2025

Report on

calculation methodologies under Regulation (EU) 2023/1805 (FuelEU)

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Version 2

This document is part of a series of documents prepared by experts gathered under a workstream established in the umbrella of the “European Sustainable Shipping Forum (ESSF)”: the sub-group of Sustainable Alternative Power for Shipping (SAPS).

The workstream gathered for the period October 2024 to May 2025 in order to provide technical expertise relevant for the implementation of Regulation (EU) 2023/1805 (the Fuel EU Maritime Regulation). This report does not reflect the official view of the European Commission, nor is it legally binding.

Sustainable Alternative Power for Shipping
Workstream 1 on FuelEU Calculation Methodologies (WS1)

EUROPEAN SUSTAINABLE SHIPPING FORUM (ESSF)

Sustainable Alternative Power for Shipping

FuelEU Calculation Methodologies Workstream

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Version history

Version	Updated	Changes
Version 1	28 May 2025 (Published)	
Version 2	17 June 2025	• Clarifications and additions to the Note on biomethane E values - page 18. • Corrected the energy content of bio-diesel (FAME) - table 20 and 21. • Added clarification on the 'consecutive condition' with regards to the penalty escalation - page 27-28. • Added reference to additional Article 2(6) exemptions used by France and updated reference to Article 2(4) exemptions used by Spain.

I. Introduction

I.1. About This Document

This document provides guidance and best practices to understand and implement the calculations as set out under Regulation (EU) 2023/1805[1] (hereafter 'FuelEU'). Developed under Workstream 1 (WS1) of the Sustainable Alternative Power for Shipping (SAPS) subgroup of the European Sustainable Shipping Forum (ESSF), it incorporates the collective knowledge and expert insights of the workstream members to explain and clarify formulas and requirements through actionable, detailed instructions.

The primary audience for this document is companies and organizations impacted by the FuelEU. This includes shipping companies (referred to as 'company'[2]) directly responsible for compliance, as well as entities throughout the maritime value chain affected by the regulation. For example, marine fuel and technology suppliers seeking to assess the potential compliance surplus or deficit associated with a given energy product under the FuelEU.

This document provides detailed methods for calculating compliance with FuelEU Article 4 and applying flexibility mechanisms in Article 20 and 21, namely banking, borrowing, and pooling. It includes practical step-by-step examples and calculation methodologies. Values used in the calculation examples are sourced from legislative texts or are illustrative values to demonstrate the calculation procedure. In practice, values that are not fixed in the legislative texts should align with the certification process which has been detailed in the SAPS Workstream 2 (WS2) document titled 'Report on Marine Fuels Certification Procedures to support implementation of FuelEU.'[3]

This document presents the legal text in a format tailored for industry implementation. Readers should note that only the referenced legislative texts are legally binding. Where interpretation of the legal requirements is necessary to support practical calculation methodologies, it is clearly identified in the document. The development of calculation methodologies was based on industry best practices and expert input from WS1. While every effort has been made to ensure accuracy and consistency with the legislation and existing interpretations, it should be noted that the ultimate authority on regulatory compliance rests with the EU legislative texts and the Court of Justice of the European Union.

I.2. Scope of the Guidance Document

This document is designed to cover necessary aspects for understanding and implementing the compliance with Article 4 with greater explanation of the greenhouse gas (GHG) intensity

[1] See Regulation (EU) 2023/1805 of the European Parliament and of the Council of 13 September 2023 on the use of renewable and low-carbon fuels in maritime transport, known as FuelEU Maritime https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1805.
[2] We use 'company' to refer generally to the entity responsible for compliance, in line with the definition provided in FuelEU Article 3(13). This refers to the shipowner or any other organisation or person, such as the manager or bareboat charterer, that has assumed responsibility for the operation of the ship and agreed to take over all duties and responsibilities imposed by the International Management Code for the Safe Operation of Ships and for Pollution Prevention (the ISM Code), also known as the ISM company.
[3] The Report can be found on the European Commission's Directorate-General for Mobility and Transport website for FuelEU https://transport.ec.europa.eu/transport-modes/maritime/decarbonising-maritime-transport-fueleu-maritime_en

and compliance balance calculations in FuelEU Annex I, IV, and V and the flexibility mechanisms in Articles 20 and 21. It is divided into four Chapters:

1. **General Calculations and Principles**: Provides guidance on the calculation methodologies needed to determine emission factors, compliance balance, and any penalties.
2. **Extra-EEA Voyages**: Explains the calculation of compliance balance for voyages between European Economic Area (EEA) Member State[4] ports and third countries or Outermost Regions.
3. **Technology-Specific Calculations**: Offers support for additional calculation methodologies required for specific technologies.
4. **Flexibility Mechanisms:** Describes the rules and requirements for implementing mechanisms outlined in FuelEU Article 20 and 21, including pooling, banking, and borrowing.

This document does not cover all aspects of FuelEU. Sections of the regulation including the obligation to use on-shore power supply (OPS), or the RFNBO subtarget are not included in the guidance.

The content stems from extensive consultations and collaboration among ESSF experts, aiming for precision and practical applicability. While the guidance represents the industry's current understanding, it is not legally binding nor should it be considered investment advice. Values used in examples are solely to illustrate calculation methodologies and should not be interpreted as recommendations.

I.3. Purpose of the Guidance

The purpose of this document is to clarify the steps needed to calculate the compliance balance laid out in Annex I, II, IV, and V of FuelEU as well as the steps for complying with flexibility mechanisms in Articles 20 and 21. It provides step-by-step instructions for stakeholders, offering practical advice and detailed breakdowns of the provisions in the regulation.

I.4. Overview of the FuelEU

Adopted in 2023 and published in the Official Journal of the EU on 22 September 2023, FuelEU is a pivotal component of the EU's strategy to reduce GHG emissions from maritime transport. The regulation mandates the progressive use of renewable and low-carbon fuels to decrease emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). It builds on the certification and GHG reduction framework developed under the Renewable Energy Directive (RED) to ensure a consistent approach to calculating emissions reductions across legislative texts.

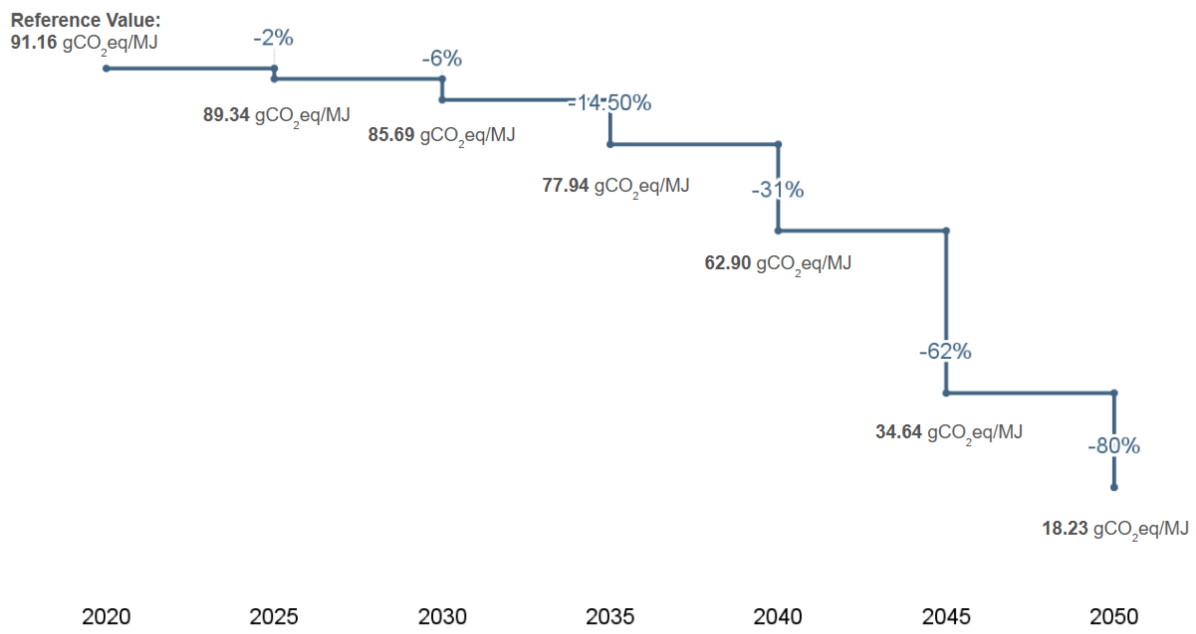
Central to the regulation is the concept of Well-to-Wake (WtW) GHG emissions, which considers the full lifecycle emissions of maritime fuels. FuelEU specifies methodologies for

[4] The FuelEU Maritime Regulation is a text with EEA relevance, which means that, following incorporation into the EEA Agreement, the Regulation will apply to EU Member States and Iceland, Liechtenstein, and Norway (except Svalbard).

calculating the GHG intensity of energy used onboard ships, outlined in Annex I, and provides default emission factors in Annex II. These methodologies are critical for ensuring that all maritime fuels, whether fossil-based or renewable, are assessed fairly and consistently.

The regulation also introduces a compliance balance mechanism, effective 1 January 2025. Verifiers annually calculate the attained GHG intensity for each ship, comparing it against a declining limit, or targets, set by the regulation. Figure 1 shows the GHG intensity limit which decreases every five years, requiring gradual improvement in GHG intensity and the adoption of lower-emission technologies. Ships can engage in flexibility mechanisms such as banking surplus emissions reductions, borrowing future allowances, or pooling emissions with other ships to meet or exceed targets. For ships that fail to meet required GHG intensity (i.e., compliance balance in deficit), a financial penalty is imposed, calculated per metric ton of deficit emissions. For stakeholders to implement the requirements requires a careful understanding of the FuelEU and associated legal texts.

Figure 1. GHG intensity limit on energy used on board (Article 4)



I.5. Legal Framework (FuelEU and Annex I, II, IV and V Overview)

The calculation of the compliance balance is focused on several key FuelEU annexes, each outlining specific aspects of compliance:

- **Annex I:** Provides methodologies for calculating the GHG intensity of maritime fuels.
- **Annex II:** Lists default emission factors for various fuel types.
- **Annex IV:** Details requirements for monitoring and reporting emissions.

- **Annex V:** Outlines provisions for verifying compliance with the regulation's standards.

Throughout this guidance, examples of calculations based on the legal framework will be provided to illustrate how maritime operators can apply these rules in practice, facilitating a better understanding and implementation of the regulation.[5]

In addition to FuelEU, the guidance also points to other EU legislation including Directive (EU) 2018/2001, so-called Renewable Energy Directive (RED) as well as relevant implementing acts and delegated regulations which are identified throughout this document.

[5] For more information, see Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652 https://eur-lex.europa.eu/eli/dir/2023/2413/oj/eng.

1. Chapter 1: General Calculations and Principles

1.1. Introduction and Key Concepts

This chapter introduces the foundational concepts and calculations required to implement Article 4 of the FuelEU. Chapter 1 focuses on the most straightforward cases: vessels operating between or within ports of the European Economic Area (EEA), using fossil fuels, biofuels, or renewable fuels of non-biological origin (RFNBOs). The EEA, comprising EU member states along with Iceland, Liechtenstein, and Norway (except Svalbard), defines the geographic scope of the regulation.

These cases serve to demonstrate the core principles and methodologies for understanding the application of the equations to calculate FuelEU compliance. Subsequent chapters build on this foundation by addressing how to apply the regulation to voyages involving non-EEA ports (Chapter 2), incorporating technologies such as wind-assisted propulsion or onshore power supply (Chapter 3), and applying flexibility mechanisms such as banking, borrowing, and pooling (Chapter 4).

Several key concepts are helpful to understanding the calculations:

- **Compliance Balance**: The measure of a ship's over- or under-compliance with the limits for the yearly average GHG intensity of the energy used on board by a ship. This calculation is performed in accordance with Part A of Annex IV, as stipulated in Article 3(35) of FuelEU.
- **E value**: The total GHG emission information found in a Proof of Sustainability (PoS), as issued by the certified fuel supplier to demonstrate compliance with GHG/sustainability certification rules. The E value is regarded as a WtW figure under RED, as it reads "from supply and use of the fuel (gCO_2eq/MJ)".[6] It is used in the FuelEU to determine the emission factor for non-fossil fuels.
- **Extra-EEA:** For voyages between a port under the jurisdiction of an EEA Member State and a port under the jurisdiction of a third country (or vice-versa), the Regulation applies to ships for one half of the energy used.
- **GHG Intensity**: The well-to-wake (WtW) greenhouse gas (GHG) emissions associated with the energy used onboard a vessel, expressed in grams of CO_2 equivalent per megajoule (gCO_2eq/MJ). This metric accounts for all GHG emissions from the extraction or cultivation of raw materials through to fuel combustion onboard. It includes emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), each converted into CO_2 equivalents using their 100-year global warming potential (GWP). The WtW GHG intensity is composed of two parts:
  - **Well-to-tank (WtT) emissions**: GHG emissions from the extraction, production, and delivery of the fuel up to the point it is onboard the vessel.
  - **Tank-to-wake (TtW) emissions**: GHG emissions from the combustion or use of the fuel onboard the vessel, including any methane slip or fugitive emissions.

[6] Directive (EU) 2018/2001, http://data.europa.eu/eli/dir/2018/2001.

- **Intra-EEA:** The Regulation applies to ships for the entirety of the energy used on voyages between ports under the jurisdiction of EEA Member States as well as the energy used while the ship is at berth[7] and the energy used within EEA ports when the ship is not at berth (e.g., moving within a port of call between two voyages).
- **LCV (Lower Calorific Value)**: The amount of usable energy released when a fuel is combusted as expressed in megajoules per gram (MJ/g), and reflecting the net energy content available for propulsion or onboard use.
- **Proof of Compliance (PoC):** A solution mentioned in EU ETS and MRV guidance document no.1[8] and endorsed by SAPS WS2,[9] for instances when the original PoS is not available, typically because it has been surrendered to meet national targets. It provides equivalent sustainability and GHG data to support claims under FuelEU.
- **Proof of Sustainability (PoS)**: A sustainability declaration document issued under an EU-approved voluntary scheme, demonstrating that a fuel meets RED II sustainability criteria. It includes the fuel's well-to-wake GHG emissions (E value, in gCO_2eq/MJ) and is required under FuelEU for non-fossil fuels.
- **Slip**: Non-combusted fuel that escapes as fugitive or engine slip emissions, most relevant for gaseous fuels such as LNG.

This chapter first outlines the general calculation principles for determining GHG intensity, followed by the methodology for calculating the compliance balance and associated penalties. It concludes with a series of examples demonstrating how these calculations are applied in practice.

1.2. GHG Intensity Calculation: Step-by-Step Guidance

1.2.1. Overview of the GHG intensity formulas

This section details the formulas and variables involved in the calculation of GHG intensity as specified in FuelEU Annex I. This is the first step to calculating compliance with the FuelEU. While the fuel specific GHG intensity calculations in paragraph 1.2 of this guidance document are considered on a per metric tonne basis, it is important to note that the GHG emission intensity of each fuel is used to derive the annual weighted average WtW emission intensity of the ship's consumed energy.

According to the FuelEU, the following formula is used to calculate the GHG intensity of the energy consumed on board a ship:

Equation (1)

$$GHG\ intensity\left[\frac{gCO_2eq}{MJ}\right] = f_{wind} \times (WtT\ +\ TtW)$$

[7] As per Article 3 of the MRV Maritime Regulation, a ship is to be considered at berth when 'securely moored or anchored in a port falling under the jurisdiction of a Member State while it is loading, unloading or hoteling, including the time spent when not engaged in cargo operations'. The ship will also be considered as 'at berth' when engaging in any operation other than cargo handling within port (e.g. bunkering, positioning, inspections, etc.) between arrival at first berth and departure from last berth as long as the ship is securely moored or anchored within port limits.
[8] See the latest EU ETS MRV guidance document linked on the EMSA website https://www.emsa.europa.eu/faq-monitoring-plan.html
[9] For more on the PoC see the WS2 Report which can be found on the European Commission's website for FuelEU https://transport.ec.europa.eu/transport-modes/maritime/decarbonising-maritime-transport-fueleu-maritime_en

Where f_{wind} is a reward factor for wind-assisted propulsion. See Section 3.3.2 for guidance on calculating the wind reward factor.

According to Equation (1) in FuelEU Annex I, WtT is calculated as follows:

$$WtT = \frac{\sum_{i}^{n\,fuel} M_i \times CO_2eq_{WtWi} \times LCV_i + \sum_{k}^{c} E_k \times CO_{2eq\,electricity,\,k}}{\sum_{i}^{n\,fuel} M_i \times LCV_i \times RWD_i + \sum_{k}^{c} E_k}$$

Furthermore, Annex I states:

For the purpose of this Regulation, the term $\sum_{k}^{c} E_k \times CO_{2eq\,electricity,\,k}$ in the numerator of Equation (1) shall be set to zero.

As a result, the WtT GHG intensity formula can be simplified to:

$$WtT = \frac{\sum_{i}^{n\,fuel} M_i \times CO_{2eq\,WtT,\,i} \times LCV_i}{\sum_{i}^{n\,fuel} M_i \times LCV_i \times RWD_i + \sum_{k}^{c} E_k}$$

Variable and subscript definitions per Annex I

- $M_{i,j}$ is the Mass of fuel i consumed by fuel consumer unit j (g fuel).
- $CO_{2eq\,WtT,\,i}$ is the WtT GHG emission factor of fuel i (g CO_2eq/MJ)
- LCV_i is the lower calorific value of fuel i (MJ/g fuel)
- RWD_i is the reward factor of 2 that can be applied from 1 January 2025 to 31 December 2033 for the use of RFNBO.[10] Otherwise $RWD_i = 1$.
- $\sum_{k}^{c} E_k$ is the sum of electricity delivered to the ship per on-shore power supply (OPS) connection point k in MJ. See Section 3.6 for further guidance on calculating the electricity delivered.

The other main component in Equation (1), i.e. TtW, is calculated as follows:

$$TtW = \frac{\sum_{i}^{n\,fuel} \sum_{j}^{m\,engine} M_{i,j} \times \left[\left(1 - \frac{1}{100} C_{slip\,j}\right) \times \left(CO_{2eq,\,TtW,\,i,\,j}\right) + \left(\frac{1}{100} C_{slip\,j} \times CO_{2eq\,TtW,\,slip,\,i,\,j}\right)\right]}{\sum_{i}^{n\,fuel} M_i \times LCV_i \times RWD_i + \sum_{k}^{c} E_k}$$

[10] For more information, see FuelEU Article 5(1), which specifically addresses RFNBO. For other non-biological-origin fuels, namely low-carbon fuels and recycled-carbon fuels, please refer to Chapter 3 of this guidance.

Variable and subscript definitions per Annex I

- $C_{slip\,j}$ is the non-combusted fuel coefficient as a percentage of the mass of the fuel i consumed by fuel unit j. C_{slip} includes fugitive and slipped emissions.

- $CO_{2eq,\,TtW,\,i,\,j}$ is the TtW CO_2 equivalent emissions of combusted fuel i in fuel consumer unit j (g CO_2eq/g Fuel).

- $CO_{2eq,\,TtW,\,slip,\,i,\,j}$ is the TtW CO_2 equivalent emissions of slipped fuel i towards fuel consumer unit j (g CO_2eq/g Fuel).

TtW emissions from combustion

The TtW CO_2 equivalent emission intensity includes CH_4 and N_2O emissions from fuels as part of $CO_{2eq\,TtW}$. Reference is made to the Columns 7 and 8 of the table in FuelEU Annex II, which provides default CH_4 and N_2O emission factors (in g CH_4/g fuel and g N_2O/g fuel respectively).

These factors are required to calculate the $CO_{2eq\,TtW}$, which is defined in FuelEU Annex I as **Equation (2)**:

$$CO_{2eq,\,TtWi,j} = \left(C_{fCO_{2,j}} \times GWP_{CO_2} + C_{fCH_{4,j}} \times GWP_{CH_4} + C_{fN_2O_j} \times GWP_{N_2O}\right)_i$$

For the calculation of the GHG intensity in carbon dioxide equivalences (CO_{2eq}) of the energy used onboard the ship (TtW), FuelEU mandates that companies should apply the GWP as defined over a period of 100 years in RED paragraph 4 of Part C of Annex V for all GHG types i.e., carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

Accordingly, the GWP100 values[11] to be used for FuelEU TtW calculations are:

Table 1. FuelEU TtW GWP100 values

Greenhouse gas	FuelEU TtW GWP100 values
CO_2	1
CH_4	25
N_2O	298

Note that while RED has been revised, certain annexes are still undergoing updates,

[11] For more information, see Report on Marine Fuels Certification Procedures to support implementation of FuelEU Maritime Section 5.4 for further discussion of the GWP https://transport.ec.europa.eu/document/download/1dd51746-c10e-4d87-a607-0494713cd416_en?filename=ESSF_SAPS_WS2_Report_on_Fuel_Certification-March_2025.pdf.Per this report we use use numbers from IPCC Assesment Report 4 https://www.ipcc.ch/assessment-report/ar4/

including the GWP100 values. For more information on the update to GWP values for FuelEU, see WS2 Report.[12] Any change in GWP factors will not apply before the 1st January of the following Reporting Period.

TtW emissions from slip

The TtW formula and the table in FuelEU Annex II account for fuel slippage, including fugitive and slipped emissions ("C_{slip}", as a percentage of mass, see table FuelEU Annex II column 9), if applicable. In case no slippage coefficient is provided in the table in FuelEU Annex II, it should be assumed as zero[13]. The slipped amount is a separate element in the TtW formula. While C_{slip} is deducted in the calculation of **combusted** fuel emissions, slip is separately accounted for by its impact on the total TtW emission intensity.

The added slip emission intensity ($\frac{1}{100} C_{slip\ j} \times CO_{2eq\ TtW,\ slip,\ i,\ j}$) follows from Annex I as:

$$\frac{1}{100} C_{slip\ j} \times CO_{2eq\ TtW,\ slip,\ i,\ j} =$$

$$\left(\frac{1}{100} C_{slip\ j} \times \left(C_{sfCO_{2,j}} \times GWP_{CO_2} + C_{sfCH_{4,j}} \times GWP_{CH_4} + C_{sfN_2O_j} \times GWP_{N_2O}\right)\right)_i$$

$$\text{, where } C_{sfCO_{2,j}} \text{ and } C_{sfN_2O_j} = 0, \text{ and } C_{sfCH_{4,j}} = 1$$

Note that the slip factors for CO_2 and N_2O are set to 0 by FuelEU Annex 1, irrespective of the fuel class or pathway. The added slip emission intensity impact can therefore be simplified to ($\frac{1}{100} C_{slip\ j} \times GWP_{CH_4}$), which suggests that all slip emissions are considered to be methane only.

It should be noted that, according to FuelEU Article 10(5), shipping companies can diverge from default values for CH_4 and N_2O by using actual values certified by laboratory testing or direct emission measurements. However, FuelEU Article 10(6) mandates an implementing act to specify which international standards and certification references are accepted for demonstrating actual tank-to-wake emission factors. The IMO is currently developing such standards, which are expected to be referenced in FuelEU only after their completion. Until then, only default factors can be used.

Apart from the mass of fuel, the wind-assisted propulsion reward factors, RFNBO reward factors, and the electricity delivered, values for the elements in the above formulas are included in the table in FuelEU Annex II for various fuel classes and pathways. These additional elements are covered in Chapter 2.

[12] For more information, see Report on Marine Fuels Certification Procedures to support implementation of FuelEU Maritime https://transport.ec.europa.eu/document/download/1dd51746-c10e-4d87-a607-0494713cd416_en?filename=ESSF_SAPS_WS2_Report_on_Fuel_Certification-March_2025.pdf.

[13] EU ETS and MRV guidance document no.1 states that where default slippage coefficients are not listed for a specific emission source class, companies should apply a slippage coefficient of zero https://www.emsa.europa.eu/faq-monitoring-plan.html. However, future revisions of the regulation could include slippage for other gases.

Figure 2. FuelEU Annex II Table column references and headers

1	2	3	4	5	6	7	8	9
			WtT	TtW				
Fuel Class	Pathway name	LCV $\left[\frac{MJ}{g}\right]$	$CO_{2eq\ WtT}$ $\left[\frac{gCO2eq}{MJ}\right]$	Fuel Consumer Unit Class	$C_{f\ CO_2}$ $\left[\frac{gCO2}{gFuel}\right]$	$C_{f\ CH_4}$ $\left[\frac{gCH_4}{gFuel}\right]$	$C_{f\ N_2O}$ $\left[\frac{gN_2O}{gFuel}\right]$	C_{slip} As % of the mass of the fuel used by the engine

The different Fuel Classes in Column 1 are Fossil, Biofuels, RFNBO/e-Fuels, and Others[14]. Since these fuel classes have different calculation methods for the WtT GHG emission factor (i.e., $CO_{2eq\,WtT}$), they are considered individually in this Chapter.

Certain TtW emission factors are still under development and some cells in the table of Annex II indicate 'To Be Measured (TBM)' or 'Not Available (N/A)'.

Where a cell indicates either TBM or N/A, unless a value is demonstrated in accordance with Article 10, the highest default value of the fuel class in the same column shall be used.

For all cells containing 'TBM' or 'N/A' in the table found in Annex II, the highest default value in the fuel class is assigned and bolded in the tables within this guidance document.

Deviating from FuelEU Annex II, note that ethane as a marine fuel in use has been added in the fossil fuel sections of this guidance document, while Annex II bio-H_2, e-LPG, and e-DME pathways are left out in this guidance document, due to the current lack of necessary default values.

1.2.2. Fossil fuels

To calculate WtW emission intensities for fossil fuels, the relevant values from the table in FuelEU Annex II should be used.

The relevant values for WtW emission intensity calculation purposes are shown in Table 2.

[14] The Fuel Class "Others" concerns the energy from electricity from on-shore power supply (OPS), elaborated on in Chapter 3. Note that Recycled Carbon Fuels (RCFs) (e.g. pyrolysis oil) and other synthetic low-carbon fuels (e.g. "blue ammonia") are not included in Annex II of FuelEU and this guidance document.

Table 2. Relevant fossil fuel parameter values including FuelEU Annex II values

Annex II Column	***2 / 5***	***3***	***4***	***6***	***7***	***8***	***9***
			WtT	**TtW**			
Pathway name / Consumer		**LCV** [MJ/g]	**CO_2eq_{WtT}** [gCO_2eq/MJ]	**$C_{f\,CO2}$** [$gCO_2/gFuel$]	**$C_{f\,CH4}$** [$gCH_4/gFuel$]	**$C_{f\,N2O}$** [$gN_2O/gFuel$]	**C_{slip}** [%]
HFO (Grades RME to RMK)		0.0405	13.5	3.114	0.00005	0.00018	0.0%
LFO (Grades RMA to RMD)		0.0410	13.2	3.151	0.00005	0.00018	0.0%
MDO MGO (Grades DMX to DMB)		0.0427	14.4	3.206	0.00005	0.00018	0.0%
LNG / LNG Otto (dual fuel medium speed)		0.0491	18.5	2.750	0.00000	0.00011	3.1%
LNG / LNG Otto (dual fuel slow speed)		0.0491	18.5	2.750	0.00000	0.00011	1.7%
LNG / LNG Diesel (dual fuel slow speed)		0.0491	18.5	2.750	0.00000	0.00011	0.2%
LNG / LBSI		0.0491	18.5	2.750	0.00000	0.00011	2.6%
Ethane[15]		0.0464	18.5	2.927	**0.00005**	**0.00018**	0.0%
LPG - Butane		0.0460	7.8	3.030	**0.00005**	**0.00018**	0.0%
LPG - Propane		0.0460	7.8	3.000	**0.00005**	**0.00018**	0.0%
H2 (natural gas) / Fuel Cells		0.1200	132.0	0.000	0.00000	0.00000	0.0%
H2 (natural gas) / ICE		0.1200	132.0	0.000	0.00000	**0.00018**	0.0%
NH3 (natural gas) / Fuel Cells		0.0186	121.0	0.000	**0.00005**	**0.00018**	0.0%
NH3 (natural gas) / ICE		0.0180	121.0	0.000	**0.00005**	**0.00018**	0.0%
Methanol (natural gas)		0.0199	31.3	1.375	**0.00005**	**0.00018**	0.0%

Note on Ethane: While ethane is not found in Annex II, it has been included as a marine fuel in use. It is recommended in the ETS/MRV General Guidance 1[16] to use the default TtW emission factor of 2.927 tCO_2/t fuel from resolution MEPC.364(79) EEDI Guidelines.[17] All other values shown are in-line with the approach outlined in FuelEU Article 10.2, which requires use of the least favorable fossil fuel pathway for fuels not covered. We aligned its WtT with LNG and non-CO_2 emission factors with HFO, assuming least favorable fossil values. This approach ensures consistency with FuelEU and relevant guidance until more specific data becomes available.

[15] Ethane is not included in Annex II and therefore the values in the grey shaded row represent suggested values for the pathway. See note on ethane.
[16] ETS/MRV GD1 can be found here: https://www.emsa.europa.eu/faq-monitoring-plan.html
[17] See MEPC.364(79) EEDI Guidelines section 2.2.1 https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.364%2879%29.pdf

The following section provides a detailed breakdown of how the WtW emission intensity of a particular fossil fuel pathway is derived, using HFO (Grade RME to RMK) as an example.

As stated in FuelEU Annex I:

> *The WtT GHG emission factors (CO_2eqWtT,i) default values are contained in Annex II. In the case of fossil fuels, only the default values contained in Annex II shall be used.*

For example, as shown in Table X, the CO_2eq_{WtT},i is 13.5 gCO_2eq/MJ. (See also FuelEU Annex II column 4).

Applying the WtT GHG intensity formula (Equation 1), using 1 metric tonne for illustrative purposes:

$$WtT = \frac{\sum_i^{n\,fuel} M_i \times CO_{2eq\,WtT,\,i} \times LCV_i}{\sum_i^{n\,fuel} M_i \times LCV_i \times RWD_i + \sum_k^c E_k} = \frac{1 \times 13.5 \times 0.0405}{1 \times 0.0405 \times 1 + 0} = 13.5\ gCO_2eq/MJ$$

In the same way, using the relevant values from the table in FuelEU Annex II, recalling the TtW formula, and given Equation (2) and the corresponding GWP100 values, the TtW emission intensity of consumed HFO is calculated as follows:

$$TtW = \frac{\sum_i^{n\,fuel} \sum_j^{m\,engine} M_{i,j} \times \left[\left(1 - \frac{1}{100} C_{slip\,j}\right) \times \left(CO_{2eq,\,TtW,\,i,\,j}\right) + \left(\frac{1}{100} C_{slip\,j} \times CO_{2eq\,TtW,\,slip,\,i,\,j}\right)\right]}{\sum_i^{n\,fuel} M_i \times LCV_i \times RWD_i + \sum_k^c E_k} =$$

$$\frac{1_{i,j} \times \left[(1) \times \left(C_{fCO_{2,j}} \times GWP_{CO_2} + C_{fCH_{4,j}} \times GWP_{CH_4} + C_{fN_2O_j} \times GWP_{N_2O}\right) + (0)\right]}{1 \times 0{,}0405 \times 1 + 0} =$$

$$\frac{1_{i,j} \times [(1) \times (3.114 + 0.00005 \times 25 + 0.00018 \times 298) + (0)]}{1 \times 0.0405 \times 1 + 0} = 78.24420\ gCO_2eq/MJ.$$

Recalling Equation (1), the total WtW emission intensity of HFO is the sum of the calculated WtT and TtW emission intensities:

$$WtW\ GHG\ intensity = 13.5\ gCO_2eq/MJ + 78.24420\ gCO_2eq/MJ = 91.74420\ gCO_2eq/MJ$$

Applying the applicable GHG intensity formula from Annex I (Equation 1) and including the values from Table 2 (FuelEU Annex II), the resulting WtW GHG intensity per unit of energy of different fossil fuels types is as shown in Table 3.

Table 3. FuelEU fossil fuel WtW GHG intensities

Pathway / Consumer	**WtT CO_2eq** [gCO_2eq/MJ]	**TtW CO_2eq** [gCO_2eq/MJ]	**WtW CO_2eq** [gCO_2eq/MJ]
HFO (Grades RME to RMK)	13.5	78.24420	91.74420
LFO (Grades RMA to RMD)	13.2	78.19244	91.39244
MDO / MGO (Grades DMX to DMB)	14.4	76.36745	90.76745
LNG / Otto (dual fuel medium speed)	18.5	70.70293	89.20293
LNG / Otto (dual fuel slow speed)	18.5	64.36808	82.86808
LNG / Diesel (dual fuel slow speed)	18.5	57.58074	76.08074
LNG / LBSI	18.5	68.44048	86.94048
Ethane[18]	18.5	64.26487	82.76487
LPG - Butane	7.8	67.06283	74.86283
LPG - Propane	7.8	66.41065	74.21065
H2 (natural gas) / Fuel Cells	132.0	0.00000	132.00000
H2 (natural gas) / ICE	132.0	0.44700	132.44700
NH3 (natural gas) / Fuel Cells	121.0	2.95108	123.95108
NH3 (natural gas) / ICE	121.0	2.95108	123.95108
Methanol (natural gas)	31.3	71.85377	103.15377

1.2.3. Biofuels (liquid and gaseous)

For RED certified liquid and gaseous biofuels, the WtT GHG emission intensity *(CO_2eq_{WtT})* for each fuel consumer is to be calculated as per column 4 of the table in FuelEU Annex II, as follows:

$$WtT\ CO_2eq = E - \frac{C_f CO_2}{LCV}$$

where E = Total GHG emission intensity (gCO_2eq/MJ) from the supply and use of the fuel, as per the Proof of Sustainability (PoS) or Proof of Compliance (PoC)[19] of the certified biofuel. Without a PoS/PoC, or where the biofuel does not meet the sustainability criteria[20] and GHG emissions savings criteria[21], or that are produced from food and feed crops, referred to in FuelEU Article 10(1)(a), the emission factors (WtT and TtW) of the least favourable fossil fuel pathway for the type of fuel in question should be used.

In Table 4, default values for E are used[22] to calculate the WtT emission intensities in column 4 accordingly. If the actual E value from the PoS / PoC differs from the default value, the value from the PoS/PoC should be used to calculate the actual WtT emission intensity of the biofuel pathway.

[18] Ethane is not included in Annex II and therefore the values in the grey shaded row represent suggested values for the pathway. See note on ethane.
[19] For more information on the PoC, see Report on Marine Fuels Certification Procedures which can be found here: https://transport.ec.europa.eu/transport-modes/maritime/decarbonising-maritime-transport-fueleu-maritime_en
[20] See RED Directive (EU) 2018/2001 article 29(2) to (7)
[21] See RED Directive (EU) 2018/2001 article 25(2)
[22] Referencing EU RED Part C of Annex V and Part B of Annex VI for E default values.

Note on biomethane E values: The default upstream emissions (E value) for biomethane used in the FuelEU Maritime context are taken from RED II Annex VI D, using the value of 14 gCO_2e/MJ for biowaste-derived biomethane with closed digestate storage and off-gas combustion. This illustrative value provides an example of emissions, including the biomethane transportation via the natural gas grid, up to the point of further utilisation. However, it does not include emissions from liquefaction or bunkering, which are necessary to deliver biomethane to ships as a marine fuel and are counted in the TtW emissions.

To provide an example value for these additional emissions we use methodologies outlined in ISCC 205 (v4.1, January 2024).[23] The guideline under the ISCC EU scheme, includes a method known as "liquefaction by equivalence" for estimating emissions when terminal-specific data is not available. Note that in case of "equivalence", the GHG intensity of the liquefaction power is specific to the location/country where the biomethane is loaded into the LNG bunker vessel.[24]

Liquefaction Emissions: Methodology and Calculation

ISCC 205 Section 4.3.5 allows operators to calculate liquefaction emissions using a benchmark method that reflects average EU conditions. Based on this method, liquefaction emissions are estimated as follows:

- **Electricity use for liquefaction**: 0.06048 MJ electricity (LV or low voltage) per MJ fuel, is converted to kWh:
  $0.06048\ MJ_{electricity,\,LV}/MJ_{fuel}\ \times\ 1kWh/\ 3.6\ MJ_{electricity}\ =\ 0.0168\ \ kWh/MJ\ fuel.$

- **GHG intensity of electricity**: EU27 low-voltage average = 308 gCO_2e/kWh

- **Resulting liquefaction emissions**: $0.0168 \times 308\ =\ 5.17\ gCO_2e/MJ_{biomethane}$

- **Adjustment for ISCC "conversion losses"**: ISCC 205 recommends applying a Feedstock Factor (FF) of 1.00013 to account for a 0.013% conversion loss, which has a negligible numerical impact but aligns with ISCC/RED methodology.

Therefore, the upstream emissions values used in our calculations, including the RED II Annex VI D value (14 gCO_2eq/MJ) plus liquefaction are:

$$E_{biomethane,\,liq} = 14 + 5.17 = 19.17\ gCO_2e/MJ$$

These liquefaction emissions are an illustrative example based on ISCC 205 Guidance. However, where actual data is available, operators can potentially achieve lower emissions factors depending on the liquefaction technology and location. Here are two examples:

- **Recondenser-based liquefaction** is the standard technology at LNG terminals, using boil-off gas to liquefy biomethane efficiently. It typically consumes ~200 kWh

[23] ISCC 205 is the guidance document titled "Greenhouse Gas Emissions", which outlines methodologies for calculating life-cycle emissions, including options for liquefaction by equivalence and bunkering emissions. The latest version (v4.1, January 2024) is available at: https://www.iscc-system.org/wp-content/uploads/2024/01/ISCC_EU_205_Greenhouse-Gas-Emissions_v4.1_January2024.pdf

[24] In the calculation example we use a general EU-wide GHG emissions value from electricity of 308 gCO2e/kWh from IR (EU) 2022/996: https://eur-lex.europa.eu/eli/reg_impl/2022/996/oj/eng. To select the actual country/location where the liquefaction takes place, see the respective Low Voltage GHG intensity from the Publications Office: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R0996

per tonne of biomethane,[25] resulting in an estimated CI of ~1.23 gCO_2e/MJ using EU low voltage grid data (see figure in previous calculation). Actual values vary by terminal and operating conditions.

- **Reliquefaction systems** use external refrigeration and are typically found at peak shaving or low-send-out terminals, with emissions depending on design and scale. No default CI exists, so site-specific data or conservative estimates should be used.

Operators are encouraged to gather terminal-specific electricity consumption data or apply "equivalence" with ISCC auditor approval, as required under ISCC EU certification schemes.

Bunkering Emissions (not included above)

Emissions from bio-LNG bunkering are also relevant and should be reported under Etd (emissions from transport and distribution). These vary with bunker vessel type, fuel used, and round-trip distance. ISCC 205 provides useful guidance on how to calculate such emissions (but does not provide relevant emissions)[26]. A value for bunkering is not included in the 19.17 gCO_2e/MJ value above but the bunkering emissions would be included in a PoS and should be considered in full well-to-wake calculations.

For LCV, the main reference in FuelEU Annex II table (see column 3) is the default LCV values in RED Annex III. In Table 4, the RED Annex III default LCV values are used (converted to MJ/g). When biofuel production pathways do not have default LCVs as per legal reference, the LCV or information to derive the LCV from the PoS/PoC provided by the fuel supplier should be based on a lab analysis.

Including additional fuel pathways and fuel consumers, the relevant values for WtW emission intensity calculation purposes are shown in Table 4.

[25] Consumption estimate is from a study by Yuan et al., 2019 https://doi.org/10.1016/j.jclepro.2019.117949
[26] A quantification of LNG terminal operations and maritime bunkering emissions (0.7 g CO_2eq/MJ) is provided in the report 2nd Life Cycle GHG Emission Study on the Use of LNG as Marine Fuel by Sphera https://sphera.com/resources/report/2nd-life-cycle-ghg-emission-study-on-the-use-of-lng-as-marine-fuel/

Table 4. Relevant biofuel parameter values including FuelEU Annex II values

Annex II Column	***2 / 5***	***3***		***4***	***6***	***7***	***8***	***9***
			E	**WtT**	**TtW**			
Pathway name / Consumer		**LCV** [MJ/g]	**Example E values per RED Annex V & VI** [gCO_2eq/MJ]	**$CO_{2eq\ WtT}$** [gCO_2eq/MJ]	**$C_{f\ CO2}$** [$gCO_2/gFuel$]	**$C_{f\ CH4}$** [$gCH_4/gFuel$]	**$C_{f\ N2O}$** [$gN_2O/gFuel$]	**C_{slip}** [%]
Bio-ethanol (wheat straw)[27]		0.027	15.70	-55.15185	1.913	**0.00005**	**0.00018**	0.0%
Bio-diesel (waste cooking oil)[28]		0.037	14.90	-61.69459	2.834	**0.00005**	**0.00018**	0.0%
Hydrotreated Vegetable Oil (waste cooking oil)[29]		0.044	16.00	-54.79545	3.115	0.00005	0.00018	0.0%
Liquefied Biomethane (bio-waste) / Otto (dual fuel medium speed)[30]		0.050	19.17	-35.83000	2.750	0.00000	0.00011	3.1%
Liquefied Biomethane / Otto (dual fuel slow speed)		0.050	19.17	-35.83000	2.750	0.00000	0.00011	1.7%
Liquefied Biomethane / Diesel (dual fuels)		0.050	19.17	-35.83000	2.750	0.00000	0.00011	0.2%
Liquefied Biomethane / LBSI		0.050	19.17	-35.83000	2.750	0.00000	0.00011	2.6%
Bio-methanol		0.020	10.40	-58.35000	1.375	**0.00005**	**0.00018**	0.0%
Other Production Pathways		0.037	15.00[31]	-69.18919	3.115	0.00005	0.00018	0.0%

For example, given the default E value of 15.70 gCO_2eq/MJ, the WtT GHG emission factor (CO_2eq_{WtT},i) of bio-ethanol is calculated as:

$$CO_2eqWtT = E - \frac{C_fCO_2}{LCV} = 15.7 - \frac{1.913}{0.027} = -55.15185 \text{ g } CO_2eq/MJ.$$

Applying the WtT GHG intensity formula accordingly, using 1 metric tonne for simplicity:

$$WtT = \frac{\sum_i^{n\,fuel} M_i \times CO_{2eq\,WtT,i} \times LCV_i}{\sum_i^{n\,fuel} M_i \times LCV_i \times RWD_i + \sum_k^c E_k} = \frac{1 \times -55.15185 \times 0.027}{1 \times 0.027 \times 1 + 0} = -55.15185 \text{ g } CO_2eq/MJ$$

[27] Default E value for bio-ethanol from wheat straw feedstock from RED is used here as an example. For other bio-ethanol feedstock default values see RED Annex V E.
[28] Default E value for bio-diesel from waste cooking oil feedstock from RED is used here as an example. For other bio-diesel feedstock default values see RED Annex V D.
[29] Default E value for HVO from waste cooking oil feedstock from RED is used here as an example. For other HVO feedstock default values see RED Annex V D.
[30] Default E value for bio-methane from bio-waste feedstock from RED is used here as an example. For other bio-methane feedstock default values see RED Annex VI D. See also the text note on biomethane E values.
[31] Illustrative example E value is used here. Default E-values for other production pathways as per specified feedstocks as per RED Annex V, VI.

Similarly, the TtW emission intensity of consumed bio-ethanol is calculated as:

$$TtW = \frac{\sum_{i}^{n\,fuel} \sum_{j}^{m\,engine} M_{i,j} \times \left[\left(1-\frac{1}{100}C_{slip\,j}\right)\times\left(CO_{2eq,\,TtW,\,i,\,j}\right)+\left(\frac{1}{100}C_{slip\,j}\times CO_{2eq\,TtW,\,slip,\,i,\,j}\right)\right]}{\sum_{i}^{n\,fuel} M_i \times LCV_i \times RWD_i + \sum_{k}^{c} E_k} =$$

$$\frac{1_{i,j} \times \left[(1)\times\left(C_{fCO_{2,j}} \times GWP_{CO_2} + C_{fCH_{4,j}} \times GWP_{CH_4} + C_{fN_2O_j} \times GWP_{N_2O}\right)+(0)\right]}{1 \times 0{,}02700 \times 1 + 0} =$$

$$\frac{1_{i,j} \times [(1)\times(1.913+0.00005\times25+0.00018\times298)+(0)]}{1 \times 0.027 \times 1 + 0} = 72.88481 \text{ g } CO_2\text{eq/MJ}.$$

The total WtW emission intensity of bio-ethanol is the sum of the calculated WtT and TtW emission intensities:

$$WtW\ CO_2eq = -55.15185\ gCO_2eq/MJ + 72.88481\ g\ CO_2eq/MJ = 17.73296 \text{ g } CO_2\text{eq/MJ}.$$

Applying the applicable GHG intensity formula from FuelEU Annex I in the same manner, and including the values from Table 4 (FuelEU Annex II), the resulting WtW GHG intensities for biofuels types are shown in Table 5.

Table 5. FuelEU biofuel WtW GHG intensities

Pathway / Consumer]	**WtT CO_2eq [gCO_2eq/MJ]**	**TtW CO_2eq [gCO_2eq/MJ]**	**WtW CO_2eq [gCO_2eq/MJ**
Bio-ethanol (wheat straw)	-55.15185	72.88481	**17.73296**
Bio-diesel (waste cooking oil)	-61.69459	78.07811	**16.38351**
Hydrotreated Vegetable Oil (waste cooking oil)	-54.79545	72.04295	**17.24750**
Liquefied Biomethane / Otto (dual fuel medium speed)	-35.83000	69.43028	**33.60028**
Liquefied Biomethane / Otto (dual fuel slow speed)	-35.83000	63.20945	**27.37945**
Liquefied Biomethane / Diesel (dual fuels)	-35.83000	56.54429	**20.71429**
Liquefied Biomethane / LBSI	-35.83000	67.20855	**31.37855**
Bio-methanol	-58.35000	71.49450	**13.14450**
Other Production Pathways	-69.18919	85.67270	**16.48351**

As a reminder, the WtT emission intensities in the above table are calculated based on example default GHG emission values from RED. For actual WtT emission intensities calculations of the various biofuel pathways ($E - \frac{C_f CO_2}{LCV}$), the actual respective emission intensity (E value) from the PoS/PoC of the biofuel should be used to calculate the WtT emission intensities of biofuels.

1.2.4. Renewable fuels of non-biological origin (RFNBOs)

FuelEU aims to support the uptake of RFNBOs or e-fuels through a 'multiplier' and potentially through a subtarget as established in Article 5(3). The RFNBO subtarget will apply from 2034 if the share of RFNBOs in the total fuel mix remains below 1% for the Reporting Period 2031, among other conditions. This subtarget is outside the scope of the current WS1 document.

Defined under Article 5(1) of FuelEU, the multiplier rewards the use of RFNBOs until 31 December 2033. FuelEU Annex 5 (1) reads:

> *For the calculation of the GHG intensity of the energy used on board by a ship, from 1 January 2025 to 31 December 2033 a **multiplier of '2'** can be used to reward the ship for the use of RFNBO. The methodology for this calculation is **set out in Annex I**.*

The methodology for calculating the GHG intensity of energy used on board, which includes the RFNBO multiplier, is specified in Annex I of FuelEU. The calculation of WtW GHG intensity with the multiplier or 'reward factor' is illustrated below. The impact on a vessel's compliance balance can be found in Examples 4 and 6 provided in Section 1.4 of this document.

For RFNBOs, the WtT emissions *(CO_2eq_{WtT})* in column 4 of the table in FuelEU Annex II refer to RED. The relevant supplementing Delegated Regulation[32] stipulates that the certified E value (from the PoS/PoC) determines the GHG emissions for RFNBOs. To calculate the WtT emissions from RFNBOs or e-fuels, the emissions from the fuel in use (e_u) include all combustion emissions and should be deducted. This aims to avoid double counting of emissions under FuelEU where the TtW emissions are added separately. A deduction of the CO_2 emission as done for biofuels, is not needed.

For RFNBOs, the FuelEU WtT emissions *(CO_2eq_{WtT})* are calculated as: $CO_2eq_{WtT} = E - e_u$, where E = Total GHG emission intensity (g CO_2eq/MJ) from the supply and use of the fuel, as per the Proof of Sustainability (PoS) or Proof of Compliance (PoC)[33] of the certified biofuel. The e_u value is the emissions from the combusted fuel in use, as per the PoS/PoC.

In Table 6, *E* values for RFNBOs we use the arbitrary value of 10 g CO_2eq/MJ to illustrate the calculation of WtT emission intensities in column 4 accordingly. This is an example value only. In practice, *E* should be taken from a PoS or PoC, demonstrating compliance with EU certification requirements.

> **Note on RFNBO E Value:** For illustrative purposes, we have selected an E value of 10 g CO_2eq/MJ. This value falls within the allowed range up to 28.2 g CO_2eq/MJ according to the RED Delegated Regulation (EU) 2023/1185, which requires a minimum reduction of 70% in GHG emissions compared to the comparator baseline of 94 gCO_2eq/MJ. The chosen value of 10 g CO_2eq/MJ is arbitrary and chosen to avoid representing any specific RFNBO pathway, while providing a credible example.

[32] For more information, see RED Delegated Regulation (EU) 2023/1185.
[33] For more information, see Report on Marine Fuels Certification Procedures to support implementation of FuelEU Maritime for a detailed explanation of the suggested PoC framework.

The e_u values in Table 6 stem from the standard values provided in Delegated Regulation (EU) 2023/1185. If the actual *E* value and e_u value from the PoS / PoC differ from the assumed and standard values, the values from the PoS/PoC should be used to calculate the actual WtT emission intensity of the RFNBO pathway.

The relevant values for WtW emission intensity calculation purposes are shown in Table 6.

Table 6. Relevant RFNBOs / e-fuels parameter values including FuelEU Annex II values

Annex II Column	***2/5***	***3***			***4***	***6***	***7***	***8***	***9***
			E	e_u	**WtT**	**TtW**			
Pathway name / Consumer		**LCV** [MJ/g]	**Based on assumed values** [gCO_2eq/MJ]	**Based on 'standard values' ([34])** [gCO_2eq/MJ]	**$CO_{2eq\ WtT}$** [gCO_2eq/MJ]	**$C_{f\ CO2}$** [$gCO_2/gFuel$]	**$C_{f\ CH4}$** [$gCH_4/gFuel$]	**$C_{f\ N2O}$** [$gN_2O/gFuel$]	**C_{slip}** [%]
e-diesel		0.0427	10	73.2	-63.2	3.206	0.00005	0.00018	0.0%
e-methanol		0.0199	10	68.9	-58.9	1.375	**0.00005**	**0.00018**	0.0%
e-LNG / Otto (dual fuel medium speed)		0.0491	10	56.2	-46.2	2.750	0.00000	0.00011	3.1%
e-LNG / Otto (dual fuel slow speed)		0.0491	10	56.2	-46.2	2.750	0.00000	0.00011	1.7%
e-LNG / Diesel (dual fuel slow speed)		0.0491	10	56.2	-46.2	2.750	0.00000	0.00011	0.2%
e-LNG / LBSI		0.0491	10	56.2	-46.2	2.750	0.00000	0.00011	2.6%
e-H2 / Fuel Cells		0.1200	10	0.0	10.0	0.000	0.00000	0.00000	0.0%
e-H2 / ICE		0.1200	10	0.0	10.0	0.000	0.00000	**0.00018**	0.0%
e-NH3 / Fuel Cells		0.0186	10	0.0	10.0	0.000	**0.00005**	**0.00018**	0.0%
e-NH3 / ICE		0.0186	10	0.0	10.0	0.000	**0.00005**	**0.00018**	0.0%

For example, for e-diesel, given the indicated E value of 10.00 gCO_2eq/MJ and standard e_u value of 73.20 gCO_2eq/MJ, the WtT GHG emission factor ($CO_2eq_{WtT,i}$) is calculated as:

$$CO_2eq_{WtT} = E - e_u = 10.00 - 73.20 = -63.20 \text{ g } CO_2eq/MJ.$$

[34] 'Standard values' for greenhouse gas emission intensities of elastic inputs according to Annex B. of Commission Delegated Regulation (EU) 2023/1185 http://data.europa.eu/eli/reg_del/2023/1185.

The WtT GHG intensity of e-diesel, including the RFNBO reward factor and for simplicity using 1 metric tonne, calculates as follows:

$$WtT = \frac{\sum_{i}^{n\,fuel} M_i \times CO_{2eq\,WtT,\,i} \times LCV_i}{\sum_{i}^{n\,fuel} M_i \times LCV_i \times RWD_i + \sum_{k}^{c} E_k} = \frac{1 \times -63.20 \times 0.0427}{1 \times 0.0427 \times 2 + 0} = -31.60 \text{ g } CO_2\text{eq/MJ}$$

Similarly, the RFNBO reward factor is also part of the TtW emission intensity formula, which gives a TtW emission intensity of consumed e-diesel as:

$$TtW = \frac{\sum_{i}^{n\,fuel} \sum_{j}^{m\,engine} M_{i,j} \times \left[\left(1 - \frac{1}{100} C_{slip\,j}\right) \times \left(CO_{2eq,\,TtW,\,i,\,j}\right) + \left(\frac{1}{100} C_{slip\,j} \times CO_{2eq\,TtW,\,slip,\,i,\,j}\right)\right]}{\sum_{i}^{n\,fuel} M_i \times LCV_i \times RWD_i + \sum_{k}^{c} E_k} =$$

$$\frac{1_{i,j} \times \left[(1) \times \left(C_{fCO_{2,j}} \times GWP_{CO_2} + C_{fCH_{4,j}} \times GWP_{CH_4} + C_{fN_2O_j} \times GWP_{N_2O}\right) + (0)\right]}{1 \times 0{,}0427 \times 2 + 0} =$$

$$\frac{1_{i,j} \times [(1) \times (3.206 + 0.00005 \times 25 + 0.00018 \times 298) + (0)]}{1 \times 0.0427 \times 2 + 0} = 38.18372 \text{ g } CO_2\text{eq/MJ.}$$

The total WtW emission intensity of e-diesel is the sum of the calculated WtT and TtW emission intensities:

$$WtW\ GHG\ intensity = -\ 31.60\ gCO_2eq/MJ\ +\ 38.18372\ gCO_2eq/MJ = 6.58372 \text{ g } CO_2\text{eq/MJ}$$

Note that the RFNBO reward factor (RWD) or multiplier, which is set at 2 in the FuelEU, has the overall effect of halving the WtW GHG emission intensity of the RFNBO.

Applying the applicable GHG intensity formula from FuelEU Annex I in the same manner and including the values from Table 7 (FuelEU Annex II), the resulting WtW GHG intensity for RFNBO type fuels, with and without applying the RFNBO reward factor, are shown in Table 7.

As a reminder, WtT emission intensities in Table 7 are calculated based on assumed indicative emission intensity values. For actual WtT emission intensities calculations of the various RFNBO pathways ($E - e_u$), the actual respective emission intensities (E and e_u values) from the PoS/PoC of the RFNBO should be used to calculate the WtW emission intensities of RFNBOs.

Table 7. FuelEU RFNBO WtW GHG intensities

Pathway / Consumer	WtT CO_2eq [gCO_2eq/MJ]	TtW CO_2eq [gCO_2eq/MJ]	WtW CO_2eq [gCO_2eq/MJ]	WtW CO_2eq [gCO_2eq/MJ]
	Excluding RWD factor			Including RWD factor
e-diesel	-63.2	76.36745	13.16745	6.58372
e-methanol	-58.9	71.85377	12.95377	6.47688
e-LNG / Otto (dual fuel medium speed)	-46.2	70.70293	24.50293	12.25146
e-LNG / Otto (dual fuel slow speed)	-46.2	64.36808	18.16808	9.08404
e-LNG / Diesel (dual fuel slow speed)	-46.2	57.58074	11.38074	5.69037
e-LNG / LBSI	-46.2	68.44048	22.24048	11.12024
e-H2 / Fuel Cells	10.0	0.00000	10.00000	5.00000
e-H2 / ICE	10.0	0.44700	10.44700	5.22350
e-NH3 / Fuel Cells	10.0	2.95108	12.95108	6.47554
e-NH3 / ICE	10.0	2.95108	12.95108	6.47554

1.3. Compliance Balance: Step-by-Step Guidance

1.3.1. Overview of the compliance balance formula

The next step in the FuelEU calculations is the 'compliance balance' formula as provided in FuelEU Annex IV. The compliance balance is defined in FuelEU Article 3(35):

> '*compliance balance' means the measure of a ship's over- or under-compliance with regard to the limits for the yearly average GHG intensity of the energy used on board by a ship or the RFNBO subtarget, which is calculated in accordance with Part A of Annex IV*

The compliance balance calculations determine a ship's positive compliance due to over-achievement of the annual target (i.e., compliance surplus), or negative compliance balance from under-achievement of the annual target (i.e., compliance deficit). At the discretion of the company,[35] ships can choose to participate in flexibility mechanisms defined in Articles 20 and 21, such as banking surplus compliance, borrowing from future compliance balance, and pooling of surplus compliance (see Chapter 4). Ships failing to meet annual targets are subject to a financial penalty. To translate this into practical terms, the following section describes the compliance balance formula and penalty, showing how to determine whether a ship has met, exceeded, or fallen short of the annual GHG intensity target.

[35] 'Company' is the entity responsible for the operation of the ship according to definition FuelEU Article 3(13).

1.3.2. Compliance balance formula breakdown (Annex IV Part A)

As specified in the FuelEU Annex IV Part A, the formula for calculating a ship's compliance balance is given as:

$$Compliance\ balance\ [gCO_{2eq}] = (GHGIE_{target} - GHGIE_{actual}) \times [\sum_{i}^{nfuel} M_i \times LCV_i + \sum_{k}^{c} E_k]$$

Variable and subscript definitions per Annex I and IV

- CO_2e: Carbon dioxide equivalent, is a measure typically expressed in grams or tonnes and is used to compare the emissions of various greenhouse gases based on their global warming potential. It provides a way of expressing the impact of methane (CH_4) and nitrous oxide (N_2O) gas in terms of the amount of CO_2 that would create the same amount of warming.
- $GHGIE_{target}$: This is the GHG intensity limit for the energy used on board the ship in a given Reporting Period, as stipulated by Article 4(2) of FuelEU.
- $GHGIE_{actual}$: This represents the yearly average of the GHG intensity of the energy used on board, calculated for the relevant Reporting Period based on Annex I (see 1.2.1).
- i: Index corresponding to the fuel types delivered to the ship in the Reporting Period.
- M_i: Mass of fuel type i, consumed by the ship in terms of grams of fuel.
- LCV_i: Lower calorific value of fuel type i in terms of megajoules per gram of fuel (MJ/gFuel), which measures the amount of heat released by burning one gram of the fuel.
- E_k: Energy in the form of electricity delivered to the ship through an OPS connection point k in terms of MJ.
- k: Index corresponding to the OPS connection points.

The compliance balance formula calculates the difference between the annual target from ($GHGIE_{target}$) and reported GHG intensity ($GHGIE_{actual}$), scaled by the sum of total energy consumption from fuels and shore-side electricity within the scope of the FuelEU. A positive result indicates surplus compliance, while a negative result signals a compliance deficit.

1.3.3. Penalty formula breakdown (Annex IV Part B)

As specified in the FuelEU Annex IV Part B, the formula for calculating a ship's penalty is given as:

$$FuelEU\ Penalty\ [EUR] = \frac{|Compliance\ Balance|}{GHGIE_{actual} \times 41{,}000} \times 2,400$$

Explanations of constants in the formula:

- $41,000\ MJ/tfuel$: This constant, expressed in megajoules per tonne (MJ/tfuel), represents the LCV of Very Low Sulphur Fuel Oil (VLSFO) which is used to convert

the compliance balance and $GHGIE_{actual}$ into a VLSFO equivalent emissions deficit in tonnes.
- $2,400\,EUR/tfuel$: This is the penalty rate applied per metric tonne of VLSFO equivalent emissions deficit.

The penalty calculation starts by taking the absolute compliance deficit on a weighted energy basis, indicating the total emission deficit. This is then divided by the attained $GHGIE_{actual}$, which is converted to an emission intensity per ton of VLSFO equivalent by multiplying with the constant LCV of 41,000 MJ/t. The result is a VLSFO equivalent deficit in tonnes. The final step in the penalty calculation process involves multiplying the VLSFO equivalent emissions by the penalty rate of 2,400 EUR to determine the total financial penalty.

Note on the Penalty Calculation: The fixed penalty rate of €2,400 per metric tonne applies to a VLSFO-*equivalent compliance deficit*. It applies to the *amount of energy* that is *in deficit relative to the respective FuelEU GHG intensity target*, expressed in VLSFO equivalent tonnes. A vessel is therefore not directly penalised for burning e.g., HFO or LFO, but rather penalized to the extent it fails to reach the respective GHG target in that particular year, resulting in an energy weighted compliance deficit.

Penalty calculation for two or more consecutive Reporting Periods

Ships with recurring compliance deficits in consecutive years will incur an additional charge. The total penalty for each subsequent year increases by an additional 10% annually. The additional charge stated in Article 23(2) can be expressed as:

$$Total\ Penalty = FuelEU\ Penalty \times (1 + (n - 1) \times 0.10)$$

- **n**: The number of consecutive non-compliant Reporting Periods.

For example, if a ship has a compliance deficit for three consecutive Reporting Periods, in the Verification Period following the third year, the calculation of the total penalty would include an additional charge of 20%. The equation above with $n = 3$ is as follows:

$$(n - 1) \times 0.10 = (3 - 1) \times 0.10 = 0.20$$

If the penalty calculated in the third year is €5,000, the total penalty would be:

$$Total\ Penalty = 5,000\,EUR \times (1 + 0.20) = 6,000\,EUR$$

In this example, the ship will have to pay a penalty of €6,000 in addition to previous penalties owed. Non-compliance with penalty payments can lead to enforcement actions as specified under Article 23.

The penalty does not increase in case the ship has a Reporting Period where it did not have any voyages in scope of the regulation (year Y), while in year Y-1 and year Y+1 was subject to penalties, since such scenario does not fulfill the 'consecutive' condition. In addition, the penalty does not increase in case of shipping company changes, since n represents the number of consecutive Reporting Periods for which the same company is subject to a

FuelEU penalty for a ship. In other words, n resets to 1 if the 'consecutive' condition is not satisfied.

1.3.4. Step-by-step guidance

The following steps provide suggested best practice for how to calculate the compliance balance using the formulas provided in FuelEU.

Step 1: Determine GHG Intensity Target

The first step is to identify the $GHGIE_{target}$ as per the specifications in Article 4(2). The FuelEU establishes limits to the yearly average GHG Intensity of the energy used on board a ship, following a reference value and reduction targets.

In accordance with Article 4(2), the GHG Intensity reference value is 91.16 gCO_2e/MJ. The $GHGIE_{target}$ reduction and timeline is illustrated in Table 8.

Table 8. FuelEU GHG intensity limit on energy used on board by a ship

Timeline	Reduction Percentage	GHGIE target
From 1 January 2025	-2%	89.33680 gCO_2e/MJ
From 1 January 2030	-6%	85.69040 gCO_2e/MJ
From 1 January 2035	-14.5%	77.94180 gCO_2e/MJ
From 1 January 2040	-31%	62.90040 gCO_2e/MJ
From 1 January 2045	-62%	34.64080 gCO_2e/MJ
From 1 January 2050	-80%	18.23200 gCO_2e/MJ

Step 2: Calculate the Total Energy Consumption

The next step is to calculate the total fuel consumed during the Reporting Period on voyages and port stays within the scope of the regulation. This requires summing the mass of each type of fuel used, applying the following formula:

$$\sum_{i}^{nfuel} M_i \times LCV_i$$

Where M_i represents the mass of each fuel type and LCV_i its corresponding lower calorific value. Each fuel's mass is multiplied by its calorific value to convert mass to energy. The total energy from all fuels is then aggregated.

If electricity was delivered via OPS during the Reporting Period in port stays within scope of the regulation, it should be included using the following formula:

$$\sum_{k}^{c} E_k$$

where E_k represents the electricity in megajoules delivered through each OPS connection point k. The sum of energy from both fuel and electricity provides the total energy consumption in megajoules (MJ) needed for the compliance balance calculation.

In case vessels performed voyages covered by the exemptions provided by FuelEU Articles 2(3), 2(4), 2(5), and 2(6) related to voyages between EEA Member States and non-EEA Member States or voyages to Outermost Region ports, energy calculated for the respective legs should be reduced. In addition, deduction relating to sailing in ice conditions or the technical characteristics of ice class ships is to be taken into consideration. Refer to Chapter 2 on Extra-EEA Voyages and Chapter 3 on Technology-Specific Calculations for more information.

Step 3: Calculate the GHG Intensity Actual

The next step is to calculate the $GHGIE_{actual}$ according to Annex I and described in Section 1.2. When calculating the $GHGIE_{actual}$ for the compliance balance, the intensity of all fuel(s) and energy used onboard falling under the FuelEU scope throughout the Reporting Period should be taken into account. This calculation effectively produces a weighted average of the GHG intensity for all fuels used, adjusted for the energy content of each fuel type used. The formula is also impacted by the use of RFNBOs, ice navigation, and the use of wind-assisted propulsion (see Chapter 3). The application of an RFNBO reward factor is covered in Section 1.4 Examples 4 and 6.

Step 4: Compute the Compliance Balance

The compliance balance equation provides the difference between the target and actual GHG intensities $(GHGIE_{target} - GHGIE_{actual})$, multiplied by the total energy consumption $[\sum_{i}^{nfuel} M_i \times LCV_i + \sum_{k}^{c} E_k]$. The result is the net compliance balance in grams of CO_2 equivalent. A positive balance indicates that the ship is performing better than the target and therefore generating a surplus. A negative balance indicates under-compliance and therefore has a deficit.

1.3.5. Rounding rules

In the absence of established rounding rules for FuelEU at the time of publication, it is recommended using the rounding conventions used in the EU Monitoring, Reporting, and Verification (MRV) system, THETIS-MRV[36], which is used to collect and manage data under

[36] For further guidance see the THETIS MRV page on the EMSA site: https://www.emsa.europa.eu/thetis-mrv.html

the EU MRV Regulation (EU) 2015/757. Alignment with MRV conventions minimizes calculation discrepancies between regulatory frameworks.

In alignment with MRV, it is proposed to round to five decimal places for all values involved in the calculations. It should be avoided to round intermediate results to avoid deviations. The only exception is in the penalty calculation, where the final penalty amount should be rounded to the nearest integer.

Note on rounding to tonnes: In practice companies may choose to estimate their compliance balance in units of tonnes CO_2eq. When doing the actual calculation this should be avoided.

For example, if you convert the following compliance balance to tonnes of CO_2eq:

$$-\ 1,255,610,552.4\ \div\ 10^{6}\ =\ 1,255\ tonnes\ CO_{2}eq$$

and convert back to grams CO_2eq you get the following compliance balance:

$$-\ 1,255\ \times\ 10^{6}\ =\ -\ 1,255,000,000\ g\ CO_{2}eq$$

This leads to a different result in the penalty calculation.

1.4. Compliance Balance Calculation Examples

This section provides a series of compliance balance calculation examples that apply the methodology for various fuels and energy combinations with consistent energy consumption.

Example 1 establishes a baseline scenario, which is then used for comparison in all subsequent cases. For combinations involving multiple fuel types, we assume blending for biofuels and dual-fuel engines for RFNBOs. Each example begins by setting an illustrative amount of non-fossil fuel, with the fossil fuel quantity adjusted to ensure total energy use is aligned with the baseline.

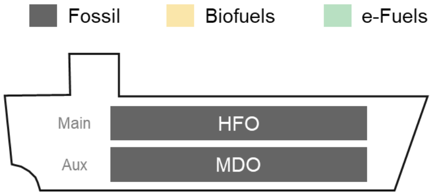
In all examples, table cells highlighted in yellow require user input, whereas white cells contain fixed values established by legislation or are calculations based on given formulas.

Values established by FuelEU and relevant EU legislation or calculations based on formulas in the text:

Values requiring user input (example values provided):

Note on the choice of example scenarios: The energy sources chosen or example values presented *are not recommended nor representative by the workstream* as compliance strategies. Vessels may choose a variety of fuel mixes given strategic and economic priorities. The example values selected are for the purpose of demonstrating the calculation methodology and to clarify how various fuel options affect compliance calculation steps.

Example 1: Fossil HFO and MDO (Intra-EEA)



In the first example, we calculate the compliance balance for a vessel operating on EEA to EEA voyages or within EEA ports, consuming 12,000 tonnes of HFO in the main engine and 1,400 tonnes of MDO in auxiliary engines. As both fuels are fossil fuels, default emission values are all taken from the FuelEU Annex II.

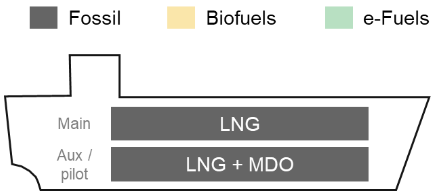
GHG intensity calculation: **Fossil HFO and MDO**

Item	Unit	HFO (Grades RME to RMK)	MDO (Grades DMX to DMB)	Notes
Lower calorific value (LCV)	MJ/g	0.0405	0.0427	Consumption of HFO and MDO is 100% covered by the FuelEU
Fuel used on EEA – EEA voyages or within EEA ports; 100% covered	tonnes	12,000	1,400	
Fuel used on EEA – non-EEA voyages; 50% covered	tonnes	0	0	
Energy use in scope (in million MJs)	10^6 MJ	12,000 x 0.0405 x 100% = 486.00	1,400 x 0.0427 x 100% = 59.78	
WtT GHG (CO_{2eqWtT})	gCO_2eq/MJ	13.50	14.40	Fossil fuel default values are from Annex II column 4
TtW CO_2	gCO_2eq/MJ	3.114 / 0.0405 = 76.88889	3.206 / 0.0427 = 75.08197	HFO and MDO TtW emission values are found in Annex II columns 6 - 9
TtW CH_4	gCO_2eq/MJ	0.00005 / 0.0405 x 25 = 0.03086	0.00005 / 0.0427 x 25 = 0.03086	
TtW N_2O	gCO_2eq/MJ	0.00018 / 0.0405 x 298 = 1.32444	0.00018 / 0.0427 x 298 = 1.25621	
CH_4 slip (C_{slip})	%	0%	0%	
TtW GHG	gCO_2eq/MJ	TtW CO_2 + TtW CH_4 + TtW N_2O = 78.24420	TtW CO_2 + TtW CH_4 + TtW N_2O = 76.36745	
RFNBO reward (RWD)	-	1	1	Fossil fuels not eligible for reward

Compliance balance and penalty calculations: **Fossil HFO and MDO**

Item	Unit	Annual totals	Notes
GHG intensity target 2025-2029 ($GHGIE_{target}$)	gCO_2eq/ MJ	91.16 x (1 – 0.02) = **89.33680**	GHG intensity limit for 2025–2029, as defined in Article 4(2). Adjusts based on reduction factor in the Reporting Period
Energy use in scope	MJ	486,000,000 + 59,780,000 = **545,780,000**	All energy in scope (now in MJ, the energy units in the compliance balance)
WtT GHG intensity	gCO_2eq/ MJ	((13.50 x 486,000,000) + (14.40 x 59,780,000)) / 545,780,000 = **13.59858**	Using the default WtT emissions factors across all fuel types divided by the total energy in scope
TtW GHG intensity	gCO_2eq/ MJ	((78.24420 x 486,000,000) + (76.36745 x 59,780,000)) / 545,780,000 = **78.03864**	Adding the total emissions across CO_2, CH_4, and N_2O
GHG intensity ($GHGIE_{actual}$)	gCO_2eq/ MJ	13.59858 + 78.03864 = **91.63722**	Adding together the WtT and TtW intensities
Compliance balance	gCO_2eq (tCO2eq)	(89.33680 - 91.63722) x 545,780,000 = **-1,255,523,227.6**	Here the compliance balance is negative, meaning there is a deficit which should be addressed either through pooling, banked compliance, borrowing, or by paying the penalty.
Penalty	EUR	|-1,255,523,227.6| / (91.63722 x 41,000) x 2,400 = **802,011**	Calculated following the penalty formula in Annex IV Part B and reflecting the period 2025 - 2029

Example 2: Fossil LNG with two engine types (Intra-EEA)



In the second example, a vessel utilizes LNG as the primary fuel source. The main engine, a LNG dual-fuel Otto cycle (low pressure 4-stroke) designed for slow-speed operations, uses LNG as well as MDO as a pilot fuel to facilitate combustion. In addition to the main engine, the vessel is equipped with LNG auxiliary engines, which are assumed to operate at medium speed. This results in varying GHG emission factors for the different engines. The auxiliary's consumption of LNG is intended to substitute approximately 1,000 tonnes of MDO, illustrating a common practice in dual-fuel LNG vessels.

GHG intensity Calculation: **Fossil LNG with two engine types**

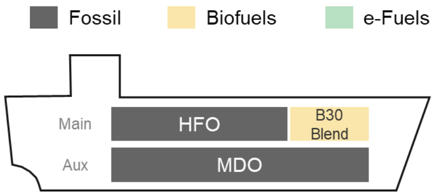
Item	Unit	LNG - Otto (dual fuel slow speed)	LNG - Otto (dual fuel medium speed)	MDO (Grades DMX to DMB)	Notes
Lower calorific value (LCV)	MJ/g	0.0491	0.0491	0.0427	Consumption of LNG and MDO is 100% covered by the FuelEU
Fuel used on EEA – EEA voyages or within EEA ports; 100% covered	tonnes	8,998	900	1,400	
Fuel used on EEA – non-EEA voyages; 50% covered	tonnes	0	0	0	
Energy use in scope (in million MJs)	10^6 MJ	8,998 x 0.0491 x 100% = 441.80180	900 x 0.0491 x 100% = 44.19	1,400 x 0.0427 x 100% = 59.78	
WtT GHG (CO_{2eqWtT})	gCO_2eq/MJ	18.50	18.50	14.40	Fossil fuel default values are in Annex II column 4
TtW CO_2	gCO_2eq/MJ	2.750 / 0.0491 = 56.00815	2.750 / 0.0491 = 56.00815	3.206 / 0.0427 = 75.08197	LNG and MDO TtW emission values are found in Annex II columns 6 - 9
TtW CH_4	gCO_2eq/MJ	0 / 0.0491 x 25 = 0.00	0 / 0.0491 x 25 = 0.00	0.00005 / 0.0427 x 25 = 0.02927	
TtW N_2O	gCO_2eq/MJ	0.00011 / 0.0491 x 298 = 0.66762	0.00011 / 0.0491 x 298 = 0.66762	0.00018 / 0.0427 x 298 = 1.25621	
Slip (C_{slip})	%	**1.7%**	**3.1%**	0%	Slip is uncombusted fuel, therefore, LNG **slip percentages** are removed from combusted fuel calculation, and multiplied by the GWP of CH_4 for TtW
TtW GHG	gCO_2eq/MJ	(1 - **0.017**) x (56.00815 + 0.00 + 0.66762) + (**0.017** x 25) / 0.0491 = 64.36808	(1 - **0.031**) x (56.00815 + 0.00 + 0.66762) + (**0.031** x 25) / 0.0491 = 70.70293	TtW CO_2 + TtW CH_4 + TtW N_2O = 76.36745	
RFNBO reward (RWD)	-	-	-	-	Fossil fuels not eligible for reward

Compliance balance and penalty calculations: **Fossil LNG with two engine types**

Item	Unit	Annual totals	Notes
GHG intensity target 2025-2029 ($GHGIE_{target}$)	gCO_2eq/MJ	91.16 x (1 – 0.02) = **89.33680**	GHG intensity limit for 2025–2029, as defined in Article 4(2); Adjusts based on reduction factor in the Reporting Period
Energy use in scope	MJ	441,801,800 + 44,190,000 + 59,780,000 = **545,771,800**	All energy in scope (now in MJ, the energy units in the compliance balance)
WtT GHG intensity	gCO_2eq/MJ	((18.50 x 441,801,800) + (18.50 x 44,190,000) + (14.40 x 59,780,000)) / 545,771,800 = **18.05091**	Using the default WtT emissions factors across all fuel types divided by the total energy in scope
TtW GHG intensity	gCO_2eq/MJ	((64.36808 x 441,801,800) + (70.70293 x 44,190,000) + (76.36745 x 59,780,000)) / 545,771,800 = **66.19533**	Adding the total emissions across CO_2, CH_4, and N_2O and slip
GHG intensity ($GHGIE_{actual}$)	gCO_2eq/MJ	18.05091 + 66.19533 = **84.24624**	Adding together the WtT and TtW intensities
Compliance balance	gCO_2eq	(89.33680 - 84.24624) x 545,771,800 = **2,778,284,094.20800** (or 2,778.28 tCO_2eq)	Here the compliance balance is positive which means the ship has surplus units that can be banked or pooled
Penalty	EUR	N/A	Not subject to a penalty, 2,778 tCO_2eq surplus compliance can be banked or pooled

Example 3: Fossil HFO and B30 biofuel blend (Intra-EEA)

In this example, a vessel primarily uses HFO. It has also bunkered 1000 tonnes of a B30 blend which is made of 70% HFO (700 tonnes) and 30% bio-diesel (300 tonnes).



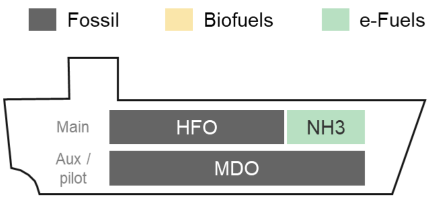
GHG intensity calculation: **Fossil HFO and B30 biofuel blend**

Item	Unit	HFO	HFO (portion of B30 blend)	Bio-diesel (portion of B30 blend)	MDO (Grades DMX to DMB)	Notes
Lower calorific value (LCV)	MJ/g	0.0405	0.0405	0.0370	0.0427	The ship bunkers both HFO and a B30 blend of 70% HFO and 30% bio-diesel; the bio-diesel LCV is from RED Annex III. The energy is 100% covered by the FuelEU
Fuel used on EEA – EEA voyages or within EEA ports; 100% covered	tonnes	11,026	700	300	1,400	
Fuel used on EEA – non-EEA voyages; 50% covered	tonnes	0	0	0	0	
Energy use in scope (in million MJs)	10^6 MJ	11,026 x 0.0405 x 100% = 446.553	700 x 0.0405 x 100% = 28.35	300 x 0.0370 x 100% = 11.10	1,400 x 0.0427 x 100% = 59.78	
WtT GHG (CO_{2eqWtT})	gCO_2eq/MJ	13.50	13.50	**14.9** - (2.834 / 0.037) = -61.70	14.40	Bio-diesel **E values** should come from the PoS; this example is FAME waste cooking oil from RED Annex V D (C_{fCO2}=2.834) from Column 6 in FuelEU Annex II
TtW CO_2	gCO_2eq/MJ	3.114 / 0.0405 = 76.88889	3.114 / 0.0405 = 76.88889	2.834 / 0.0370 = 76.59459	3.206 / 0.0427 = 75.08197	Bio-diesel CH_4 and N_2O are listed in Annex II as “TBM”, therefore, they are assigned the maximum in the fuel class according to Annex II. No slip for all fuel types
TtW CH_4	gCO_2eq/MJ	0.00005 / 0.0405 x 25 = 0.03086	0.00005 / 0.0405 x 25 = 0.03086	0.00005 / 0.0370 x 25 = 0.03378	0.00005 / 0.0427 x 25 = 0.02927	
TtW N_2O	gCO_2eq/MJ	0.00018 / 0.0405 x 298 = 1.32444	0.00018 / 0.0405 x 298 = 1.32444	0.00018 / 0.0370 x 298 = 1.44973	0.00018 / 0.0427 x 298 = 1.25621	
Slip (C_{slip})	%	0%	0%	0%	0%	
TtW GHG	gCO_2eq/MJ	TtW CO_2 + TtW CH_4 + TtW N_2O = 78.24420	TtW CO_2 + TtW CH_4 + TtW N_2O = 78.24420	76.59459 + 0.03378 + 1.44973 = 78.07811	TtW CO_2 + TtW CH_4 + TtW N_2O = 76.36745	
RFNBO reward (RWD)	-	-	-	-	-	Fossil/bio fuels not eligible for reward

Compliance balance and penalty calculations: **Fossil HFO and B30 biofuel blend**

Item	Unit	Annual totals	Notes
GHG intensity target 2025-2029 ($GHGIE_{target}$)	gCO_2eq/ MJ	91.16 x (1 – 0.02) = **89.33680**	GHG intensity limit for 2025–2029, as defined in Article 4(2); adjusts based on reduction factor in the Reporting Period
Energy use in scope	MJ	446,553,000 + 28,350,000 + 11,100,000 + 59,780,000 = **545,783,000**	All energy in scope (now in MJ, the energy units in the compliance balance)
WtT GHG intensity	gCO_2eq/ MJ	((13.50 x 446,553,000) + (13.50 x 28,350,000) + (-61.70 x 11,100,000) + (14.40 x 59,780,000)) / 545,783,000 = **12.06929**	Default WtT emissions factors for fossil fuels and a WtT factor for bio-diesel based on example value from RED Annex V D
TtW GHG intensity	gCO_2eq/ MJ	((78.24420 x 446,553,000) + (78.24420 x 28,350,000) + (78.07811 x 11,100,000) + (76.36745 x 59,780,000)) / 545,783,000 = **78.03525**	Adding the total emissions across CO_2, CH_4, and N_2O and slip
GHG intensity ($GHGIE_{actual}$)	gCO_2eq/ MJ	12.06929 + 78.03525 = **90.10454**	Adding together the WtT and TtW intensities
Compliance balance	gCO_2eq	(89.33680 - 90.10454) x 545,783,000 = **-419,019,440.42000** (or -419.02 tCO_2eq)	Despite bunkering 1000 tonnes of B30, the compliance balance is negative, meaning there is a deficit
Penalty	EUR	|-419,019,440.42000| / (90.10455 x 41,000) x 2,400 = **272,217**	Calculated following the penalty formula in Annex IV Part B and reflecting the period 2025 - 2029

Example 4: Fossil HFO and RFNBO e-NH3 (Intra-EEA)



This example shows a dual-fuel ammonia vessel that is primarily using HFO and MDO, and has bunkered 400 tonnes of ammonia produced from renewable electricity, or eNH3. In this example, we assume the eNH3 is certified as an RFNBO and is therefore able to apply the RFNBO multiplier, i.e., RWD = 2.

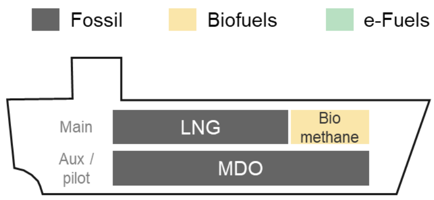
GHG intensity calculation: **Fossil HFO and RFNBO e-NH3**

Item	Unit	HFO	e-NH3 - ICE	MDO (Grades DMX to DMB)	Notes
Lower calorific value (LCV)	MJ/g	0.0405	0.0186	0.0427	The ship bunkers both HFO and a small amount of e-NH3 The bio-diesel LCV is from RED Annex III. The energy is 100% covered by the FuelEU
Fuel used on EEA – EEA voyages or within EEA ports; 100% covered	tonnes	11,816	400	1,400	
Fuel used on EEA – non-EEA voyages; 50% covered	tonnes	0	0	0	
Energy use in scope (in million MJs)	10^6 MJ	11,816 x 0.0405 x 100% = 478.548	400 x 0.0186 x 100% = 7.44	1,400 x 0.0427 x 100% = 59.78	
WtT GHG (CO_{2eqWtT})	gCO_2eq/ MJ	13.50	10 - 0 = 10	14.40	eNH3 E values should come from the PoS. Here, we use 10 gCO_2eq/MJ as an illustrative value; see section 3.3 for description of the WtT calculation
TtW CO_2	gCO_2eq/ MJ	3.114 / 0.0405 = 76.88889	0 / 0.0186 = 0	3.206 / 0.0427 = 75.08197	CH_4 and N_2O for eNH3 are listed in Annex II as "N/A" and "TBM", therefore, they are assigned the maximum in the fuel class according to Annex II; we use a value of **zero for eNH3 slip** in-line with EU ETS and MRV GD1 section 4.4
TtW CH_4	gCO_2eq/ MJ	0.00005 / 0.0405 x 25 = 0.03086	0.00005 / 0.0186 x 25 = 0.06720	0.00005 / 0.0427 x 25 = 0.02927	
TtW N_2O	gCO_2eq/ MJ	0.00018 / 0.0405 x 298 = 1.32444	0.00018 / 0.0186 x 298 = 2.88387	0.00018 / 0.0427 x 298 = 1.25621	
Slip (C_{slip})	%	0%	**0%**	0%	
TtW GHG	gCO_2eq/ MJ	TtW CO_2 + TtW CH_4 + TtW N_2O = 78.24420	TtW CH_4 + TtW N_2O = 2.95108	75.08197 + 0.02927 + 1.25621 = 76.36745	
RFNBO reward (RWD)	-	-	2	-	eNH3 is eligible for RFNBO reward

Compliance balance and penalty calculations: **Fossil HFO and RFNBO e-ammonia**

Item	Unit	Annual totals	Notes
GHG intensity target 2025-2029 ($GHGIE_{target}$)	gCO_2eq/ MJ	91.16 x (1 – 0.02) = **89.33680**	GHG intensity limit for 2025–2029, as defined in Article 4(2); adjusts based on reduction factor in the Reporting Period
Energy use in scope	MJ	478,548,000 + 7,440,000 + 59,780,000 = **545,768,000**	All energy in scope (now in MJ, the energy units in the compliance balance)
WtT GHG intensity	gCO_2eq/ MJ	((13.50 x 478,548,000) + (10 x 7,440,000 + 76.37 x 59,780,000)) / (478,548,000 + 7,440,000 **x 2** + 59,780,000) = **13.36862**	The **reward factor** is used to calculate the WtT GHG intensity according to Annex I
TtW GHG intensity	gCO_2eq/ MJ	((78.24420 x 478,548,000) + (2.95108 x 7,440,000) + (76.36745 x 59,780,000)) / (478,548,000 + 7,440,000 **x 2** + 59,780,000) = **75.97650**	The **reward factor** is used to calculate the TtW GHG intensity according to Annex I
GHG intensity ($GHGIE_{actual}$)	gCO_2eq/ MJ	13.36862 + 75.97650 = **89.34512**	Adding together the WtT and TtW intensities
Compliance balance	gCO_2eq	(89.33680 - 89.34512) x 545,768,000 = **-4,540,789.76** (or -4.54 tCO_2eq)	While the 400 tonnes of eNH3 has reduced the emissions, there remains a small deficit.
Penalty	EUR	|-4,540,789.76| / (89.34512 x 41,000) x 2,400 = **2,975**	Calculated following the penalty formula in Annex IV Part B and reflecting the period 2025 - 2029

Example 5: Fossil LNG and biomethane (Intra-EEA)



In this example, we show a vessel navigating between EEA ports, utilizing LNG as the primary fuel source and bunkering a small amount of liquified biomethane. The main engine, a LNG dual-fuel Otto cycle (low pressure 4-stroke) designed for medium-speed operations, is using three fuels: fossil LNG, liquified biomethane, as well as MDO as a pilot fuel to facilitate combustion. MDO is also used in auxiliary engines.

GHG intensity calculation: **Fossil LNG and Biomethane**

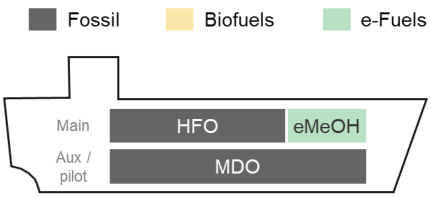
Item	Unit	LNG - Otto (medium speed)	Liquefied Biomethane - Otto (medium speed)	MDO (Grades DMX to DMB)	Notes
Lower calorific value (LCV)	MJ/g	0.0491	0.050	0.0427	The ship bunkers LNG, MDO, and a small amount of biomethane which displaces some of the fossil LNG in the main engine; biomethane LCV is from RED Annex III. The energy is 100% covered by the FuelEU
Fuel used on EEA – EEA voyages or within EEA ports; 100% covered	tonnes	9,491	400	1,400	
Fuel used on EEA – non-EEA voyages; 50% covered	tonnes	0	0	0	
Energy use in scope (in million MJs)	10^6 MJ	9,491 x 0.0491 x 100% = 466.0081	400 x 0.0500 x 100% = 20.00	1,400 x 0.0427 x 100% = 59.78	
WtT GHG (CO_{2eqWtT})	gCO_2eq/MJ	18.50	19.17 - (2.75/0.050) = -35.83000	14.40	Biomethane **E value** should come from the PoS. Here, we use RED Annex VI D plus added liquefaction emissions from literature[37] as an example
TtW CO_2	gCO_2eq/MJ	2.750 / 0.0491 = 56.00815	2.750 / 0.050 = 55.00	3.206 / 0.0427 = 75.08197	LNG and MDO TtW emission values are found in Annex II columns 6 - 9.
TtW CH_4	gCO_2eq/MJ	0 / 0.0491 x 25 = 0.00	0 / 0.050 x 25 = 0.00	0.00005 / 0.0427 x 25 = 0.02927	
TtW N_2O	gCO_2eq/MJ	0.00011 / 0.0491 x 298 = 0.66761	0.00011 / 0.050 x 298 = 0.6556	0.00018 / 0.0427 x 298 = 1.25621	
Slip (C_{slip})	%	3.1%	3.1%	0%	
TtW GHG	gCO_2eq/MJ	(1 - 0.031) x (56.00815 + 0.00 + 0.66761) + (0.031 x 25) / 0.0491 = 70.70293	(1 - 0.031) x (55.00 + 0.00 + 0.6556) + (0.031 x 25) / 0.050 = 69.43028	75.08197 + 0.02927 + 1.25621 = 76.36745	LNG and biomethane should factor in the methane slip
RFNBO reward (RWD)	-	-	-	-	Fossil and biofuels not eligible for reward

[37] See note on E-values for biomethane in Section 1.2.3 for more details

Compliance balance and penalty calculations: **Fossil LNG and Biomethane**

Item	Unit	Annual totals	Notes
GHG intensity target 2025-2029 ($GHGIE_{target}$)	gCO_2eq/ MJ	91.16 x (1 – 0.02) = **89.33680**	GHG intensity limit for 2025–2029, as defined in Article 4(2). Adjusts based on reduction factor in the Reporting Period
Energy use in scope	MJ	466,008,100 + 20,000,000 + 59,780,000 = **545,788,100**	All energy in scope (now in MJ, the energy units in the compliance balance)
WtT GHG intensity	gCO_2eq/ MJ	((18.50 x 466,008,100) + (-35.83000 x 20,000,000) + (14.40 x 59,780,000)) / 545,788,100 = **16.06005**	Using the default WtT emissions factors for the fossil fuels and an example WtT factor for biomethane
TtW GHG intensity	gCO_2eq/ MJ	((70.70293 x 466,008,100) + (69.43028 x 20,000,000) + (76.36745 x 59,780,000)) / 545,788,100 = **71.27672**	Adding the total emissions across CO_2, CH_4, and N_2O and slip
GHG intensity ($GHGIE_{actual}$)	gCO_2eq/ MJ	16.06005 + 71.27672 = **87.33677**	Adding together the WtT and TtW intensities
Compliance balance	gCO_2eq	(89.33680 - 87.33677) x 545,788,100 = **1,091,592,573.64** (or 1,091.59 tCO_2eq)	The LNG and biomethane lead to a compliance balance surplus
Penalty	EUR	N/A	Not subject to a penalty; 1,092 tCO_2eq surplus compliance can be banked or pooled

Example 6: Fossil HFO and two different WtT footprints of e-MeOH (Intra-EEA)



This example shows a vessel that is primarily using HFO and bunkers e-methanol (e-MeOH) with different emission factors due to different WtT GHG emission values reported on the PoS. Both are eligible for RFNBO rewards, i.e., RWD = 2.

GHG intensity calculation: **Fossil HFO and two different WtT footprint of e-MeOH**

Item	Unit	HFO	e-MeOH - ICE	e-MeOH - ICE	MDO (Grades DMX to DMB)	Notes
Lower calorific value (LCV)	MJ/g	0.0405	0.0199	0.0199	0.0427	The ship bunkers both HFO and a small amount of e-NH3 The bio-diesel LCV is from RED Annex III. The energy is 100% covered by the FuelEU
Fuel used on EEA – EEA voyages or within EEA ports; 100% covered	tonnes	11,816	200	200	1,400	
Fuel used on EEA – non-EEA voyages; 50% covered	tonnes	0	0	0	0	
Energy use in scope (in million MJs)	10^6 MJ	11,816 x 0.0405 x 100% = 478.548	200 x 0.0199 x 100% = 3.98	200 x 0.0199 x 100% = 3.98	1,400 x 0.0427 x 100% = 59.78	
WtT GHG (CO_{2eqWtT})	gCO_2eq/MJ	13.50	**10** - 68.90 = -58.90	**5** - 68.90 = -63.90	14.40	eMeOH E values come from the PoS. Here, we use **two example E values**. The Eu (68.90 gCO_2e/MJ combustion emissions) is from DR 2023/1185 Annex Part B
TtW CO_2	gCO_2eq/MJ	3.114 / 0.0405 = 76.88889	1.375 / 0.0199 = 69.09548	1.375 / 0.0199 = 69.09548	3.206 / 0.0427 = 75.08197	CH_4 and N_2O for eNH3 are listed in Annex II as “TBM”, therefore, they are assigned the maximum in the fuel class according to Annex II
TtW CH_4	gCO_2eq/MJ	0.00005 / 0.0405 x 25 = 0.03086	0.00005 / 0.0199 x 25 = 0.06281	0.00005 / 0.0199 x 25 = 0.06281	0.00005 / 0.0427 x 25 = 0.02927	
TtW N_2O	gCO_2eq/MJ	0.00018 / 0.0405 x 298 = 1.32444	0.00018 / 0.0199 x 298 = 2.69548	0.00018 / 0.0199 x 298 = 2.69548	0.00018 / 0.0427 x 298 = 1.25621	
Slip (C_{slip})	%	0%	0%	0%	0%	
TtW GHG	gCO_2eq/MJ	TtW CO_2 + TtW CH_4 + TtW N_2O = 78.24420	69.09548 + 0.06281 + 2.69548 = 71.85377	69.09548 + 0.06281 + 2.69548 = 71.85377	TtW CO_2 + TtW CH_4 + TtW N_2O = 76.36745	
RFNBO reward (RWD)	-	-	2	2	-	eMeOHis eligible for RFNBO reward

Compliance balance and penalty calculations: **Fossil HFO and two different WtT footprint of e-MeOH**

Item	Unit	Annual totals	Notes
GHG intensity target 2025-2029 ($GHGIE_{target}$)	gCO_2eq/MJ	91.16 x (1 – 0.02) = **89.33680**	GHG intensity limit for 2025–2029, as defined in Article 4(2); adjusts based on reduction factor in the Reporting Period
Energy use in scope	MJ	478,021,500 + 3,980,000 + 3,980,000 + 59,780,000 = **545,761,500**	All energy in scope (now in MJ, the energy units in the compliance balance)
WtT GHG intensity	gCO_2eq/MJ	((13.50 x 478,021,500) + **(-58.9000 x 3,980,000)** + **(-63.90 x 3,980,000)** + (14.40 x 59,780,000)) / (478,021,500 + 3,980,000 **x 2** + 3,980,000 **x 2** + 59,780,000) = **12.32637**	The **two different WtT footprints** apply here; the **reward factor** is used to calculate the WtT GHG intensity according to Annex I
TtW GHG intensity	gCO_2eq/MJ	((78.24420 x 478,021,500) + (71.85377 x 3,980,000) + (71.85377 x 3,980,000) + (76.36745 x 59,780,000)) / (478,021,500 + 3,980,000 x 2 + 3,980,000 x 2 + 59,780,000) = **76.82492**	The reward factor is used to calculate the TtW GHG intensity according to Annex I
GHG intensity ($GHGIE_{actual}$)	gCO_2eq/MJ	12.32637 + 76.82492 = **89.15129**	Adding together the WtT and TtW intensities
Compliance balance	gCO_2eq	(89.33680 - 89.15129) x 545,761,500 = **101,244,215.86500** (or 101.24 tCO_2eq)	The 400 tonnes of methanol are able to reduce emissions enough to produce a small surplus
Penalty	EUR	NA	Not subject to a penalty, 101 tCO_2eq surplus compliance can be banked or pooled

Building on the foundational principles for calculating GHG intensity and the compliance balance in this chapter, Chapter 2 addresses how these same calculation principles are applied to ships operating between EEA ports and non-EEA ports and Outermost Regions. This includes how to implement exemptions and allocation of fuels to compliance balance calculations.

2. Chapter 2: Extra-EEA Voyages

2.1. Introduction and Key Concepts

The following section provides guidance for applying the calculation methodologies from Chapter 1 to voyages between European Economic Area (EEA) Member States and non-EEA Member States within the scope of FuelEU, known as "Extra-EEA" voyages. The section is complemented by additional guidance for technology-specific conditions in Chapter 3.

In both the MRV Maritime Regulation and FuelEU, a voyage is considered from the last berth or ship-to-ship transfer within a port of call[38] to the first berth or ship-to-ship transfer in the following port of call.

Furthermore, EU regulations also refer to Extra-EEA as 'International Voyages'. This is defined as a voyage by sea from a port in a Member State to a port outside that Member State, and vice versa. Conversely, a 'domestic voyage' is a sea voyage from a port in a Member State to the same or another port within that Member State.[39]

While voyages between EEA Member States (hereafter "Intra-EEA Voyages") are in principle international voyages, from a FuelEU perspective, these are treated differently from international voyages between EEA Member States and third countries (hereafter "Extra-EEA"). This distinction is important for calculation and compliance purposes, as it defines the scope of energy falling under the FuelEU, as described in Article 2(1) of FuelEU:

> *This Regulation applies to all ships of above 5 000 gross tonnage that serve the purpose of transporting passengers or cargo for commercial purposes, regardless of their flag, in respect of:*
>
> *(a) the energy used during their stay within a port of call under the jurisdiction of a Member State;*
>
> *(b) the entirety of the energy used on voyages from a port of call under the jurisdiction of a Member State to a port of call under the jurisdiction of a Member State;*
>
> *(c) notwithstanding point (b), one half of the energy used on voyages arriving at or departing from a port of call located in an outermost region under the jurisdiction of a Member State; and*
>
> *(d) one half of the energy used on voyages arriving at or departing from a port of call under the jurisdiction of a Member State, where the previous or the next port of call is under the jurisdiction of a third country."*

The FuelEU is relevant to the EEA, meaning that once incorporated into the EEA Agreement, it will apply to EU Member States as well as Iceland, Liechtenstein, and Norway

[38] FuelEU defines "port of call" as the port where a ship stops to load or unload cargo or to embark or disembark passengers. Regulation (EU) 2023/1805 Article 3, 'Definitions.'

[39] Source: Maritime Transport: A Selection of Essential EU Legislation Dealing with Safety and Pollution Prevention, Article 2, Definitions, ISBN 978-92-79-53489-8, doi: 10.2832/263538, 2016, https://transport.ec.europa.eu/system/files/2017-02/maritime_safety_eu_acquis.pdf.

(except Svalbard).[40] In that case,ports of those countries should be understood as Member State ports. Pending incorporation of the FuelEU into the EEA Agreement, Norwegian and Icelandic ports should be treated as third-country (non-Member State) ports.

In addition, ports in **Overseas Countries and Territories ('OCT') of the European Union do not qualify as ports of call** under the jurisdiction of a Member State.[41] Additionally the Faroe Islands (Denmark) and Svalbard (Norway) are excluded. Practically, this means that voyages between a port of call in the excluded territories listed above and a port of call under the jurisdiction of an EEA State constitute as "incoming" or "outgoing" voyages and should be monitored and reported.

For regulatory clarity, we can identify **four main FuelEU application scenarios**, excluding the various exemptions to FuelEU, that will be discussed in more detail in this chapter.

- **Within port of call:** Refers to the energy used while the ship is at berth[42] and the energy used within ports when the ship is not at berth (e.g., moving within a port of call between two voyages).
- **Intra-EEA Voyages:** The Regulation applies to ships for the entirety of the energy used on voyages between ports under the jurisdiction of EU/EEA Member States.
- **Voyages to or from Outermost Regions (OMRs):** OMRs are regions that, although geographically distant from continental Europe, are part of the EU, including the Azores, Canary Islands, and French Guiana. For voyages that start or end in an OMR under the jurisdiction of an EU Member State, the Regulation applies to ships for one half of the energy used.[43]
- **Extra-EEA Voyages:** For voyages between a port under the jurisdiction of an EU/EEA Member State and a port under the jurisdiction of a third country (or vice versa), the Regulation applies to ships for one half of the energy used.

Certain stops do not qualify as ports of call under FuelEU as stated in definition in Article 3(10), these are:

- Stops for the sole purposes of refuelling; obtaining supplies (including fodder for vessels transporting animals as cargo); relieving the crew; going into dry-dock or making repairs to the ship and/or its equipment;
- Stops in port because the ship is in need of assistance or in distress;
- Ship to ship transfers carried out outside ports;
- Stops for the sole purpose of taking shelter from adverse weather or rendered necessary by search and rescue activities;
- Stops of containerships in a neighbouring container transhipment port listed in the implementing act adopted pursuant to Article 2(2) of the FuelEU.

The fact that the above stops are excluded from the definition of 'port of call' does not mean that the relevant energy falls out of scope, because whether the energy will fall within scope

[40] For more information, on the current EEA agreement, see the legal texts in the European Free Trade Association website: https://www.efta.int/about-efta/legal-documents/eea-legal-texts
[41] see list of OCT countries https://international-partnerships.ec.europa.eu/countries/overseas-countries-and-territories_en
[42] As per Article 3 of the MRV Maritime Regulation, a ship is to be considered at berth when 'securely moored or anchored in a port falling under the jurisdiction of a Member State while it is loading, unloading or hoteling, including the time spent when not engaged in cargo operations'. The ship will also be considered as 'at berth' when engaging in any operation other than cargo handling within port (e.g. bunkering, positioning, inspections, etc.) between arrival at first berth and departure from last berth as long as the ship is securely moored or anchored within port limits.
[43] Unless specifically excluded by Member State, for more information see section 2.2.4.

will ultimately depend on the previous and the next stop and more specifically on whether one of these two stops is a port of call within FuelEU.[44]

The same applies where multiple stops excluded from the definition of 'port of call' are carried out one after the other.

2.2. Special Voyage Scenarios

This section outlines specific voyage scenarios requiring special considerations in terms of the FuelEU calculations.

2.2.1. Exemptions for outermost region - Article 2(1)

Regulatory reference

Article 2(1)(c) of FuelEU applies to all ships of above 5,000 gross tonnage that transport passengers or cargo for commercial purposes, regardless of their flag. This applies to **one half of the energy used** on voyages arriving at or departing from a port of call located in an outermost region under the jurisdiction of a Member State.

Introduction

Due to the special characteristics and constraints of the OMRs of the Union, particularly their remoteness and insularity, special consideration is given to maintaining their accessibility and efficient connectivity by maritime transport.

Two types of voyages related to OMR ports are exempted from the scope of FuelEU. These exemptions will affect the reporting of energy used on board, GHG intensity calculation, and the compliance strategies of relevant ships. This section focuses on the permanent exemption for OMRs, while the following section covers the temporary exemptions for specific OMR routes and ports as outlined in Article 2(4).

Definition of Outermost Regions

The EU includes nine OMRs, defined as territories in Article 349 TFEU[45].

As explained in Chapter 2 of the EU ETS and MRV guidance document no.1[46], the term 'ports of call under the jurisdiction of a Member State' refers to ports located in EU territory where EU law fully applies. Not all ports belonging to a Member State are considered EU territories (see list below). For a voyage to be covered by the MRV Maritime Regulation, at least one port of call should be located in an EU territory.

[44] For more information, see for reference the Questions and Answers on FuelEU webpage https://transport.ec.europa.eu/transport-modes/maritime/decarbonising-maritime-transport-fueleu-maritime/questions-and-answers-regulation-eu-20231805-use-renewable-and-low-carbon-fuels-maritime-transport_en#article-2---scope.
[45] For more information, see Treaty on the Functioning of the European Union (TFEU) https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:12012E/TXT.
[46] See the latest EU ETS MRV guidance document linked on the EMSA website https://www.emsa.europa.eu/faq-monitoring-plan.html

Table 9. Ports of call in the nine EU OMRs are considered ports of call under the jurisdiction of a Member State

Member State	Outermost Regions
Spain	Canary Islands
France	Guadeloupe French Guyana Martinique Mayotte Saint Martin Reunion
Portugal	Madeira Azores

Energy scope falling under FuelEU

Only half of the energy used on voyages "departing from" or "arriving at" a port of call in an OMR should be included in the scope of this Regulation, as per Article 2(1)(c). This is due to the unique characteristics and constraints of the OMRs in the Union, particularly their remoteness and insularity. Special consideration is given to preserving their accessibility and efficient connectivity by maritime transport.

For the same reasons, there may be temporary exemptions for specific OMRs routes and ports, as per Article 2(4). This will be discussed in Chapter 2.2.4.

Possible voyage combinations involving at least one end of port call involved in a OMR can be divided into two main categories:

1. **Extra-EU voyages between**
   - an OMR port and a non-EEA port
2. **Intra-EU voyages between**
   - An OMR port and an EEA-port in the same EEA Member State
   - An OMR port and an EEA-port in a different EEA Member State
   - Two ports within the same OMR
   - Two OMR ports of the same EEA Member State
   - Two OMR ports of different EEA Member States

For Extra-EEA voyages, 50% of the energy used should be included in the scope of this Regulation, as per Article 2(1)(d). This also applies to voyages between an OMR port and a non-EEA port:

> *Article 2(1)(d): one half of the energy used on voyages arriving at or departing from a port of call under the jurisdiction of a Member State, where the previous or the next port of call is under the jurisdiction of a third country.*

For Intra-EEA voyages, 100% of the energy used should be included in the scope of this Regulation, as per Article 2(1)(b).

Article 2(1)(b): the entirety of the energy used on voyages from a port of call under the jurisdiction of a Member State to a port of call under the jurisdiction of a Member State;

However, Article 2(1)(c) provides specific rules to voyages "departing from" or "arriving at" an OMR port and supersedes Article 2(1)(b). Only 50% of the energy used in these voyages is included in the scope of this Regulation.

*Article 2(1)(c): **notwithstanding point (b)**, one half of the energy used on voyages arriving at or departing from a port of call located in an outermost region under the jurisdiction of a Member State;*

This means that a voyage between an OMR port and a Member State port falls under Article 2(1)(c), despite being an Intra-EEA voyage, and only 50% of the energy falls under the scope of this Regulation. A complete set of examples and the corresponding Article numbers are listed in Table 10. At the time of publication, Member States notified the Commission of a list of exempted OMR ports (Article 2(4)). Some examples do not include specific OMR ports and are shown with grey text, but they are retained in the table to illustrate the functioning of Article 2(1)(c) once Article 2(4) exemption expires in 2030.

Table 10. Examples illustrating the functioning of FuelEU Article 2(1)

Activities	Port of calls			FuelEU scope	Article reference	Voyages between	Example
Extra-EEA voyages	EEA	⇄	Non-EEA	50%	Art. 2(1)(d)	a MS port and a non-MS port	Rotterdam - Houston [Netherlands - US]
	OMR	⇄	Non-EEA	50%	Art. 2(1)(d)	an OMR port and a non-MS port	Arrecife (Lanzarote) - Casablanca [Canary Islands - Morocco]
Intra-EEA voyages	EEA	⇄	EEA	100%	Art. 2(1)(b)	two MS-ports	Hamburg - Antwerp [Germany - Belgium]
	OMR (A)	⇄	EEA (A)	50%	Art. 2(1)(c)	an OMR port and a MS-port in the same Member State	Arrecife (Lanzarote) - Valencia [Canary Islands - Spain]
	OMR (A)	⇄	EEA (B)	50%	Art. 2(1)(c)	an OMR port and a MS-port in the different Member State	Arrecife (Lanzarote) - Marseille [Canary Islands - France]
	OMR1 (A)	⇄	OMR1 (A)	50%	Art. 2(1)(c)	Two ports within the same OMR	Not available
	OMR1 (A)	⇄	OMR2 (A)	50%	Art. 2(1)(c)	Two OMR ports of the same Member State	Not available
	OMR (A)	⇄	OMR (B)	50%	Art. 2(1)(c)	Two OMR ports of the different Member States	Not available

The FuelEU approach differs from the EU ETS approach, as outlined in Table 11. FuelEU provides this exemption on a permanent basis, while the EU ETS Directive covers the period up to 31 December 2030 (see EU ETS guidance document n°1[47]). The fuel consumption of voyages from/to OMR should be monitored and reported. However, from 2031, for the purpose of calculating the yearly average GHG intensity of energy used on board, the energy scope will be reduced accordingly.

Table 11. Comparison of FuelEU and EU ETS approach - voyages to/from OMR ports

Activities	Port of calls			FuelEU scope (energy)	ETS scope (emissions)	Voyages between	Example
Extra-EEA voyages	EEA	⇄	Non-EEA	50%	50%	a MS port and a non-MS port	Rotterdam - Houston [Netherlands - US]
	OMR	⇄	Non-EEA	50%	50%	a OMR port and a non-MS port	Arrecife (Lanzarote) - Casablanca [Canary Islands - Morocco]
Intra-EEA voyages	EEA	⇄	EEA	100%	100%	two MS-ports	Hamburg - Antwerp [Germany - Belgium]
	OMR (A)	⇄	EEA (A)	50%[48]	0%[49] until 31 Dec 2030	an OMR port and a MS-port in the same Member State	Arrecife (Lanzarote) - Valencia [Canary Islands - Spain]
	OMR (A)	⇄	EEA (B)	50%[50]	100%	an OMR port and a MS-port in the different Member State	Arrecife (Lanzarote) - Marseille [Canary Islands - France]
	OMR1 (A)	⇄	OMR1 (A)	50%[51]	0%[52] until 31 Dec 2030	Two ports within the same OMR	Not available
	OMR1 (A)	⇄	OMR2 (A)	50%[53]	0%[54] until 31 Dec 2030	Two OMR ports of the same Member State	Not available
	OMR (A)	⇄	OMR (B)	50%[55]	100%	Two OMR ports of the different Member States	Not available

[47] For more information, see the latest guidance document linked on the EMSA website: https://www.emsa.europa.eu/faq-monitoring-plan.html
[48] This is provided by Article 2(1)(c) on the scope of FuelEU and has no expiration date.
[49] ETS surrendering obligations are exempted via Article 12(3)(b) of ETS Directive 2003/87/EC with an expiration date of 31 Dec 2030.
[50] This is provided by Article 2(1)(c) on the scope of FuelEU and has no expiration date.
[51] This is provided by Article 2(1)(c) on the scope of FuelEU and has no expiration date.
[52] ETS surrendering obligations are exempted via Article 12(3)(b) of ETS Directive 2003/87/EC with an expiration date of 31 Dec 2030.
[53] This is provided by Article 2(1)(c) on the scope of FuelEU and has no expiration date.
[54] ETS surrendering obligations are exempted via Article 12(3)(b) of ETS Directive 2003/87/EC with an expiration date of 31 Dec 2030.
[55] This is provided by Article 2(1)(c) on the scope of FuelEU and has no expiration date.

2.2.2. Voyages to ports identified as neighbouring transhipment ports

Similar to the concept used under the MRV/ETS, FuelEU stipulates that stops made by containerships at a neighbouring container transhipment port, as listed in the relevant implementing act adopted by the Commission, are excluded from the definition of a port of call. At the time of writing this document, this act is pending adoption. In the draft available for public consultation, the following ports were identified as neighbouring container transhipment ports:

- East Port Said, Egypt
- Tanger Med, Morocco

This list aligns with the respective list under MRV/ETS (Implementing Regulation (EU) 2023/2297), thereby aligning the definitions of voyages under FuelEU and EU MRV.
Stops made by containerships at the ports identified in the adopted act are considered part of a voyage. The scope of the voyage and the energy contribution, as per Article 2(1), depends on the vessel's last port of call and the next port of call. Consequently, the respective voyage will always fall under one of the predefined voyage categories, eliminating the need for specific calculation examples.

2.2.3. Small islands - Article 2(3)

Regulatory reference

Article 2(3) of FuelEU allows Member States to request exemptions for the energy used by ships on specific routes and in ports served by **passenger ships, other than cruise ships**. This applies to routes connecting a port of a Member State with small islands of the same Member State that have a population of fewer than 200,000, as well as the duration of stay within a port of that island.

Member States should notify the European Commission of these exemption requests, which will be published by the Commission in the Official Journal of the EU. They are subject to a time limit, expiring no later than **31 December 2029**.

The following Member States have requested exemptions for their small islands shown in Table 12.

Table 12. List of Member States that have requested exemption pursuant to FuelEU Article 2(3)

Member State	Link	Exemption
Croatia	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500636	This implementing act combines exemptions under Article 2(3) and 2(6) and covers numerous routes between mainland ports and small islands ports, as well as connections between ports of small islands.
Denmark	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202407471	This implementing act covers two low small islands and one specifically exempted port on each island.
Finland	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500969	This implementing act covers three ports from islands with less than 200 000 inhabitants.
Greece	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202407469	This implementing act covers numerous small islands and one or more ports on those islands.
Italy	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202407470	This implementing act covers numerous small islands and archipelagos. With the exception of San Pietro island, the act exempts all ports on the listed islands.
Malta	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202407472	This implementing act covers one small island and a specific port of that island.
Portugal	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500358	This implementing act covers three routes including specific ports on small islands.
Spain	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500356	This implementing act covers eight islands meeting low population criteria and exempts specific ports on those islands.

While some exemptions have been published in the Official Journal of the EU after the entry into force of FuelEU on 1 January 2025, they apply from 1 January 2025. They are shown in Table 13.

Table 13. Examples illustrating the functioning of FuelEU Article 2(3)

Activities	Port of calls (country)			FuelEU scope	Article reference	Voyages between	Example
Extra-EEA voyages	Small island (EU)	⇄	Non-EEA	50%	Art. 2.1(d)	A small island port and a non-MS port	Lampedusa - Casablanca [Italy (island) - Morocco]
Intra-EEA voyages	Small island (A)	⇄	EEA (A)	0%	Art. 2.3	A small island port and a MS-port in the same Member State	Mgarr - Valetta [Malta (island) - Malta]
	Small island (A)	⇄	EEA (B)	100%	Art. 2.1 (b)	A small island port and a MS-port in the different Member State	Mgarr - Pozallo [Malta (island) - Italy (island)]
	Small island 1 (A)	⇄	Small island 1 (A)	0%	Art. 2.3	Two ports within the same low-populated island	Eivissa - Sant Antoni de Portmany [Spain(island) - Spain (island)]
	Small island 1 (A)	⇄	Small island 2 (A)	0%	Art. 2.3	Ports of two low-populated islands of the same Member State	Lampedusa - Linosa [Italy(island) - Italy(island)]
	Small island (A)	⇄	Small island (B)	100%	Art. 2.1 (b)	Ports of two low-populated islands of different Member States	Mgarr - Linosa [Malta(island) - Italy(island)]

The FuelEU approach differs from the EU ETS approach. FuelEU provides for this possible exemption with an expiration date no later than 31 December 2029, while the EU ETS directive covers the period up to 31 December 2030 (see EU ETS guidance document n°1[56]). Additionally, FuelEU exempts only the port of call of the low-populated island, not both ports of call for the specific voyage. For differences between EU ETS and FuelEU obligations for specific voyage examples, consult the list of exempted islands under the EU ETS Directive and FuelEU.

Energy falling under the scope of FuelEU

The energy consumption of these voyages as well as the relevant port of calls, should be monitored and reported. However, for the purpose of calculating the yearly average GHG intensity of energy used on board, the energy scope will be reduced accordingly.

[56] For more information, see the latest guidance document linked on the EMSA website: https://www.emsa.europa.eu/faq-monitoring-plan.html

Even though exempted voyages and port stays do not contribute to the FuelEU energy scope, fuels used during these voyages and port stays may still be allocated to the annual FuelEU scope of energy. This applies if there are voyages or port stays in the Reporting Period that fall under the FuelEU scope. For more information on fuel allocation, see Section 2.5.

2.2.4. Voyages between outermost region ports - Article 2(4)

Regulatory reference

In addition to the permanent exemption provided by Article 2(1) of FuelEU (see previous section), Article 2(4) allows Member States to request exemptions from the regulation's scope for specific routes and ports. This applies to the energy used by ships on voyages between port of calls in OMRs, and during their stay within the ports of call in those ports. Moreover, all ports of call within the exempted OMR ports are excluded from application of FuelEU Article 2(1), regardless of previous or next port of call.

Member States should notify the European Commission of these exemption requests, which will be published by the Commission in the Official Journal of the European Union. These exemptions are subject to a time limit, expiring no later than **31 December 2029**.

At the time of writing, the following Member States have requested exemptions for their OMRs:

Table 14. List of Member States that have requested exemption pursuant to FuelEU Regulation Article 2(4)

Member State	Link	Exemption
France	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500357	This implementing act covers 24 ports from all French OMRs.
Portugal	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500358	Portugal has exempted seven routes related to its OMRs.
Spain	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202503449	This implementing act covers 29 ports from all Spanish OMRs. It replaces the table included in Communication C/2025/356.

Exemptions should be notified by Member States prior to entry into force. While some exemptions have been published in the Official Journal of the European Union after 1 January 2025, all are assumed to apply from 1 January 2025.

Shown in Table 15, all OMR ports included in the table are assumed to be ports specifically exempted by Member States, pursuant to Article 2(4) of the Regulation. Refer to Table 10 for extra-EU voyages.

Table 15. Examples illustrating the functioning of FuelEU Article 2(4)

Activities	Port of calls			FuelEU scope	Article reference	Voyages between	Example
Intra-EEA voyages	OMR1 (A)	⇄	OMR1 (A)	0%	Art. 2(4)	Two ports within the same OMR	Arrecife (Lanzarote) - Puerto del Carmen (Lanzarote) [Canary Islands - Canary Islands]
	OMR1 (A)	⇄	OMR2 (A)	0%	Art. 2(4)	Two OMR ports of the same Member State	Longoni (Mayotte) - Le port (Reunion) [Mayotte - Reunion]
	OMR (A)	⇄	OMR (B)	0%	Art. 2(4)	Two OMR ports of the different Member States	Arrecife (Lanzerote) - Le port (Reunion) [Canary Islands - Reunion]

FuelEU provides for this possible exemption with an expiration date no later than 31 December 2029, while the EU ETS directive covers the period up to 31 December 2030 (see EU ETS guidance document n°1[57]). The FuelEU exemption applies only to specific outermost region ports (OMR1 (A) - OMR2 (A) and OMR1 (A) - OMR1 (A) voyages scenarios from Table 15), while EU ETS derogation also covers the OMR1 (A) - EEA (A) voyage scenario. In addition, **FuelEU exempts any port of call in the specific outermost region ports, while under EU ETS only port of calls in relation to an exempted voyage fall under the scope of the derogation**.

Shown in Table 16, all OMR ports included in the table are assumed to be ports specifically exempted by Member States, pursuant to Article 2(4) of the Regulation. Refer to Table 11 for extra-EU voyages.

Table 16. Comparison of FuelEU and EU ETS approach - voyages to/from OMR ports (FuelEU Article 2(4))

Activities	Port of calls			FuelEU scope (energy)	ETS scope (emissions)	Voyages between	Example
Intra-EEA voyages	OMR1 (A)	⇄	OMR1 (A)	0%[58] until 31 Dec 2029	0%[59] until 31 Dec 2030	Two ports within the same OMR	Arrecife (Lanzarote) - Puerto del Carmen (Lanzarote) [Canary Islands - Canary Islands]
	OMR1 (A)	⇄	OMR2 (A)	0%[60] until 31 Dec 2029	0%[61] until 31 Dec 2030	Two OMR ports of the same Member State	Longoni (Mayotte) - Le port (Reunion) [Mayotte - Reunion]
	OMR (A)	⇄	OMR (B)	0%[62] until 31 Dec 2029	100%	Two OMR ports of the different Member States	Arrecife (Lanzerote) - Le port (Reunion) [Ibiza - Reunion]

[57] For more information, see the latest guidance document linked on the EMSA website: https://www.emsa.europa.eu/faq-monitoring-plan.html.
[58] For more information, see Article 2(4) on the scope of FuelEU.
[59] EU ETS surrendering obligations are exempted via Article 12(3-b) of ETS Directive 2003/87/EC with an expiration date of 31 Dec 2030.
[60] For more information, see Article 2(4) on the scope of FuelEU.
[61] EU ETS surrendering obligations are exempted via Article 12(3-b) of ETS Directive 2003/87/EC with an expiration date of 31 Dec 2030.
[62] For more information, see Article 2(4) on the scope of FuelEU.

Energy falling under the scope of FuelEU

The energy consumption of voyages between two ports of call located in the concerned OMRs, as well as emissions within these ports of call, should be monitored and reported. However, for the purpose of calculating the yearly average GHG intensity of energy used on board, the energy scope will be reduced accordingly.

Even though exempted voyages and port stays do not contribute to the FuelEU energy scope[63] fuels used during these voyages and port stays may still be allocated to the annual FuelEU scope of energy. This applies if there are voyages or port stays in the Reporting Period that fall under the FuelEU scope. For more information on fuel allocation, see Section 2.5.

2.2.5. Public service obligations or public service contracts - Article 2(5) and 2(6)

Articles 2(5) and 2(6) of FuelEU allow Member States to request complete exemptions from FuelEU for:

- Passenger ships performing public service obligations/contracts between a port of a Member State that does not share a land border with any other Member State and ports of other Member States.
- Specific routes served by passenger ships providing maritime transport services under EU “cabotage” rules (Regulation (EEC) No 3577/92 under public service obligations/contracts, operating before 12 October 2023, between the mainland and an island of the same Member State or the cities of Ceuta and Melilla). For the purposes of this exemption, the cities of Ceuta and Melilla will be considered as ports of call located on an island.

Member States should notify the European Commission of these exemption requests, which will be published by the Commission in the Official Journal of the EU. At the time of writing, the following Member States have requested exemptions related to public service obligations and contracts:

[63] FuelEU energy scope should be understood as the energy used throughout voyages and port of calls within the scope of the Regulation, reduced respectively as per Article 2.1(c), 2.1(d) and Articles 2.3, 2.4, 2.5, 2.6.

Table 17. List of Member States that have requested exemption pursuant to FuelEU Regulation Article 2(5)/2(6)

Member State	Link	Exemption
Croatia	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500636	This implementing act combines exemptions under Article 2(3) and 2(6) and covers numerous national routes.
Cyprus	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500635	This implementing act covers a single ship operating under a Public Service Contract between Cyprus and Greece.
France	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500357	This implementing act covers five routes and specific companies and ships operating on those routes.
France	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202503448	This communication complements list of exemptions used by France and exempts specific ships on 5 routes.
Italy	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202407470	This implementing act covers 16 ships and their specific routes, some with seasonal time limitations.
Spain	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500356	This implementing act covers 16 routes.

FuelEU provides for this possible exemption with an expiration date no later than 31 December 2029, while the EU ETS directive covers the period up to 31 December 2030 (see EU ETS guidance document no.1[64]).

Energy falling under the scope of FuelEU

The energy consumption of these voyages, as well as the relevant port of calls, should be monitored and reported. However, for the purpose of calculating the yearly average GHG intensity of energy used on board, the energy scope will be reduced accordingly.

Even though exempted voyages and port stays do not contribute to the FuelEU energy scope, fuels used during these voyages and port stays may still be allocated to the annual FuelEU scope of energy. This applies if there are voyages or port stays in the Reporting Period that fall under the FuelEU scope. For more information on fuel allocation, see Chapter 2.5.

2.3. Data Aggregation Categories

Annex I to Implementing Regulation (EU) 2024/2027 provides the template for the FuelEU report. Part E of the Annex details different aggregations for energy consumption data. For the purpose of submitting the FuelEU report, shipping companies should ensure that the monitoring and reporting process accurately captures the following categories.[65]

Aggregation of fuel consumed at sea for all voyages:

- Between ports under a Member State's jurisdiction

[64] For more information, see the latest guidance document linked on the EMSA website: https://www.emsa.europa.eu/faq-monitoring-plan.html.
[65] For more information, see Annex I of Implementing Regulation (EU) 2024/2027. This Chapter illustrates only selected data aggregation categories.

- Departing from ports under a Member State's jurisdiction
- To ports under a Member State's jurisdiction
- Arriving at or departing from a port of call located in an outermost region under the jurisdiction of a Member State
- Performed by passenger ships (excluding cruise passenger ships) between a port of call under the jurisdiction of a Member State and a port of call under the jurisdiction of the same Member State located on an island with fewer than 200,000 permanent residents exempted by a Member State (pursuant to Article 2(3) of Regulation (EU) 2023/1805, see Section 2.2.3)
- Between a port of call located in an outermost region and another port of call located in an outermost region, exempted by a Member State (pursuant to Article 2(4) of Regulation (EU) 2023/1805, see Section 2.2.4)
- Under public service obligations or public service contracts to the ports of call of other Member States exempted by a Member State (pursuant to Article 2(5) of Regulation (EU) 2023/1805, see Section 2.2.5)
- Performing voyages under public service obligations or public service contracts to the ports of call of other Member States, exempted by a Member State (pursuant to Article 2(6) of Regulation (EU) 2023/1805, see Section 2.2.5)

Aggregation of fuel consumed while moored at the quayside and anchorage:

- During their stay within a port of call under the jurisdiction of a Member State
- In ports of call of a Member State island with fewer than 200,000 permanent residents, exempted by a Member State (pursuant to Article 2(3) of Regulation (EU) 2023/1805, see Section 2.2.3)
- In ports of call of outermost regions, exempted by a Member State (pursuant to Article 2(4) of Regulation (EU) 2023/1805, see Section 2.2.4)

In addition, the following items related to energy consumption should be reported:

- The amount of electricity delivered to the ship via on-shore power supply (OPS)
- The amount of energy from a zero-emission technology consumed at berth
- The amount of each type of substitute source of energy consumed at sea

2.4. Mass of Fuel used for Establishing GHG Intensity of Energy used Onboard a Ship

Annex I of the FuelEU provides:

> *The [M_i] mass of fuel must be determined using the amount reported under Regulation (EU) 2015/757 for voyages within the scope of this Regulation, based on the monitoring methodology chosen by the company.*

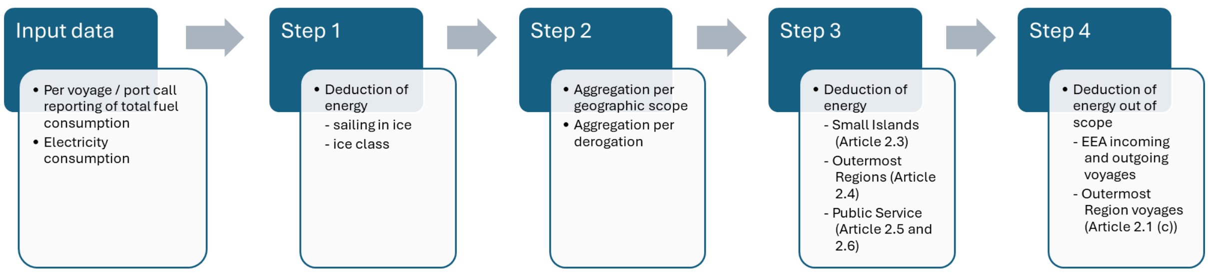
To determine the fuel quantity consumed, the MRV Maritime Regulation[66] allows three different approaches: method A, method B or method C.

Additionally, for the purpose of determining GHG emissions directly, a measurement-based approach (method D) may be used. In such cases, fuel consumption should still be reported, which can be done through back-calculation using emissions and the CO_2 emission factor. However, it is beneficial to use a second monitoring method to verify the results of the primary method. Generally, back-calculation should be considered a secondary option. It is recommended to use a supplementary method (method A, method B, method C) to directly determine fuel consumption utilized in reporting.

The above quoted definition provided in FuelEU Annex I implies that **fuel quantities reported for MRV Regulation and FuelEU should be consistent**, to limit the administrative burden imposed on shipping companies, verifiers and competent authorities. Fuel quantities should be grouped according to the categories indicated in Section 2.3 and as set out by Implementing Regulation 2023/2449, which provides the template for the MRV Emission Report.

As outlined in earlier sections, FuelEU may not apply to all energy used on monitored voyages. Voyage-specific and ship-specific deductions will lead to differences between the mass of fuel reported for both monitoring schemes and the mass of fuel used to establish the GHG intensity of the energy used on board a ship, to calculate the compliance balance and to determine FuelEU penalties. For example, for a vessel performing Extra-EEA or voyages within the scope of any of the exemptions described in Section 2.2, the mass of fuel used for calculating the greenhouse gas intensity will be reduced according to the actual FuelEU energy scope. Subsequent calculation steps, illustrated in Figure 3, demonstrate how input data representing the fuel consumption reporting for EU MRV purposes is used in FuelEU calculations.

Figure 3. Illustration of subsequent FuelEU calculation steps and order of calculations



2.5. Allocation of Fuels

FuelEU does not prescribe a specific methodology for allocating fuels to complete the energy scope under Article 2. The European Commission Questions and Answers on FuelEU webpage[67] states that allocation of fuels is possible in the calculation of the contribution to the GHG intensity of the covered energy. In absence of a defined

[66] For more information, see Regulation (EU) 2015/757.
[67] For more information, see the European Commission's FuelEU Questions and Answers here: https://transport.ec.europa.eu/transport-modes/maritime/decarbonising-maritime-transport-fueleu-maritime/questions-and-answers-regulation-eu-20231805-use-renewable-and-low-carbon-fuels-maritime-transport_en.

methodology in the legislative text and based on the interpretation in the Questions and Answers, it is understood that the fuels used on different types of voyages or port calls can be freely allocated to meet the total energy scope within one calendar year, provided they have been reported under the MRV Regulation. **Thus, allocation can consider the intensity associated with different fuel types across any fuel class,** based on their respective emission factors, as well as the emission factors linked to different fuel consumers.

For example, LNG used in multiple onboard engines with different slippage coefficients can be allocated according to their intensity. Since reporting of fuels under the MRV Regulation and FuelEU is on component basis, it is also possible to de-couple component blends and allocate them to FuelEU energy scope separately. However, it is not permitted to report fuel consumption of a fuel blend in proportions different from the actual proportion of components in a fuel blend, even if the amounts of fuel under each component of the blend can be allocated freely (e.g. the bio-diesel component of a B30 blend with fossil fuel oil can be allocated independently from the fossil fuel component).

Lastly, sources of energy other than traditional fuels (such as electricity) can be also allocated to the FuelEU energy scope. Electricity may form part of the energy used on Extra-EEA voyages, in the case of use of OPS during an intermediate stop forming part of a FuelEU/MRV voyage, or in case of hybrid or other innovative propulsion systems.

2.6. Step-by-Step Guidance for Extra-EEA Voyages

This Section includes a total of four examples aiming to clarify calculation principles where, unlike the examples in Section 1.4, a portion of energy used throughout voyages and port of calls contribute to the energy falling under the scope of FuelEU.

The following are calculation steps specific to such scenarios:

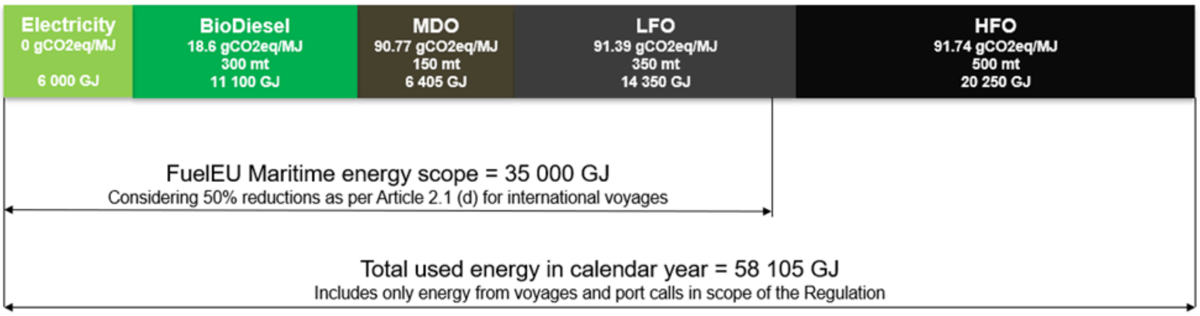
1. **Determine energy used per voyage/port of call** using mass of each fuel type and respective LCVs. Add consumption of electrical energy where applicable.
2. For each voyage/port of call, **calculate the energy in scope of the Regulation**, as per Article 2(1) and consider exemptions given through Articles 2(3), 2(4), 2(5), 2(6). Add the individual leg contribution to determine total FuelEU energy scope.
3. **Allocate different sources of energy considered** under point 1, until FuelEU energy scope is covered. Using LCV, obtain fuel mass per each respective fuel type and energy from electricity allocated to FuelEU energy scope.
4. **Calculate GHG intensity and FuelEU Compliance Balance** using fuel masses determined under point 3) as well as energy from electricity, if applicable, by using principles outlined in Chapter 1.

Example 1: General case

Figure 4 illustrates the most beneficial allocation of fuels to the FuelEU energy scope. In the assumed scenario, the vessel performed several Extra-EEA voyages, which, as per Article 2(1)(d), reduced the energy in scope of FuelEU. The overall voyage pattern in the Reporting Period year resulted in approximately a 40% reduction in the FuelEU energy scope (from

58,105 GJ to 35,000 GJ). Considering the fuel mix, which includes energy from OPS, certified bio-diesel, MDO, LFO and HFO, the most favourable fuels are used first in the calculation of GHG intensity. This increases the impact of using low-GHG-intensity energy sources on the compliance balance, effectively incentivizing the introduction of such energy sources into the energy mix up to the amount of energy in scope of FuelEU.

Figure 4. Illustration of fuel mix for voyages/port of calls in scope of FuelEU Regulation in calendar year and most beneficial fuel allocation to FuelEU energy scope



Fuels used during voyages outside the scope of MRV and FuelEU reporting cannot be allocated to the FuelEU energy scope (e.g., fuels used on voyages between two non-Member State ports). However, fuels used during voyages and port calls exempted under Articles 2(3), 2(4), 2(5), and 2(6) may be allocated to the FuelEU energy scope as long as there are other voyages and port calls that contribute to the FuelEU energy scope source (e.g., intra-EU voyages within the same calendar year).

For all practical purposes, all examples in this document assume allocation of fuels to the FuelEU energy scope is optimized to the benefit of the ship's compliance balance.

Example 2: LNG used on Extra-EEA voyages with different slippage coefficients

This example serves to illustrate the allocation of fuels to the FuelEU energy scope for a vessel performing a voyage from a non-Member State port to a Member State port and a return voyage to the same non-Member State port. In the assumed scenario, the vessel uses LNG for its main engines, auxiliary engines and boiler. Additionally, MDO and HFO are used as pilot fuel and during diesel-only mode operations within port of call.

Table 18. Voyage scenario representing a ship using LNG on Extra-EU-voyages across engines with different slippage coefficients

Leg type	Relation	Fuel type	Engines	C_{slip}s[%]	Mass [mt]	Energy [GJ]	Leg energy total [GJ]	FuelEU energy [GJ]
Voyage arriving at MS port	US-FR	LNG	ME	0,2	1,500	73,650	112,290	56,145
		LNG	AE	3,1	500	24,550		
		LNG	BLR[68]	0	200	9,820		
		MDO	AE	N/A	100	4,270		
Port of call	FR	LNG	AE	3,1	50	2,455	6,615	6,615
		HFO	BLR	N/A	50	2,025		
		MDO	AE	N/A	50	2,135		
Voyage departing from MS port	FR-US	LNG	ME	0,2	1,500	7,3650	112,290	56,145
		LNG	AE	3,1	500	24,550		
		LNG	BLR	0	200	9,820		
		MDO	AE	N/A	100	4,270		
				Total	**4,750**	**231,195**	**231,195**	**118,905**

Table 19. Fuels used throughout voyages and port of call in example 2, including their contribution to FuelEU

Fuel type	Total mass [mt]	Energy [GJ]	FuelEU energy contribution [GJ][69]	FuelEU mass contribution[70] [mt]	WtW GHG intensity [gCO_2eq/MJ]
LNG (0.0%)	400	19,640	19,640	400	75.18
LNG (0.2%)	3,000	147,300	99,265	2324.71	76.08
LNG (3.1%)	1,050	51,555	0	0	89.20
MDO	250	10,675	0	0	90.77
HFO	50	2,025	0	0	91.74

The Well-to-Wake GHG intensity for the voyage sequence, calculated in accordance with Chapter 1, using fuel mass determined per each fuel, is equal to 75.93 gCO_2eq/MJ.

The principles presented in this example can be directly applied to bio-methane and e-methane scenarios. The overall principle applies to any voyage sequence where the fuel mix consists of fuels with different GHG intensities. It is important to note that allocation has been applied as if the three legs (extra-EU,port of call, extra-EU) were the only legs within the scope of FuelEU in the calendar year. If there were more legs within the scope of the Regulation, the most beneficial fuel allocation might differ. For instance, if the vessel consumed bio-methane on other voyages and within port calls, bio-methane could partially or completely displace fossil fuels from the FuelEU energy fuel mix.

[68] As per EU ETS and MRV guidance document no.1, Chapter 7.4.2: *Where default slippage coefficients are not listed for a specific emission source class, companies should apply a slippage coefficient of zero.*
[69] FuelEU energy contribution should be understood as the energy contribution from each fuel type towards the FuelEU energy. Where equal to zero, specific fuel type is not taken into account in the GHG intensity calculations due to application of the most beneficial allocation principles.
[70] FuelEU mass contribution should be understood as the mass of each fuel type [M_i] taken into consideration for the purpose of establishing greenhouse gas intensity of energy used onboard a ship.

Example 3: Sustainable biofuel used on EEA-outgoing voyage

This example illustrates a scenario where a vessel arrives at a Member State port from a non-Member State port and then departs from the Member State port to another non-Member State port. In this scenario, the vessel uses fossil fuels (MDO and HFO) en route to the Member State port and within the port of call. However, on the outgoing leg, a biofuel bunkered in the Member State port, fulfilling the certification criteria of FuelEU Article 10, is used. The WtW GHG intensity of the biofuel batch is assumed in this example to be 18.6 gCO_2eq/MJ and LCV equal to 37 MJ/kg. It is noteworthy that the bio-diesel could be a component in a physical blend (e.g., B30), in which case the fossil and biofuel components are to be reported separately and allocated independently, similarly to how it is calculated in this example.

Table 20. Voyage scenario representing a ship using sustainable biofuel on an EU-outgoing voyage

Leg type	Relation	Fuel type	Mass [mt]	Energy [GJ]	Leg energy total [GJ]	FuelEU energy [GJ]
Voyage arriving at MS port	GB - NL	MDO	100	4,270	20,470	10,235
		HFO	400	16,200		
Port of call	NL	MDO	50	2,135	2,135	2,135
Voyage departing from MS port	NL - CN	MDO	100	4,270	78,270	39,135
		Bio-diesel (FAME)	2,000	74,000		
		Total	**2,650**	**100,875**	**100,875**	**51,505**

Considering that biofuel is used on a voyage where the energy is not entirely applicable to the FuelEU energy scope, this low-GHG intensity fuel displaces other fuels used on the voyage arriving at the Member State port and fuels used within the port call under the scope of the Regulation. This example illustrates a scenario where the entirety of sustainable biofuel used by the ship is not allocated to FuelEU energy scope. While such a scenario might not be preferable to a shipping company, it may occur if the FuelEU energy scope is relatively small compared to used quantities of low GHG intensity fuels. As mentioned in Example 2, the allocation is applied as if the three legs were the only legs in scope of the Regulation in the calendar year. If there are other voyages within the scope of the Regulation in the same year, the remaining mass of biofuel may be allocated to the FuelEU energy scope to displace fuels of higher GHG intensity. If this is not the case, it is not possible to 'bank' the surplus from the biofuel mass to a different calendar year or pool it with another ship.

Table 21. Fuels used throughout voyages and port of call in Example 3 including their contribution to FuelEU

Fuel type	Total mass [mt]	Energy [GJ]	FuelEU energy contribution [GJ]	FuelEU mass contribution [mt]	WtW GHG intensity [gCO_2eq/MJ]
Bio-diesel (FAME)	2,000	74,000	51,505	1,392.03	18.6
MDO	250	10,675	0	0.00	90.77
HFO	400	16,200	0	0	91.74

The Well-to-Wake GHG intensity for the voyage sequence, calculated in accordance with Chapter 1, using fuel mass determined per each fuel, is equal to 18.6 gCO_2eq/MJ.

The principles used in this example apply similarly to voyages that arrive at or depart from a port of call located in an OMR under the jurisdiction of a Member State, following Article 2(1)(c). Since most, if not all, OMR ports are covered by Article 2(4), a separate example is not provided to illustrate a voyage applicable for a 50% energy scope deduction as per Article 2(1)(c).

Example 4: Voyages excluded under Article 2(3), 2(4), 2(5) or 2(6)

To further clarify fuel allocation, it is necessary to illustrate that all fuels reported under the scope of the MRV Regulation can be allocated to meet the total FuelEU energy scope within one calendar year. In the constructed example, a voyage between two OMR ports excluded under FuelEU Article 2(4) is the first leg considered in the calculation, followed by a port of call in the OMR port, which is also excluded under Article 2(4). The last leg in the example is a voyage between OMR port and Member State port, which is an intra-EU voyage, nevertheless covered by Article 2(1)(c). For better understanding of the principles, fuel used throughout a fully exempted voyage and port of call is assumed to be a biofuel fulfilling the certification criteria of FuelEU Article 10, while fuels used on a voyage where 50% energy is covered are fossil fuels. The WtW GHG intensity of the biofuel batch is assumed in this example to be 18.6 gCO_2eq/MJ and LCV equal to 37 MJ/kg.

Table 22. Voyage scenario representing a ship performing voyage excluded under Article 2(4)

Leg type	Relation	Fuel type	Mass [mt]	Energy [GJ]	Leg energy total [GJ]	FuelEU energy [GJ]
Voyage departing from MS OMR port and arriving at MS OMR port	ES (OMR1) - ES (OMR2)	MDO	50	2,135	13,235	0
		Bio-diesel (FAME)	300	11,100		
Port of call	ES (OMR2)	Bio-diesel (FAME)	50	1,850	1,850	0
Voyage departing from MS OMR port and arriving at MS port	ES (OMR2) - ES	MDO	200	8,540	16,640	8,320
		HFO	200	8,100		
		Total	**800**	**31,725**	**31,725**	**8,320**

Although exempted legs have zero contribution towards FuelEU scope of energy, sustainable fuel used during those legs can displace significant quantities of higher GHG intensity fuels.

Table 23. Fuels used throughout voyages and port of call in Example 4, including their contribution to FuelEU

Fuel type	Total mass [mt]	Energy [GJ]	FuelEU energy contribution [GJ]	FuelEU mass contribution [mt]	WtW GHG intensity [gCO_2eq/MJ]
Bio-diesel (FAME)	350	12,950	8320	224.86	18.6
MDO	250	10,675	0	0	90.77
HFO	200	8,100	0	0	91.74

The Well-to-Wake GHG intensity for the voyage sequence, calculated in accordance with Chapter 1, using fuel mass determined per each fuel, is equal to 18.6 gCO_2eq/MJ.

The resulting FuelEU fuel mix demonstrates that the use of low-GHG intensity fuels on exempted voyages is incentivized equally to any other voyages, with the FuelEU energy scope being covered by bio-diesel.

Principles used in this example apply similarly to voyages or port calls exempted under Articles 2(3), 2(5), and 2(6) of the FuelEU. Given the limited number of ships benefiting from these Articles, specific examples are not provided.

In cases where vessels benefit from Articles 2(3), 2(4), 2(5) or 2(6) for most or all voyages and port calls within a calendar year, as explained in Example 3, it is not possible to bank a surplus of low-GHG intensity fuel to another calendar year or share it between ships if the FuelEU energy scope is relatively small and does not accommodate the entirety of low-GHG intensity fuel mass.

FuelEU applies a differentiated approach depending on whether a voyage is Intra-EEA or Extra-EEA, and whether it involves OMRs or small island ports exempted under the regulation. This creates opportunities for strategic fuel allocation and places emphasis on accurate reporting and careful interpretation of exemptions. Building on this foundation, the next chapter examines how specific technologies and fuel types, such as wind propulsion and onshore power, influence a ship's compliance balance under FuelEU.

3. Chapter 3: Technology-specific Calculations

3.1. Introduction

This Chapter is focused on **technology-specific FuelEU compliance balance results**, i.e., the impact of those technologies on the yearly compliance balance (in mass gCO_2eq), as the measure of a ship's over- or under-compliance under FuelEU (see Section 1.3). The specific technologies and fuels covered include:

- **Ice classed vessel** and **navigation in ice**: Calculation of fuel consumption adjustments;
- **Wind-assisted propulsion**: Effects of reward factors and operational fuel consumption;
- **Biomethane**: Impact of negative emissions on compliance;
- **Low-carbon and recycled fuels**: Future eligibility and main differences from Renewable Fuels of Non-Biological Origin (RFNBOs or e-fuels);
- **Zero Emission Technologies at berth (Annex III technologies)**: Impact of using Zero Emission Technologies at berth on the final yearly compliance balance.

This document does **not** include calculations or demonstrations related to GHG or sustainability certification of marine bunker fuels. Current calculations start with the GHG emission value of fuels, in gCO_2eq/MJ, as determined at point of delivery to the ship (bunkering) and as stated on the Proof of Sustainability (PoS) or equivalent document of compliance provided to the ship. For guidance on certification requirements of fuels related to FuelEU and EU ETS compliance, refer to the SAPS WS2 document titled 'Report on Marine Fuels Certification Procedures to support implementation of FuelEU.'[71]

Finally, any examples and conclusions in this Chapter are illustrative and non-exhaustive. They are intended only as **guidance for a shipping company to conduct its own more comprehensive calculations and analyses following FuelEU calculation principles and other considerations**. This document does not constitute an endorsement or recommendation for adopting particular technologies.

3.2. Key Concepts and Definitions

Below is a list of concepts and definitions used throughout this Chapter, as per the official text of the FuelEU regulation[72] (except otherwise noted):

- **'Compliance balance'** refers to the measure of a ship's over- or under-compliance with the limits for the yearly average GHG intensity of the energy used on board by a ship or the RFNBO subtarget. This calculation is performed in accordance with Part A of Annex IV, as stipulated in Article 3(35) of FuelEU.
- **'E value'** means the GHG emissions of a fuel product, in gCO_2eq/MJ, according to EU Renewable Energy Directive (RED) methodology.[73]

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[71] The Report can be found on the European Commission's Directorate-General for Mobility and Transport website for FuelEU https://transport.ec.europa.eu/transport-modes/maritime/decarbonising-maritime-transport-fueleu-maritime_en
[72] FuelEU Maritime, Regulation (EU) 2023/1805, https://eur-lex.europa.eu/eli/reg/2023/1805.
[73] Directive (EU) 2018/2001, http://data.europa.eu/eli/dir/2018/2001.

- **‘Electrical power demand at berth’** refers to the electricity used by a ship at berth to meet all energy needs of its electrical consumers onboard, as stipulated in Article 3(25) of FuelEU.
- **‘Low-carbon fuels’ (LCF)**, according to Article 2 of Directive (EU) 2024/1788 (Gas Directive), refers to the recycled carbon fuels (see ‘recycled carbon fuels’), low-carbon hydrogen and synthetic gaseous and liquid fuels the energy content of which is derived from low-carbon hydrogen (from non-renewable sources), that meet the GHG emission reduction threshold of 70 % compared to the fossil fuel comparator for RFNBOs set out in the adopted methodology pursuant to RED Article 29a(3).
- **‘Recycled carbon fuels’ (RCF)**, according to EU RED Article 2, RCF refers to liquid and gaseous fuels that are produced from liquid or solid waste streams of non-renewable origin which are not suitable for material recovery in accordance with Article 4 of Directive 2008/98/EC, or from waste processing gas and exhaust gas of non-renewable origin which are produced as an unavoidable and unintentional consequence of the production process in industrial installations. The GHG emissions savings (according to EU RED methodology, i.e., *E* value in a PoS) from the use of recycled carbon fuels should be at least 70 %.[74]
- **‘Zero-emission technology’** refers to a technology that, when used to provide energy, does not result in the release of the following greenhouse gases and air pollutants into the atmosphere by ships: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur oxides (SO_x), nitrogen oxides (NO_x) and particulate matter (PM) , as stipulated in Article 3(7) of FuelEU;
- “**Ice class**” refers to the notation assigned to a ship by the competent national authorities of the flag state or an organisation recognised by that state, indicating that the ship has been designed for navigation in sea-ice conditions, as stipulated in Article 3(21) of FuelEU.
- ‘**Sailing in ice conditions**’, also referred to in this guidance document as “navigation in ice” means the sailing by an ice-class ship in a sea area within the ice edge, as stipulated in Article 3(22) of FuelEU.
- **‘Ice edge**’ refers to the demarcation at any given time between the open sea and sea ice of any kind, whether fast or drifting, as set out in paragraph 4.4.8 of the World Meteorological Organisation Sea-Ice Nomenclature, March 2014, as stipulated in Article 3(23) of FuelEU.
- “**Wind-assisted propulsion**” means propulsion, whether partial or full, of a ship by wind energy harnessed by means of wind-assistance propulsion systems such as, among other things, rotor sails, kites, hard or rigid sails, soft sails, suction wings or turbines, as stipulated in Article 3(9) of FuelEU.
- “**Biomethane**” refers to the resulting product of upgrading biogas (a gaseous fuel produced from biomass), where biogas is purified to natural gas quality and then further liquified for use as transportation fuel in the form of liquified biomethane or Bio-LNG.

[74] Commission Delegated Regulation (EU) 2023/1185 http://data.europa.eu/eli/reg_del/2023/1185.

3.3. Technology-specific Calculations

3.3.1. Ice class and ice navigation

Annex IV of FuelEU provides that:

> *for any ship having the ice class IC, IB, IA or IA Super or an equivalent ice class, the company may request, until 31 December 2034, to exclude the additional energy consumption, due to sailing in ice conditions. For any ship having the ice class IA or IA Super or an equivalent ice class, the company may request to exclude the additional energy consumption, due to the technical characteristics of the ship*.

The fuel consumption of voyages by ships with ice class IC, IB, IA or IA Super, or an equivalent ice class, should be monitored and reported. However, for the purpose of calculating the yearly average GHG intensity of energy used on board, the energy scope will be reduced according to Annex V of FuelEU. This derogation is in the form of an adjusted amount of fuel mass under the scope of FuelEU targets, awarded to these ships since they consume more fuel navigating in ice compared to periods sailing in open water. An additional derogation is awarded if the vessel has *ice class IA or IA Super, or an equivalent ice class,* as these vessels are at a disadvantage from an energy efficiency design perspective. Both derogations are expressed as a combined deduction in the mass of fuels that fall under the scope of FuelEU calculation (Annex I and IV), as described in the methodology of Annex V of the Regulation.

To deduct a mass of fuels from FuelEU scope due to ice class and navigation in ice (combined), an **adjusted mass of fuel $M_{i,A}$** is calculated according to Annex V of the Regulation. This adjusted mass is then used **instead of the mass of fuels M_i** when calculating a ship's GHG intensity according to Annex I, as well as in calculating the compliance balance and FuelEU penalty according to Annex IV of the Regulation.

Calculations Example

In this section, a calculation example is provided for a ship with ice class 1A Super undertaking a 2-day voyage of 600 nautical miles, with 75 nautical miles navigated under ice conditions. It is assumed that the vessel consumes 7.5 tonnes of LFO (ISO 8217 Grades RMA to RMD) while navigating in ice, out of a total voyage consumption of 51.25 tonnes of LFO in both ice and open-water conditions. These fuel consumption amounts and distances are assumed to be entirely within the scope of the Regulation, as further explained in the note on Extra-EEA voyages.

Note on Extra-EEA voyages:

The starting point of the Regulation's Annex V "Calculation of adjusted mass of fuel for ice navigation" is the energy used and distance sailed "within the scope of this Regulation", according to definitions in Annex V:

> "$M_{i,\ voyages,\ total}$" (and "$M_{i,voyages,ice\ conditions}$") denotes the mass of fuel i consumed for all voyages (or for "$M_{i,voyages,ice\ conditions}$" for sailing in ice conditions) **within the scope of this Regulation**.
>
> "D_{total}" (and "$D_{ice\ conditions}$") denotes the aggregated annual distance travelled (or for "$D_{ice\ conditions}$" when sailing in ice conditions) **within the scope of this Regulation**.

The key aspect in these definitions is the expression, "**within the scope of this Regulation**", which limits the scope of Annex V calculations to 50% of the energy use and distance sailed between EEA and non-EEA port calls, as well as all other exemptions from the "scope of this Regulation", as provided in Article 2 (Scope) of the Regulation.

Therefore, for the current calculation example, all fuel (energy) amounts and distances sailed are already limited to the scope of the Regulation, i.e. **after** deducting all energy used and distance sailed that is **not** within scope of the Regulation, and allocations thereof, as illustrated in Chapter 2 (Extra-EEA Voyages).

Example: for voyages between EEA and non-EEA port calls, D_{total} is already 50% of the total distance travelled, and D_{ice} is also 50% of the distance travelled in ice conditions. Same for $M_{i,\ voyages,\ total}$ and $M_{i,voyages,ice\ conditions}$, which are each 50% of the total and "in ice" fuel consumption (respectively) on voyages between EEA and non-EEA port calls.

Table 24 shows a breakdown of the relevant numbers needed for the calculation, with the corresponding notation used in Annex V where appropriate. Although the notation from Annex V is used throughout, the calculations are presented in a different order than in Annex V for simplicity of understanding. In this document the formulas are presented in the order required for calculating the results.

Table 24. Breakdown of the relevant numbers needed for the calculation

Notation in Annex V	Description	Value
D_{total}	Total Distance	600 nm
$D_{ice\ conditions}$	Distance in ice	75 nm
$D_{open\ water} = D_{total} - D_{ice\ conditions}$	Distance in open water	525 nm
$M_{i,\ voyages} = M_{LFO}$	Total fuel (LFO)	51.25 tonnes
	Fuel in ice (LFO)	7.5 tonnes
	Fuel in open water (LFO)	43.75 tonnes
LCV_{LFO}	Lower calorific value	0.041 MJ/gram

The steps to calculate the adjusted mass of fuel are outlined. Example calculations are shown in blue text.

Step 1: Calculate energy used in ice and open water.

Energy for each sailing condition is calculated using the tonnes of fuel and corresponding Lower Calorific Value (LCV).

$$E_{voyages,\ total} = total\ fuel\ during\ voyages(tonnes) \times 1,000,000 \times LCV_{LFO}\ (MJ/gram))$$

$$E_{voyages,total} = 51.25 * 1,000,000 * 0.041$$

$$= 2,101,250\ MJ$$

$$E_{voyages,ice\ conditions} = fuel\ in\ ice\ (tonnes) \times 1,000,000 \times LCV_{LFO}\ (MJ/gram) = energy\ in\ ice\ (MJ)$$

$$E_{voyages,ice\ condition} = 7.5 \times 1,000,000 \times 0.041$$

$$= 307,500\ MJ$$

$$E_{voyages,\ open\ water} = E_{voyages,\ total} - E_{voyages,\ ice\ conditions} = energy\ in\ open\ water\ (MJ)$$

$$E_{voyages,\ open\ water} = 2,101,250 - 307,500$$

$$= 1,793,750\ MJ$$

Step 2: Calculate the adjusted energy in ice conditions.

The adjusted energy in ice conditions represents the *baseline energy in open water* that the vessel sailing in ice would have used if it had been sailing in open waters. In other words, this is the reference energy that the ship would have consumed over the distance sailed in ice, $D_{ice\ conditions}$, had the ship sailed in open water. This baseline is calculated as:

$$E_{voyages,\,ice\ conditions,\,adjusted} = D_{ice\ conditions}\ x\ (E_{voyages,\,total} - E_{voyages,\,ice\ conditions})\ /\ (D_{total} - D_{ice\ conditions}) =$$

$$= D_{ice\ conditions} \times E_{voyages,\,open\ water} / D_{open\ water} = adjusted\ energy\ in\ ice\ (MJ)$$

$$E_{voyages,\,ice\ conditions,\,adjusted} = D_{ice\ conditions} \times (E_{voyages,\,total} - E_{voyages,\,ice\ conditions})\ /\ (D_{total} - D_{ice\ conditions}) =$$

$$E_{voyages,\,ice\ conditions,\,adjusted} = 75 \times (1,793,750\ /\ 525)$$

$$= 256,250\ MJ$$

Note on cases where a ship navigates in ice throughout the entire Reporting Period:

In the event that a ship sails under ice conditions for the entire duration of the Reporting Period, the formula $E_{voyages,\ ice\ conditions,\ adjusted}$ cannot be computed due to a "divided by zero" error. This occurs because the total distance would be under ice conditions, i.e. $D_{total} = D_{ice\ conditions}$, and fuel consumption occurs only under ice conditions, i.e. $E_{voyages,\ total} = E_{voyages,\ ice\ conditions}$, resulting in:

$$E_{voyages,\,ice\ conditions,\,adjusted} = D_{ice} \times (E_{open\ water}/D_{open\ water}) =$$

$$= D_{ice} \times (E_{voyages,\,total} - E_{voyages,\,ice\ conditions})\ /\ (D_{total} - D_{ice\ conditions}) =$$

$$= D_{ice} \times (E_{voyages,\,total} - E_{voyages,\,total})\ /\ (D_{total} - D_{total}) =$$

$$= D_{ice} \times (0)\ /\ (0) = error:\ divided\ by\ zero.$$

While the situation of only sailing in ice is admittedly rare, the Regulation does not currently provide a solution for this possibility. Some potential solutions might include (if accepted by the verifier) using additional data to prove the increased fuel consumption of the vessel due to sailing in ice conditions versus open water conditions, by referring to previous Reporting Periods. Alternatively, in extreme cases, the ship could be re-routed to perform open water navigation *at least once* during the Reporting Period.

Step 3: Calculate the additional energy due to ice conditions

The additional energy due to ice conditions, which is ultimately to be deducted from the total fuel consumption to account for the excess consumption from navigating in ice, is calculated as the total energy minus the open water energy and the adjusted ice condition energy (open-water baseline for the distance sailed in ice). As set out in Annex V, there is a cap on the amount of energy that can be deducted, which is presented as a cap on the additional ice condition energy, and is set at 1.3 times the open water energy.

$$E_{additional\ due\ to\ ice\ conditions} = E_{voyages,total} - E_{voyages,open\ water} - E_{voyages,ice\ conditions,adjusted}$$

$$= additional\ energy\ from\ sailing\ in\ ice\ (MJ)$$

where $E_{additional\ due\ to\ ice\ conditions}$ cannot be higher than $1.3 * E_{voyages,\ open\ water}$

Which means that if

$$E_{voyages,\ total} - E_{voyages,\ open\ water} - E_{voyages,\ ice\ conditions,\ adjusted} > 1.3 \times E_{voyages,\ open\ water}$$

the calculation in this example yields:

$$E_{additional\ due\ to\ ice\ conditions} = E_{voyages,\ total} - E_{voyages,\ open\ water} - E_{voyages,\ ice\ conditions,\ adjusted}$$

$$= 2,101,250 - 1,793,750 - 256\ 250$$

$$= 51,250\ MJ$$

We should also check that this result satisfies:

$$E_{additional\ due\ to\ ice\ conditions} < 1.3 \times E_{voyages,\ open\ water}$$

and in this example, this is confirmed:

$E_{additional\ due\ to\ ice\ conditions} = 51,250\ MJ$, which is $< 1.3 \times 1,793,750 = 2,331,875\ MJ$

Since the condition $E_{additional\ due\ to\ ice\ conditions} < 1.3 \times E_{voyages,\ open\ water}$ is satisfied, calculation may proceed, with the result:

$$E_{additional\ due\ to\ ice\ conditions} = 51,250\ MJ$$

Step 4: Calculate the additional energy due to ice class

Once the additional energy due to ice navigation is calculated, we can proceed to calculate the additional energy due to ice class. This is because only 5% of the remaining energy, *after* deducting ice navigation energy, is allowed to be deducted.

$$E_{additional\ due\ to\ ice\ class} = 0.05 \times (E_{voyages,\ total} - E_{additional\ due\ to\ ice\ conditions})$$

$$E_{additional\ due\ to\ ice\ class} = 0.05 \times (2,101,250 - 51,250)$$

$$= 102,500\ MJ$$

Step 5: Calculate the total additional energy due to ice.

The total additional energy due to ice class and navigation in ice is the sum of both ice-class and navigation-in-ice deductions:

$$E_{additional\ ice} = E_{additional\ due\ to\ ice\ class} + E_{additional\ due\ to\ ice\ conditions}$$

$$E_{additional\ ice} = 102,500 + 51,250$$

$$= 153,750\ MJ$$

Step 6: Adjust mass of fuel

Finally this additional energy is removed from the different fuels used during the year:

$$M_{i,A} = M_i - E_{i,\,additional\ ice}/(LCV_i)$$

Where M_i is the mass of fuel (i) consumed. In this example, for LFO:

$$M_{i,A} = M_{LFO,A} = M_{LFO} - E_{LFO,\,additional\ ice}\ /\ (LCV)_{LFO})$$

$E_{i,\ additional\ ice}$ should be allocated as a share of $E_{additional\ ice}$ to each fuel. In the current example, as there is only one fuel type, all of the additional ice energy $E_{additional\ ice}$ is deducted from this fuel:

$$E_{LFO,\,additional\ ice} = E_{additional\ ice}$$

$$M_A = M_{LFO} - E_{additional\ ice}\ /\ (LCV_{LFO})$$

$$= 51.25\ tonnes - 153,750\ MJ\ /\ (0.041\ MJ/g\ *\ 1,000,000\ g/tonne)$$

$$= 47.5\ tonnes$$

Note on cases with multiple fuel types:

It should be noted that the above example is simplified, as most vessels consume more than one type of fuel. In such cases, the final calculation of adjusted mass of fuel ($M_{i,A} = M_i - E_{i,\,additional\ to\ ice}\ /\ LCV_i$) allows shipping companies to allocate the deduction due to ice class and navigation **to the fuels with highest GHG intensity**, provided there is sufficient fuel amount M_i to subtract from as $- E_{i,\,additional\ to\ ice}\ /\ LCV_i$. This is expressed in Annex V of the Regulation as:

> *The company shall allocate the total additional ice energy* $E_{i\ additional\ ice}$ *to the different fuels i used during the year, with the following conditions:*
>
> $\Sigma\, E_{i\ additional\ ice} = E_{additional\ ice}$
>
> *For each fuel i,*
>
> $E_{i,\,additional\ ice} \leq M_i \times LCV_i$

This creates a further incentive for the uptake of low-GHG intensity fuels when operating an ice-classed vessel and for vessels navigating in ice.

Finally, in order to calculate the effects on FuelEU compliance, the adjusted mass of fuel $M_{i,A}$ is applied to the calculation of GHG intensity and compliance balance formulas of Annexes I and IV, respectively (see Chapter 1). In Table 25, an example of the final voyage result demonstrates the benefits in terms of compliance balance and FuelEU penalty for the current example. As a result of applying the ice derogation, the compliance deficit and respective FuelEU penalty are both reduced, saving around 200€ in FuelEU penalties related to that single voyage: a reduced penalty of €2,564, instead of a baseline €2,767 penalty without ice derogation.

Table 25. Results of compliance balance[75] for a single voyage of 600 NM by an ice classed vessel navigating 75 NM in ice conditions

	Fuel consumption	**GHG intensity [gCO_2eq/MJ]**	**Compliance balance (CB) [ton CO_{2eq}]**	**$\Delta CB_{base\ case}$ [ton CO_{2eq}]**	**Penalty [€]**
Required - 2025-2029		**89.34**	-	-	-
Baseline without ice derogation	51.25 t LFO	91.39	-4.3	-	€2,767
With adjusted fuel mass for ice class and ice navigation	47.5 t LFO	91.39	-4.0	+0.3	€2,564

3.3.2. Wind-assisted propulsion

FuelEU rewards wind-assisted propulsion by considering a reward factor f_{wind}. This factor is applied in the GHG intensity formula (Equation 1 of Annex I of the FuelEU) which helps bring the actual GHG intensity of a ship closer or beyond the ship GHG intensity targets set in Article 4.

An additional positive consequence of installing wind-assisted propulsion for non-compliant vessels under FuelEU (e.g., a ship running solely on fossil fuels or not using enough low GHG fuels to reach the GHG intensity targets) is a reduction in fuel consumption during operation. This results in a lower compliance deficit and a correspondingly lower FuelEU penalty.

The reward factor f_{wind} as set out in Annex I is as follows:

f_{wind}	P_{wind} / P_{prop}
1	$P_{wind}/P_{prop} < 0.05$
0.99	$0.05 \leq P_{wind} / P_{prop} < 0.1$
0.97	$0.1 \leq P_{wind} / P_{prop} < 0.15$
0.95	$0.15 \leq P_{wind} / P_{prop}$

[75] Note on displayed decimals: for readability, values are rounded here, even if all calculations follow a rule of 5 decimals rounding, according to units set out in FuelEU Maritime regulation, e.g. GHG intensity in gCO2eq/MJ with 5 decimals, which is rounded to 2 decimals for display in this table.

- P_{wind} is the available effective power of the wind-assisted propulsion systems and corresponds to $f_{eff} * P_{eff}$ as calculated in accordance with the 2021 guidance on the treatment of innovative energy efficiency technologies for the calculation and verification of the attained energy efficiency design index (EEDI) and energy efficiency existing ships index (EEXI) (MEPC.1/Circ.896).[76]
- P_{Prop} is the propulsion power of the ship and corresponds to P_{ME} as defined in the 2018 guidelines on the method of calculation of the attained EEDI for new ships (IMO resolution MEPC.364(79)) and the 2021 guidelines on the method of calculation of the attained EEXI (IMO resolution MEPC.333(76)). Where shaft motor(s) are installed, $P_{Prop} = P_{ME} + P_{PTI(i), shaft}$.

Mid-year installation

The reward factor is calculated at the end of the Reporting Period based on verified documentation available on 31 December of the Reporting Period. To be eligible for the reward factor, the EEDI/EEXI technical file should be updated and verified to include the calculation of wind-assisted propulsion contribution. In the case of mid-year installation, the same reward factor is applied for the entire year. Currently FuelEU only specifies in Annex I that:

> *GHG intensity index of the ship is (...) calculated by multiplying the result of Equation (1) by the reward factor*

and no further detailed methodology is provided on how to handle periods when wind-assisted propulsion installation had not yet been verified within the Reporting Period according to EEDI for new ships (IMO resolution MEPC.364(79)) or the 2021 guidelines on the method of calculation of the attained EEXI (IMO resolution MEPC.333(76)). Therefore, the reward factor applies to the entire Equation 1 of Annex I of FuelEU, meaning the entire Reporting Period (see calculation Example 1).

3.3.3 Wind-assisted propulsion examples

Table 26 presents three scenarios that demonstrate the impact of wind-assisted propulsion on FuelEU compliance balance, GHG intensity, and associated penalties. These examples vary by installation timing, reward, and propulsion, illustrating how different design and operational choices impact compliance outcomes.

[76] EEXI evaluates the energy efficiency of existing ships to meet specific standards, while the EEDI assesses new ships' designs for compliance with IMO energy efficiency criteria. An overview and links to resolutions can be found here: https://www.imo.org/en/OurWork/Environment/Pages/Improving%20the%20energy%20efficiency%20of%20ships.aspx

Table 26. Results of compliance balance[77] for three examples of wind-assisted propulsion

	Fuel consumption	**GHG intensity [gCO_2eq/MJ]**	**Compliance balance (CB) [ton CO_{2eq}]**	**$\Delta CB_{base\ case}$ [ton CO_{2eq}]**	**Penalty [€]**
Required - 2025-2029		**89.34**	-	-	-
Baseline (only HFO and MDO/MGO)	12,000 t HFO 1,400 t MGO	91.64	-1256	-	€802,007
Example 1: Mid-year installation and f_{wind} = 0.97	11,250 t HFO 1,400 t MGO	88.88	+234	+1490	€0
	12,000 t HFO 1,400 t MGO	88.89	+245	+1500	€0
Example 2: Full Reporting Period and f_{wind} = 0.95	10,200 t HFO 1,400 t MGO	87.04	+1086	+2341	€0
	12,000 t HFO 1,400 t MGO	87.05	+1245	+2501	€0
Example 3: Full Reporting Period and f_{wind} = 0.99	11,100 t HFO 1,400 t MGO	90.71	-701	+554	€452,395
	12,000 t HFO 1,400 t MGO	90.72	-755	+500	€487,400

Example 1: Mid-year installation

In this example a ship is retrofitted with wind-assisted propulsion, with the installation taking place in July 2025. The EEDI/EEXI technical file is updated to include information on the wind-assisted propulsion and it is approved in July 2025. According to the EEDI[78] and EEXI[79] technical files the $P_{wind} = 900kW\ and\ P_{prop} = 7,000kW$.

Reward factor is calculated as:

$$P_{wind}/P_{prop} = 900/7,000 = 0.129$$

$$0.1 \leq P_{wind}/P_{prop} < 0.15$$

leading to

$$f_{wind} = 0.97$$

The same reward factor is applied for the entire Reporting Period, in this case, the year 2025, even if the installation takes place (and is verified) in the middle of the Reporting Period.

[77] **Note on displayed decimals:** for readability, values are rounded here, even if all calculations follow a rule of 5 decimals rounding, in alignment with MRV reporting, e.g. GHG intensity in $gCO2_{eq}$/MJ with 5 decimals, which is rounded to 2 decimals for display in this table.
[78] For more information, see IMO Resolution MEPC.364(79): https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.364%2879%29.pdf
[79] For more information, see IMO Resolution MEPC.333(76): https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.333(76).pdf

For demonstration purposes, the ship in this calculation example consumes the following amounts during one full Reporting Period as a **baseline case without wind-assisted propulsion**.

Fuel consumption baseline:

- **12,000** tonnes Heavy Fuel Oil (HFO) used in main engines for propulsion, and
- **1,400** tonnes Marine Gas Oil (MDO/MGO) used for auxiliary power.

For the same ship **with installed wind-assisted propulsion**, the following assumption is made' a reduction in HFO consumption is achieved in the second half of year 2025, i.e., after the installation. In this example, the reduction is estimated at approximately 12.5% savings for half of the year. Note that this is an arbitrary value and that actual fuel consumption in operation will depend on various factors related to the ship, operational profile, and weather conditions on the actual route.

Fuel consumption with savings from wind-assisted propulsion:

- **11,250** tonnes HFO used in main engines for propulsion, and
- 1,400 tonnes MDO/MGO used for auxiliary power.

Note on Example 1 in Table 26: Where it is noted that the compliance balance improves by 1,490 tonnes CO_2eq due to **lower achieved GHG intensity** relative to the baseline without wind-assisted propulsion (91.64 → 88.88 gCO_2eq/MJ). This improvement is the result of applying the **reward factor f_{wind}**. Since the achieved GHG intensity is below the 2025 target (89.34 gCO_2eq/MJ), there is no FuelEU penalty associated with this wind-assisted propulsion example, resulting in a 100% reduction in the penalty. It is noteworthy that the **reduction in yearly fuel consumption has a negative effect** on the amount of compliance surplus generated: 234 tonnes CO_2eq of compliance balance is generated in this example, which is lower than in a case without a reduction in operational fuel consumption in the baseline (i.e., if the wind-assisted propulsion equipment was not operational and HFO consumption was 12,000 tonnes). In the case of higher baseline consumption, the compliance surplus would instead be 245 tonnes CO_2eq, but this would come at the cost of higher fuel consumption (12,000 tonnes instead of 11,250 tonnes).

Example 2: Full reporting period

A ship has an approved EEDI/EEXI technical file for a full Reporting Period. The ship is equipped with engine power limitation (EPL) and wind-assisted propulsion.
According to the EEDI/EEXI technical file, P_{wind} is 1,100kW and the P_{ME} is 10,000 kW. The ship is equipped with EPL at 9,000kW. Therefore the P_{prop} considered is:

$$P_{prop} = 0.75 * P_{ME, LIM} = 0.75 * 9,000kW = 6,750kW.$$

The reward factor is calculated:

$$P_{wind} / P_{prop} = 1,100kW / (0.75 * 9,000\ kW) = 1,100kW / 6,750\ kW = 0.163$$

$$0.15 \leq P_{wind} / P_{prop} \ = \ 0.163$$

$$f_{wind} = \ 0.95$$

For demonstration purposes, a baseline ship **without wind-assisted propulsion** consumes the same amount of fuel as in the previous example (12,000 tonnes HFO and 1,400 tonnes MGO).

For the same ship **with installed wind-assisted propulsion**, it is assumed that some HFO consumption reduction is achieved throughout the entire year. In this example, the reduction is estimated at approximately 15% savings for the entire year. As with the first example, this is an arbitrary value, actual values depend on a number of factors related to the ship, operational profile, and weather conditions on the actual route.

Fuel consumption with savings from wind-assisted propulsion:

- **10,200** tonnes Heavy Fuel Oil, HFO, used in main engines for propulsion, and
- 1,400 tonnes Marine Gas Oil, MDO/MGO, used for auxiliary power.

Note on Example 2 in Table 26: Where it is noted that the compliance balance improves by 2,341 tonnes CO_2eq due to the **lower achieved GHG intensity** relative to the baseline without wind-assisted propulsion (91.64 → 87.04 gCO_2eq/MJ). This improvement is the result of applying the **reward factor f_{wind}**. Since the achieved GHG intensity is below the 2025 target (89.34 gCO_2eq/MJ), there is no FuelEU penalty associated with this wind-assisted propulsion example, resulting in a 100% reduction in the penalty.

As with the first example, the **reduction in yearly fuel consumption has a negative effect** on the amount of compliance surplus generated: 1,086 tonnes of CO_2eq compliance balance is generated in this example, which is lower than in a case without a reduction in operational fuel consumption in the baseline (i.e. if the wind-assisted propulsion equipment was not operational and HFO consumption was 12,000 tonnes). In the case of higher baseline consumption, the compliance surplus would instead be 1,245 tonnes CO_2eq, but this would come at the cost of a higher fuel consumption (12,000 tonnes instead of 10,200 tonnes).

Example 3: Non-conventional propulsion

The ship has non-conventional propulsion (diesel-electric) and is therefore exempted from reaching the EEDI/EEXI target, but the ship still needs to generate and submit an EEDI/EEDI technical file for verification. Thus, following the same principles and verification as would have been required for EEDI/EEXI target, the power used for propulsion is in this example 7,000kW, and the respective reference vessel speed is 16kn. Also, the P_{wind} at a ship speed of 16kn is 400 kW in this example.

Calculation of the reward factor is as follows:

$$P_{prop} \ = \ 7,000 \ kW, \ P_{wind} \ = \ 400 \ kW$$

$$P_{wind}/P_{prop} = 400\,kW\,/\,7{,}000kW = 0.057$$

$$0.05 \le P_{wind}/P_{prop} = 0.057 < 0.1$$

$$f_{wind} = 0.99$$

For demonstration purposes, a baseline ship **without wind-assisted propulsion** consumes the same amounts as in the previous example (12,000 tonnes HFO and 1,400 tonnes MGO).

It is assumed that with wind-assisted propulsion, a reduction in HFO consumption is achieved throughout the year. In this example, the reduction is estimated at approximately 7.5%. As with previous examples this is an arbitrary value, actual values will rely on various factors related to the ship, its operational profile and weather conditions on the actual route.

Fuel consumption with savings from wind-assisted propulsion:

- **11,100** tonnes Heavy Fuel Oil, HFO, used in main engines for propulsion, and
- 1,400 tonnes Marine Gas Oil, MDO/MGO, used for auxiliary power.

Example 3 results in Table 26 show that the compliance balance improves by 554 tonnes CO_2eq due to **lower achieved GHG intensity** relative to the baseline without wind-assisted propulsion (91.64 → 90.71 gCO_2eq/MJ). This improvement is attributed to the application of the **reward factor f_{wind}.** However, the achieved GHG intensity is not compliant with the 2025 target (89.34 gCO_2eq/MJ), resulting in a compliance deficit of -701 tonnes CO_2eq and a **FuelEU penalty** of ~€ 0.45 million. Despite having a penalty, it is significantly lower than the baseline penalty without wind-assisted propulsion (~€0.8 million), due to the **combined effect of the reward factor f_{wind} and reduced operational fuel consumption**. The **reduction in yearly fuel consumption positively impacts** the compliance deficit, decreasing it by 54 tonnes CO_2eq compared to the baseline scenario without operational wind-assisted propulsion equipment and with HFO consumption of 12,000 tonnes. In such a scenario with higher consumption (wind-assisted propulsion installed, but not in use), the compliance deficit would be -755 tonnes CO_2eq, leading to a higher FuelEU penalty of ~€0.487 million (example 3.2.3 with 12,000 tonnes HFO / year), instead of ~€0.452 million (example 3.2.3 with 11,100 tonnes HFO / year).

3.4. Biomethane: Negative or Zero WtT Emissions

FuelEU recognizes that biogas can be utilized to meet a ship's GHG intensity reduction targets.[80] "Biogas" is defined as gaseous fuels produced from biomass, which can be purified to natural gas quality, resulting in biomethane.[81] Biomethane can then be further liquified to produce liquified biomethane, or "Bio-LNG" as it is called in the FuelEU, using the same

[80] Article 10(1a) of Regulation (EU) 2023/1805. The biogas must derive from waste and residues from Annex IX Part A of Directive (EU) 2018/2001, and not from food/feed crops.
[81] Article 3(3) of Regulation (EU) 2023/1805.

liquefaction process as fossil-based natural gas to LNG. Bio-LNG, like all non-fossil fuels, should be certified under a voluntary scheme recognized by the European Commission.[82]

Bio-LNG can be certified as having zero or negative well-to-wake emission intensity. Vessel operators can account for Bio-LNG with zero or negative well-to-wake emission intensity towards their vessel's GHG intensity reduction target. Therefore, guidance on how to apply calculations for Bio-LNG with zero or negative well-to-wake emission intensity within the context of FuelEU is deemed useful.

In the context of FuelEU, the *E* value is used, and this value can be negative. The well-to-tank GHG emission factor $CO_{2eq,wtt}$ for Bio-LNG will apply a deduction of C_{fCO2} (as stated in Annex II of FuelEU), which will be subtracted from the *E* value presented in the PoS, yielding:

$$CO_{2eqWtT,\, BioLNG} = E\,(BioLNG) - C_{fCO2}/LCV(BioLNG)$$

This deduction is intended to offset the biogenic CO_2 combustion emissions of Bio-LNG, resulting in net-zero emissions from a biogenic carbon perspective.

3.4.1 Biomethane examples

The following examples demonstrate how Biomethane with negative or zero well-to-wake GHG intensity, used across different engine types, affects compliance balance and FuelEU penalties.

Example 1: Vessel uses bio-LNG (-15 gCO_2eq/MJ) - DF Otto medium speed

A vessel uses Bio-LNG in a dual-fuel (DF) Otto-cycle medium speed engine. The biomethane was produced from manure. Based on the proof of sustainability (an example value is presented here for demonstration purpose only, not corresponding to any actual product nor any default value), the following GHG emissions according to EU RED certification are obtained:

$$E\,(BioLNG) = -15.00\, gCO_2e/MJ,$$

Note: the Bio-LNG GHG intensity value is an example for the purpose of demonstrating the calculations.

$$C_{fCO2}/LCV\,(BioLNG) = (2.750\, gCO_2/gFuel\,/\,0.050\, MJ/gFuel) = 55.00\ gCO_2e/MJ,$$

The well-to-tank emissions for this fuel become:

$$CO_{2eqWtT,\, BioLNG} = E\,(BioLNG) - CfCO_2/LCV(BioLNG) = -15.00 - 55.00 = -70.00\, gCO_2eq/MJ$$

[82] Article 10(3) of Regulation (EU) 2023/1805. For more information on biomethane and Bio-LNG certification, refer to Report on Marine Fuels Certification Procedures to support implementation of FuelEU Maritime.

A simplified well-to-wake emissions calculation for Bio-LNG yields:

$$GHG\ Intensity\ WtW\ of\ BioLNG\ [gCO_2eq/MJ] = CO_{2eq\,WtT,i}/RWD_i +$$
$$+ (1 - C_{slip\,j}/100)\times CO_{2eq,\,TtW,i,j}/(LCV_i \times RWD_i) +$$
$$+ (C_{slip\,j}/100)\times CO_{2eq\,TtW,\,slip\,i,j}/(LCV_i \times RWD_i) =$$

$$= (E - C_{fCO2,j}/LCV_i)/RWD_i +$$
$$+ (1 - C_{slip\,j}/100)\times (C_{fCO2,j}\times GWP_{CO2} + C_{fCH4,j}\times GWP_{CH4} + C_{fN2O,j}\times GWP_{N2O})_i/(LCV_i \times RWD_i) +$$
$$+ (C_{slip\,j}/100)\times (C_{sfCH4,j}\times GWP_{CH4})/(LCV_i \times RWD_i) =$$

$$= (-15 - 2.750/0.050)/1 +$$
$$+ (1 - 3.1/100)\times (2.750\times 1 + 0\times 25 + 0.00011\times 298)/(0.050\times 1) +$$
$$+ (3.1/100)\times (1\times 25)/(0.050\times 1) =$$

$$= -0.56972\ gCO_2eq/MJ$$

During one Reporting Period, the ship in this example consumes:

- Example 1a (100% Bio-LNG):
  - 0 metric tons Fossil LNG
  - 9,720 metric tons Bio-LNG
  - 1,400 tonnes MDO/MGO.
- Example 1b (30% Bio-LNG):
  - 6,929 metric tons Fossil LNG
  - 2,916 metric tons Bio-LNG
  - 1,400 tonnes MDO/MGO.

Compliance balance results are presented in Table 27. The amount of Bio-LNG, combined with the consumption of other fuels (MDO/MGO and LNG), is sufficient to achieve compliance (CB > 0), resulting in a zero FuelEU penalty.

Table 27. Results[83] for two examples with Bio-LNG, compared to a baseline with only conventional fossil LNG and MGO/MDO

	GHG intensity [gCO_2eq/MJ]	Compliance balance (CB) [ton CO_{2eq}]	$\Delta CB_{base\ case}$ [ton CO_{2eq}]	Penalty [€]
Required - 2025-2029	**89.34**	-	-	-
Baseline (only LNG and MDO/MGO)	89.37	-21	-	€14,171
Example 1a - Bio-LNG, 9,720 tonnes	9.43	+43,609		€0
Example 1b - Bio-LNG, 2,916 tonnes	65.39	+13,068		€0

[83] **Note on displayed decimals:** for readability, values are rounded here, even if all calculations follow a rule of 5 decimals rounding, in alignment with MRV reporting, e.g. GHG intensity in $gCO2_{eq}$/MJ with 5 decimals, which is rounded to 2 decimals for display in this table.

Example 2: Vessel uses bio-LNG (-15 gCO_2eq/MJ) - DF Diesel slow speed

A vessel uses Bio-LNG in a DF Diesel slow speed engine. The Bio-LNG was produced from manure (an example value is presented here for demonstration purpose only, not corresponding to any actual product nor any default value). As shown in Example 1, the well-to-tank emissions for this fuel become:

$$CO_{2eqWtT,\, BioLNG} = E\,(BioLNG) - CfCO_2/LCV(BioLNG) = -15.00 - 55.00 = -70.00\; gCO_2eq/MJ$$

Note: the Bio-LNG GHG intensity value is an example for the purpose of demonstrating the calculations.

A simplified well-to-wake emissions calculation for Bio-LNG yields:

$$GHG\ Intensity\ WtW\ of\ BioLNG\ [gCO_2eq/MJ] = CO_{2eq\,WtT,i}/RWD_i +$$
$$+ (1 - C_{slip\,j}/100) \times CO_{2eq,\,TtW,i,j}/(LCV_i \times RWD_i) +$$
$$+ (C_{slip\,j}/100) \times CO_{2eq\,TtW,\,slip\,i,j}/(LCV_i \times RWD_i) =$$

$$= (E - C_{fCO2,j}/LCV_i)/RWD_i +$$
$$+ (1 - C_{slip\,j}/100) \times (C_{fCO2,j} \times GWP_{CO2} + C_{fCH4,j} \times GWP_{CH4} + C_{fN2O,j} \times GWP_{N2O})_i/(LCV_i \times RWD_i) +$$
$$+ (C_{slip\,j}/100) \times (C_{sfCH4,j} \times GWP_{CH4})/(LCV_i \times RWD_i) =$$

$$= (-15 - 2.750/0.050)/1 +$$
$$+ (1 - 0.2/100) \times (2.750 \times 1 + 0 \times 25 + 0.00011 \times 298)/(0.050 \times 1) +$$
$$+ (0.2/100) \times (1 \times 25)/(0.050 \times 1) =$$

$$= -13.45571\; gCO_2eq/MJ$$

During one Reporting Period, the ship in this example consumes:

- Example 2a (100% Bio-LNG):
  - 0 metric tons Fossil LNG
  - 9,720 metric tons Bio-LNG
  - 1,400 tonnes MDO/MGO.
- Example 2b (30% Bio-LNG):
  - 6,929 metric tons Fossil LNG
  - 2,916 metric tons Bio-LNG
  - 1,400 tonnes MDO/MGO.

Compliance balance results are presented in Table 28. The combined consumption of Bio-LNG with the consumption of other fuels (MDO/MGO and LNG), is sufficient to achieve compliance (CB > 0), resulting in a zero FuelEU penalty.

Table 28. Results[84] for two examples with Bio-LNG, compared to a baseline with only conventional fossil LNG and MGO/MDO

	GHG intensity [gCO_{2eq}/MJ]	**Compliance balance (CB) [ton CO_{2eq}]**	**$\Delta CB_{base\ case}$ [ton CO_{2eq}]**	**Penalty [€]**
Required - 2025-2029	**89.34**	-	-	-
Baseline (only LNG and MDO/MGO)	77.72	+6,241	-	€0
Example 2a - Bio-LNG, 9,720 tonnes	-2.04	+49,871		€0
Example 2b - Bio-LNG, 2,916 tonnes	53.77	+19,411		€0

Example 3: Vessel uses bio-LNG (0 gCO_2eq/MJ) - DF Otto medium speed

A vessel uses Bio-LNG in a DF Otto medium speed engine. Bio-LNG is produced from bio-waste. Based on the proof of sustainability, the following GHG emissions are obtained according to EU RED certification:

$$E\,(BioLNG) \;=\; 0.00\; gCO_2eq/MJ,$$

Note: the Bio-LNG GHG intensity value is an example for the purpose of demonstrating the calculations.

$$C_{fCO2}/LCV\,(BioLNG) \;=\; (2.750\; gCO_2/gFuel\,/\,0.050\; MJ/gFuel) \;=\; 55.00\;\; gCO_2eq/MJ,$$

The well-to-tank emissions for this fuel become:

$$CO_{2eqWtT,\,BioLNG} = E\,(BioLNG) - \;CfCO_2/LCV(BioLNG) \;=\; 0.00 \;-\; 55.00 \;=\; -55.00\; gC_2eq/MJ$$

A simplified well-to-wake emissions calculation for Bio-LNG yields:

$$\begin{aligned} GHG\ Intensity\ WtW\ of\ BioLNG\,[gCO_2eq/MJ] \;&=\; CO_{2eq\,WtT,i}/RWD_i + \\ &+ (1 - C_{slip\,j}/100)\times CO_{2eq,\,TtW,i,j}/(LCV_i\times RWD_i) + \\ &+ (C_{slip\,j}/100)\times CO_{2eq\,TtW,\,slip\,i,j}/(LCV_i\times RWD_i) = \end{aligned}$$

$$\begin{aligned} &= (E \;-\; C_{fCO2,j}/LCV_i)/RWD_i + \\ &+ (1 - C_{slip\,j}/100)\times (C_{fCO2,j}\times GWP_{CO2} + C_{fCH4,j}\times GWP_{CH4} + C_{fN2O,j}\times GWP_{N2O})_i/(LCV_i\times RWD_i) + \\ &+ (C_{slip\,j}/100)\times (C_{sfCH4,j}\times GWP_{CH4})/(LCV_i\times RWD_i) = \end{aligned}$$

$$\begin{aligned} &= (0 \;-\; 2.750/0.050\,)/1 + \\ &+ (1 - 3.1/100)\times (2.750\times 1 + 0\times 25 + 0.00011\times 298)\,/(0.050\times 1) + \\ &+ (3.1/100)\times (1\times 25\,)/(0.050\times 1) = \\ &= 14.43\; gCO_2eq/MJ \end{aligned}$$

[84] **Note on displayed decimals:** for readability, values are rounded here, even if all calculations follow a rule of 5 decimals rounding, in alignment with MRV reporting, e.g. GHG intensity in $gCO2_{eq}$/MJ with 5 decimals, which is rounded to 2 decimals for display in this table.

During one Reporting Period, the ship in this example consumes:

- Example 3a (100% Bio-LNG):
  - 0 metric tons Fossil LNG
  - 9,720 metric tons Bio-LNG
  - 1,400 tonnes MDO/MGO.
- Scenario 3b (30% Bio-LNG):
  - 6,929 metric tons Fossil LNG
  - 2,916 metric tons Bio-LNG
  - 1,400 tonnes MDO/MGO.

Compliance balance results are presented in Table 29. The combined consumption of Bio-LNG with the consumption of other fuels (MDO/MGO and LNG), is sufficient to achieve compliance (CB > 0), resulting in a zero FuelEU penalty.

Table 29. Results[85] for two examples with Bio-LNG, compared to a baseline with only conventional fossil LNG and MGO/MDO

	GHG intensity [gCO_2eq/MJ]	Compliance balance (CB) [ton CO_{2eq}]	$\Delta CB_{base\ case}$ [ton CO_{2eq}]	Penalty [€]
Required - 2025-2029	**89.34**	-	-	-
Baseline (only LNG and MDO/MGO)	89.37	-21	-	€14,171
Example 3a: Bio-LNG, 9,720 tonnes	22.79	+36,319		€0
Example 3b: Bio-LNG, 2,916 tonnes	69.40	+10,881		€0

Example 4: Vessel uses bio-LNG (0 gCO_2eq/MJ) - DF Diesel slow speed

A vessel uses Bio-LNG in a dual-fuel (DF) Diesel slow speed engine. The biomethane was produced from manure. As shown in Example 3, the well-to-tank emissions for this fuel become:

$$CO_{2eqWtT,\,BioLNG} = E\,(BioLNG) - \,CfCO_2/LCV(BioLNG) \;=\; 0.00 \;-\; 55.00 \;=\; -70.00\;gCO_2eq/MJ$$

Note: the Bio-LNG GHG intensity value is an example for the purpose of demonstrating the calculations.

A simplified well-to-wake emissions calculation for Bio-LNG yields:

$$GHG\ Intensity\ WtW\ of\ BioLNG\ [gCO_2eq/MJ] \;=\; CO_{2eq\ WtT,i}/RWD_i \;+$$
$$+\;(1 - C_{slip\ j}/100)\times\,CO_{2eq,\,TtW,i,j}\,/(LCV_i\times RWD_i)\;+$$
$$+\;(C_{slip\ j}/100)\times\,CO_{2eq\ TtW,\,slip\ i,j}\,/(LCV_i\times RWD_i)\;=$$

[85] **Note on displayed decimals:** for readability, values are rounded here, even if all calculations follow a rule of 5 decimals rounding, according to units set out in FuelEU Maritime regulation, e.g. GHG intensity in $gCO2_{eq}/MJ$ with 5 decimals, which is rounded to 2 decimals for display in this table.

$$= (E - C_{fCO2,j}/LCV_i)/RWD_i +$$
$$+ (1 - C_{slip\,j}/100)\times(C_{fCO2,j}\times GWP_{CO2} + C_{fCH4,j}\times GWP_{CH4} + C_{fN2O,j}\times GWP_{N2O})_i/(LCV_i\times RWD_i) +$$
$$+ (C_{slip\,j}/100)\times(C_{sfCH4,j}\times GWP_{CH4})/(LCV_i\times RWD_i) =$$

$$= (0.00 - 2.750/0.050)/1 +$$
$$+ (1 - 0.2/100)\times(2.750\times1 + 0\times25 + 0.00011\times298)/(0.050\times1) +$$
$$+ (0.2/100)\times(1\times25)/(0.050\times1) =$$

$$= 14.43\ gCO_2eq/MJ$$

During one Reporting Period, the ship in this example consumes:

- Example 4a (100% Bio-LNG):
  - 0 metric tons Fossil LNG
  - 9,720 metric tons Bio-LNG
  - 1,400 tonnes MDO/MGO.
- Example 4b (30% Bio-LNG):
  - 6,929 metric tons Fossil LNG
  - 2,916 metric tons Bio-LNG
  - 1,400 tonnes MDO/MGO.

Compliance balance results are presented in Table 30. The combined consumption of Bio-LNG with the consumption of other fuels (MDO/MGO and LNG), is sufficient to achieve compliance (CB > 0), resulting in a zero FuelEU penalty.

Table 30. Results[86] for two examples with Bio-LNG, compared to a baseline with only conventional fossil LNG and MGO/MDO

	GHG intensity [gCO_2eq/MJ]	Compliance balance (CB) [ton CO_{2eq}]	$\Delta CB_{base\ case}$ [ton CO_{2eq}]	Penalty [€]
Required - 2025-2029	**89.34**	-	-	-
Baseline (only LNG and MDO/MGO)	77.72	+6,241	-	€0
Example 4a: Bio-LNG, 9,720 tonnes	11.32	+42,581		€0
Example 4b: Bio-LNG, 2,916 tonnes	57.78	+17,224		€0

3.5. Low-Carbon and Recycled Fuels

In addition to biofuels[87] and RFNBO/e-fuels, FuelEU also recognizes the following certified fuels towards meeting ship GHG intensity reduction targets:

- **Low Carbon Fuels (LCF)**: Derived from non-renewable sources, including fossil energy with carbon capture and storage (CCS) and nuclear power energy, the

[86] **Note on displayed decimals:** for readability, values are rounded here, even if all calculations follow a rule of 5 decimals rounding, in alignment with MRV reporting, e.g. GHG intensity in $gCO2_{eq}$/MJ with 5 decimals, which is rounded to 2 decimals for display in this table.
[87] Excluding food and feed crop biofuels.

energy content of which is derived from low-carbon hydrogen (from non-renewable sources), following the definition in Article 2 of Directive (EU) 2024/1788 (Gas Directive).

- **Recycled Carbon Fuels (RCF)**: Specific type of low-carbon fuels produced from liquid or solid waste streams of non-renewable origin that are not suitable for material recovery in accordance with Article 4 of Directive 2008/98/EC, or from waste processing gas and exhaust gas of non-renewable origin which are produced as an unavoidable and unintentional consequence of industrial production process, following the definition in Article 2 of Directive (EU) 2018/2001 (Renewable Energy Directive).

These fuels should be certified[88] under a scheme recognised by the Commission in accordance with Article 30(5) and (6) of Directive (EU) 2018/2001 or, where applicable, the relevant provisions of Union legal acts concerning the internal markets in renewable and natural gases and in hydrogen.

RCFs are certified according to a methodology for assessing GHG emissions savings, as per Regulation (EU) 2023/1185 supplementing EU RED. An equivalent methodology is still being drafted for LCFs,[89] which are defined as fuels with energy content derived from non-renewable sources.

Nevertheless, calculation guidance within the context of FuelEU is useful to illustrate how calculations would be applied to both RCFs and LCFs. This guidance is based on the already mandated minimum greenhouse gas emission reduction criteria[90] for both these classes of fuels, which require **at least a 70 % reduction** compared to the fossil fuel comparator for transport fuels of 94 gCO_2eq/MJ.[91] This minimum reduction means that the **maximum** GHG emission will be stated in a PoS (or equivalent certification document) as a **maximum *E* value** GHG emissions of:

$$E\,(RCF) \leq (100\% - 70\%) \times 94 = 28.20000\; gCO_2eq/MJ$$

$$E\,(LCF) \leq (100\% - 70\%) \times 94 = 28.20000\; gCO_2eq/MJ$$

Similarly to the RFNBO case, the *E* value in the PoS document for an RCF or an LCF already includes fuel-in-use (combustion) emissions according to EU RED methodology (note: this differs in most cases from FuelEU definition of tank-to-wake emissions). The *E* value for RCFs and LCFs is used under FuelEU in a manner equivalent to the calculation examples for RFNBOs/e-fuels (see Section 1.2.4), where *E* includes a TtW component "e_u", representing "emissions from combusting the fuel in its end-use (gCO_2eq/MJ fuel)", which

[88] Article 10 - Certification of fuels and emission factors, Regulation - 2023/1805 - EN - EUR-Lex, Official Journal of the European Union, 22.9.2023. https://eur-lex.europa.eu/eli/reg/2023/1805/oj
[89] For more information, see draft Delegated Regulation https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=intcom%3Ares%282024%296848064.
[90] Commission Delegated Regulation (EU) 2023/1185 http://data.europa.eu/eli/reg_del/2023/1185 for RCFs, and Directive (EU) 2024/1788, http://data.europa.eu/eli/dir/2024/1788 for LCFs.
[91] Commission Delegated Regulation (EU) 2023/1185 http://data.europa.eu/eli/reg_del/2023/1185 for RCFs: Annex A.2.: "For all renewable liquid and gaseous transport fuels of non-biological origin and recycled carbon fuels, the total emissions from the fossil fuel comparator shall be 94 gCO2eq/MJ", and Directive (EU) 2024/1788, http://data.europa.eu/eli/dir/2024/1788 for LCFs: Article 2 - Definition (13) "'low-carbon fuels' (...) compared to the fossil fuel comparator for renewable fuels of non-biological origin set out in the methodology adopted pursuant to Article 29a(3) of Directive (EU) 2018/2001".

refer to the "total combustion emissions of the fuel in use"[92]. Under FuelEU Annex I, the calculation "Methodology for establishing the GHG intensity of the energy used on board by a ship", requires that the well-to-tank GHG emission factor CO_{2eqWtT} for RFNBOs and RCFs (and by extension LCFs, once the methodology for GHG certification is in place) will necessarily apply a deduction of "e_u" , to be subtracted from the E value presented in the PoS or equivalent certification document, yielding:

$$CO_{2eqWtT,\,RCF} = E\,(RCF) - \; e_u(RCF)$$
$$CO_{2eqWtT,\,LCF} = E\,(LCF) - \; e_u(LCF)$$

To avoid erroneously double-counting emissions of the fuel in use, it's important to note that the GHG intensity formula (Equation 1) in FuelEU Annex I already includes combustion emissions under tank-to-wake emissions of combusted fuel, "$CO_{2eqTtWi,j}$".[93]

Additionally, the **RFNBO reward factor does not apply to RCF and LCF**. This distinction is crucial: RFNBOs are rewarded with a multiplier of '2' applied to the fuel energy in the denominator of GHG intensity (Article 5(1) and Annex I of FuelEU). This reward factor (RWD_i = 2) is applicable from 1 January 2025 to 31 December 2033. However, this reward factor **does not apply for RCFs and LCFs**, as they are **not covered under Article 5,** "Use of Renewable Fuels of Non-Biological Origin".[94] Therefore, an RWD_i of '1' applies if fuel *i* is certified as an RCF or LCF.

3.5.1 Low-carbon and recycled fuels examples

The following examples demonstrate how certified LCF and RCF affect a ship's compliance balance and FuelEU penalties, particularly in the absence of a reward factor multiplier.

Example 1: Recycled Carbon Fuel (RCF)

A ship uses certified recycled carbon methanol RCF methanol, produced from a solid non-renewable waste stream that is unsuitable for material recovery.[95]

Based on the PoS (or an equivalent certification document) provided with the fuel delivery, the following GHG emissions are obtained according to EU RED certification, exemplified here with a limit value, i.e., the highest accepted in EU RED:[96]

$$E\,(RCF\ Methanol) \; = 28.20000\ gCO_2eq/MJ,$$

of which: $e_u\,(RCF\ Methanol) \; = 68.9\ gCO_2eq/MJ$[97]

[92] Commission Delegated Regulation (EU) 2023/1185 http://data.europa.eu/eli/reg_del/2023/1185, Annex A.1. (formula for *E* value) and A.13.: "Emissions from combustion of the fuel refer to the total combustion emissions of the fuel in use".
[93] FuelEU Maritime, Regulation (EU) 2023/1805, https://eur-lex.europa.eu/eli/reg/2023/1805, Annex I.
[94] FuelEU Maritime, Regulation (EU) 2023/1805, https://eur-lex.europa.eu/eli/reg/2023/1805, Article 5.
[95] In accordance with Article 4 of Directive 2008/98/EC.
[96] Commission Delegated Regulation (EU) 2023/1185 http://data.europa.eu/eli/reg_del/2023/1185 for RCFs.
[97] Combustion emissions for methanol, according to Annex B. of Commission Delegated Regulation (EU) 2023/1185 http://data.europa.eu/eli/reg_del/2023/1185.

Note that "$e_u > E$" even if "e_u" is a parcel of "E", due to another parcel of the E formula being negative, specifically "$-e_{ex-use}$" which represents avoided "emissions from inputs' existing use or fate" ([98]).

The well-to-tank emissions for this fuel become:

$$CO_{2eqWtT,\,RCF} = E\,(RCF) - e_u(RCF) = 28.2 - 68.9 = -40.7\,gCO_2eq/MJ$$

The entire well-to-wake emissions calculation for this fuel is thus (note: here RCF methanol fuel is shown in isolation from all other energy consumed onboard):

$$GHG\ Intensity\ WtW\ of\ RCF\ methanol\,[gCO_2eq/MJ] = CO_{2eq\,WtT,i}/RWD_i +$$
$$+ (C_{fCO2,j}\times GWP_{CO2} + C_{fCH4,j}\times GWP_{CH4} + C_{fN2O,j}\times GWP_{N2O})_i/(LCV_i\times RWD_i) =$$

$$= (-40.7)/(1) + (1.375\times1 + 0.00005\times25 + 0.00018\times298)/(0.0199\times1) =$$
$$= 31.15377\,gCO_2eq/MJ$$

From here, the calculation steps are the same as in Section 1.2.4, except that the multiplier of 2 as a reward factor for RFNBOs **does not apply** to RCF methanol in the denominator of GHG intensity calculation.

In this example, the ship consumes the following amounts over the course of 1 year (full year 2025), with the baseline case of consuming only HFO and MDO/MGO given in brackets:

- 11,460 tonnes HFO (baseline: 12 000 tonnes HFO)
- 1,100 tonnes RCF methanol (baseline: 0 tonnes methanol)
- 1,400 tonnes MDO/MGO (baseline: 1400 tonnes MDO/MGO).

Compliance balance results are presented in Table 31. The amount of RCF methanol, combined with the consumption of other fuels (HFO and MDO/MGO), is sufficient to achieve compliance (CB = 70 ton CO_{2eq} > 0), resulting in zero FuelEU penalty. It should be noted that the energy from RCF methanol is **not** double counted (no RFNBO reward multiplier applicable, RWD = 1). Therefore, the amount of RCF methanol (~1,100 tonnes) required to reach compliance (i.e. a CB of at least 0 or positive) is larger than the amount of e-methanol needed (~400 tonnes of e-methanol, Section 1.4 - Example 6). This is due to two factors: a) No reward factor for RCF methanol ($RWD_{RCF\ methanol}$ = 1) and b) The certified GHG emissions (*E* value) assumed for RCF methanol (*E* = 28.2 gCO_2eq/MJ) are higher than those assumed for e-methanol (*E* = 5 to 10 gCO_2eq/MJ, Section 1.4 - Example 6).

Table 31. Results[99] for three examples with blend-in of a RCF and two LCFs, compared to a baseline with only conventional fossil HFO and MDO, and cases with e-methanol Section 1.4 - Example 6

[98] Commission Delegated Regulation (EU) 2023/1185 http://data.europa.eu/eli/reg_del/2023/1185
[99] **Note on displayed decimals:** for readability, values are rounded here, even if all calculations follow a rule of 5 decimals rounding, in alignment with MRV reporting, e.g. GHG intensity in $gCO2_{eq}$/MJ with 5 decimals, which is rounded to 2 decimals for display in this table.

	GHG intensity [gCO_2eq/MJ]	Compliance balance (CB) [ton CO_{2eq}]	$\Delta CB_{base\ case}$ [ton CO_{2eq}]	Penalty [€]
Required - 2025-2029	**89.34**	-	-	-
Baseline (only HFO and MDO/MGO)	91.64	-1,256	-	€802,007
11,460 t HFO + 400 t e-methanol	89.15	+101	-1357	€0
3.4.5-1 - RCF methanol, 1,100 tonnes	89.21	+70	-1326	€0
3.4.5-2 - LCF methanol, 1,100 tonnes	89.21	+70	-1326	€0
3.4.5-3 - LCF ammonia, **1,176** tonnes	89.21	+70	-1326	€0

Example 2: Low Carbon Fuel (LCF), carbon-containing fuel

A ship uses certified low-carbon methanol (LCF methanol), produced from energy sourced from low-carbon hydrogen. In this example, the hydrogen is produced by steam-reforming of natural gas with carbon capture and storage[100] (CCS), combined with a biogenic CO_2 source[101].

Based on the PoS (or an equivalent certification document) provided with the fuel delivery, the following GHG emissions are obtained according to EU RED certification, exemplified here with a limit value, i.e. the highest accepted in EU RED:[102]

$$E\ (LCF\ Methanol)\ =\ 28.20000\ gCO_2eq/MJ,$$

of which: $e_u\ (LCF\ Methanol)\ =\ 68.9\ gCO_2eq/MJ$[103]

Note that "$e_u > E$" even if "e_u" is a parcel of "E", due to another parcel of the *E* formula being negative, namely " $-\ e_{ex-use}$" which represents avoided "emissions from inputs' existing use or fate" ([104]).

The well-to-tank emissions for this fuel become:

$$CO_{2eqWtT,\ LCF} = E\ (LCF) -\ e_u(LCF)\ =\ 28.2 -\ 68.9\ = -40.7\ gCO)_2eq/MJ$$

The entire well-to-wake emissions calculation for this fuel is as follows (note: here LCF methanol fuel is shown in isolation of all other energy consumed onboard):

$$GHG\ Intensity\ WtW\ of\ LCF\ methanol\ [gCO_2eq/MJ]\ =\ CO_{2eq\ WtT,i}/RWD_i\ +$$
$$+\ (C_{fCO2,j}\times GWP_{CO2} + C_{fCH4,j}\times GWP_{CH4} + C_{fN2O,j}\times GWP_{N2O})_i/(LCV_i\times RWD_i)\ =$$

[100] Note: the carbon incorporated in the chemical composition of the low-carbon methanol is NOT from natural gas (this carbon is captured for geological storage permitted under Directive 2009/31/EC), but instead from a separate carbon source, in this example a biogenic carbon source.
[101] Referring to latest draft of Commission Delegated Regulation supplementing Directive (EU) 2024/1788, in this example the captured CO_2 stems from biofuels, bioliquids or biomass fuels complying with the sustainability and greenhouse gas saving criteria set out in Article 29 of Directive (EU) 2018/2001.
[102] Directive (EU) 2024/1788, http://data.europa.eu/eli/dir/2024/1788 for LCFs.
[103] Combustion emissions for methanol, according to Annex B. of Commission Delegated Regulation (EU) 2023/1185 http://data.europa.eu/eli/reg_del/2023/1185.
[104] For more information, see the latest draft of Commission Delegated Regulation supplementing Directive (EU) 2024/1788.

$$= (-40.7)/(1) + (1.375\times1 + 0.00005\times25 + 0.00018\times298)/(0.0199\times1) =$$
$$= 31.15377\ gCO_2eq/MJ$$

From here, the calculation steps are the same as in Section 1.2.4, except that the multiplier of 2 as a reward factor for RFNBOs does **not** apply to LCF methanol in the denominator of the GHG intensity calculation.

In this example, the ship consumes the following amounts over the course of 1 year (full year 2025), with the baseline case of consuming only HFO and MDO/MGO given in brackets:

- 11,460 tonnes HFO (baseline: 12,000 tonnes HFO)
- 1,100 tonnes LCF methanol (baseline: 0 tonnes methanol)
- 1,400 tonnes MDO/MGO (baseline: 1,400 tonnes MDO/MGO).

Compliance balance results are presented in Table 31. The amount of LCF methanol in this example, combined with the consumption of other fuels (HFO and MDO/MGO), is sufficient to achieve compliance (CB = 70 ton CO_{2eq} > 0), resulting in zero FuelEU penalty. It should be noted that the amount of energy from LCF methanol is **not** double counted (no RFNBO reward multiplier applicable, RWD = 1). Therefore, the amount of LCF methanol (~1100 tonnes) required to reach compliance (i.e. a CB of at least 0 or positive) is larger than the amount of e-methanol needed (~400 tonnes of e-methanol, Section 1.4 - Example 6). This is due to two factors: a) No reward factor for LCF methanol, $RWD_{LCF\ methanol}$ = 1, and b) The certified GHG emissions (*E* value) assumed for LCF methanol (*E* = 28.2 gCO_2eq/MJ) are higher than those for e-methanol (*E* = 5 to 10 gCO_2eq/MJ, Section 1.4 - Example 6).

Example 3: Low Carbon Fuel (LCF), chemically carbon-free fuel

A ship uses certified low-carbon ammonia (LCF ammonia), produced from energy sourced from low-carbon hydrogen. In this example, the hydrogen is produced by steam-reforming of natural gas with carbon capture and storage (CCS). Note that there is no need for a carbon source in this case, as ammonia does not contain carbon in its chemical composition.

Based on the PoS (or an equivalent certification document) provided with the fuel delivery, the following GHG emissions are obtained according to EU RED certification, exemplified here with a limit value, i.e., the highest accepted in EU RED[105]:

$$E\ (LCF\ Ammonia) = 28.20000\ gCO_2eq/MJ,$$

of which: $e_u\ (LCF\ Ammonia)$ assumed to be 0 gCO_2eq/MJ.

The well-to-tank emissions for this fuel become:

$$CO_{2eqWtT,\ LCF} = E\ (LCF) - e_u(LCF) = 28.2 - 0 = 28.2\ gCO_2eq/MJ$$

[105] Directive (EU) 2024/1788, http://data.europa.eu/eli/dir/2024/1788 for LCFs..

The entire well-to-wake emissions calculation for this fuel is as follows (note: here LCF ammonia fuel is shown in isolation from all other energy consumed onboard):

$$GHG\ Intensity\ WtW\ of\ LCF\ ammonia\ [gCO_2eq/MJ] = CO_{2eq\ WtT,i}/RWD_i +$$
$$+ (C_{fCO2,j} \times GWP_{CO2} + C_{fCH4,j} \times GWP_{CH4} + C_{fN2O,j} \times GWP_{N2O})_i/(LCV_i \times RWD_i) =$$

$$= (28.2)/(1) + (0\times 1 + 0.00005\times 25 + 0.00018\times 298)/(0.0186\times 1) =$$
$$= 31.15108\ gCO_2eq/MJ$$

From here, the calculation steps are the same as in Section 1.2.4, except that the multiplier of 2 as reward factor for RFNBOs does **not** apply to LCF ammonia in the denominator of GHG intensity calculation.

In this example, the ship consumes the following amounts over the course of 1 year (full year 2025), with the baseline case of consuming only HFO and MDO/MGO given in brackets:

- 11,460 tonnes HFO (baseline: 12,000 tonnes HFO)
- 1,176 tonnes LCF ammonia (baseline: 0 tonnes ammonia)
- 1,400 tonnes MDO/MGO (baseline: 1,400 tonnes MDO/MGO).

Compliance balance results are presented in Table 31. The amount of LCF ammonia in this example, combined with the consumption of other fuels (HFO and MDO/MGO), is sufficient to achieve compliance (CB = 70 ton CO_{2eq} > 0), resulting in zero FuelEU penalty.

3.6. Zero-Emission Technologies at Berth (Annex III)

In addition to ship GHG intensity targets (Article 4), the FuelEU mandates zero-emission requirements for energy use for all electrical power demand at berth (Article 6) for specific ship types, namely containerships and passenger ships, from 1 January 2030. Specifically, it requires these ships to connect to on-shore power (OPS) when moored for 2 hours or more. One exemption[106] from the obligation to use OPS while moored at the quayside is the use of 'zero-emission technologies' (ZET) that are demonstrated to be 'equivalent to the use of OPS', in which case a ship should be exempted from using OPS.

Article 3(7) defines ZET as technologies that, when in use, do not release GHGs (CO_2, CH_4, N_2O) or air pollutants (SO_x, NO_x and particulate matter) into the atmosphere while providing energy to a ship's electrical power demand at berth. Essentially, emissions from using ZET are considered from a tank-to-wake perspective for the purpose of Article 6, zero-emission requirements for energy use for all electrical power demand at berth.

By nature, OPS has zero tank-to-wake emissions, but depending on the electrical production pathway, electricity may be associated with upstream emissions. FuelEU stipulates that OPS should be incentivized by attributing zero upstream emissions (rated as 0 gCO_2eq/MJ) to all electricity delivered by OPS (Recital (44) and Appendix I).

[106] The other exemptions are related to lack of OPS availability, among other exemptions not represented by a direct technological alternative to OPS connection, as is the case for ZETs.

As ZET is referred to as an equivalent to OPS (FuelEU Recital 39), one might mistakenly think that the mass of the fuel used for operating the ZET and its associated well-to-tank carbon factor also should be similarly counted as zero, as is the case for OPS. However, this is not the case for ZET: the provisions of Article 4 (accounting for the energy used onboard) should still be complied with, even when using an “equivalent technology” to OPS. This requirement is substantiated by Article 7, paragraph 2, which states that:

Monitoring and reporting shall be complete and cover the energy used on board by ships at any time, whether at sea or at berth.

It is therefore important to note that while Annex I exempts well-to-tank emissions from the use of electricity, no such exemption is mentioned for ZET in Annex I, II or III.

ZETs are listed in a non-exhaustive table in Annex III of the Regulation, along with general requirements for such technologies. This list is expected to be amended by future delegated acts and complemented by implementing acts that define detailed criteria for acceptance, including the definition of system boundaries and certification requirements for ZETs. The current non-exhaustive list in Annex III includes the following technologies.

- **Fuel cells using fuels with zero emissions from a tank-to-wake perspective:** Fuels that would have zero tank-to-wake CO_2 emissions include any kind of hydrogen and ammonia (fossil, biofuels, e-fuels) as these fuels contain no carbon. However, it should be noted that ZETs also need to have zero emissions of the other two defined greenhouse gases, N_2O and CH_4. In practice, this might exclude NH_3 as its use in fuel cells produces low amounts of N_2O, but not zero emissions.

  Since fuels used in ZETs form part of the GHG intensity calculation, their upstream production pathway will impact the compliance balance. See Section 3.6.1 Examples 1 and 2 for renewable hydrogen versus fossil hydrogen, respectively.

- **On-board electrical energy storage:** This includes scenarios such as 1) ‘onboard power generation at sea’, where onboard equipment is used for charging on-board batteries during the voyage, 2) ‘shore side battery charging,’ meaning OPS charging of on-board batteries, or 3) swapping on-board batteries with pre-charged batteries from ashore. All scenarios will have zero tank-to-wake emissions.

  Since fuels used in ZETs form part of the GHG intensity calculation, their upstream production pathway will impact the compliance balance. See examples in Section 3.6.1 for OPS charging of batteries versus onboard generation at sea.

- **On-board power generation from wind and solar power:** Equipment directly connected to the ship’s switchboard or charging as on-board intermediate electrical energy storage (such as batteries) is eligible as ZET, provided it supplies enough power to meet the ship’s electrical demand at berth.

Since no fuel consumption is involved, this technology is treated as equivalent to using OPS, with a zero GHG intensity contribution (0 g CO_2eq/MJ) to the GHG intensity of the energy used on board by a ship (Article 4 and Annex I). However, because the energy is generated onboard, it does not fall under the scope of Annex I definition of E_k, “Electricity delivered to the ship per OPS connection point k [MJ].”

Calculation examples on the effect of onboard power generation on the ship’s compliance balance are provided below, including example 3.5.0 (baseline case using OPS) and example 3.5.5 (using onboard power generation from wind and solar power).

As mentioned, the list of ZETs identified in Annex III may be expanded when delegated acts under Article 6(6) are adopted and regularly updated by the Commission. Amendments and additions to this list may require an update of this section showcasing calculation examples.

3.6.1 Zero-emission technology examples

The following examples illustrate how different zero emission technologies used at berth, ranging from OPS alternatives to onboard renewable generation, impact a ship’s FuelEU compliance balance, GHG intensity, and potential penalties.

Table 32. Results for ZET Examples

	GHG intensity [gCO_2eq/MJ]	Compliance balance (CB) [ton CO_{2eq}]	$\Delta CB_{\text{base case}}$ [ton CO_{2eq}]	Penalty [€]
Required - 2030-2034	**85.69**	-	-	-
Example 1 - Base case (OPS)	88.63	-1,602	-	€1,057,942
Example 2 - Fuel cells with fossil H2	93.95	-4,651	-3,049	€2,897,664
Example 3 - Fuel cells with RFNBO e-H2	81.58	+2,312	+3,913	€0
Example 4 - OPS charged batteries	88.16	-1,358	+244	€901,319
Example 5 - Onboard fuel charged batteries	91.41	-3,334	-1,733	€2,135,163
Example 6 - Solar/wind generated electricity	91.49	-3,067	-1,465	€1,962,301

Note on assumptions: When reading the following ZET examples, the following assumptions were made to calculate the results.

- **Chosen values**: The examples provided for ZET are solely for illustrating the FuelEU calculation principles and do not constitute any endorsement or recommendation for the adoption of particular technologies
- **Displayed decimals**: for readability, values are rounded, even if all calculations follow a rule of 5 decimals rounding, in alignment with MRV reporting, e.g., GHG intensity in gCO2eq/MJ with 5 decimals, which is rounded to 2 decimals for display in Table 32.

- **GWP**: In these examples, it is assumed that GWP values for CH4 and N2O follow IPCC AR5 values, which are expected to be adopted in FuelEU by the time of this example scenario (2030-2034).

Example 1: Base case with OPS

In this example, a ship consumes the following annual amount of fuels and OPS in the Reporting Period 2030 (the first year of mandatory connection to OPS for passenger ships and containerships), all intra-EU (i.e., all port calls and voyages within FuelEU scope):

- 11,578 tonnes HFO;
- 1,400 tonnes MGO/MDO;
- E_k = 4.75 GWh = 17,100,000 MJ OPS, as per electricity delivery notes.

Results in Table 32 show achieved GHG intensity, compliance balance, and resulting FuelEU penalty. (see step-by-step compliance balance instructions in Section 1.3).

The selected fuel and OPS energy consumption lead to a compliant year for Reporting Periods 2025-2029. However, since the OPS requirements do not fully enter into force until 2030, the period 2030-2034 has been chosen to better reflect a scenario with the 2030 OPS mandate. It should be noted however that this does not exclude the voluntary application (and benefits) of implementing and reporting OPS and ZETs already **before** 2030.

For the base case scenario with fossil fuels and OPS, an actual GHG intensity of 88.63 g/MJ is achieved. For the period 2030-2034, the required GHG intensity value is lower than the achieved GHG intensity, at 85.69 g/MJ, which means that the base case scenario results in a compliance deficit of 1,602 tonnes, equivalent to a penalty of approximately € 1.1 million.

Throughout Examples 2 through 6, this base case scenario is used as the reference for comparison.

Example 2: 100% fossil-based hydrogen used in fuel cells to replace OPS

Earlier, it was defined for the purpose of illustrating the compliance balance calculations that the port stay energy demand for the chosen ship over one year is 4.75 GWh of electrical energy. This electrical energy demand can be converted into a corresponding fuel mass using the lower calorific value and the energy converter's efficiency as follows (same nomenclature and units as FuelEU):

$$M_{i,j} = E_k \,/\, (LCV_i \cdot \eta_j) \qquad \text{[grams]},$$

where η_j is the energy efficiency of the energy converter j, E_k is the shore power energy delivered to the ship, in MJ, and LCV_i is the lower calorific value of the fuel, in MJ/g.

This equation is generic for any kind of fuel, but it will be used for hydrogen in this example. It is assumed in this example that fuel cells would have a fuel conversion efficiency into electricity of 50% (η_j=0.5). Using the lower calorific value provided in FuelEU for hydrogen (0.120 MJ/g) and the chosen E_k value of 4.75 GWh = 17,100,000 MJ, the corresponding mass of hydrogen to be used in a fuel cell system would be 285 tonnes. This amount is independent of the production pathway of the hydrogen.

Using this value in the FuelEU calculation for compliance balance and comparing it with the OPS base case, it is found that the CO_{2eq} compliance deficit is *increased* by approximately 3,049 tonnes, leading to more than double the penalty, from approximately €1.1 million to approximately €2.9 million. The GHG intensity for the ship in this operational scenario is 93.95 gCO_2eq/MJ, of which the contribution of fossil hydrogen is based on default FuelEU emission factor of 132 gCO_2eq/MJ WtW for H2 (natural gas) - Fuel Cells, which moves the GHG intensity of the ship further above the FuelEU GHG intensity target compared to the base case of using OPS (see Table 32). This is due to the upstream emissions of the fossil production pathway of hydrogen, which should thus be taken into account in the calculation according to default FuelEU emission factors for fossil fuels (Annex II of the Regulation). Furthermore, the impact on GHG intensity also results from the fact that fuels are weighted by their chemical energy content, typically higher than that of electricity, while OPS provides electrical energy, which is rated as zero in the numerator of the GHG intensity formula. Therefore, removal of OPS is affecting both the numerator and the denominator of the GHG intensity equation.

Example 3: 100% RFNBO hydrogen used in fuel cells to replace OPS

This example does not differ from Example 1 in terms of equipment and consumption patterns, assuming the same amounts of hydrogen energy used in fuel cells to replace the use of OPS. The only difference lies in the upstream emissions associated with the production pathway of the fuel. FuelEU Annex II does not provide the default value for RFNBO hydrogen upstream emissions. However, for this example, it is assumed to be 10 gCO_2eq/MJ, based on hypothetical GHG emissions in an accepted fuel certificate (PoS or equivalent certificate) accompanying the bunker delivery note of hydrogen to the ship.

Again, the 4.75 GWh corresponds to the same amount of 285 tonnes of hydrogen as demonstrated in Example 1 above. However, using a lower-GHG upstream emission hydrogen and comparing it with the OPS baseline, it is found that the CO_{2eq} compliance deficit using OPS is reversed to a compliance *surplus* of 2,312 tonnes, resulting in a difference in the compliance balance of +3,913 tonnes.

The GHG intensity for this scenario is 81.58 gCO_2eq/MJ which is lower than the GHG intensity target and better than the baseline with OPS. Because the GHG intensity target is met, there will be no penalty for this scenario in 2030 (see Table 32). This improvement compared to the base case is explained by the fact that more energy (of low-GHG intensity) is required to produce the OPS corresponding amount of electricity using fuel cells; in other words, this energy of low GHG intensity exceeds E_k.

Example 4: Using OPS and charging batteries

This example assumes that for half of the yearly port stays (assuming all port stays last equally long), the ship will receive OPS delivery corresponding to the hotel load demand plus additional OPS delivery to charge installed batteries. These batteries will be used later during the other half of the yearly port stays where OPS is also required. This means the ship uses OPS for half of its port stays and ZET in the form of pre-charged batteries for the other half. Ports are not obliged to deliver more energy than what corresponds to the ship's hotel load per port stay, so ships should be cautious of using this scenario as a compliance strategy.

Due to the charging and discharging of batteries, there will be an energy loss, leading to an increase in energy demand with this strategy. The total energy needed can be expressed using the equation below, where "portsA" represents half the OPS required during port stays, charging somewhat more than double the energy demand, accounting for the energy efficiency penalty for energy storage in batteries, η_B:

$$E_{k,\,portsA} = E_{d\;portsA} + (E_{d\;portsB})/\eta_B \qquad \text{[MWh]}$$

$$= 0.5 \cdot E_k + (0.5 \cdot E_k)/\eta_B \qquad \text{[MWh],}$$

where, $E_{d\;portsA}$, represents the OPS energy demand for the port stays in ports A,
$E_{d\;portsB}$, represents the energy demand from ZET for the port stays of ports B , and
η_B, is the overall energy efficiency of battery storage (charging and discharging).

Using this equation and assuming that η_B is 0.75,[107] the amount of OPS that needs to be delivered to the ship in ports A is 5.54 GWh, instead of the base case E_k of 4.75 GWh.

Using 5.54 GWh as OPS yearly consumption in the FuelEU compliance balance calculation and comparing it with the OPS base case, it is found that the CO_{2eq} compliance deficit is lowered by 244 tonnes, due to the increased amount of low-GHG energy required for OPS charging of batteries as ZET at berth, as a result of losses in battery charging/discharging. However, this reduction is not sufficient to reach the GHG intensity target. The ship's GHG intensity for this scenario is 88.16 gCO_2eq/MJ, which is still higher than the GHG intensity target of 85.60 gCO_2eq/MJ, but better than the baseline case with OPS. Again, this improvement is due to the increased amount of low-GHG energy required for OPS charging of batteries as ZET at berth, as a result of losses in battery charging/discharging (see Table 32).

[107] Kanchiralla et al., Life-Cycle Assessment and Costing of Fuels and Propulsion Systems in Future Fossil-Free Shipping, ACS Publications, 23 Aug. 2022, DOI: 10.1021/acs.est.2c03016, Figure 3 - Case 8.

Example 5: Charging batteries while at sea with additional fuel on onboard generators for utilisation of battery power at berth

This scenario provides zero emissions at berth but will result in increased fuel consumption while at sea. It considers using MGO as fuel in generators or auxiliary engines to charge batteries with enough electricity to cover the electrical demand at berth, without considering low-GHG intensity fuels in those generators. This example demonstrates how a ZET can work against achieving the GHG intensity target. If a lower GHG intensity fuel, such as bio-diesel, were used instead of MGO, the 2030 GHG intensity target would likely be met. Note that the current scenario does not consider the possibility in some vessels to charge the batteries by shaft generators / Power Take Out (PTO) connected to main engines, which would also be more efficient than auxiliary engines.

For the energy conversion into the mass of fuel, the specific fuel oil consumption (SFOC) of an auxiliary engine is utilized, as this provides a conservative case compared to PTO. Besides the propulsion power conversion efficiency, which is included in the SFOC factor, the energy efficiency of battery storage (charging and discharging losses) also needs to be considered (η_B). Hence, the mass of fuel can be found using the equation below (same nomenclature and units as FuelEU):

$$M_{i,j} = (E_k \cdot SFOC_{i,j})/\eta_B \qquad \text{[grams]}$$

$SFOC_{i,j}$ is assumed to be 200 g/kWh[108] of MGO and the energy storage efficiency of batteries, η_B, is assumed to be 0.75.[109] Therefore, the 4.75 GWh of electrical energy from OPS corresponds to 1,267 tonnes of MGO when generating electricity at sea for storing in batteries and utilization as ZET at berth.

In this scenario of charging batteries at sea with fossil MGO, the GHG intensity results in 91.41 gCO_2eq/MJ, which is well above the GHG intensity target for 2030 and also higher than the base case of using OPS at berth. This results in a penalty of approximately €2.1 million, about double compared to OPS baseline case. The total CO_{2eq} compliance deficit is 3,334 tonnes, which is worse than the OPS base case by 1,733 tonnes. However, it should be noted that if another fuel, such as drop-in bio-diesel, had been used at sea to charge the batteries, the vessel would probably reach the GHG intensity target with zero FuelEU penalty.

Example 6: Solar and/or wind generated electricity while in port

This scenario assumes that a ship can generate enough direct electricity using solar power and/or wind power while in port. Although this scenario might not be the most realistic as it does not include the use of batteries, it provides valuable insights into the consequences of such choice in terms of FuelEU GHG intensity and compliance balance. Generating electricity at sea would require battery installation, which would come with respective energy losses.

[108] MAN Energy Solutions, Shaft generators for low speed engines, MAN Energy Solutions, 5510-0003-03ppr Apr 2021, page 18.
[109] Kanchiralla et al., Life-Cycle Assessment and Costing of Fuels and Propulsion Systems in Future Fossil-Free Shipping, ACS Publications, 23 Aug. 2022, DOI: 10.1021/acs.est.2c03016, Figure 3 - Case 8.

Since only the electricity source from OPS, E_k, can be included in the FuelEU calculation, electricity generated onboard from solar or wind will not positively impact a ship's GHG intensity calculation. Instead, it reduces the amount of energy reported, reducing M_i and E_k in the compliance balance formula of Annex IV.

In this example, the GHG intensity for the scenario of onboard solar/wind generation of electricity is 91.49 g/MJ, which is above the GHG intensity target for 2030 and higher than the baseline case. This results in a penalty of approximately €2 million, almost double of the OPS baseline case. The total CO_{2eq} compliance deficit is 3,067 tonnes, which is 1,465 tonnes worse than the OPS baseline case.

3.6.2 Conclusion for Annex III zero emission technologies at berth

Where a ship is required to use OPS per FuelEU Article 6, the only other options to substitute OPS to meet or exceed compliance in terms of GHG intensity targets is by using renewable or other low-GHG fuel in fuel cells, or using low-GHG intensity fuels (e.g., bio-diesel) in onboard generators or shaft generators for charging batteries (note this example is not provided in this document).

To allow for comparability across the examples in this chapter, the same energy demand and fuel types as in the base case are used. As the OPS requirement for passenger and container ships begins on 1 January 2030, that year is used as the reference, unlike Chapter 1, which uses 2025–2029. In most examples, OPS or fossil-based ZET alone at berth is not sufficient to meet the GHG intensity target. This demonstrates that the main contributor to compliance is typically the choice of fuels used at sea.

It should be noted that, provided there is no change in other fuels used at sea, only the ZET example of fuel cells with RFNBO-hydrogen lead to compliance with the GHG intensity target in the year 2030. This result would change in 2035 when a lower GHG intensity target is mandated. In this case, even fuel cells with RFNBO-hydrogen would not meet the 2035 GHG targets.

Disclaimer on the calculations in Chapter 3: The conclusions in this section are meant to be illustrative and non-exhaustive, serving only as guidance for a shipping company to carry out its own comprehensive calculations and analyses following FuelEU calculation principles and other considerations**.** As such, it does not constitute any endorsement or recommendation for the adoption of particular technologies.

4. Chapter 4: Flexibility Mechanisms

4.1. Introduction

The compliance balance for the Reporting Period is calculated using the formula set out in FuelEU Annex IV Part A, based on the GHGIE actual[110] derived from the FuelEU Report data.[111] Compliance balances can be positive, negative, or zero. The regulation is designed to incentivize companies to achieve a compliance balance below the GHGIE target established in FuelEU Article 4. To support compliance, the FuelEU provides flexibility mechanisms.

Flexibility mechanisms create an alternative compliance option for ships with a FuelEU deficit and support the deployment of the most advanced solutions for ships with a compliance surplus. The mechanism aims to create a virtuous cycle, incentivizing the lowest GHG intensity technologies and accelerating the uptake of such technologies in the maritime industry.

4.2. Key Concepts and Definitions

FuelEU Articles 20 and 21 define three flexibility options, which are described below.

1. **Banking:** is a compliance option that allows companies to accumulate the over-performance of one ship in terms of compliance balance over the years. This accumulated surplus can be used in subsequent years to offset deficits of that specific ship or other ships through the pooling mechanism.; or
2. **Borrowing:** is a compliance option that allows companies to borrow an Advance Compliance Surplus from the following year, with the obligation to repay it with an additional 10% in the next period; or
3. **Pooling:** to avoid technology lock-in and continue supporting the deployment of the most performant solutions, companies are allowed to pool the compliance balance of ships. This means using the over-compliance (surpluses) of one or more ships to compensate for the under-compliance (deficits) of other ships, provided that the total pooled compliance is positive. As with all flexibility mechanisms, the possibility to pool compliance is voluntary and requires prior agreements between the participating companies.

Below is a list of definitions used throughout this Chapter.

- **Adjusted Compliance Balance Year N** (Adjusted CB Year N) [gCO_2eq]: The sum of the Initial Compliance Balance Year N plus the Banked Surplus from previous periods, minus the Aggravated Advance Compliance Surplus Year N-1 from the previous Reporting Period Year N-1. It can be positive, negative or zero. Calculated by 31 March of the Verification Period Year N+1.

[110] For more information, see Chapter 1, section 1.2 on GHGIE actual calculations
[111] The FuelEU Report is a ship-specific compliance report required under Article 15(3) of the FuelEU. It must be submitted annually by 31 January to the verifier and contains all the monitored and recorded data specified in Article 15(1).

- **Advance Compliance Surplus Year N** (ACS Year N) [gCO_2eq]: The amount a company borrows under the Borrowing compliance option during Verification Period Year N+1, ensuring that the Verified Compliance Balance is zero.
- **Aggravated Advance Compliance Surplus Year N** (Aggravated ACS Year N) [gCO_2eq]: The ACS aggravated by 10%, to be repaid in the following period. It has to be considered in the Adjusted CB Year N+1 calculations.
- **Associated Administering State**: The Administering State linked to an ISM company. It is responsible for calculating penalties in cases of negative compliance balance or non-compliant Port Calls (under FuelEU Article 6, which from 2030 mandates connection to Onshore Power Supply (OPS) at berth). It also has the authority to oversee the full compliance process for all ships associated with that ISM company.
- **Banked Surplus Year N** [gCO_2eq]: The positive Amount of Verified Compliance Balance Year N that can be stored in the THETIS MRV system for a certain ship.
- **Compliance Deficit Year N** [gCO_2eq]: A negative amount of Verified Compliance Balance Year N.
- **Flexibility Mechanism**: Pooling, Borrowing, and Banking mechanisms in the FuelEU. Using flexibility mechanisms starts on 1 April and ends on 30 April of each Verification Period year N+1.
- **FuelEU Document of Compliance (DoC):** A document specific to a ship, issued to a company by a verifier, which confirms that that ship has complied with this Regulation for a specific Reporting Period;
- **Initial Compliance Balance Year N** (Initial CB Year N) [gCO_2eq]: The Compliance Balance of Reporting Period Year N, calculated as defined in Part A, Annex IV of FuelEU (see Figure 5). It can be positive, negative or zero.
- **ISM Company:** Refers to the shipowner or any other organisation or person, such as the manager or the bareboat charterer, that has assumed responsibility for the operation of the ship from the shipowner and that, on assuming such responsibility, has agreed to take over all the duties and responsibilities imposed by the International Management Code for the Safe Operation of Ships and for Pollution Prevention as implemented within the Union by Regulation (EC) No 336/2006 of the European Parliament and of the Council.
- **Pooled Surplus Year N** [gCO_2eq]: A positive Amount of Verified Compliance Balance Year N, generated by a pool, that can be stored as Banked Surplus in the THETIS MRV system for a certain ship.
- **Verified Compliance Balance Year N** [gCO_2eq]: The final Compliance Balance Year N, calculated after the flexibility mechanism during Verification Period Year N+1. If it is positive or equal to zero, the Verifier can issue a Document of Compliance to the ship. If it is negative, the Associated Administering State calculates the related Penalty and issues the Document of Compliance once the penalties are paid.

Figure 5. FuelEU Annex IV compliance balance formula

Compliance balance [gCO_{2eq}] =	$(GHGIE_{target} - GHGIE_{actual}) \times [\sum_{i}^{nfuel} M_i \times LCV_i + \sum_{k}^{c} E_k]$

Where:

gCO_{2eq}	Grams of CO_2 equivalent
$GHGIE_{target}$	GHG intensity limit of the energy used on-board a ship according to Article 4(2)
$GHGIE_{actual}$	Yearly average of the GHG intensity of the energy used on-board a ship calculated for the relevant reporting period

4.3. Borrowing

4.3.1. Guidance on borrowing compliance

Borrowing, as defined above, is a compliance option that allows companies to borrow a certain amount of compliance balance (referred to as "Advance Compliance Surplus" in FuelEU) to compensate for a deficit in the Adjusted Compliance Balance of the Reporting Period Year N, calculated during Verification Period Year N+1. Borrowing is always meant to be from the following year, i.e., Reporting Period Year N+1.

Companies should repay this amount with an aggravation of 10% (the Aggravated Advance Compliance Surplus, see Section 4.3.2) in the next period, deducting it from the Adjusted Compliance Balance Year N+1, as stated in Article 20 of FuelEU.

Requirements

The Advance Compliance Surplus may not be:

- borrowed for two consecutive Reporting Periods; or
- borrowed for an amount exceeding 2% of the greenhouse gas (GHG) intensity target of Reporting Period Year N, multiplied by the ship's energy consumption, as calculated in accordance with FuelEU Annex I.

Timeline and responsibilities

Borrowing is possible during the Verification Period Year N+1, after the issuance of the Adjusted Compliance Balance and before 30 April of the Verification Period Year N+1. The ISM company is responsible for requesting borrowing in THETIS MRV system, while the Verifier is responsible for assessing and verifying the requested and correct amount to be borrowed.

Rules and formulas

The Superior Advance Compliance Balance limit is calculated as follows:

$$ACB\ Year\ N\ limit\ = 2\%\ \times\ GHGIE\ target\ Year\ N\ \times \left[\sum_{i}^{n\,fuel} Mi\ \times\ LCVi\ +\ \sum_{j}^{l} Ej\right]$$

The GHGIE target Year N to be considered for the calculation of the Advance Compliance Surplus is the **one related to the Reporting Period (Year N)**. **Year N** in the calculation refers to the **Reporting Period**. For example, during the calculation of the Adjusted Compliance Balance for Year 2029, which occurs during the Verification Period in Year 2030, the GHGIE target will be the 2029 GHGIE target. This remains true even though the GHGIE target changes between the Reporting and Verification Periods from 2% to 6 % reduction of the reference value 91.16 gCO_2eq/MJ, changing from 89.33680 gCO_2eq/MJ in 2029 to 85.69040 gCO_2eq/MJ in 2030). Therefore, **the GHGIE target for Year 2029 to be considered for the calculation of the ACB Year N limit will be 89.33680 gCO_2eq/MJ**, even if the ship is actually borrowing from the following period (2030), where the GHGIE target is 85.6904 gCO_2eq/MJ.

With the example of 15,000 MJ of energy in scope, below is the calculation of maximum ACS for Reporting Periods 2029 and 2030:

$$ACS\,Year\,2029 \le 2\% \times (98\% \times 91.16\,gCO_2eq/MJ) \times 15,000\,MJ$$
$$ACS\,Year\,2029 \le 2\% \times 89.3368\,gCO_2eq/MJ \times 15,000\,MJ = 26,801.04\,gCO_2eq$$

$$ACS\,Year\,2030 \le 2\% \times (94\% \times 91.16\,gCO_2eq/MJ) \times 15,000\,MJ$$
$$ACS\,Year\,2030 \le 2\% \times 85.6904\,gCO_2eq/MJ \times 15000\,MJ = 25,707.12\,gCO_2eq$$

As defined in Annex-I, Question A.20,[112] the Advance Compliance Surplus borrowed from the next Reporting Period should exactly match the amount corresponding to the compliance deficit calculated. Therefore, **borrowing is not possible if the Adjusted Compliance Balance of the Reporting Period Year N exceeds 2% x (GHGIE target Year N) x Energy consumption**:

$$if\ ACB\,Year\,N > 2\% \times GHGIE\,target\,Year\,N \times \left[\sum_{i}^{n\,fuel} Mi \times LCVi + \sum_{j}^{l} Ej\right],\ not\ possible\ to\ borrow$$

Borrowing during a Verification Period prevents a company from joining a Pool during the same Verification Period. Nevertheless, if a company borrowed during a Verification Period, it is still possible to join a pool during the following year, even if the ship's compliance balance is affected by the resulting Aggravated Advance Compliance Surplus.

Lastly, it is important to highlight what happens in the event of no EU port calls for a ship which applied for borrowing in the previous year. The ISM company will be notified by the associated Administering State of the amount of the FuelEU penalty according to the Article 20(4):

where a ship does not have any port call in the Union during the Reporting Period and borrowed an advance compliance surplus in the previous Reporting Period, the competent authority of the administering State shall notify by 1 June of the Verification Period to the company concerned the amount of the FuelEU penalty as referred to in Article 23(2) that it

[112] See *FuelEU Maritime Questions and Answers*, Annex I, Question A.20: https://transport.ec.europa.eu/transport-modes/maritime/decarbonising-maritime-transport-fueleu-maritime/questions-and-answers-regulation-eu-20231805-use-renewable-and-low-carbon-fuels-maritime-transport_en

initially avoided by means of borrowing that advance compliance surplus, multiplied by 1.1.

4.3.2. Definition of the aggravated advance compliance surplus

Starting with the calculation of the GHG Intensity target of the Energy used on board, namely GHGIE target Year N:

$$GHGIE\ target\ Year\ N\left[gCO_2eq/MJ\right] = 91.16\ gCO_2eq/MJ \times reduction\ Year\ N\%$$

The **Initial Compliance Balance of Year N** (ICB Year N) is calculated during Verification Period Year N+1 and refers to the ship's energy performance during the Reporting Period Year N, using relevant input data (e.g., fuel consumption, GHGIE target Year N). It considers the difference between the GHGIE target for Year N and the actual GHGIE for Year N, as shown in the examples in Section 1.4. The Initial Compliance Balance formula is:

$$ICB\ Year\ N\ [gCO_2eq] = (GHGIE\ target\ Year\ N - GHGIE\ actual\ Year\ N) \times \left[\sum_{i}^{nfuel} Mi \times LCVi + \sum_{j}^{l} Ej\right]$$

The **Adjusted Compliance Balance of Year N** (ACB Year N) considers the **Previous Banked Surplus** (PBS Year (N-1)) stored in the previous period Year N-1 and the **Aggravated Advance Compliance Surplus (Aggravated ACS Year N-1)**, which is 10% more of the Advance Compliance Surplus, coming from the previous period if borrowed.

$$ACB\ Year\ N = ICB\ Year\ N + PBS\ Year\ (N-1) - Aggravated\ ACS\ Year\ (N-1)$$

The Aggravated ACS Year (N-1) is equal to zero if the company decided not to opt for borrowing during Year N-1. If this applies and if the Adjusted Compliance Balance Year N is less than 2% x GHGIE target Year N x Energy in Scope, companies are entitled to opt for Borrowing in the event of a negative Adjusted Compliance Balance of Year N.

Before 31 March of the Verification Period Year N+1, verifiers calculate the Adjusted Compliance Balance Year N, considering the input data (e.g., fuel consumption, GHGIE target Year N) of the Reporting Period Year N. When the flexibility mechanism starts during Verification Period Year N+1, if a company chooses to opt for borrowing, the **Advance Compliance Surplus Year N** has to be calculated.

The **Advance Compliance Surplus Year N** (ACS Year N) to be borrowed during Verification Period Year N+1 has a maximum limit equal to 2% of the GHGIE target Year N multiplied by the energy in scope of FuelEU for Reporting Period Year N.

$$0 \leq ACS\ Year\ N \leq 2\% \times GHGIE\ target\ Year\ N \times \left[\sum_{i}^{n\,fuel} Mi \times LCVi + \sum_{j}^{l} Ej\right]$$

The Aggravated ACB Year N will have to be deducted from the Initial Compliance Balance Year N+1 of Reporting Period Year N+1 (Aggravated ACS Year N).

$$Aggravated\ ACS\ Year\ N\ =\ 1,1\ \times\ \ ACS\ Year\ N$$

Subsequently,

$$ACB\ Year\ (N\ +\ 1)\ \ =\ \ ICB\ Year\ (N\ \ +\ 1)\ \ +\ \ PBS\ \ Year\ N\ -\ Aggravated\ ACS\ Year\ N$$

Example

Figure 6 shows an example describing borrowing compliance options from 2025 through 2050. Please note that this is an illustrative example and based on two important assumptions in this case:

1. No Pooling occurs, and no Banked Surplus comes from Pooling.
2. When possible, ships always opt to Borrow. They could choose not to borrow but for explanatory purposes, we are assuming they always do.

Figure 6. Annex IV of FuelEU

Year	Reduction	GHGIE target	GHGIE actual	Energy used	Initial Compliance Balance	Previous Banked Surplus	Aggravated Advance Compliance Surplus	Adjusted Compliance Balance	Advance Compliance Surplus limit	Possible to Borrow?	Borrowed Advance Compliance Surplus	Verified Compliance Balance	Penalty	Considering consecutive non-compliant years	Penalty considering non-compliant consecutive years
	%	*gCO2eq/MJ*	*gCO2eq/MJ*	*MJ*	*tonne CO2eq*	*tonne CO2eq*	*tonne CO2eq*	*tonne CO2eq*	*tonne CO2eq*		*tonne CO2eq*	*tonne CO2eq*	*euro*		*euro*
2025	2.0%	89.34	86.34	59,821	179	0	0	179	107	Not necessary	0	179	€ -	0	€ -
2026	2.0%	89.34	92.34	58,821	-176	179	0	3	105	Not necessary	0	3	€ -	0	€ -
2027	2.0%	89.34	92.34	58,821	-176	3	0	-173	105	NO	0	-173	€ 109,704	1	€ 109,704
2028	2.0%	89.34	91.34	58,821	-118	0	0	-118	105	NO	0	-118	€ 75,217	2	€ 82,739
2029	2.0%	89.34	89.34	58,821	0	0	0	0	105	Not necessary	0	0	€ -	0	€ -
2030	6.0%	85.69	85.69	59,821	0	0	0	0	103	Not necessary	0	0	€ -	0	€ -
2031	6.0%	85.69	88.69	60,821	-182	0	0	-182	104	NO	0	-182	€ 120,140	1	€ 120,140
2032	6.0%	85.69	87.69	61,821	-124	0	0	-124	106	NO	0	-124	€ 82,341	2	€ 90,575
2033	6.0%	85.69	86.69	61,821	-62	0	0	-62	106	YES	62	0	€ -	0	€ -
2034	6.0%	85.69	86.69	60,821	-61	0	68	-129	104	NO	0	-129	€ 86,788	1	€ 86,788
2035	14.5%	77.94	78.94	60,821	-61	0	0	-61	95	YES	61	0	€ -	0	€ -
2036	14.5%	77.94	79.94	60,821	-122	0	67	-189	95	NO	0	-189	€ 137,738	1	€ 137,738
2037	14.5%	77.94	80.94	60,821	-182	0	0	-182	95	NO	0	-182	€ 131,641	2	€ 144,805
2038	14.5%	77.94	78.94	60,821	-61	0	0	-61	95	YES	61	0	€ -	0	€ -
2039	14.5%	77.94	80.94	60,821	-182	0	67	-249	95	NO	0	-249	€ 179,914	1	€ 179,914
2040	31.0%	62.90	62.90	59,821	0	0	0	0	75	Not necessary	0	0	€ -	0	€ -
2041	31.0%	62.90	65.90	59,821	-179	0	0	-179	75	NO	0	-179	€ 159,028	1	€ 159,028
2042	31.0%	62.90	65.90	60,821	-182	0	0	-182	77	NO	0	-182	€ 161,687	2	€ 177,856
2043	31.0%	62.90	64.90	60,821	-122	0	0	-122	77	NO	0	-122	€ 109,455	3	€ 131,346
2044	31.0%	62.90	63.90	59,821	-60	0	0	-60	75	YES	60	0	€ -	0	€ -
2045	62.0%	34.64	35.64	58,821	-59	0	66	-125	41	NO	0	-125	€ 204,217	1	€ 204,217
2046	62.0%	34.64	37.64	57,821	-173	0	0	-173	40	NO	0	-173	€ 269,114	2	€ 296,025
2047	62.0%	34.64	36.64	57,821	-116	0	0	-116	40	NO	0	-116	€ 184,311	3	€ 221,173
2048	62.0%	34.64	34.64	57,821	0	0	0	0	40	Not necessary	0	0	€ -	0	€ -
2049	62.0%	34.64	34.64	57,821	0	0	0	0	40	Not necessary	0	0	€ -	0	€ -
2050	80.0%	18.23	19.23	57,821	-58	0	0	-58	21	NO	0	-58	€ 175,590	1	€ 175,590
Reference	91.16	*gCO2eq/MJ*													

4.4. Banking

4.4.1. Guidance on banking compliance

After calculating the **Adjusted Compliance Balance for Year N** during the Verification Period Year N+1, ships may either have a deficit or a surplus. Ships can then join a pool (see Section 4.5) to reduce or cancel their deficits or to pass on their surplus. Once a ship exits a pool, it may have a surplus or a remaining deficit (but not a higher one). Surplus can be banked according to FuelEU Article 20(1).

Requirements for banking a surplus

ISM companies are allowed to bank **only if the Verified Compliance Balance of Year N is positive**.

In the event of a surplus of the Adjusted Compliance Balance, the company may choose to directly bank the surplus in THETIS MRV IT system, pool the surplus or opt not to bank. The decision not to bank may occur if, for example, the company participates in a voluntary GHG emission reduction scheme with additionality restrictions. On the other hand, in the event of a deficit of the Adjusted Compliance Balance, the company may join a pool (and exit with a reduced deficit or a surplus from it) or decide not to join a pool and immediately pay the penalties.

Ultimately, once the **Verified Compliance Balance Year N is assessed by the Verifier and if it is positive**, the ISM company again may bank this surplus or **opt not to bank**.

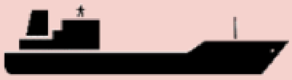
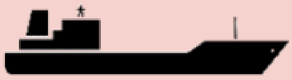
Timeline and responsibilities

In the event of a surplus resulting from a positive Verified Compliance Balance, whether from a pooling mechanism or over-compliant energy performance, companies are entitled to **register the surplus as Banked Surplus in THETIS MRV**. This has to be done by the ISM company after the calculation and assessment of the Verified Compliance Balance by its Verifier and **before 30 June of the Verification Period Year N+1**. The Verifier then needs to confirm and accept the amount of banked surplus in THETIS MRV. It is important to note that once the FuelEU DoC is issued by the Verifier, **it will no longer be possible to register the surplus in THETIS MRV**.

Rules for banking a Surplus

Banked surpluses are cumulative and can be used in all subsequent Verification Periods without any expiration limitations. It is also possible to use banked surpluses from previous Reporting Periods in a compliance pool in future periods, as these surpluses are added to the Adjusted Compliance Balance calculations.

Figure 7. Rules for banking a surplus

Year N	Year N+1	Year N+2
		
CBi > 0	CBi > 0	CBi < 0
Banked Surplus	Banked Surplus	Use Banked Surplus and/or joins a Pool

As previously explained, ships with a surplus may choose not to bank or pool, but instead to cancel the surplus. In such cases, the Compliance Balance for that Verification Period will be zero, and no penalties will be incurred. In addition, for auditing and tracking purposes, it would be appropriate for verifiers to issue a receipt or a certificate in the event of a surplus not banked.

4.5. Pooling

4.5.1. Guidance on pooling compliance

Pooling is a compliance option that allows companies to compensate for the under-performance (deficit) of one or more ships with the over-performance (surplus) of one or more ships from one or more ISM companies. The exchange of Pooling Compliance Balance quotas (in tonnes CO_2eq) is a linear and direct exchange among a pool of ships, not a weighted average. According to ISM Companies private agreements, ships will “sell and/or buy” their surplus and/or deficits of Adjusted Compliance Balances, initially calculated as per FuelEU Annex IV Part A.

Requirements

The requirements for a pool to be valid are:

1. The ship is within the scope of FuelEU: ships above 5,000 GT and that carry cargo or passengers, with at least one EEA port call in one Reporting Period from 2025, are in scope of FuelEU;
2. The ship has not borrowed compliance in the current Verification Period;
3. The ship is not included in another pool of Compliance Balance for GHG intensity;
4. The sum of the initial Compliance Balance of the ships included in the pool is positive or zero (including banking and borrowing of previous periods);
5. Ships in the pool must possess a valid FuelEU DoC from the most recent Verification Period during which they were within the scope of FuelEU.

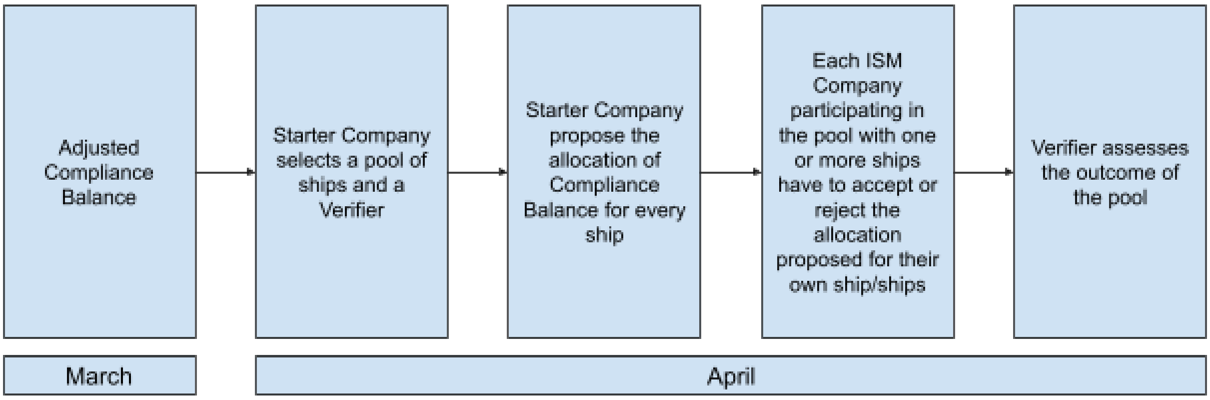
Timeline and responsibilities

One ISM Company (from now on the "Starter Company") with responsibility with one or more vessels which intends to trigger a pooling, first needs to identify the ships to be included in the pool. Secondly, the Starter Company proposes, after concluding private agreements among the companies, the allocation of compliance balances. Then all ISM Companies involved in the pooling arrangement should accept or reject the allocation proposed.

The Starter Company identifies a **Unique Verifier,** who could be different from the verifiers that calculated the adjusted Compliance Balances for each ship before 31 March of the Verification Period. This Unique Verifier has to assess and verify the final outcome of the pooling arrangement.

Once a ship exits a pool, it cannot borrow, participate in other pools, or accumulate more surplus. Below a simple timeline of a pooling option.

Figure 8. Timeline and responsibilities



Rules for the allocation of Compliance Balances

There are essentially two main rules for pooling allocation:

- A ship that enters the pool with a deficit may not exit with an increased deficit.
- A ship that enters a pool with a positive or zero compliance balance may not exit with a deficit.

It is possible that all ships in the executed pool exit with compliance balances equal to zero or with a surplus. However, due to Requirement 4 (see above) which states that the **sum** of compliance balances should be zero or positive, it is also possible for ships to exit the pool with a deficit, provided that the total compliance balance is zero or positive and the deficit is not greater than the ship's initial deficit (see Table 33).

It is also possible to join a pool where all ships are already compliant (i.e., all compliance balances are positive), to simply exchange surplus among ships and reallocate the compliance balances.

Table 33. Pooling Examples with Alternative Allocations

Ships	Adjusted Compliance Balance	Allocation Alternative 1	Allocation Alternative 2
Ship A	200	Verified CB1 = 30 (-170)	Verified CB1 = 105 (-95)
Ship B	-30	Verified CB2 = 0 (+30)	Verified CB2 = 0 (+30)
Ship C	-50	Verified CB3 = 0 (+50)	Verified CB3 = 0 (+50)
Ship D	10	Verified CB4 = 0 (-10)	Verified CB4 = 5 (-5)
Ship E	-100	Verified CB5 = 0 (+100)	Verified CB5 = -80 (+20)
Sum	**30**	**30**	**30**

In Allocation Alternative 1, Ship A and D have shared surplus so that all ships in the pool have a positive compliance balance. In Allocation Alternative 2, the sum of the compliance balances for all ships is positive but Ship E exits the pool with a remaining deficit less than the pre-pool deficit. Both allocations are allowed within the boundaries of the requirements and rules (along with numerous other options). Please note that in Allocation Alternative 2, Ship E will have a negative Verified Compliance Balance equal to -80, meaning the ISM company of Ship E will be required to pay a penalty.

Ships with residual Banked surpluses or Borrowing Deficits, without EEA port calls in Year N

If there are **no EEA port calls** during a certain Reporting Period Year N, a ship that was in scope during a previous Reporting Period from 2025, with a residual Banked Surplus or with a Borrowing Deficit (Aggravated Advance Compliance Surplus), can join a pool during the related Verification Period Year N+1.

Therefore, such a ship can:

- Use its residual Banked Surplus to join a pool and potentially monetize surpluses, or
- Compensate for its residual Borrowing Deficit by joining a Pool.

This is also true when the ship does not have EEA port calls in the following Reporting Period.

4.5.2. Revisions of compliance balance by administering states and additional checks

Administering States may, at any time, conduct additional checks on the entire compliance process under FuelEU for the two previous Reporting Periods. This could lead to the detection of incorrect Adjusted Compliance Balances, which would affect previous pools. In such cases, it would mean that certain requirements for the validity of those pools were mistakenly considered fulfilled.

If an Administering State detects an error in compliance balance, FuelEU Article 17(4) provides that the company responsible for the error will be notified of this and, if a negative compliance balance results, the company in question should pay a penalty equal to the related amount in Euros to resolve the inconsistency.

If an Administering State detects such an error in the Compliance Balance of a ship that **joined a pool**, this ship will have to revise its final Verified Compliance Balance for that year and eventually pay a penalty if its compliance balance ends up being negative in that Reporting Period.

It is important to note that such a correction may also retroactively invalidate the pool. A pool is deemed invalid if, following an additional check by an Administering State, both of the following conditions are met:

1. One or more ships have to consider a lower Adjusted Compliance Balance for a specific previous Verification Period; and
2. One or more of these ships joined a pool in previous Verification Periods and the initial sum of the Adjusted Compliance Balances is now negative, after these additional checks.

Specifically, the above situation does not satisfy Requirement 4 (See Section 4.5.1, the sum of the initial Compliance Balance of the ships in the pool is not positive or zero, including banking and borrowing from previous periods). The outcome of the pool remains valid for the other ships not affected directly by the findings of the additional checks. This ensures that other ships, without errors in their Adjusted Compliance Balances, are not impacted by this additional check. The ship(s) identified as having an error will have their Verified Compliance Balances revised accordingly and will incur a penalty to the extent their revised pool-allocation Verified Compliance Balances are negative, i.e., taking into account that the already allocated compliance to other ships in the pool remains unchanged.

Regardless of whether the ship participated in a pool or not, a new FuelEU DoC should be issued by the Administering State whenever an Additional Check results in a downward revision of the Adjusted Compliance Balance. The new DoC should not have a longer validity than the DoC held at the time of the Additional Check and, in any case, should expire at the next regular DoC issuance deadline for the subsequent Verification Period.

Consider the following Example in Table 34. The initial compliance balance sum was 25 tCO_2eq for this pool of five ships. After an additional check conducted within two years by Administering State X on Ship A, an error was found in the calculations of its Adjusted Compliance Balance, which should have been 95, not 150 tCO_2eq. Pooling should have been invalid because the initial sum would have been negative (in this case -30), but pooling still took place.

Therefore, the pool's outcome is considered frozen. Only ship A is impacted by the additional check of Member State X. In this case, since the revised Verified Compliance Balance for Ship A is negative, a penalty is calculated with a compliance balance of -30 tonnes CO_2eq, and communicated by the Administering State X. Once the penalty is paid, a new DoC will be issued by the Administering State X.

Table 34. Example of a Revised Pool Allocation

	Adjusted CBs	**Pool Allocation**	**Revised Adjusted CBs after Additional Checks**	**Revised Pool Allocation**
Ship A	150	25 (-125)	**95**	**-30** (-125)
Ship B	-20	0 (+20)	-20	0 (+20)
Ship C	-50	0 (+50)	-50	0 (+50)
Ship D	-30	0 (+30)	-30	0 (+30)
Ship E	-15	0 (+15)	-15	0 (+15)
Ship F	-10	0 (+10)	-10	0 (+10)
Sum	25		-30	

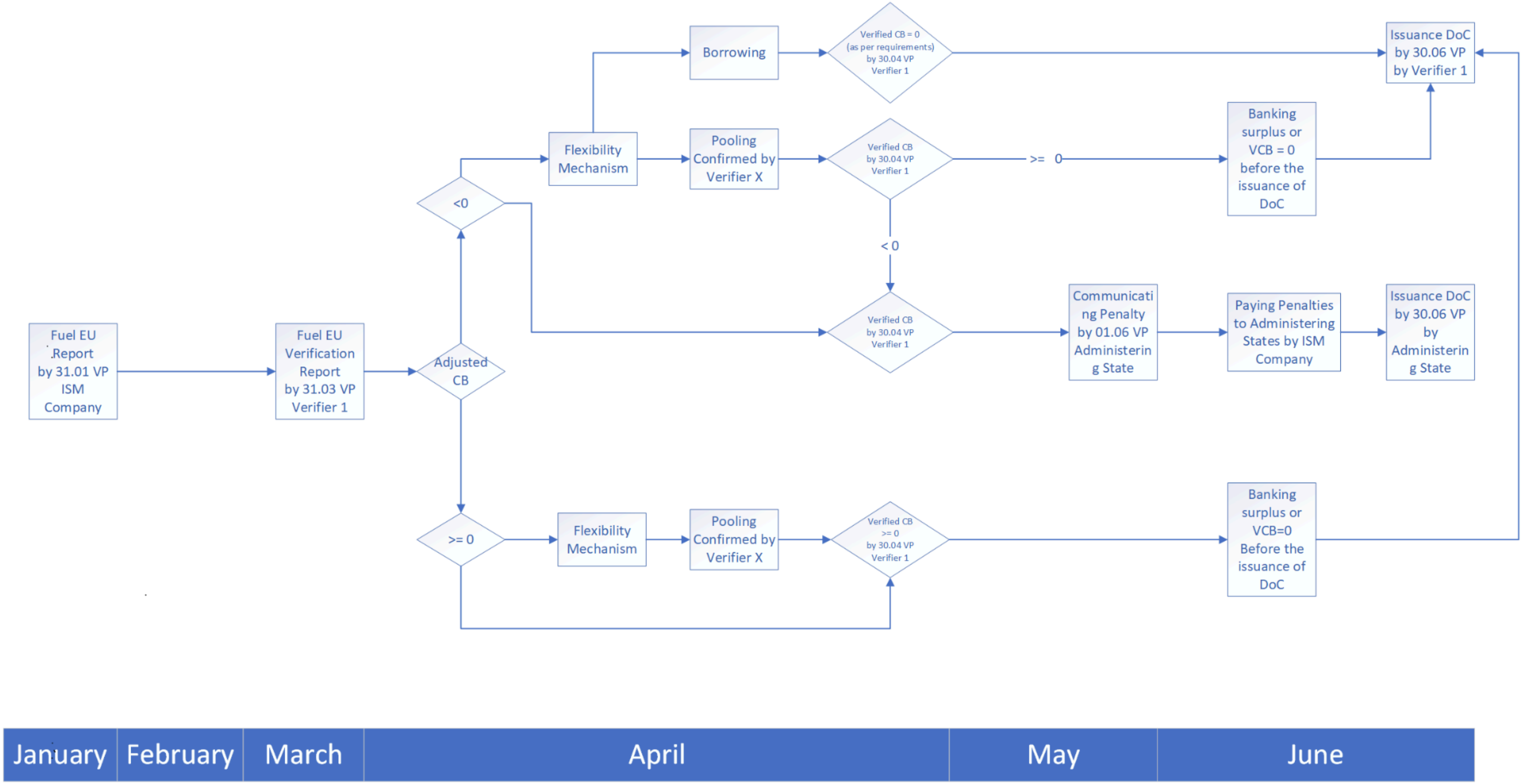
4.6. Timeline and Workflow

The following outlines the timeline and possible pathways from the submission of the FuelEU Report by the ISM company to the issuance of the FuelEU DoC by the verifier or administering authority. It covers key elements of the compliance process, including:

- The ship's **Adjusted Compliance Balance (ACB)**, which may be positive or negative;
- The application of **flexibility mechanisms** (such as banking, borrowing, and pooling);
- The calculation of **penalties** where applicable;
- The determination of the **Verified Compliance Balance (VCB)**; and
- The final **issuance of the DoC**, including any reissuance due to Additional Checks or errors.

Each step represents a potential outcome or action depending on the ship's compliance performance and the data reported and verified during the annual reporting cycle.

Figure 10. Timeline and workflow of all possible pathways



5. Abbreviations

ACB	Adjusted Compliance Balance
ACS	Advance Compliance Surplus
CB	Compliance Balance
CCS	Carbon Capture and Storage
DoC	Document of Compliance
EEA	European Economic Area
EEDI	Energy Efficiency Design Index
EEXI	Energy Efficiency Existing Ship Index
ESSF	European Sustainable Shipping Forum
ETS	Emissions Trading System
EU	European Union
GHG	Greenhouse Gas(es)
GHGIE	Greenhouse Gas Intensity of Energy
HFO	Heavy Fuel Oil
IMO	International Maritime Organization
ISM	International Safety Management
kW	Kilowatt
LBSI	Lean-Burn Spark-Ignited engines
LCF	Low-Carbon Fuel
LCV	Lower Calorific Value
LFO	Light Fuel Oil
LNG	Liquefied Natural Gas
MDO	Marine Diesel Oil
MEPC	Marine Environment Protection Committee
MGO	Marine Gas Oil

MJ	Megajoule
MRV	Monitoring, Reporting, and Verification
MS	Member State
OCT	Overseas Countries and Territories
OMR	Outermost Region
OPS	Onshore Power Supply
PBS	Previous Banked Surplus
PoC	Proof of Compliance
PoS	Proof of Sustainability
RCF	Recycled Carbon Fuels
RFNBO	Renewable Fuels of Non-Biological Origin
SAPS	Sustainable Alternative Power for Shipping
SFOC	Specific Fuel Oil Consumption
TtW	Tank-to-Wake
VCB	Verified Compliance Balance
VLSFO	Very Low Sulphur Fuel Oil
WtW	Well-to-Wake
ZET	Zero Emission Technology

6. Relevant Legislative Texts

FuelEU: Regulation (EU) 2023/1805 of the European Parliament and of the Council of 13 September 2023 on the use of renewable and low-carbon fuels in maritime transport, and amending Directive 2009/16/EC (Text with EEA relevance).
https://eur-lex.europa.eu/eli/reg/2023/1805/oj

RED: Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast).
http://data.europa.eu/eli/dir/2018/2001/2023-11-20

MRV Maritime Regulation: Regulation (EU) 2015/757 of the European Parliament and of the Council of 29 April 2015 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, and amending Directive 2009/16/EC.
http://data.europa.eu/eli/reg/2015/757/2024-01-01

Relevant Implementing and Delegated Acts:

ETS Implementing Regulation: (EU) 2023/2297 Commission Implementing Regulation (EU) 2023/2297 of 26 October 2023 identifying neighbouring container transhipment ports pursuant to Directive 2003/87/EC of the European Parliament and of the Council
https://eur-lex.europa.eu/eli/reg_impl/2023/2297/oj/eng

Port State Control Implementing Regulation: (EU) 2024/2027 Commission Implementing Regulation (EU) 2024/2027 of 26 July 2024 on verification activities pursuant to Regulation (EU) 2023/1805 of the European Parliament and of the Council on the use of renewable and low-carbon fuels in maritime transport, and amending Directive 2009/16/EC
https://eur-lex.europa.eu/eli/reg_impl/2024/2027/oj/eng

MRV Implementing Regulation (EU) 2023/2449 of 6 November 2023 laying down rules for the application of Regulation (EU) 2015/757 of the European Parliament and of the Council as regards templates for monitoring plans, emissions reports, partial emissions reports, documents of compliance, and reports at company level, and repealing Commission Implementing Regulation (EU) 2016/1927
https://eur-lex.europa.eu/eli/reg_impl/2023/2449/oj/eng

RED Delegated Regulation (EU) 2023/1185 Commission Delegated Regulation (EU) 2023/1185 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a minimum threshold for greenhouse gas emissions savings of recycled carbon fuels and by specifying a methodology for assessing greenhouse gas emissions savings from renewable liquid and gaseous transport fuels of non-biological origin and from recycled carbon fuels
https://eur-lex.europa.eu/eli/reg_del/2023/1185/oj/eng

Commission Implementing Acts Granting Exemptions Under FuelEU, as Notified by Member States

Croatia: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500636

Denmark: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202407471

Finland: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500969

Greece: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202407469

Italy: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202407470

Malta: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202407472

Portugal: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500358

Spain: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500356

France: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500357

Cyprus: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202500635