 21%, 2031: 25.4%, 2032: 29.8%, 2033: 34.2%, 2034: 38.6%, 2035: 43%	%	direct compliance target

REMEDIAL AND SURPLUS UNITS

$$\begin{aligned}
 GFI > T_{base} : & \quad U_2 = (GFI - T_{base})E, \quad U_1 = (T_{base} - T_{direct})E \\
 T_{direct} < GFI \leq T_{base} : & \quad U_1 = (GFI - T_{direct})E \\
 GFI \leq T_{direct} : & \quad SU = (T_{direct} - GFI)E
 \end{aligned}
 \quad \text{Cost} = 100 U_1 +$$

WHERE			
E	energy, in MJ; U and SU in t CO ₂ e (÷ 10 ⁶)	MJ	
100,380	Tier 1 and Tier 2 remedial unit prices	US\$/t	MEPC 83 draft

WORKED EXAMPLE: 3,000 T HFO, SCENARIO YEAR 2028

GFI	91.74 (FuelEU WtW values as provisional defaults)
Targets	base 89.57, direct 77.44
Tier 2 units	$(91.74 - 89.57) \times 121.5 = 263.9 \text{ t}$
Tier 1 units	$(89.57 - 77.44) \times 121.5 = 1,473.7 \text{ t}$

US\$247,649 in remedial units (scenario)

10 The four-score ship card

REGULATORY HEALTH

$$H = \min(100, \max(0, P_{rating} - 15 [CB < 0])) \quad (10.1)$$

WHERE

P_{rating}	A 100, B 85, C 65, D 35, E 10	points
$[CB < 0]$	1 when the FuelEU balance is a deficit	–

COST EXPOSURE

$$\text{Exposure} = \text{Cost}_{EU} + \text{Penalty}_{FuelEU} + \text{Cost}_{\text{pounds } FX}, \quad \text{Exposure}_{pooled} = \min(\text{Exposure}_{EU}, \text{Exposure}_{pounds})$$

COMPLIANCE ASSET

$$\text{Asset} = 0.5 \times \frac{CB}{I \times 41\,000} \times 2\,400 \quad (CB > 0) \quad (10.3)$$

WHERE

0.5	a negotiated midpoint: half the penalty the counterparty avoids	–	planning proxy
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WORKED EXAMPLE: 3,000 T HFO EXAMPLE, 2026

Health	A = 100, deficit –15 → 85
Exposure	€806,590 + €186,309 = €992,899
Pooled exposure	€838,709

Future readiness is the NZF scenario of section 9.

11 What-if levers and scenario comparison

FUEL AT SEA

$$\frac{M'_{sea}}{M_{sea}} = (1 - a) (1 + \Delta v)^{n-1} (1 - e) + \frac{a}{1 + \Delta v}, \quad \frac{t'_{sea}}{t_{sea}} = \frac{1}{1 + \Delta v} \quad (11.1)$$

WHERE

Δv	speed change on the same distance (−0.10 = 10% slower)	–	user
n	speed–power exponent, 3 by default (2 to 4.5)	–	user
a	auxiliary and boiler share of fuel at sea, default 10%	–	user
e	main-engine fuel saved by hull, propeller and trim	–	user or section 19

BIOFUEL, SAME ENERGY

$$M_{B100} = \beta \sum_{f \text{ fossil}} M_f \frac{LCV_f}{LCV_{B100}}, \quad M'_f = (1 - \beta) M_f \quad (11.2)$$

WHERE

β	share of fossil energy switched to certified B100	–	user
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BIOFUEL BREAK-EVEN

$$\text{Break-even premium} = \frac{-\Delta \text{Carbon} - \Delta M_{fossil} P_{fuel}}{M_{B100}} - P_{fuel} \quad (11.3)$$

WORKED EXAMPLE: 10% SLOWER, N = 3

Main engine only ($a = 0$) $0.9^2 = 0.8100$

With $a = 10\%$ $0.9 \times 0.81 + 0.1 \div 0.9 = 0.8401$

Fuel at sea falls by about 16% (not 10%); berth fuel is unchanged, and each scheme then applies only its own scope.

12 Owner and time-charterer split

PRO-RATA SHARE

$$s_{ch} = \frac{\text{charter days in the year}}{\text{days in the year}} \text{ (or the stated emissions share),} \quad \text{Charterer} = s_{ch} \times \text{Cos}$$

WORKED EXAMPLE: 1 MARCH–31 AUGUST 2025 ON A €100,000 EU ETS COST

Days 184 of 365

Share 50.41%

Charterer **€50,411**, owner €49,589

Basis: BIMCO ETS Allowances Clause for Time Charter Parties 2022 and FuelEU Maritime Clause 2024. The clauses allocate the emissions reported for the charter period; days are a proxy when voyage data is missing.

13 EU ETS statement to charterers (document)

ALLOWANCES TO TRANSFER	
$A_v = \left[\text{CO}_{2v} + \delta_{y_v} (28 \text{ CH}_{4v} + 265 \text{ N}_2\text{O}_v) \right] \sigma_v \phi_{y_v} (1 - 0.05 \iota), \quad A = \left\lceil \sum_v A_v \right\rceil \quad (13.1)$	
WHERE	
v	a voyage in the charter period, counted in the year it starts (Reg. 2015/757 Art. 3(m))
$\lceil \cdot \rceil$	allowances are whole units: rounded up

Example (release-gate check): 40 t MDO between EU ports in 2026 = $40 \times (3.206 + 0.00005 \times 28 + 0.00018 \times 265) = 130.3 \rightarrow$ **131 allowances**. With cash settlement, $\times$ the agreed price.

14 FuelEU pooling: allocation, settlement and the optimiser

ALLOCATION IN PROPORTION TO SURPLUS	
$\text{valid} \iff \sum_{i \in \text{pool}} CB_i \geq 0, \quad CB'_i = \begin{cases} 0 & CB_i < 0 \\ CB_i (1 - \theta) & CB_i > 0 \end{cases}, \quad \theta = \frac{\sum_{def} CB }{\sum_{sur} CB} \quad (14.1)$	
WHERE	
θ	share of each surplus used; the rest stays with its ship and may be banked (Art. 21(6))

TRANSFERS AND MONEY	
$T_{s \rightarrow d} = CB_d \frac{CB_s}{\sum_{sur} CB}, \quad \text{Pays}_d = P CB_d , \quad \text{Receives}_s = P \sum_d T_{s \rightarrow d} (1 - \text{fee}) \quad (14.2)$	
WHERE	
P	agreed price per t CO ₂ e €
fee	platform share of the gross, from the surplus side %

OPTIMISER (0/1 KNAPSACK)	
$\max_{S \subseteq \text{deficits}} \sum_{d \in S} \text{Penalty}_d \quad \text{s.t.} \quad \sum_{d \in S} CB_d \leq \sum_{sur} CB \quad (14.3)$	

Solved exactly by dynamic programming at 1-tonne granularity below 500,000 t of capacity, by penalty density above. Each deficit ship's saving = its penalty (6.5) – what it pays.

15 Allowance planner

NEED

$$N_{ship} = \lceil A_{2026} \rceil, \quad N_{co} = \sum_{ships} N_{ship} \tag{15.1}$$

WHERE		
A_{2026}	(4.5) on the ship's last reported year under 2026 rules (100%, CO ₂ + CH ₄ + N ₂ O)	EUA
co	the filing company, grouped by its IMO company number	

LOTS PER MONTH

$$L = \lceil \frac{N_{co}}{500} \rceil, \quad \ell_m = \left\lfloor \sum_{k \leq m} s_k L \right\rfloor - \sum_{k < m} \ell_k \tag{15.2}$$

WHERE		
500	EUAs per lot at EEX primary auctions	
s_m	share of the need in month m by pattern: steady 1/M; early ⅓ by March 2027; as emitted	–
ℓ_m	whole lots bought in month m; any remainder in the last buying month	lots

BUDGET AND PEERS

$$\text{Budget}_m = 500 \ell_m P, \quad \text{Percentile} = 100 \frac{\#\{c : x_c < x_{me}\}}{\#\text{peers}} \tag{15.3}$$

WHERE		
P	price: latest EEX auction clearing price, or the year's low and high as scenarios	€ data/eua_market.json
x	allowances per ship in scope; peers run mainly the same type with a similar number of ships (≥ 5 companies)	EUA

WORKED EXAMPLE: OLDENDORFF CARRIERS GMBH & CO. KG, 52 SHIPS IN SCOPE, PLANNED ON 31 OCTOBER 2026

Need	205,461 EUAs
Lots	$\lceil 205,461 \div 500 \rceil = 411$ (spare 39)
Price	latest EEX auction €84.7
Auctions to August 2027	180, 0.056% of the supply
About €17,405,850 at €84.7	

16 MOHA workspace: obligations, reconciliation, funding, penalty watch

REQUIRED PER COMPANY

$$R_c = \left[\phi_y \sum_{i \in c} E_{ETS,i} \right] \quad (16.1)$$

WHERE

c	the responsible shipping company (registered owner, or the ISM company with a mandate); ships below 5,000 GT left out	Directive Art. 3(w)
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OUTSTANDING AND FUNDING CALL

$$O_c = \max(0, R_c - H_c - S_c), \quad O'_c = \max(0, O_c - T_c), \quad \text{Call}_c = O'_c P_{EUA} \quad (16.2)$$

WHERE

H_c, S_c	in the company's own MOHA, and already surrendered	EUA	Registry statement
T_c	pending transfers into that company's own MOHA only	EUA	

PENALTY WATCH

$$\text{Penalty}_{\text{watch}} = 100 \times \text{short}, \quad \text{still owed} = \text{short} \times P_{EUA} \quad (16.3)$$

RULES

- Each company has one MOHA; a surplus in one never offsets a shortfall in another; a transfer to the wrong company's MOHA does not count (Delegated Reg. 2019/1122 Art. 15a).
- States: early, watch (from 120 days before 30 September), at risk (30 days), missed; expulsion risk after a previous miss.
- Example: required 9,490, covered 9,000, on 10 September 2027 → short 490, penalty €49,000, still owed €41,650, state "at risk".

17 Poseidon Principles climate alignment

ATTAINED (EQUATION 2)

$$AER_{WtW} = \frac{\sum_f M_f WtW_f^{PP} \times 10^6}{DWT \times D} \quad (17.1)$$

WHERE

WtW^{PP}	Table 8 factors, section 2	g CO ₂ e/g	Technical Guidance v5.2
DWT	GT for cruise, ferries and vehicle carriers (cgDIST)		

TRAJECTORY

$$r_s = (aY^3 + bY^2 + cY + d) \text{ Size}^e \quad (17.2)$$

WHERE

$a \dots e$ Table 6 (minimum) and Table 7 (striving), Appendix table A4

Size DWT, GT, TEU or m³ by type; bulk from 279,000 DWT uses its own line

ALIGNMENT DELTA (EQUATION 3)

$$\Delta = \frac{AER_{wtw} - r_s}{r_s} \times 100 \quad (17.3)$$

Check against the guidance's worked example, 80,000 DWT bulk carrier, 2024: minimum 3.88, striving 3.66 g CO₂e/dwt-nm (the guidance prints 3.9 and 3.7).

18 SEEMP Part III plan

COMBINED EFFECT

$$C\Pi_{target}(y) = C\Pi_{attained} \prod_{m \in \text{force}(y)} \varphi_m, \quad \varphi_{speed} = (1 + \Delta v)^{n-1}, \quad \varphi_m = 1 - \frac{s_m}{100} \quad (18.1)$$

WHERE

s_m routing 2.5%, jit 2%, hull_clean 4%, trim 1.5%, aux 1%, % planning defaults (VERIFY per ship)
coating 4%, esd 3%

INTERACTIONS

- With a speed reduction in force, weather routing and just-in-time arrival count at half their effect.
- Hull cleaning and a low-friction coating address the same loss: only the larger counts.
- Target: at least C in the first plan year and at or below the required CII in later years; the automatic plan keeps a 2% margin (MEPC.395(82) Appendix 3 layout).

19 Hull and propeller performance (ISO 19030 approach)

REFERENCE CURVE

$$P = aV^n \text{ (fit } \ln P = \ln a + n \ln V), \quad P_T = P_{T_{ref}} \left(\frac{T}{T_{ref}} \right)^{2/3} \quad (19.1)$$

WHERE

T mean draught; between laden and ballast curves In a and n are interpolated

PERFORMANCE VALUES

$$\Delta P = \frac{P_{meas}}{P_{exp}(V_{meas}, T)} - 1, \quad \text{speed loss} = 1 - \frac{V_{meas}}{V_{exp}(P_{meas}, T)} \quad (19.2)$$

COST OF FOULING

$$M_{excess} = M_{ME} \frac{\Delta P}{1 + \Delta P}, \quad c_t = C_F P_{EUA} s_{EU} + (WtW - I_{target}) LCV P_{pool} s_{EU} \times 10^{-6}$$

WHERE

s_{EU}	share of fuel in EU scope	–
c_t	carbon cost of one tonne of fuel	€/t

Only steady, fair-weather days: ≥ 20 h under way, Beaufort ≤ 4 when reported, speed within 10% and draught within 1 m of the reference. Records are split at cleanings, polishes and dry-dockings; an event's effect is the mean speed loss in the 30 days before minus the 30 days after. A cleaning pays back when its cost (default €25,000) $\div$ the daily cost of the excess.

20 Part-year data: annualising

LINEAR SCALING

$$k_{year} = \frac{365}{\text{days observed}}, \quad M' = k_{year} M, \quad D' = k_{year} D \quad (20.1)$$

The CII is unchanged by scaling (a ratio); costs grow with it. Confidence: ≥ 270 days HIGH, ≥ 90 MEDIUM, ≥ 30 LOW, otherwise INDICATIVE. Seasonality, dry-dock and idle time are not modelled.

21 Appendix: parameter tables

A1. CII reference lines (G2) and rating vectors (G4)

Ship type	a	c	d ₁ / d ₂ / d ₃ / d ₄
Bulk carrier	4745	0.622	0.86 / 0.94 / 1.06 / 1.18
Tanker	5247	0.61	0.82 / 0.93 / 1.08 / 1.28
Container	1984	0.489	0.83 / 0.94 / 1.07 / 1.19
General cargo	31948	0.792	0.83 / 0.94 / 1.06 / 1.19
Gas carrier	8104	0.639	0.85 / 0.95 / 1.06 / 1.25
Refrigerated cargo	4600	0.557	0.78 / 0.91 / 1.07 / 1.2
Combination carrier	5119	0.622	0.87 / 0.96 / 1.06 / 1.14
Ro ro	1967	0.485	0.76 / 0.89 / 1.08 / 1.27
Ro pax	2023	0.46	0.76 / 0.92 / 1.14 / 1.3

Cruise	930	0.383	0.87 / 0.95 / 1.06 / 1.16
General cargo below 20,000 DWT	588	0.3885	as general cargo
Gas carrier 65,000 DWT and above	14405×10 ⁷	2.071	0.81 / 0.91 / 1.12 / 1.44
LNG carrier 100,000 DWT and above	9.827	0	0.89 / 0.98 / 1.06 / 1.13
LNG carrier 65,000–100,000 DWT	14479×10 ¹⁰	2.673	0.78 / 0.92 / 1.1 / 1.37
LNG carrier below 65,000 DWT (at 65,000)	14779×10 ¹⁰	2.673	0.78 / 0.92 / 1.1 / 1.37
Vehicle carrier 30,000 GT and above (cap 57,700 GT)	3627	0.590	0.86 / 0.94 / 1.06 / 1.16
Vehicle carrier below 30,000 GT	330	0.329	0.86 / 0.94 / 1.06 / 1.16

A2. EEXI reference lines (Reg. 24.3 Table 2) and reduction factors (Reg. 25 Table 3)

Ship type	a	c	Y by size band (DWT; GT for cruise)
Bulk carrier	961.79	0.477	10,000–20,000: 0→20%; 20,000–200,000: 20%; 200,000–∞: 15%
Gas carrier	1120	0.456	2,000–10,000: 0→20%; 10,000–15,000: 20%; 15,000–∞: 30%
Tanker	1218.8	0.488	4,000–20,000: 0→20%; 20,000–200,000: 20%; 200,000–∞: 15%
Container	174.22	0.201	10,000–15,000: 0→20%; 15,000–40,000: 20%; 40,000–80,000: 30%; 80,000–120,000: 35%; 120,000–200,000: 45%; 200,000–∞: 50%
General cargo	107.48	0.216	3,000–15,000: 0→30%; 15,000–∞: 30%
Refrigerated cargo	227.01	0.244	3,000–5,000: 0→15%; 5,000–∞: 15%
Combination carrier	1219	0.488	4,000–20,000: 0→20%; 20,000–∞: 20%
Lng carrier	2253.7	0.474	10,000–∞: 30%
Vehicle carrier	780.36	0.471	10,000–∞: 15%
Ro ro	1686.17	0.498	1,000–2,000: 0→5%; 2,000–∞: 5%
Ro pax	902.59	0.381	250–1,000: 0→5%; 1,000–∞: 5%
Cruise	170.84	0.214	25,000–85,000: 0→30%; 85,000–∞: 30%

A3. FuelEU and NZF targets

From	FuelEU reduction	FuelEU limit, g CO ₂ e/MJ
2025	2%	89.34
2030	6%	85.69
2035	14.5%	77.94
2040	31%	62.90
2045	62%	34.64
2050	80%	18.23

Year	NZF base %	NZF direct %	Base, g CO ₂ e/MJ	Direct, g CO ₂ e/MJ
2028	4	17	89.57	77.44

2029	6	19	87.70	75.57
2030	8	21	85.84	73.71
2031	12.4	25.4	81.73	69.60
2032	16.8	29.8	77.63	65.50
2033	21.2	34.2	73.52	61.39
2034	25.6	38.6	69.42	57.29
2035	30	43	65.31	53.18

A4. Poseidon Principles trajectory coefficients

Trajectory	Type	Size	a	b	c	d	e
minimum	Bulk carrier	DWT	0.209808	-1278.76	2.59776e+06	-1.75894e+09	-0.621796
minimum	Bulk carrier (279k DWT and above)	DWT	8.62515e-05	-0.525695	1067.93	-723097	0
minimum	Chemical tanker	DWT	0.764174	-4657.57	9.46172e+06	-6.40652e+09	-0.708012
minimum	Container	TEU	0.0170465	-103.897	211064	-1.42911e+08	-0.428275
minimum	Cruise	GT	3.40417	-20734.6	4.20938e+07	-2.84824e+10	-0.781306
minimum	Ferry-RoPax	GT	0.33488	-2044.33	4.15975e+06	-2.8212e+09	-0.533656
minimum	General cargo	DWT	0.039377	-240	487552	-3.30121e+08	-0.434669
minimum	Liquefied gas tanker (100k CBM and above)	CBM	0.000507847	-3.09529	6287.98	-4.25758e+06	-0.00798691
minimum	Liquefied gas tanker (below 100k CBM)	DWT	0.12737	-776.312	1.57705e+06	-1.06782e+09	-0.50641
minimum	Oil tanker	DWT	0.911577	-5555.99	1.12868e+07	-7.64229e+09	-0.710709
minimum	Refrigerated bulk	DWT	1.05901	-6454.59	1.31123e+07	-8.87832e+09	-0.689616
minimum	Ro-Ro	DWT	1.66276	-10134.4	2.05877e+07	-1.39399e+10	-0.736571
minimum	Vehicle	GT	1.61483	-9843.08	1.99977e+07	-1.35416e+10	-0.798599
striving	Bulk carrier	DWT	0.182599	-1111.05	2.25324e+06	-1.52305e+09	-0.621796
striving	Bulk carrier (279k DWT and above)	DWT	7.50661e-05	-0.456752	926.303	-626123	0
striving	Chemical tanker	DWT	0.665073	-4046.75	8.20689e+06	-5.54734e+09	-0.708012
striving	Container	TEU	0.0148359	-90.2713	183072	-1.23745e+08	-0.428275
striving	Cruise	GT	2.86535	-17417.1	3.52856e+07	-2.38256e+10	-0.781306
striving	Ferry-RoPax	GT	0.318318	-1941.05	3.94515e+06	-2.67265e+09	-0.533656
striving	General cargo	DWT	0.0342705	-208.524	422892	-2.85848e+08	-0.434669
striving	Liquefied gas tanker (100k CBM and above)	CBM	0.000441988	-2.68935	5454.06	-3.6866e+06	-0.00798691
striving	Liquefied gas tanker (below 100k CBM)	DWT	0.110853	-674.501	1.3679e+06	-9.24616e+08	-0.50641
striving	Oil tanker	DWT	0.793361	-4827.34	9.78994e+06	-6.61739e+09	-0.710709
striving	Refrigerated bulk	DWT	0.921676	-5608.09	1.13733e+07	-7.68765e+09	-0.689616
striving	Ro-Ro	DWT	1.44713	-8805.3	1.78573e+07	-1.20704e+10	-0.736571
striving	Vehicle	GT	1.41164	-8590.43	1.74238e+07	-1.1779e+10	-0.798599

A5. Open items (marked VERIFY in the code)

CHECKED BEFORE RELYING ON THEM FOR A CUSTOMER

- Load shares λ for the deadweight estimate (3.6): container 0.68 checked on six ships; the others are physical defaults.
- Biofuel treatment: MEPC.1/Circ.905 (CII) and RED certification (ETS, FuelEU); B100 WtW per the actual certificate.
- SEEMP measure savings and interaction rules are planning defaults, to check against the ship's own data.
- NZF targets and unit prices against the final adopted text.
- The excess emissions penalty: €100 indexed since 2013, shown as "at least" until the year's indexed figure is published.

A6. Primary sources

Directive 2003/87/EC (consolidated) and Directive (EU) 2023/959; Regulation (EU) 2015/757 and Delegated Regulation (EU) 2023/2776; Delegated Regulation (EU) 2020/1044; Regulation (EU) 2023/1805 (FuelEU Maritime); Delegated Regulation (EU) 2019/1122 as amended by 2023/2904 (Union Registry); SI 2026/392 (UK ETS maritime); MARPOL Annex VI as revised by MEPC.328(76), MEPC.338(76), MEPC.350(78), MEPC.351(78), MEPC.352(78)–355(78), MEPC.364(79), MEPC.395(82), MEPC.400(83); Poseidon Principles Technical Guidance v5.2 (July 2025); ISO 19030; BIMCO ETS Allowances Clause 2022 and FuelEU Clause 2024; EMSA THETIS-MRV public emission reports; EEX primary auction results.