Webinar

Preparing for FuelEU Maritime: Deep Dive Together with the European Commission

Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

European Commission

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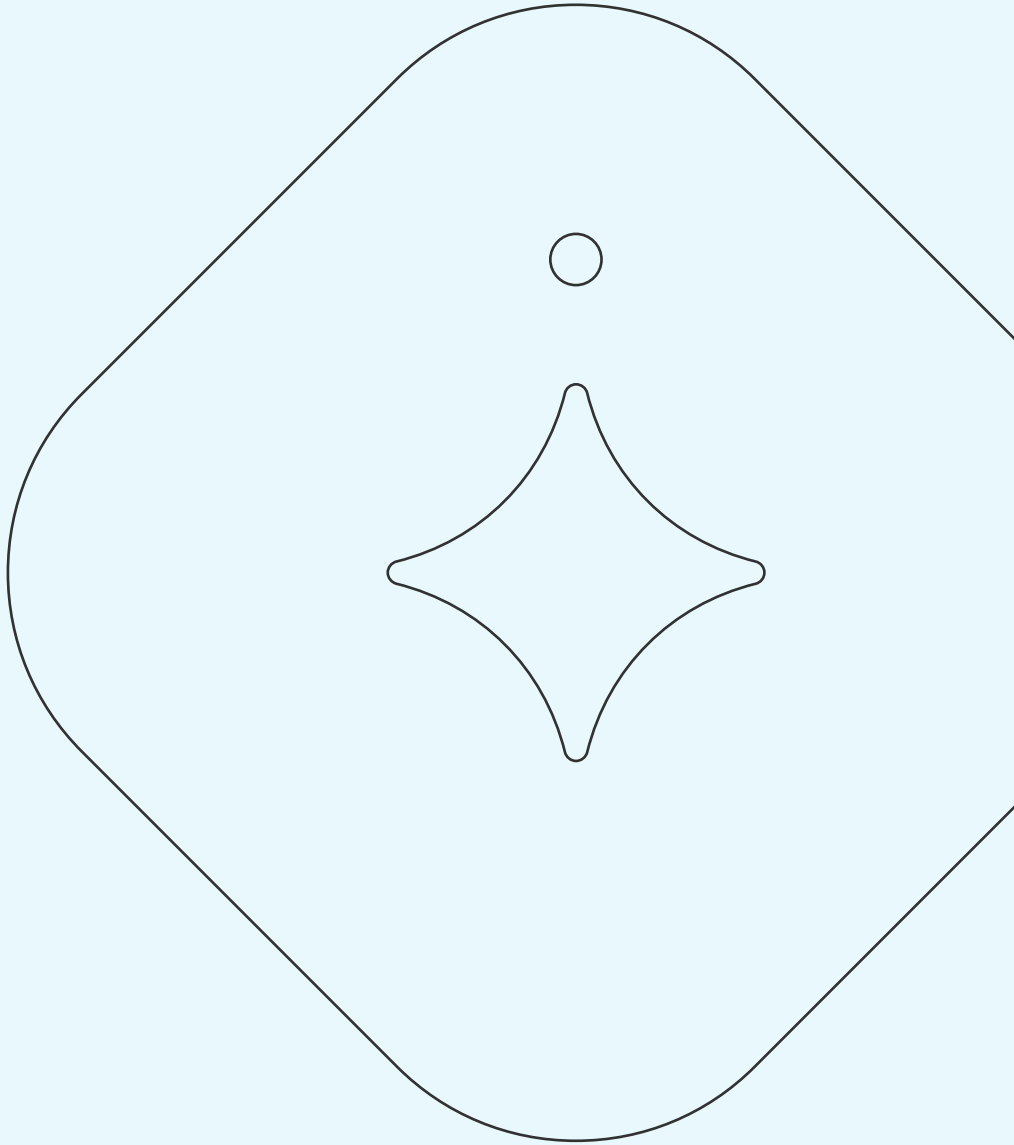
Introduction to Webinar



Webinar Agenda

10:00 – 10:05	• Introduction
10:05 – 11:00	• European Commission Presentation
11:00 – 11:10	• Mini Questions & Answers (Q&A)
11:10 – 11:30	• Center Presentations 1. Certification of Fuels 2. FuelEU Pooling 3. Commercial Contracts for FuelEU
11:30 – 12:00	• Panel Questions & Answers (Q&A)


Join at
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European Commission Presentations

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SUSTAINABLE & SMART
MOBILITY STRATEGY

FuelEU Maritime



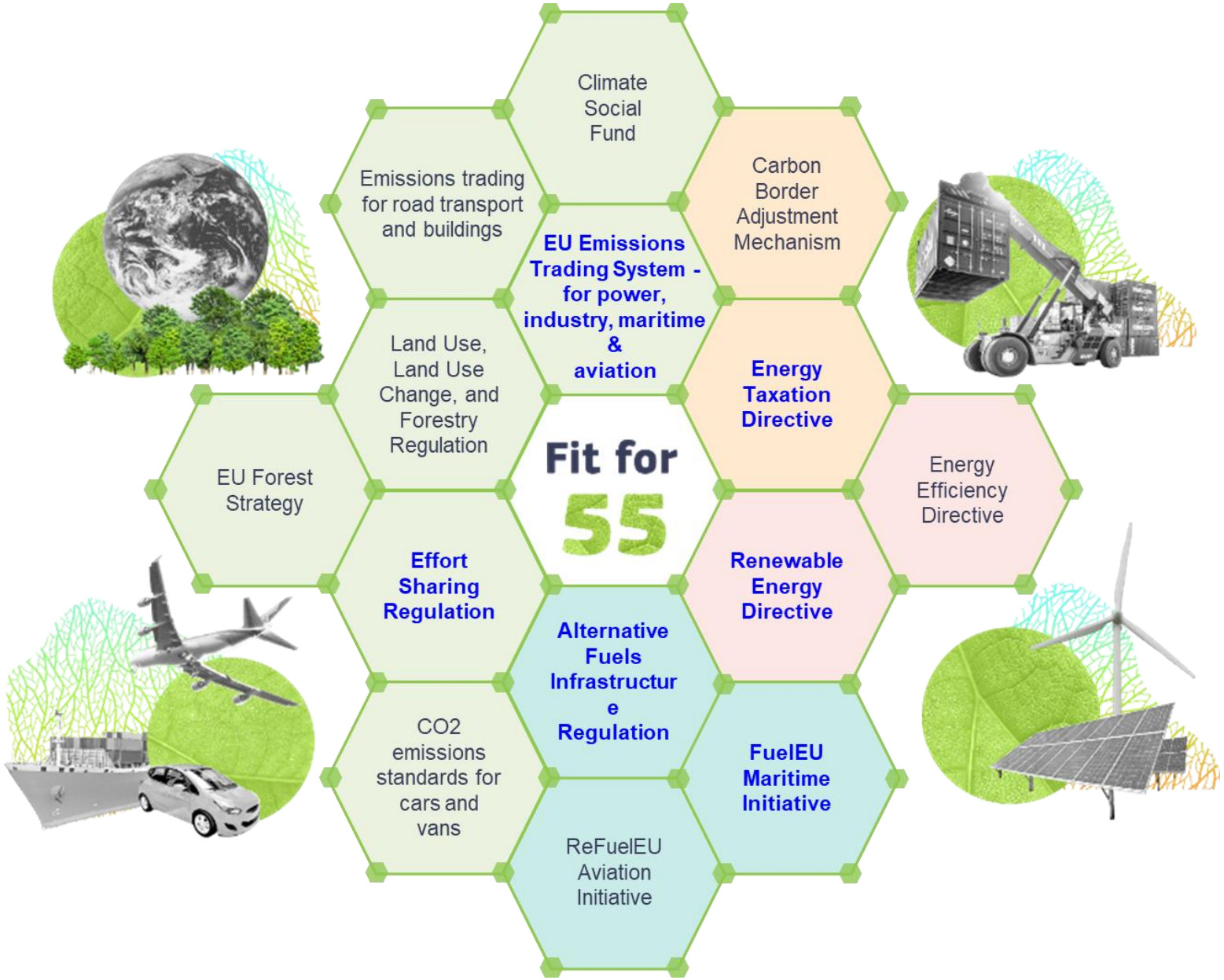
FuelEU Workshop - 16 January 2024

Maersk McKinney Moller Center for Zero Carbon Shipping

European Commission

Directorate-General for Mobility and Transport

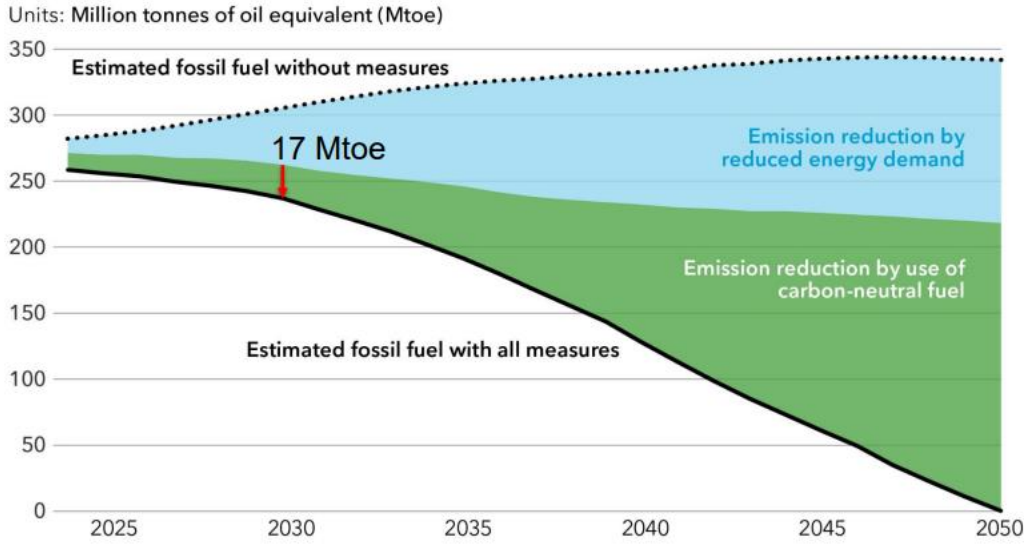
Unit D.1 – Maritime Transport and Logistics


Climate Social Fund
Emissions trading for road transport and buildings
Carbon Border Adjustment Mechanism
EU Emissions Trading System - for power, industry, maritime & aviation
Land Use, Land Use Change, and Forestry Regulation
Energy Taxation Directive
EU Forest Strategy
Fit for 55
Energy Efficiency Directive
Effort Sharing Regulation
Renewable Energy Directive
Alternative Fuels Infrastructure Regulation
CO2 emissions standards for cars and vans
FuelEU Maritime Initiative
ReFuelEU Aviation Initiative

Fitfor5 maritime instrument	In short/ Objective
ETS – Extension of the Emission Trading Scheme to maritime transport	• Carbon tax/ Trading scheme • Promote Energy Efficiency and Energy Transition
AFIR – Alternative Fuels Infrastructure Regulation	• Require EU ports to develop shore-power • Bunkering infrastructure for alternative fuels.
FuelEU Maritime Regulation	• Promote the use of renewable and low-carbon fuels in maritime transport.

MARITIME

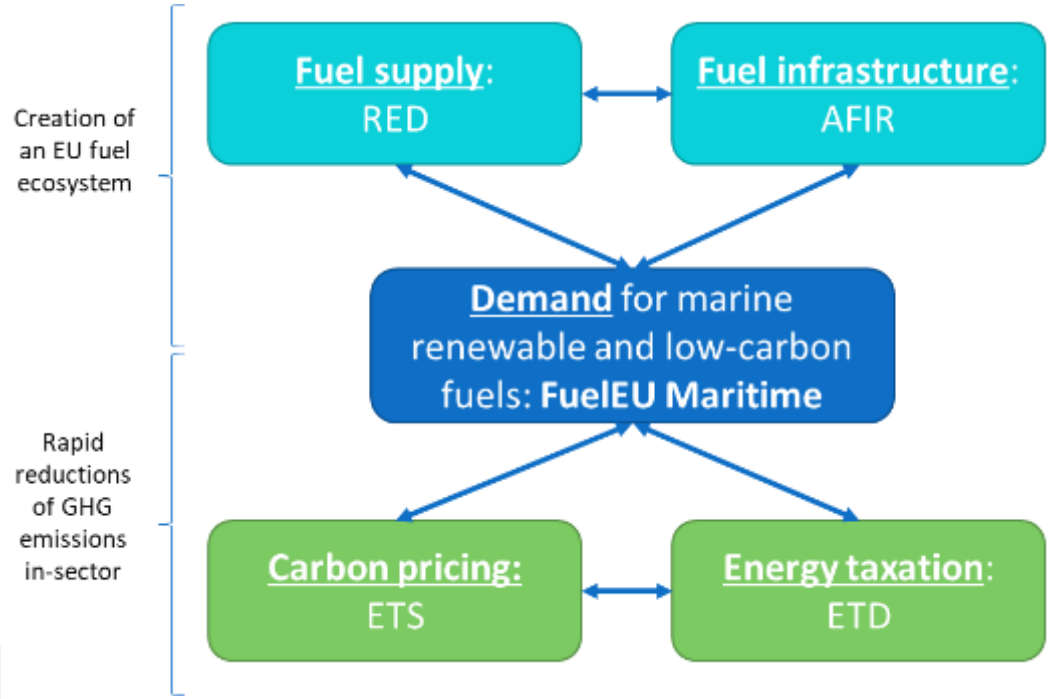
FuelEU maritime



DNV-GL (2023) | Maritime Forecast to 2050

Abating maritime emissions requires:

- Improving energy efficiency ➔ **using less fuel**
- Using renewable and low carbon fuels ➔ **using cleaner fuels**



Complementary FuelEU – ETS – AFIR - ETD

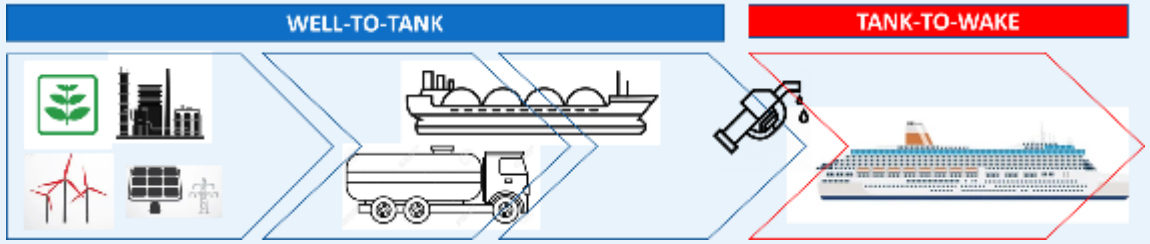
- ETS promotes energy savings while FuelEU addresses **fuel technology**.
- FuelEU addresses fuel demand, RED fuel supply and AFIR fuel distribution
- Taxation levels for renewable and low-carbon fuels and for electricity at berth are consistent with FuelEU goals.

- Focus on **fuel** and on **demand – promotion of uptake of renewable and low-carbon fuels** for maritime transport – complement to Energy Efficiency
- **Technology-neutral approach:** maritime operators will need to use an increasing proportion of zero and low carbon sustainable fuels, without obligation to use a specific technology
- **Establishes** target reduction % for the yearly average GHG intensity of the energy used on-board **(gCO2eq/MJ)**

2025	2030	2035	2040	2045	2050
-2%	-6%	-14,5%	-31%	-62%	-80%

- **Exemptions:** Small islands < 200,000 residents; PSO connections between island MS and another MS and between an island and the mainland of the same MS; outermost regions; transhipment ports; ice class ships and ships navigating in ice**.**
- **Scope:** ships above 5000 GT, intra-EU traffic + 50% international, EU ports (same as for ETS)
- **Additional requirement for Zero-Emission at berth** (OPS and alternative zero-emission technologies) - compulsory as of 2030 for container and passenger vessels (some exemptions up to 2035)

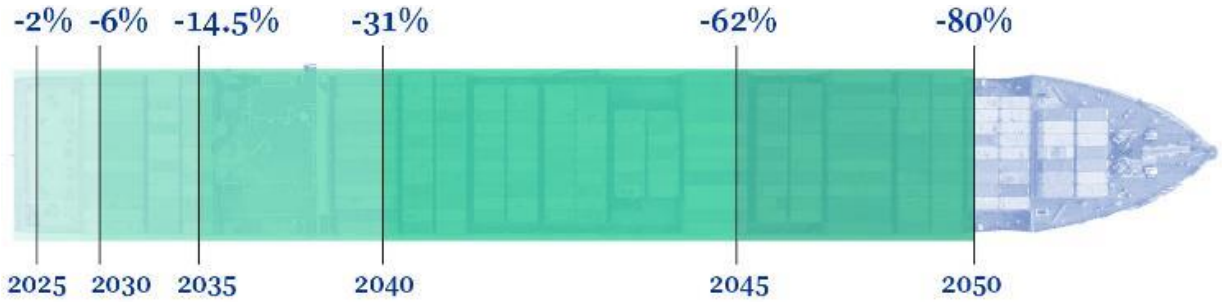
- Inclusion of **CO_2, methane and nitrous oxide** on a full Well-to-Wake calculation: allows fair comparison of fuels



$$\boldsymbol{GHGe}\left[gCO_{2eq}\right] = (\boldsymbol{WtT}\ (fuel, electricity) + \boldsymbol{TtW}(\text{combustion, slip}))$$

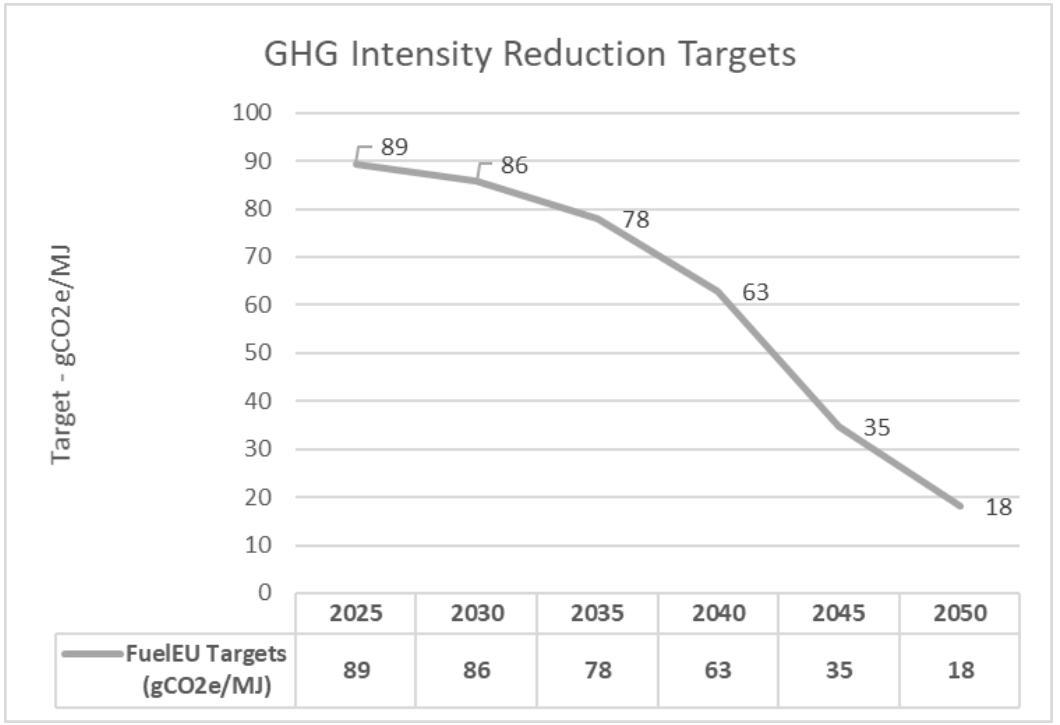
- **Flexibility mechanism** via banking and borrowing: surpluses and (small) deficits can be carried over to the next year
- Voluntary and open **pooling mechanism** to reward/ incentivise overachievers and encourage the rapid deployment of the most advanced options
- **Non-compliance** – deterrent financial penalty
- Monitoring and Reporting is based on **MRV approach,** with some additional data (e.g. calculation of Compliance Balance)

FuelEU maritime GHG Intensity Targets



- **General targets**: Establishes limits on the annual average GHG intensity of the energy used on-board. **Reference value: 91.16 g CO_2eq/MJ**.

- Ref Value:
  - Calculated based on 2020 MRV fleet data
  - LNG fuelled fleet considered
  - Fuel Mix as per MRV reported fuel consumption



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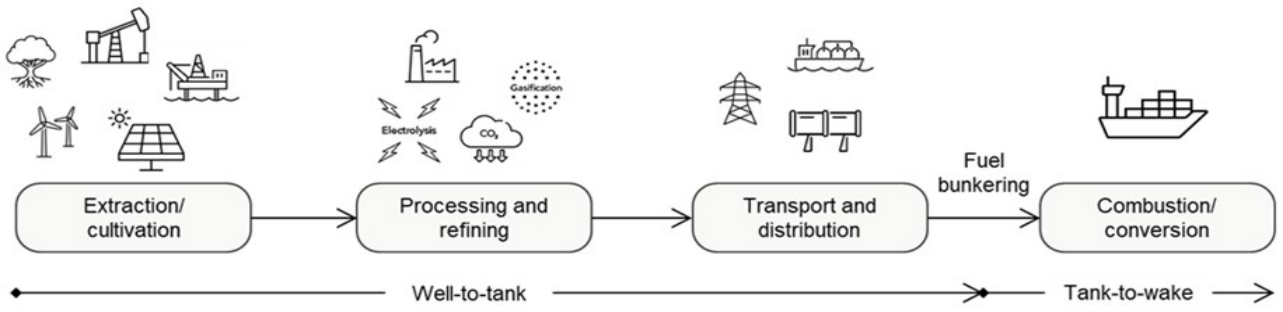
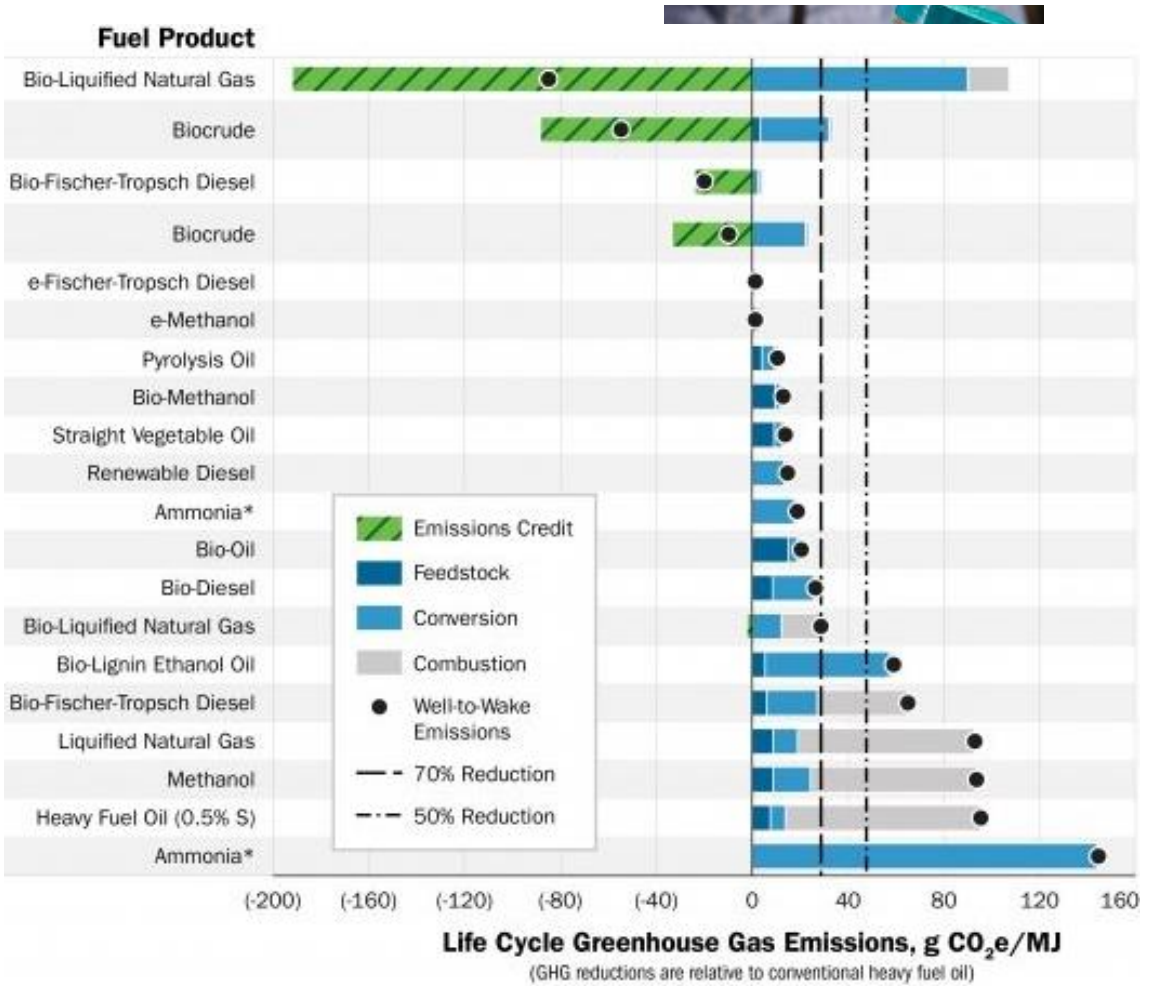
Life Cycle – Well-to-Wake (WtW) Methodology



$$\boldsymbol{GHGe}\left[gCO_{2eq}\right] = (\boldsymbol{WtT}\ (fuel, electricity) + \boldsymbol{TtW}(\text{combustion, slip}))$$



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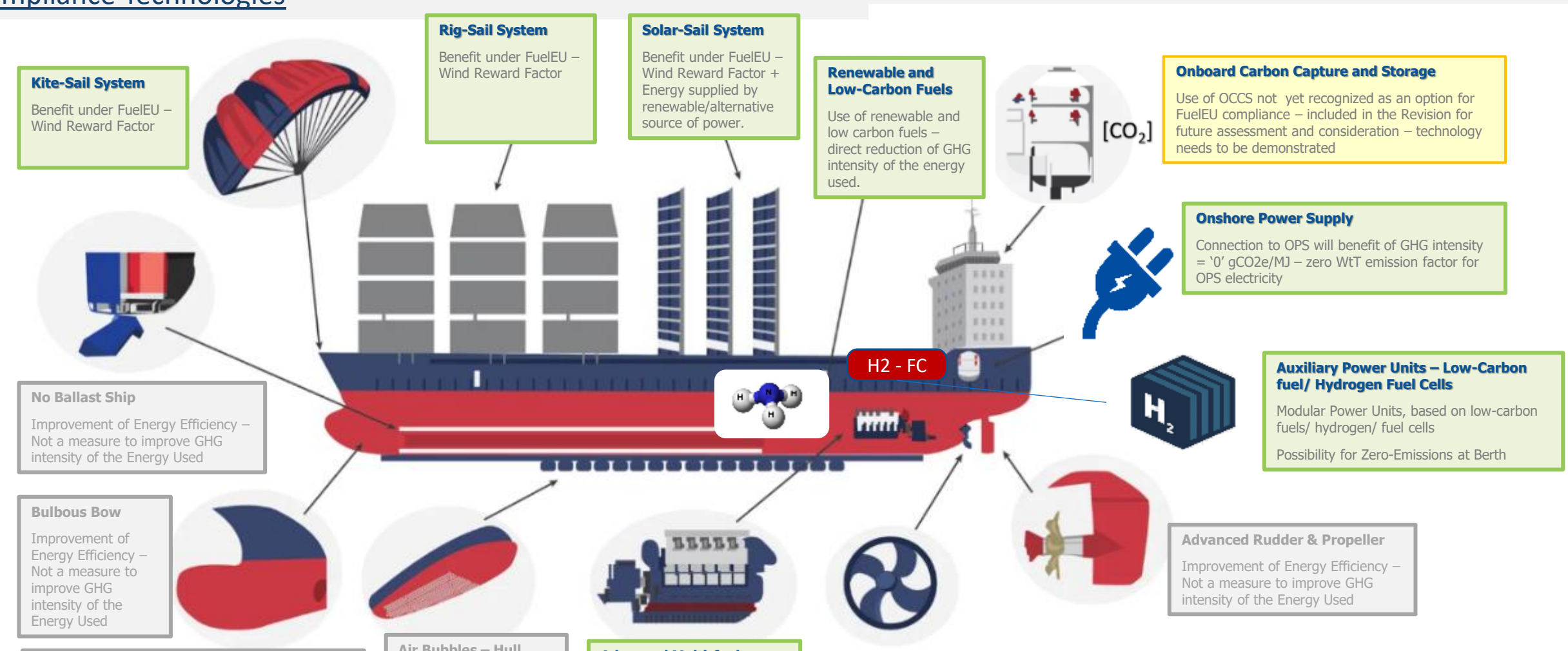
Compliance Technologies



Wind Assisted Propulsion

- Wind Assisted Propulsion is incentivized through a reward factor given in function of installed Wind Power

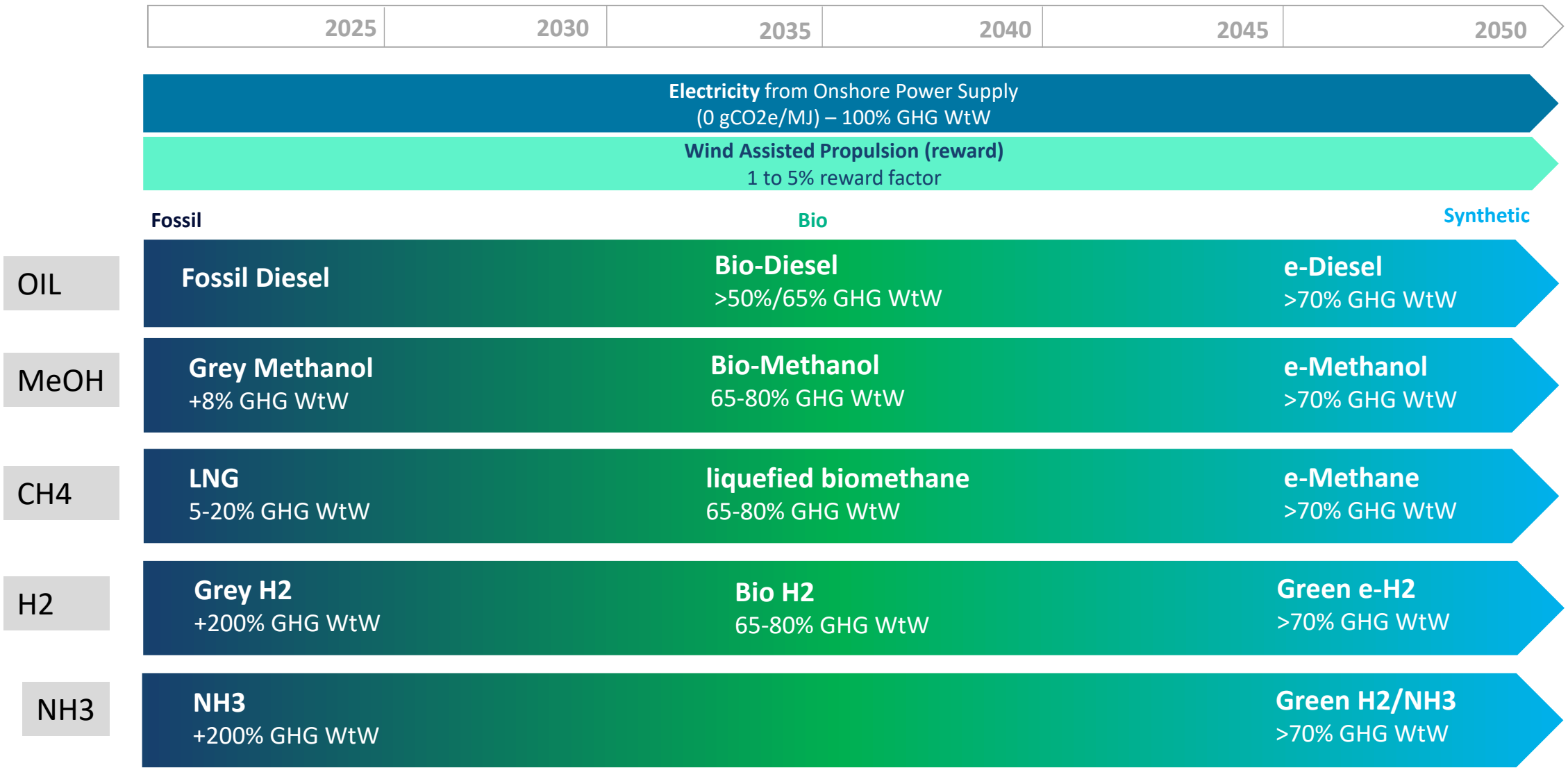
Reward factor (f_{WIND})	P_{WIND}/P_{PROP}
0,99	0,05
0,97	0,1
0,95	≥ 0,15

P_{WIND} - available effective power of the wind-assisted propulsion systems - 2021 guidance on treatment of innovative energy efficiency technologies for calculation and verification of the attained energy efficiency design index (EEDI) and energy efficiency existing ships index (EEXI) (MEPC.1/Circ.896);
P_{PROP} - propulsion power of the ship and corresponds to PME 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)).

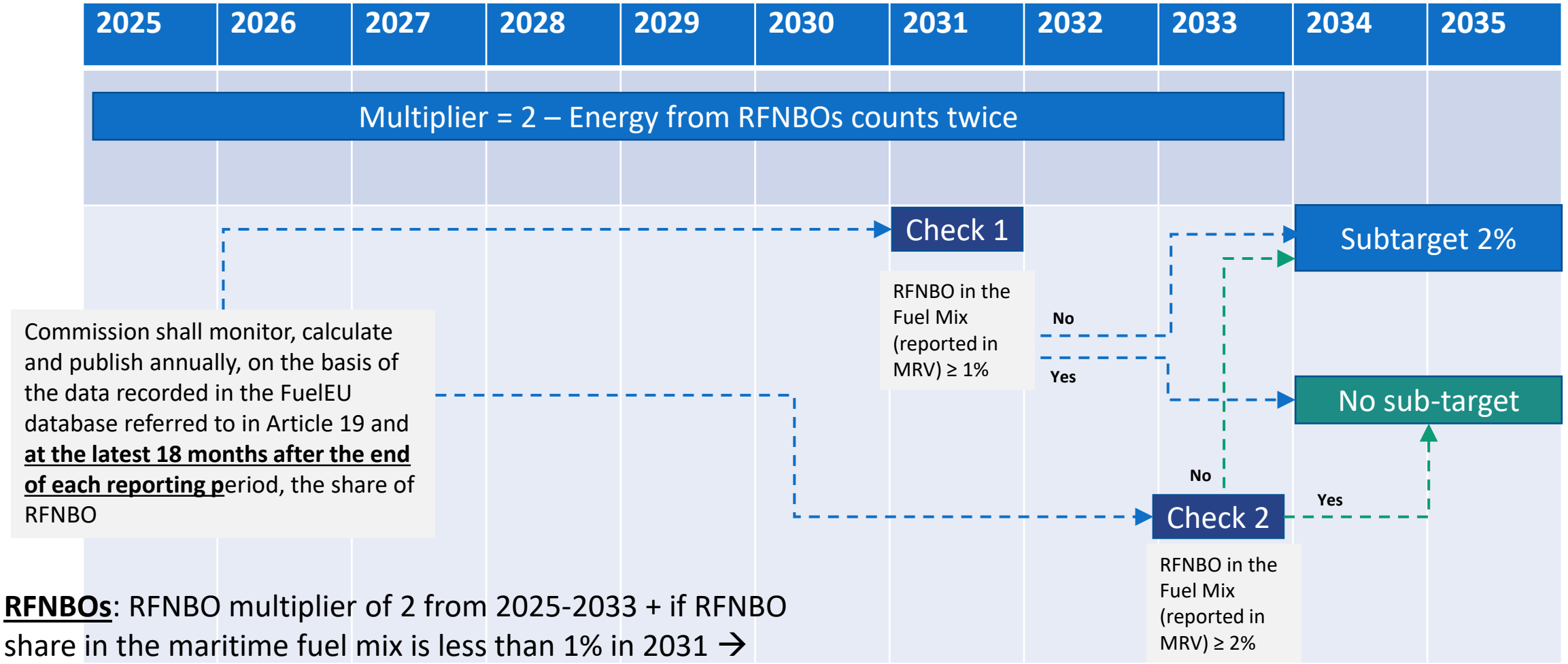
- GHG intensity (gCO2e/MJ) = f_{WIND} x (WtT + TtW)

- FuelEU rewards Wind Installed Power. In the future a possibility to integrate Wind Energy used for propulsion in the GHG intensity formula may be considered (methodology currently missing)

Compliance Technologies



RFNBOs



RFNBOs: RFNBO multiplier of 2 from 2025-2033 + if RFNBO share in the maritime fuel mix is less than 1% in 2031 → RFNBO subtarget of 2 % will kick in from 2034.

Additional Zero Emissions at Berth

- Containerships and passenger ships (>5,000GT) required to connect to onshore power supply, securely moored at berth, **in all AFIR ports, as from 1 January 2030**.
- Also, **in all non-AFIR ports, as from 1 January 2035, for all ports that develop OPS capacity**.
- Ships at anchorage not covered, but voluntary opt-in provision for MS.

- **Exemptions** for:
  1. Short stays (<2hrs)
  2. Unscheduled port call due to safety
  3. Use of **zero emission technologies**
  4. Unavailable OPS connection in port
  5. Incompatible equipment in port
  6. In case of risk to the grid stability
  7. During emergency
  8. When requested by authorities for the purposes of maintenance/inspection.
- **Limit on exemptions (4), (5) and (6) from 1 January 2035**, 10% of the port call or to maximum 10 port calls during the reporting period, whichever is lower.

Eligibility of Renewable and Low-Carbon Fuels

(Biofuels):

- **Sustainability** and GHG saving criteria - **RED Article 29**
- No "**food-and-feed**" crop Biofuels

(RFNBOs and Recycled Carbon Fuels):

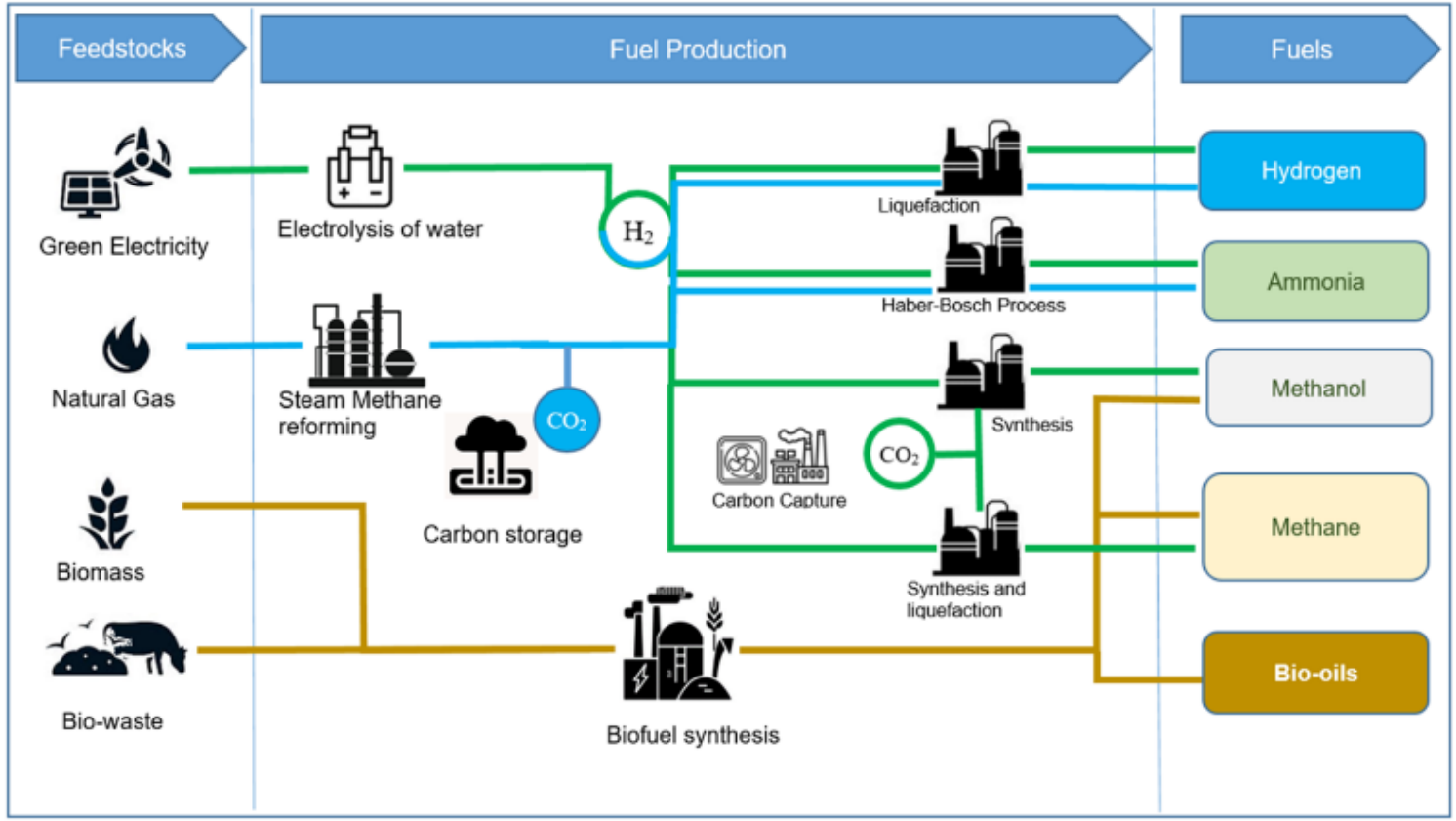
- GHG saving threshold - **RED Article 27(2)**

(Low-Carbon Synthetic Fuels):

Revised (recast) **Gas Directive**

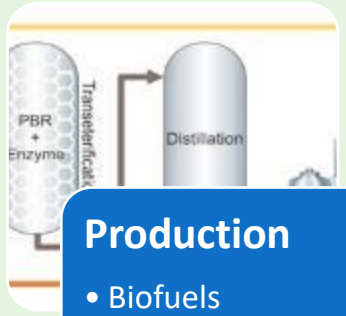
Fuels not meeting criteria treated as fossil fuels

Several Pathways possible:



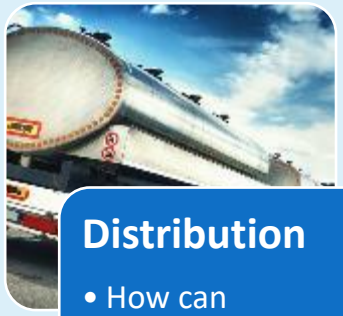
GHG Fuel Certification

Feedstock
- Biomass
- Renewable



Production
- Biofuels
- RFNBOs
- Low-Carbon Synthetic Fuels

RED Certification – Proof of Sustainability



Distribution
- How can distribution be considered (should be at all?)

Blending

(Blending with fossil fuels will be the predominant case)

Bunkering

(How to include Bunkering in the Certification of the Fuel)

FuelEU – GHG Fuel Certification

- **GHG Fuel Certification –** Essential for level playingfield
- Fuel Certificate – to be **submitted together with BDN**
- Need to include **GHG savings for each fuel product** supply
- Blends need to provide relevant information to **ALL parts blended**
- **Book & Claim** not possible under FuelEU
- Fuel Certification for Bunkering **outside EU – OK**! – Fuel Certification Companies

EU Guidelines on GHG Marine Fuel Certification

- European Sustainable Shipping Forum (ESSF) subgroup on Sustainable Alternative Power for Ships – **Workstream on GHG Fuel Certification**
- Leadership by **Maersk Mc-Kinney Moller Center for Zero Carbon Shipping – ISCC support**
- **EU GHG Fuel Certification Guidelines** – main output/Deliverable – 1Q 2024
- Support to **FuelEU** and **ETS (maritime)** implementation
- **Support to Stakeholders** (Shipping companies, Fuel Suppliers, Verifiers, Certification Companies) in certification of Sustainable Marine Fuels and
- **Demonstration of compliance with RED and Fu**elEU for all sustainable fuel fraction bunkered
- Contribute to solve dilemmas such as:
  1. **Reproduction of Proof of Sustainability for different fuel fractions of the same batch.**
  2. **RED Certification outside the EU**

European Commission

EU Guidelines on GHG Marine Fuel Certification

Bridging the gap between RED and FuelEU implementation

BIOFUELS

- In FuelEU, needs at least between 50% and 65% saving relative to RED Fuel Comparator ref 94 gCO2eq /MJ so only fuels with GHG intensity below 32.9 and 47 gCO_{2eq}/MJ can be considered.
- If the above is not met, it is considered to have the same WtT value as a fossil fuel.
- Safeguard against uptake of biofuels form "food-and-feed" crops.
- Credit given to biofuels (E – Cf_CO2/LCV) to account for biomass growth. Well-to-Tank Emission Factor effectively reduced by the

E-FUELS

- 70% saving threshold required for ReRFNBO in FuelEU – below that = same as fossil fuel.
- No credit given in FuelEU Well-to-Tank (as in the case of Biofuels) – Credit for CCS included in RED Delegated Regulation
- RFNBOs - multiplier to double their energy in (i.e. halving their GHG intensity), which can be applied until 31 December 2033
- Low-Carbon Synthetic Fuels – Methodology for GHG intensity calculation under development (Gas Directive – waiting for December 2024)
- RED DAs FAQ - https://energy.Commission Delegated Regulation (EU) 2023/1184 Commission Delegated Regulation (EU) 2023/1185 07/2023_07_26_Document_Certification_questions.pdf

Every Fuel at Every Port?

- **New FuelEU paradigm –** Demand for renewable and low carbon fuels will require Fuel Supply Contracts for supply of fuel products with specific GHG intensity.
- International Shipping will move from "**Spot Bunkering" to "Fuel Supply Contracts"** – Not expected that all port will have available "on spot" each required fuel.

Fuel Supply Contracts - Important to Consider:

1. **Price reference –** Ideally use agreed global reference
2. **Duration –** Agree on a duration (longer duration – better possibility to negotiate more favourable prices for 1st years
3. **Fuel Specifications**
4. **Volumes required –** including conservative margin
5. **GHG Fuel Certification requirements**
6. **Fuel Supply details/ Delivery Terms**
7. **Penalties for non-compliance with contractual terms.**

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Certification of Fuels:

- **Biofuels** – RED Annex-V, Part C
- **RFNBOs/RCF** – RED New Delegated Acts
- **Low-Carbon Synthetic Fuels –** Gas Directive

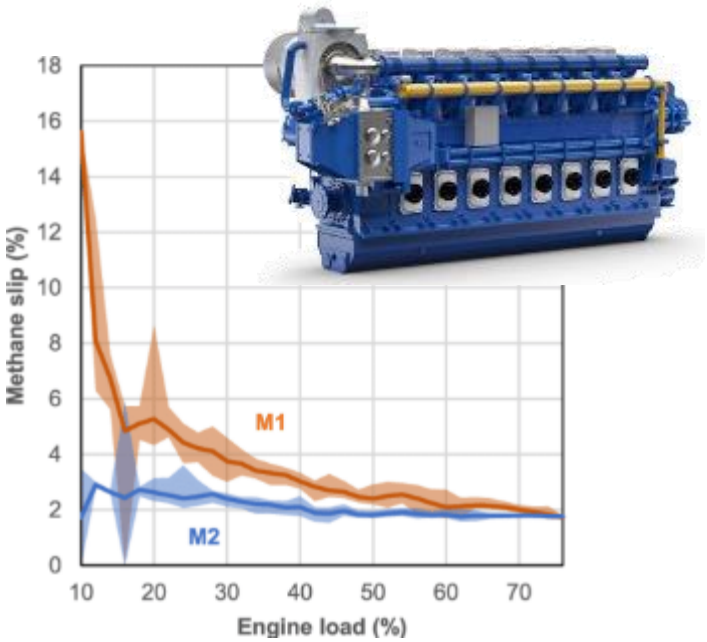
Certification of Energy Converters:

- Possibility to certify "actual values" for Tank-to-Wake Emission Factors, except TtW CO2 emission factor for Fossil Fuels

*Where can "**actual emission factors**" be calculated?*	WTT	TTW			
		Combustion Emission Factors			Slippage
		CO2	CH4	N20	
Fossil	No(1)	No(3)	yes(5)	Yes(5)	Yes(5)
Bio	Yes(2)	Yes(4)	Yes(5)	Yes(5)	Yes(5)
Synthetic	Yes(2)	Yes(4)	Yes(5)	Yes(5)	Yes(5)

***(1)** – WTT for fossil fuels – always DEFAULT.*
***(2)** – WTT for bio/RFNBO RED/recast Gas Directive methodologies.*
***(3)** –TTW CO2 emission factor fossil fuels - always DEFAULT.*
***(4), (5)** – ACTUAL VALUE possible if demonstrated by International Standard*

Methane Slip from LNG engines



Default Values in FuelEU

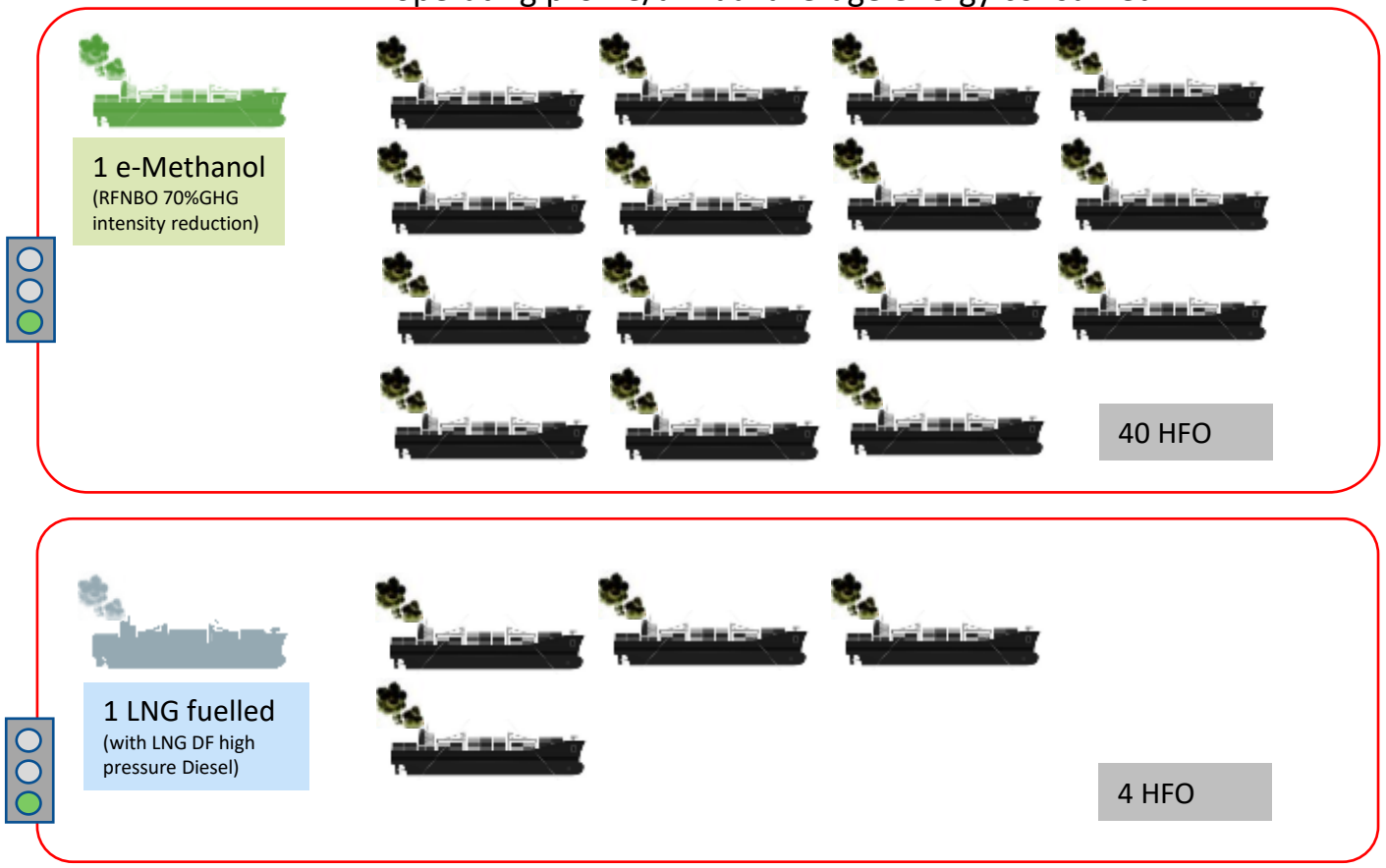
LNG engine technology	Cslip (% of used fuels)
LNG Otto (dual fuel medium speed)	3,1
LNG Otto (dual fuel slow speed)	1,7
LNG Diesel (dual fuels)	0,2
Lean-Burn Spark Ignited Gas Engine (LBSI)	2,6

- FuelEU contains **default values for Methane Slip Emissions (Cslip)** from LNG internal combustion engines (ref: 4th IMO GHG Study)
- Possible to determine/demonstrate "Methane Slip" (Cslip) values if demonstrated based on existing international standards.
- ESSF SAPs (Expert Group) currently working on technical elements for Methane Slip certification

Flexibility Mechanisms - Pooling

- Voluntary and open **pooling mechanism** to reward/ incentivise **overachievers** and encourage the rapid deployment of the most advanced options
- **Together with the Multiplier** for RFNBOs, pooling represents an opportunity for fleets to go beyond compliance already for early years 2025 or 2030.

Examples of **pooling** for **2025 compliance** – ships with same operating profile/annual average energy consumed



Simplified compliance balance calculations

CB(e-Methanol) = (GHGt – GHGa) x E
= (0.98x91.16-0.15x91.16) x E
= (0.98-0.15) x 91.16 x E
= 75,66E gCO2e

CB(LNG) = (GHGt – GHGa) x E
= (0.98x91.16-80) x E
= 9.33E gCO2e

CB(HFO) = (GHGt – GHGa) x E
= (0.98x91.16-92) x E
= -2.663E gCO2e

Flexibility Mechanisms - Banking

- **Banking and borrowing**: surpluses and (small) deficits can be carried over to the next year

Banking

Year N	Year N+1	Year N+2
		
CBi > 0	CBi > 0	CBi < 0
Banked Surplus	Banked Surplus	Use Banked Surplus

CB – Compliance Balance

Flexibility Mechanisms - Borrowing

- **Banking and borrowing**: surpluses and (small) deficits can be carried over to the next year

Borrowing

Year N	Year N	Year N+1
		
CB < 0 (A)	CB + (A) ≥ 0	CB - 1,1x(A) ≥ GHGreq
Deficit = (A) Ship non-compliant	advance compliance surplus	Aggravated

CB – Compliance Balance

Compliance

Governance:

- Monitoring and reporting is based on MRV approach – MRV data input.
- FuelEU-specific additional data (e.g. calculation of compliance balance, recording of penalties, exchange and notifications between user groups)
- **Monitoring Template → FuelEU Report → Verification Report**

FuelEU Database:

- Central IT system to support compliance and functioning of the Regulation.
- Associated to THETIS-MRV – "FuelEU Module"
- Developed, hosted and managed by EMSA

FuelEU Penalties:

- Deterrent financial penalty in case of non-compliance with GHG intensity target.
- Compliance Balance (Function of **deficit/surplus** x **energy used**)
- **Separate penalty** in case of non-compliance with requirements for additional Zero-Emissions at berth.
- Allocation of revenues from penalties to MS budgets.

Report and review:

- Extensive report and review clause with the first reporting deadline on 31 December 2027 and every five years thereafter.
- Commitment to look in the future at:
  - Onboard Carbon Capture and Storage
  - Black Carbon
  - Geographic Scope and Ship Size
  - Alignment with IMO.

port

Compliance Timeline

	Jan	Feb	Mar	Apr	May	Jun	…
Company	31JAN – FuelEU Report submitted to Verifier			30APR – limit for application of Flexibility Mechanisms			
Verifier			31MAR – Verification Report uploaded to FuelEU database			30JUN – FuelEU document of Compliance	
CA of Administering State							

Secondary Legislation

- **14 Implementing and Delegated Acts**
- Important building blocks for implementation of FuelEU
- Covering OPS, updates to Annex-II, RFNBOs, Zero Emission Technologies, Governance, FuelEU database, amongst others.

FuelEU Maritime
Dimensions of FuelEU Implementation

RLCF Alliance

Renewable and Low-Carbon Fuels Alliance

- Focus on uptake of **availability and scalability of renewable and low carbon fuels**.
- 200+ members, including operators, fuel suppliers, member states, etc.
- **Maritime Roundtable** focused on forecasting low-GHG marine fuel demand, in accordance with the FuelEU GHG intensity reduction curve.

EMSA

- EMSA supporting with **Governance** aspects of the FuelEU
- **FuelEU Data Base** currently under development – will be the "heart" of the Implementation

Other Fitfor55

- **Implementation of other Fitfor55 waterborne instruments** will be decisive for successful FuelEU implementation
- **Interdependency mainly on AFIR** (for shore-power availability) and in **RED** (for fuel certification)
- ETS implementation will also present important interdependencies, notably regarding the mitigation of risk of re-routing.

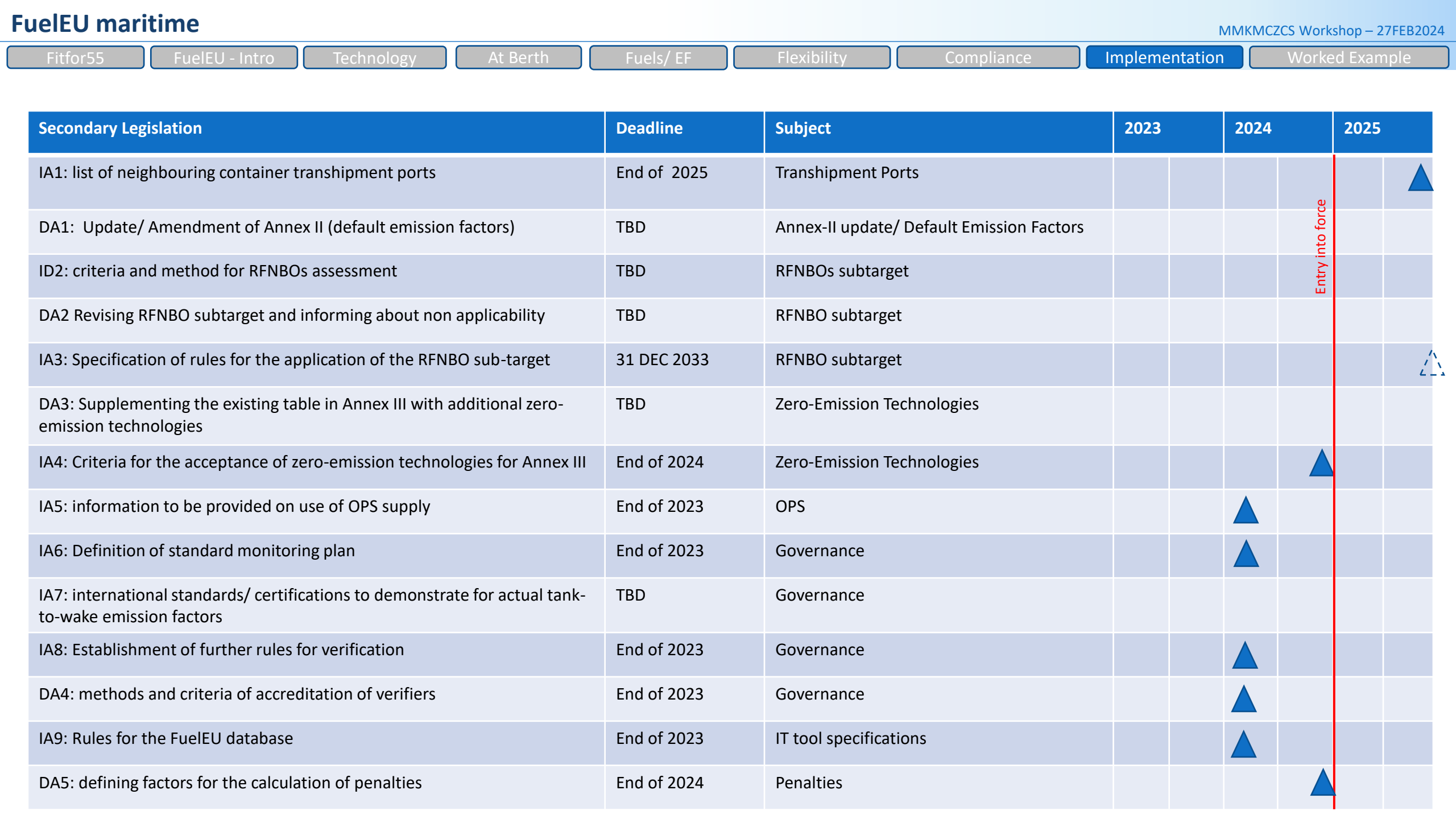
ESSF

European Sustainable Shipping Forum

- Sub-group on Sustainable Alternative Power fro Shipping working on FuelEU implementation
- Workstreams on Zero Emission Technologies, GHG Fuel Certification, Certification of Engines for lower methane emissions

FuelEU maritime

Secondary Legislation	Deadline	Subject	2023	2024	2025
IA1: list of neighbouring container transhipment ports	End of 2025	Transhipment Ports			
DA1: Update/ Amendment of Annex II (default emission factors)	TBD	Annex-II update/ Default Emission Factors			
ID2: criteria and method for RFNBOs assessment	TBD	RFNBOs subtarget			
DA2 Revising RFNBO subtarget and informing about non applicability	TBD	RFNBO subtarget			
IA3: Specification of rules for the application of the RFNBO sub-target	31 DEC 2033	RFNBO subtarget			
DA3: Supplementing the existing table in Annex III with additional zero-emission technologies	TBD	Zero-Emission Technologies			
IA4: Criteria for the acceptance of zero-emission technologies for Annex III	End of 2024	Zero-Emission Technologies			
IA5: information to be provided on use of OPS supply	End of 2023	OPS			
IA6: Definition of standard monitoring plan	End of 2023	Governance			
IA7: international standards/ certifications to demonstrate for actual tank-to-wake emission factors	TBD	Governance			
IA8: Establishment of further rules for verification	End of 2023	Governance			
DA4: methods and criteria of accreditation of verifiers	End of 2023	Governance			
IA9: Rules for the FuelEU database	End of 2023	IT tool specifications			
DA5: defining factors for the calculation of penalties	End of 2024	Penalties			



Practical Examples

Worked Example – Setting the Scene

$$GHG\ intensity = f_{wind} \times (WtT + TtW)$$

$$\frac{\sum_i^{n\ fuel} M_i \times CO_{2eq\ WtT,i} \times LCV_i + \sum_k^c E_k \times (CO_{2eq\ electricity,k} = 0)}{\sum_i^{n\ fuel} M_i \times LCV_i \times RWD_i + \sum_k^c E_k}$$

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

Units are $\frac{gCO2eq}{MJ}$, basically $\frac{\text{Fuel converted into WtW } CO_{2eq}}{\text{Total Energy}}$

Compliance balance = (GHG target intensity – GHG actual intensity) x Total Energy

Worked Example – Setting the Scene

Reference value 91.16 gCO_{2eq}/MJ

Target 2025	**2.0%**	**89.3**
Target 2030	6.0%	**85.7**
Target 2035	14.5%	**77.9**
Target 2040	31.0%	**62.9**
Target 2045	62.0%	**34.6**
Target 2050	80.0%	**18.2**
HFO		**91.6**
MGO		**90.6**
LNG Otto Medium speed		**91.0**
Fossil methanol		**~100.4**
Fossil ammonia		**~121.0**
Fossil H_2		**~132.0**

- **Reference value from 2020 is 91.16 gCO_{2eq}/MJ – this was based on the fuel mix reported in MRV in 2020**
- **VLSFO, MGO & LNG in 4 stroke Otto cycle engine will not lead to compliance in 2025 and beyond, unless blend-in/drop-in low-GHG compatible fuels are introduced**
- **Neither will fossil-based methanol, ammonia or H_2**
- **In an IMO context, you can still build LNG and methanol powered vessels, obtain a good attained EEDI, and also have some benefit in CII**

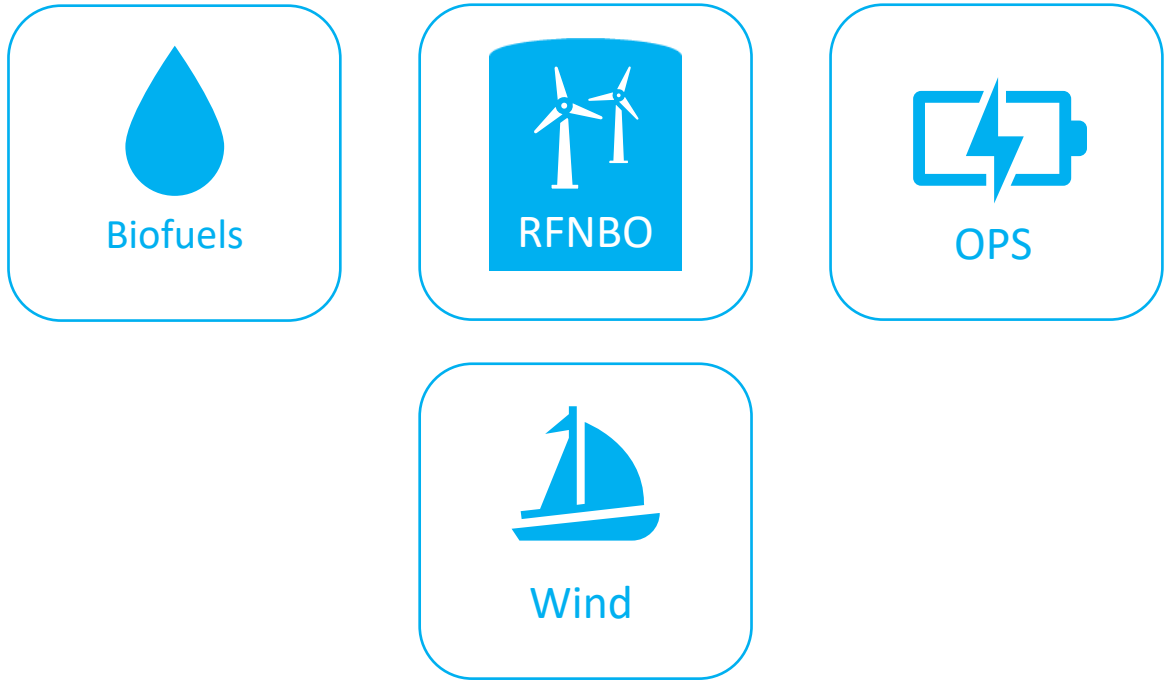
Worked Example – Setting the Scene

Reference value		91.16 gCO_{2eq} /MJ
Target 2025	**2.0%**	**89.3**
Target 2030	6.0%	**85.7**
Target 2035	14.5%	**77.9**
Target 2040	31.0%	**62.9**
Target 2045	62.0%	**34.6**
Target 2050	80.0%	**18.2**
LNG Otto Slow speed		**83.8**
LNG Diesel Slow speed		**76.1**
LPG & Ethane		***72~75**

*Estimated

Amongst fossil fuels, LNG and LPG slow speed engines are compliant to 2034 or 2039.

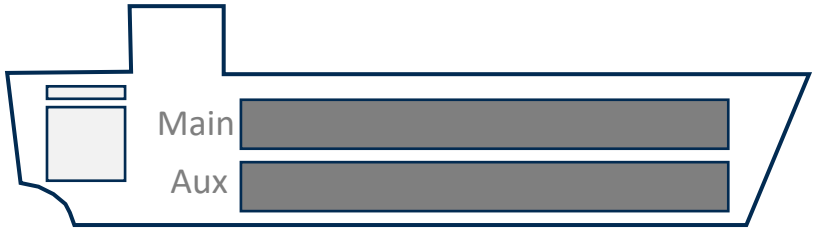
The other main options for individual ships are:



CASE 1: HFO + MDO / Intra-EU

Summary

Fossil
Bio
E-fuels
Natural gas



GHG Intensity Calc

WtT		7,42E+09	gCO2e
TtWi		4,26E+10	gCO2e
WtW		5,00E+10	gCO2e
WtTi		1,36E+01	gCO2e/MJ
TtWi		7,80E+01	gCO2e/MJ
f_wind			
GHGi		**91,62**	gCO2e/MJ

Fail 2025

Year	% Reduction	GHGIEtarget
2025	2	89,34
2030	6	85,69
2035	14,5	77,94
2040	31	62,90
2045	62	34,64
2050	80	18,23

Summary Data

- Containership > 5,000GT/ Intra-EU Voyages
- 12,000 tons HFO + 1400 tons MDO = 546 million MJ
- Assumed Aux Fuel Consumption (FC) ≈ 10% Total Fuel Consumption
- Typical conventional oil-based installation

Compliance

$$CB = (GHG_{i,target} - GHG_{i,actual}) \times Energy_{total}$$

$$FuelEU\ Penalty = \frac{|CB|}{GHG_{i,actual} \times 41000} \times 2400$$

Compliance Balance Calculation

Year	CB (gCO2e)	CB (tCO2e)
2025	-1,25E+09	-1247,41
2030	-3,24E+09	-3237,55
2035	-7,47E+09	-7466,58
2040	-1,57E+10	-15675,87
2045	-3,11E+10	-31099,40
2050	-4,01E+10	-40054,99

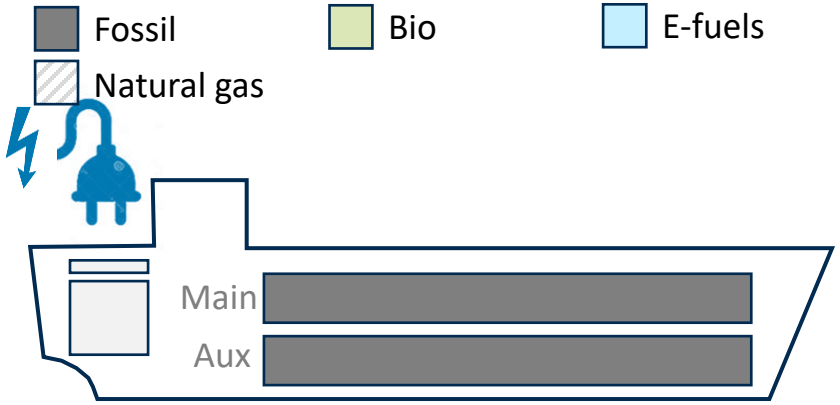
FuelEU Penalty

Year	CB (gCO2e)	FuelEU Penalty
2025	-1,25E+09	796.959,55 €
2030	-3,24E+09	2.068.434,57 €
2035	-7,47E+09	4.770.318,99 €
2040	-1,57E+10	10.015.153,45 €
2045	-3,11E+10	19.869.084,86 €
2050	-4,01E+10	25.590.722,46 €

- Compliance Balance negative for all years.
- FuelEU Penalty 2025 close to 800k€
- If fuel consumption is doubled, achieved GHG intensity is still the same, but compliance balance and penalty would be doubled
- If instead she did only extra EU, then only 50% of the energy is in scope, compliance balance and penalty would be halved

CASE 2: HFO + MDO / OPS / Intra-EU

Summary



GHG Intensity Calc

WtT		7,18E+09	gCO2e
TtWi		4,13E+10	gCO2e
WtW		4,85E+10	gCO2e
WtTi		1,31E+01	gCO2e/MJ
TtWi		7,56E+01	gCO2e/MJ
f_wind			
GHGi		**88,79**	gCO2e/MJ

Year	% Reduction	GHGIEtarget
2025	2	89,34
2030	6	85,69
2035	14,5	77,94
2040	31	62,90
2045	62	34,64
2050	80	18,23

Pass 2025

Fail ≥2030

Summary Data

- Containership > 5,000GT/ Intra-EU Voyages
- 12,000 tons HFO + 1000 tons MDO = 546 million MJ
- 400 tonnes MDO replaced by OPS electricity supply at berth (4,74E+06 kWh)
- Typical conventional oil-based installation

Compliance

$$CB = (GHG_{i,target} - GHG_{i,actual}) \times Energy_{total}$$

$$FuelEU\ Penalty = \frac{|CB|}{GHG_{i,actual} \times 41000} \times 2400$$

Compliance Balance Calculation

Year	CB (gCO2e)	CB (tCO2e)
2025	3,01E+08	300,58
2030	-1,69E+09	-1689,55
2035	-5,92E+09	-5918,58
2040	-1,41E+10	-14127,88
2045	-2,96E+10	-29551,40
2050	-3,85E+10	-38507,00

FuelEU Penalty

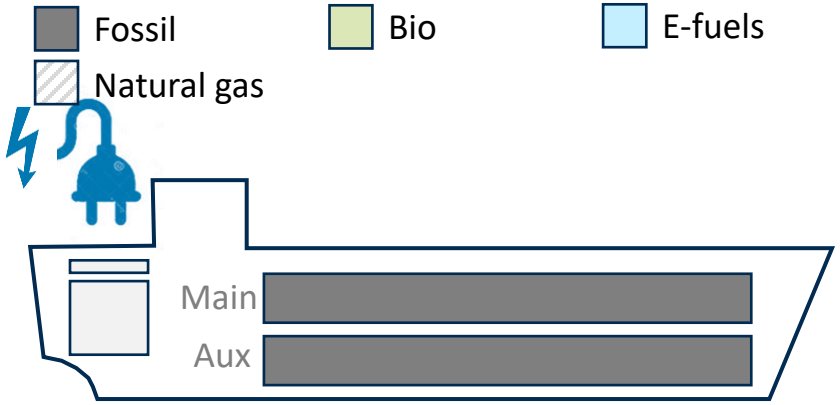
Year	CB (gCO2e)	FuelEU Penalty
2025	3,01E+08	No Penalty
2030	-1,69E+09	1.113.921,30 €
2035	-5,92E+09	3.902.118,09 €
2040	-1,41E+10	9.314.500,09 €
2045	-2,96E+10	19.483.217,80 €
2050	-3,85E+10	25.387.634,53 €

If this ship doubled her fuel consumption, achieved GHG intensity is still the same, but compliance balance and penalty would be doubled

If instead she did only extra EU, then only 50% of the energy is in scope, compliance balance and penalty would be halved

CASE 2: HFO + MDO / OPS / Intra-EU (OPS Calculations)

Summary



Summary OPS

- Containership > 5,000GT/ Intra-EU Voyages
- 400 tonnes MDO replaced by OPS electricity supply at berth (4,74E+06 kWh)
- 10 compliant port calls
- Typical conventional oil-based installation

Port Call History

Energy at berth (total, MJ)	1,71E+07	MJ
Energy at berth (total, kWh)	4,74E+06	kWh

Total Installed Power	60	MW
Established Power demand at berth	10	MW
Established Power demand at berth (w/o load bal)	15	MW

Port Call	Time at berth	Energy (kWh)	Av Power (MW)	Compliant
1	48	4,74E+05	9,88	Yes
2	48	4,74E+05	9,88	Yes
3	48	4,74E+05	9,88	Yes
4	48	4,74E+05	9,88	Yes
5	48	4,74E+05	9,88	Yes
6	48	4,74E+05	9,88	Yes
7	48	4,74E+05	9,88	Yes
8	48	4,74E+05	9,88	Yes
9	48	4,74E+05	9,88	Yes
10	48	4,74E+05	9,88	Yes

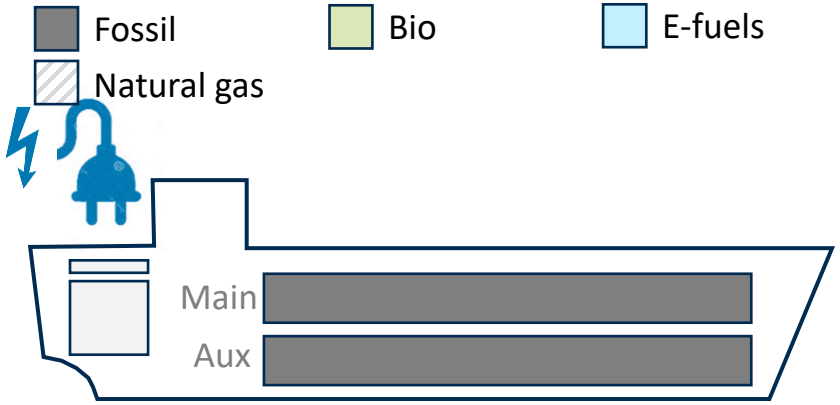
OPS Compliance

$$OPS\ Penalty = 1{,}5 \times Established\ Power\ Demand\ at\ Berth \times Hours\ at\ Berth$$

- Compliant Port Calls determined from 2030, considering FuelEU Article 6.
- Established Power Demand at Berth (EPDB) calculated based on either 1) 25% of Total Installed Power or 2) Electrical Load Balance (approved by RO)
- In case the ship does not connect to OPS during a port call after 2030 (and does not meet any of the criteria for exception), then a penalty will be applied, separate from any penalty resulting from not meeting the GHG intensity limit.
- Calculated using concept of Established Total Electrical Power demand of the ship at berth, which is either the load balance or 25% of the total MCR of the main engines. The load balance value is typically the lower of the two
- Exceptions for connection to OPS as defined in Article 6(5) of FuelEU.

CASE 3: HFO + MDO / OPS / Intra-EU (including non-compliant Port Calls)

Summary



GHG Intensity Calc

WtT		7,30E+09	gCO2e
TtWi		4,19E+10	gCO2e
WtW		4,92E+10	gCO2e
WtTi		1,34E+01	gCO2e/MJ
TtWi		7,68E+01	gCO2e/MJ
f_wind			
GHGi		**90,20**	gCO2e/MJ

Fail 2025

Year	Target Reduction	GHGIEtarget
2025	2	89,34
2030	6	85,69
2035	14,5	77,94
2040	31	62,90
2045	62	34,64
2050	80	18,23

Summary Data

- Containership > 5,000GT/ Intra-EU Voyages
- 12,000 tons HFO + 1000 tons MDO = 546 million MJ
- 200 tonnes MDO replaced by OPS electricity supply at berth (2,37E+06 kWh) + 200 tonnes of MDO @ berth.
- Typical conventional oil-based installation

Compliance

$$CB = (GHG_{i,target} - GHG_{i,actual}) \times Energy_{total}$$

$$FuelEU\ Penalty = \frac{|CB|}{GHG_{i,actual} \times 41000} \times 2400$$

Compliance Balance Calculation

Year	CB (gCO2e)	CB (tCO2e)
2025	-4,73E+08	-473,42
2030	-2,46E+09	-2463,55
2035	-6,69E+09	-6692,58
2040	-1,49E+10	-14901,88
2045	-3,03E+10	-30325,40
2050	-3,93E+10	-39281,00

FuelEU Penalty

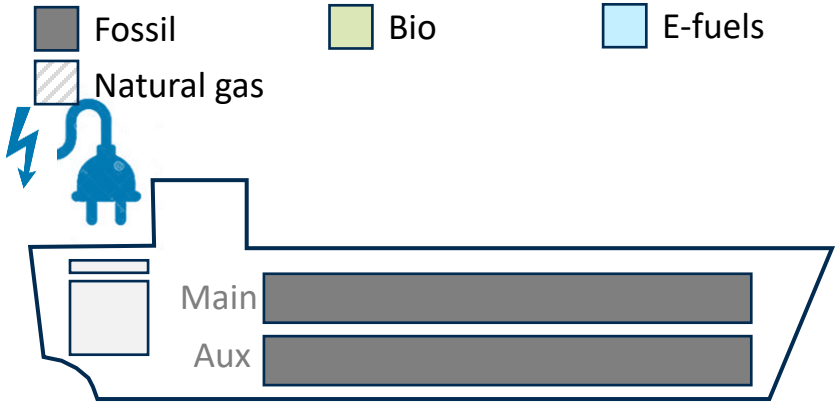
Year	CB (gCO2e)	FuelEU Penalty
2025	-4,73E+08	307.216,60 €
2030	-2,46E+09	1.598.681,13 €
2035	-6,69E+09	4.343.043,25 €
2040	-1,49E+10	9.670.334,44 €
2045	-3,03E+10	19.679.184,54 €
2050	-3,93E+10	25.490.774,92 €

Only the failure to meet compliance for half of the port call in one year would lead to failure to meet the target for 2025.

FuelEU penalty 2025 = **307,2 k€**

CASE 3: HFO + MDO / OPS / Intra-EU (including non-compliant Port Calls) (OPS Calculations)

Summary



GHG Intensity Calc

Energy at berth (total, MJ)	8,54E+06	MJ
Energy at berth (total, kWh)	2,37E+06	kWh

Total Installed Power	60	MW
Established Power demand at berth	10	MW
Established Power demand at berth (w/o load bal)	15	MW

Port Call	Time at berth	Energy (kWh)	Av Power (MW)	Compliant
1	48	4,74E+05	9,88	Yes
2	48			No
3	48	4,74E+05	9,88	Yes
4	48			No
5	48	4,74E+05	9,88	Yes
6	48			No
7	48	4,74E+05	9,88	Yes
8	48			No
9	48	4,74E+05	9,88	Yes
10	49			No

Summary Data

- Containership > 5,000GT/ Intra-EU Voyages
- 12,000 tons HFO + 1000 tons MDO = 546 million MJ
- 200 tonnes MDO replaced by OPS electricity supply at berth (2,37E+06 kWh) + 200 tonnes of MDO @ berth.
- Typical conventional oil-based installation

Compliance

$$OPS\ Penalty = 1{,}5 \times Established\ Total\ Power\ Demand\ at\ Berth \times Hours\ at\ Berth$$

Port Call	Compliant	Penalty (1)	Penalty (2)
1	Yes		
2	No	720.000,00 €	1.080.000,00 €
3	Yes		
4	No	720.000,00 €	1.080.000,00 €
5	Yes		
6	No	720.000,00 €	1.080.000,00 €
7	Yes		
8	No	720.000,00 €	1.080.000,00 €
9	Yes		
10	No	720.000,00 €	1.080.000,00 €
	TOTAL	3.600.000,00 €	5.400.000,00 €

Penalty (1) ETPDB with Load Balance

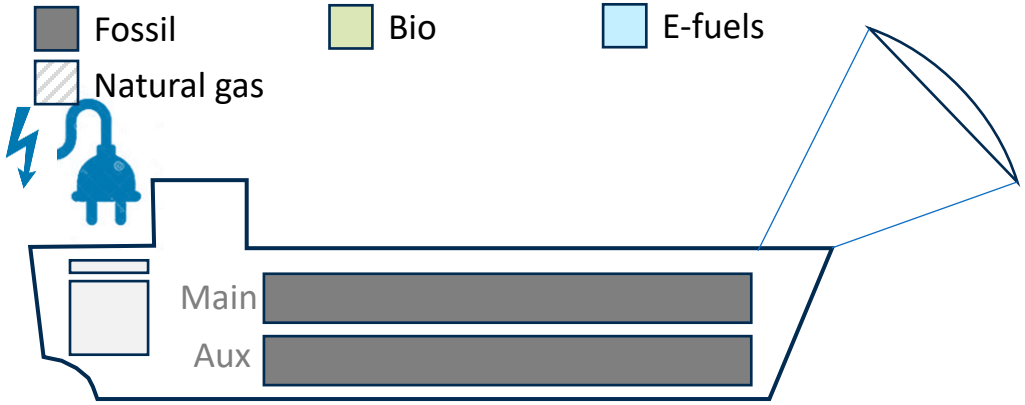
Penalty (2) ETPDB without Load Balance – 25% of total installed power

From 2030, for ships under the scope of FuelEU Article 6, the OPS penalties can be very signification (depending on factors above) .

FuelEU penalty 2030 + OPS penalty (1) = 1,598 + 3,600 = 5,2 million €

CASE 4: HFO + MDO / OPS / Wind/ Intra-EU

Summary



GHG Intensity Calc

WtT		7,18E+09	gCO2e
TtWi		4,13E+10	gCO2e
WtW		4,85E+10	gCO2e
WtTi		1,31E+01	gCO2e/MJ
TtWi		7,56E+01	gCO2e/MJ
f_wind		0,97	
GHGi		**86,12**	gCO2e/MJ

Pass 2025

Year	Target Reduction	GHGIEtarget
2025	2	89,34
2030	6	85,69
2035	14,5	77,94
2040	31	62,90
2045	62	34,64
2050	80	18,23

$$\boldsymbol{GHG\ intensity} = f_{wind} \times (\boldsymbol{WtT} + \boldsymbol{TtW})$$

Summary Data

Wind assisted propulsion is treated differently from fuels and OPS and uses a reward multiplier f_{wind} which ranges from 0.99 to 0.95

f_{wind} is calculated as P_{wind}/P_{prop} where P_{wind} is the effective power as calculated via MEPC.1/Circ.896 and P_{prop} is P_{ME} used in the EEDI calculation – assume our ship fits a kite P_{wind}/P_{prop} = 0.12, **f_{wind} = 0.97**

Compliance

$$CB = (GHG_{i,target} - GHG_{i,actual}) \times Energy_{total}$$

$$FuelEU\ Penalty = \frac{|CB|}{GHG_{i,actual} \times 41000} \times 2400$$

Compliance Balance Calculation

Year	CB (gCO2e)	CB (tCO2e)
2025	1,75E+09	1754,31
2030	-2,36E+08	-235,82
2035	-4,46E+09	-4464,85
2040	-1,27E+10	-12674,15
2045	-2,81E+10	-28097,67
2050	-3,71E+10	-37053,27

FuelEU Penalty

Year	CB (gCO2e)	FuelEU Penalty
2025	1,75E+09	no penalty
2030	-2,36E+08	160.286,98 €
2035	-4,46E+09	3.034.716,66 €
2040	-1,27E+10	8.614.491,92 €
2045	-2,81E+10	19.097.706,05 €
2050	-3,71E+10	25.184.733,61 €

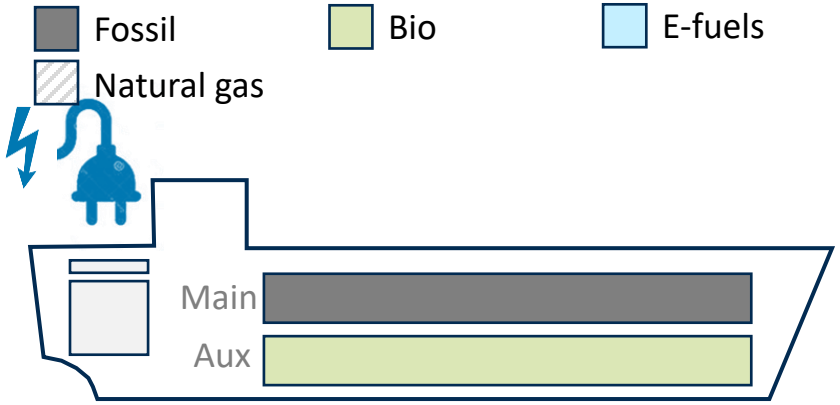
Wind Assisted Propulsion is rewarded through a factor designed to incentivize installation.

Positive CB of 1754,31 tonnes of CO2.

The combined effect of OPS and WAP allows compliance with no modification of the conventional fuel installations.

CASE 5: HFO + UCO / OPS / intra-EU

Summary



GHG Intensity Calc

WtT		6,57E+09	gCO2e
TtWi		4,20E+10	gCO2e
WtW		4,86E+10	gCO2e
WtTi		1,20E+01	gCO2e/MJ
TtWi		7,70E+01	gCO2e/MJ
f_wind			
GHGi		**88,98**	gCO2e/MJ

Year	Target Reduction	GHGIEtarget
2025	2	89,34
2030	6	85,69
2035	14,5	77,94
2040	31	62,90
2045	62	34,64
2050	80	18,23

Pass 2025

Fail ≥2030

Summary Data

- Containership > 5,000GT/ Intra-EU Voyages
- 12,000 tons HFO + 1220 tons HVO/UCO = 546 million MJ
- 400 tonnes MDO replaced by OPS electricity supply at berth (4,74E+06 kWh)
- WtT (HVO, Used Cooking Oil) = 0,1 gCO2e/MJ

Compliance

$$CB = (GHG_{i,target} - GHG_{i,actual}) \times Energy_{total}$$

$$FuelEU\ Penalty = \frac{|CB|}{GHG_{i,actual} \times 41000} \times 2400$$

Compliance Balance Calculation

Year	CB (gCO2e)	CB (tCO2e)
2025	1,94E+08	194,13
2030	-1,80E+09	-1796,00
2035	-6,03E+09	-6025,04
2040	-1,42E+10	-14234,33
2045	-2,97E+10	-29657,86
2050	-3,86E+10	-38613,45

FuelEU Penalty

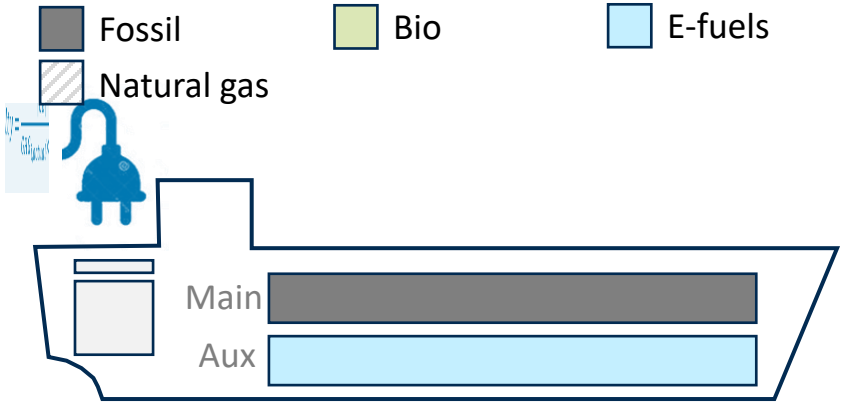
Year	CB (gCO2e)	FuelEU Penalty
2025	1,94E+08	no penalty
2030	-1,80E+09	1.181.509,10 €
2035	-6,03E+09	3.963.594,22 €
2040	-1,42E+10	9.364.112,41 €
2045	-2,97E+10	19.510.540,52 €
2050	-3,86E+10	25.402.014,91 €

Despite significant investment in replacing all MDO by HVO/UCO, the influence of HFO is still very high.

No FuelEU penalty 2025

CASE 6: HFO + FTD / OPS / intra-EU

Summary



GHG Intensity Calc

WtT		6,58E+09	gCO2e
TtWi		4,13E+10	gCO2e
WtW		4,79E+10	gCO2e
WtTi		1,12E+01	gCO2e/MJ
TtWi		7,01E+01	gCO2e/MJ
f_wind			
GHGi		**81,34**	gCO2e/MJ

Year	Target Reduction	GHGIEtarget
2025	2	89,34
2030	6	85,69
2035	14,5	77,94
2040	31	62,90
2045	62	34,64
2050	80	18,23

Pass 2030

Fail ≥2035

Summary Data

- Containership > 5,000GT/ Intra-EU Voyages
- 12,000 tons HFO + 1000 tons FT-Diesel = 546 million MJ (increased to 588 million MJ (due to RFNBO multiplier) - Multiplier of 2 applied to Energy provided FT-Diesel
- 400 tonnes MDO replaced by OPS electricity supply (4,74E+06 kWh)
- WtT (FT-Diesel, 70% GHG savings RFNBO) = 0,5 gCO2e/MJ

Compliance

$$CB = (GHG_{i,target} - GHG_{i,actual}) \times Energy_{total}$$

$$FuelEU\ Penalty = \frac{|CB|}{GHG_{i,actual} \times 41000} \times 2400$$

Compliance Balance Calculation

Year	CB (gCO2e)	CB (tCO2e)
2025	4,71E+09	4708,79
2030	2,56E+09	2562,96
2035	-2,00E+09	-1996,94
2040	-1,08E+10	-10848,50
2045	-2,75E+10	-27478,71
2050	-3,71E+10	-37134,96

FuelEU Penalty

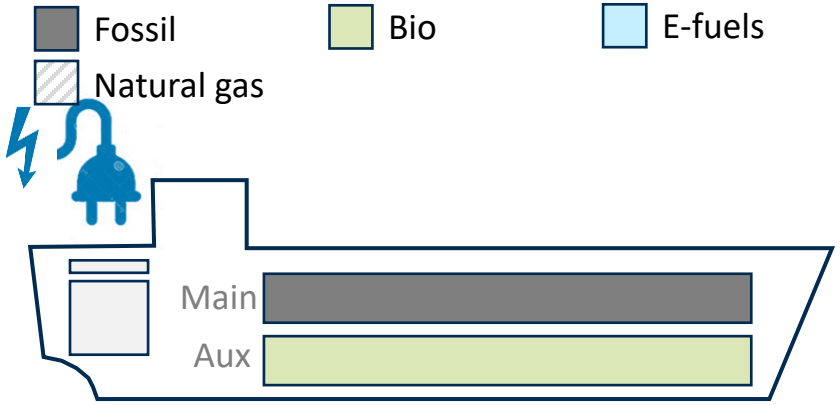
Year	CB (gCO2e)	FuelEU Penalty
2025	4,71E+09	no penalty
2030	2,56E+09	no penalty
2035	-2,00E+09	1.437.188,85 €
2040	-1,08E+10	7.807.620,95 €
2045	-2,75E+10	19.776.311,57 €
2050	-3,71E+10	26.725.873,87 €

The virtual increase of the energy due to the RFNBO multiplier allows increasing gains in terms of CB.

Note that around half the amount of RFNBO is needed to comply compared with the waste cooking oil.

CASE 7: HFO + UCO / OPS / extra-EU

Summary



GHG Intensity Calc

WtT		3,00E+09	gCO2e
TtWi		2,13E+10	gCO2e
WtW		2,43E+10	gCO2e
WtTi		1,06E+01	gCO2e/MJ
TtWi		7,57E+01	gCO2e/MJ
f_wind			
GHGi		**86,37**	gCO2e/MJ

Year	Target Reduction	GHGIEtarget
2025	2	89,34
2030	6	85,69
2035	14,5	77,94
2040	31	62,90
2045	62	34,64
2050	80	18,23

Pass 2025

Fail ≥2030

Summary Data

- 12,000 tons HFO + 1220 tons HVO/UCO = 546 million MJ
- Total Energy in international voyages counted at 50% - Energy in Scope = **281 million MJ**.
- 400 tonnes MDO replaced by OPS electricity supply at berth (4,74E+06 kWh)
- WtT (HVO, Used Cooking Oil) = 0,1 gCO2e/MJ

Compliance

$$CB = (GHG_{i,target} - GHG_{i,actual}) \times Energy_{total}$$

$$FuelEU\ Penalty = \frac{|CB|}{GHG_{i,actual} \times 41000} \times 2400$$

Compliance Balance Calculation

Year	CB (gCO2e)	CB (tCO2e)
2025	8,34E+08	833,64
2030	-1,93E+08	-192,56
2035	-2,37E+09	-2373,25
2040	-6,61E+09	-6606,35
2045	-1,46E+10	-14559,45
2050	-1,92E+10	-19177,38

FuelEU Penalty

Year	CB (gCO2e)	FuelEU Penalty
2025	8,34E+08	no penalty
2030	-1,93E+08	130.501,87 €
2035	-2,37E+09	1.608.366,97 €
2040	-6,61E+09	4.477.163,93 €
2045	-1,46E+10	9.867.024,89 €
2050	-1,92E+10	12.996.621,57 €

Despite significant investment in replacing all MDO by HVO/UCO, the influence of HFO is still very high.

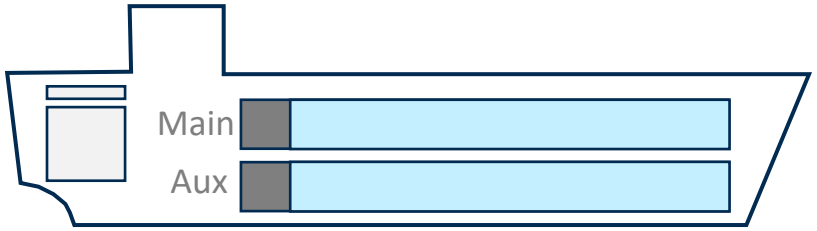
No FuelEU penalty 2025

CASE 8: e-MeOH/ Intra-EU

Summary

Fossil-oil Bio E-fuels

Natural gas



GHG Intensity Calc

WtT		2,63E+09	gCO2e
TtWi		3,80E+10	gCO2e
WtW		4,06E+10	gCO2e
WtTi		2,50E+00	gCO2e/MJ
TtWi		3,62E+01	gCO2e/MJ
f_wind			
GHGi		**38,75**	gCO2e/MJ

Year	% Reduction	GHGIEtarget
2025	2	89,34
2030	6	85,69
2035	14,5	77,94
2040	31	62,90
2045	62	34,64
2050	80	18,23

Pass 2040

Fail ≥2045

Summary Data

- Containership > 5,000GT/ Intra-EU Voyages
- 25,276 tons e-Methanol + 1000 tons MDO = **546 million MJ**
- Multiplier of 2 applied to Energy provided by e-Methanol (RFNBO)
- **e-Methanol** WtT emission factor (70% GHG saving) = 4 gCO2e/MJ

Compliance

$$CB = (GHG_{i,target} - GHG_{i,actual}) \times Energy_{total}$$

$$FuelEU\ Penalty = \frac{|CB|}{GHG_{i,actual} \times 41000} \times 2400$$

Compliance Balance Calculation

Year	CB (gCO2e)	CB (tCO2e)
2025	5,51E+10	55062,50
2030	5,12E+10	51238,52
2035	4,31E+10	43112,56
2040	2,73E+10	27338,64
2045	-2,30E+09	-2297,20
2050	-1,95E+10	-19505,11

FuelEU Penalty

Year	CB (gCO2e)	FuelEU Penalty
2025	5,51E+10	no penalty
2030	5,12E+10	no penalty
2035	4,31E+10	no penalty
2040	2,73E+10	no penalty
2045	-2,30E+09	3.650.972,52 €
2050	-1,95E+10	30.999.767,31 €

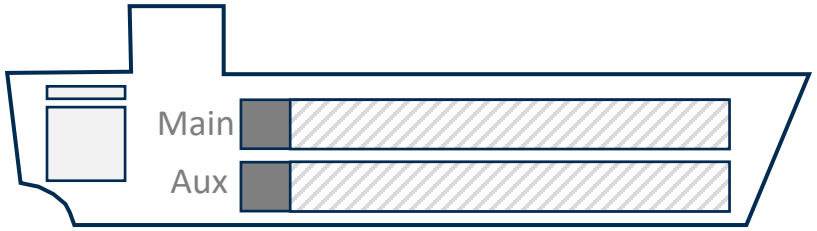
- Use of large share of e-Methanol allows for compliance already up to 2044.
- Pooling potential in 2030 would allow 15 ships (base case HFO/MDO) to be pooled for compliance.

CASE 9: LNG/ High Speed DF Engine/ Extra-EU

Summary

Fossil-oil Bio E-fuels

Natural gas



GHG Intensity Calc

WtT		7,40E+09	gCO2e
TtWi		2,79E+10	gCO2e
WtW		3,53E+10	gCO2e
WtTi		1,25E+01	gCO2e/MJ
TtWi		4,72E+01	gCO2e/MJ
f_wind			
GHGi		**59,69**	gCO2e/MJ

Year	% Reduction	GHGIEtarget
2025	2	89,34
2030	6	85,69
2035	14,5	77,94
2040	31	62,90
2045	62	34,64
2050	80	18,23

Pass 2040

Fail ≥2045

Summary Data

- Containership > 5,000GT/ Intra-EU Voyages
- 20,000 tons LNG + 2200 tons MDO (pilot fuel) = **1080 million MJ**
- Total Energy in international voyages counted at 50% - Energy in Scope = **591 million MJ**.
- Methane Slip (High Speed DF Engine) = 3,1%

Compliance

$$CB = (GHG_{i,target} - GHG_{i,actual}) \times Energy_{total}$$

$$FuelEU\ Penalty = \frac{|CB|}{GHG_{i,actual} \times 41000} \times 2400$$

Compliance Balance Calculation

Year	CB (gCO2e)	CB (tCO2e)
2025	1,75E+10	17528,72
2030	1,54E+10	15372,46
2035	1,08E+10	10790,40
2040	1,90E+09	1895,82
2045	-1,48E+10	-14815,21
2050	-2,45E+10	-24518,39

FuelEU Penalty

Year	CB (gCO2e)	FuelEU Penalty
2035	1,75E+10	no penalty
2040	1,54E+10	no penalty
2030	1,08E+10	no penalty
2045	1,90E+09	no penalty
2050	-1,48E+10	14.527.854,71 €
2025	-2,45E+10	24.042.829,82 €

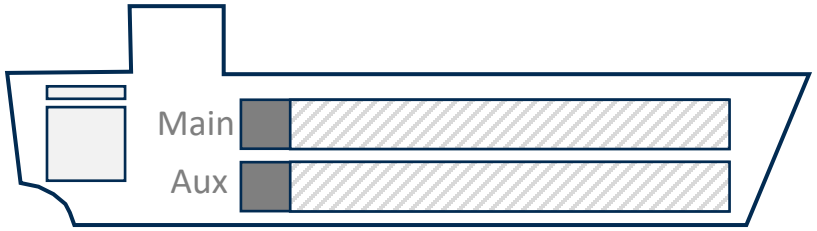
- LNG has an important potential for reduction of emissions – strongly affected however by dual-fuel engine technology)
- Pooling potential in 2030 would allow 4 ships (base case HFO/MDO) to be pooled for compliance.

CASE 10: LNG/ High Speed DF Engine/ Intra-EU

Summary

Fossil-oil Bio E-fuels

Natural gas



GHG Intensity Calc

WtT		1,63E+10	gCO2e
TtWi		7,66E+10	gCO2e
WtW		9,29E+10	gCO2e
WtTi		1,52E+01	gCO2e/MJ
TtWi		7,12E+01	gCO2e/MJ
f_wind			
GHGi		**86,37**	gCO2e/MJ

Year	% Reduction	GHGIEtarget
2025	2	89,34
2030	6	85,69
2035	14,5	77,94
2040	31	62,90
2045	62	34,64
2050	80	18,23

Pass 2025

Fail ≥2030

Summary Data

- Containership > 5,000GT/ Intra-EU Voyages
- 20,000 tons LNG + 2200 tons MDO (pilot fuel) = **1080 million MJ**
- All Energy under scope.
- Methane Slip (High Speed DF Engine) = 3,1%

Compliance

$$CB = (GHG_{i,target} - GHG_{i,actual}) \times Energy_{total}$$

$$FuelEU\ Penalty = \frac{|CB|}{GHG_{i,actual} \times 41000} \times 2400$$

Compliance Balance Calculation

Year	CB (gCO2e)	CB (tCO2e)
2025	3,19E+09	3191,80
2030	-7,32E+08	-731,50
2035	-9,07E+09	-9068,53
2040	-2,53E+10	-25252,18
2045	-5,57E+10	-55657,81
2050	-7,33E+10	-73312,69

FuelEU Penalty

Year	CB (gCO2e)	FuelEU Penalty
2035	3,19E+09	no penalty
2040	-7,32E+08	495.769,10 €
2030	-9,07E+09	6.146.106,53 €
2045	-2,53E+10	17.114.408,61 €
2050	-5,57E+10	37.721.521,60 €
2025	-7,33E+10	49.686.942,05 €

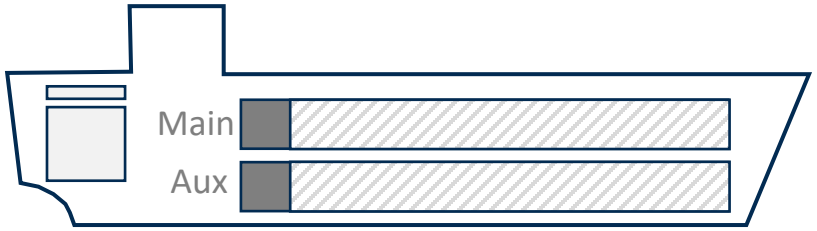
- **Use of LNG, for intra-EU voyages, with high-speed dual-fuel engines, does not offer guarantee of medium-term compliance.**

CASE 10: **LNG-LBM/ High Speed DF Engine/ Intra-EU**

Summary

Fossil-oil Bio E-fuels

Natural gas



GHG Intensity Calc

WtT		1,50E+10	gCO2e
TtWi		7,52E+10	gCO2e
WtW		9,02E+10	gCO2e
WtTi		1,39E+01	gCO2e/MJ
TtWi		6,99E+01	gCO2e/MJ
f_wind			
GHGi		**83,81**	gCO2e/MJ

Year	% Reduction	GHGIEtarget
2025	2	89,34
2030	6	85,69
2035	14,5	77,94
2040	31	62,90
2045	62	34,64
2050	80	18,23

Pass 2030

Fail ≥2035

Summary Data

- Containership > 5,000GT/ Intra-EU Voyages
- 18,000 tons LNG, **blended with 2000 tons of Liquefied Biomethane** + 2200 tons MDO (pilot fuel) = **1080 million MJ -** All Energy under scope.
- Liquefied Biomethane (WtT = 0 gCO2e/MJ
- Methane Slip (High Speed DF Engine) = 3,1%

Compliance

$$CB = (GHG_{i,target} - GHG_{i,actual}) \times Energy_{total}$$

$$FuelEU\ Penalty = \frac{|CB|}{GHG_{i,actual} \times 41000} \times 2400$$

Compliance Balance Calculation

Year	CB (gCO2e)	CB (tCO2e)
2025	5,94E+09	5941,79
2030	2,02E+09	2018,48
2035	-6,32E+09	-6318,55
2040	-2,25E+10	-22502,19
2045	-5,29E+10	-52907,83
2050	-7,06E+10	-70562,71

FuelEU Penalty

Year	CB (gCO2e)	FuelEU Penalty
2035	5,94E+09	no penalty
2040	2,02E+09	no penalty
2030	-6,32E+09	4.412.922,36 €
2045	-2,25E+10	15.715.698,58 €
2050	-5,29E+10	36.951.217,53 €
2025	-7,06E+10	49.281.518,85 €

- **Blending of Liquefied Biomethane allows extension of compliance up to 2034.**

Case-Study Summary

	1 HFO/MDO/ intra-EU	2 HFO/MDO/ OPS/intra-EU	3 HFO/MDO/ OPSnc/ intra-EU	4 HFO/MDO /OPS/Wind /intra-EU	5 HFO+UCO /OPS/ intra-EU	6 HFO/FTD/ OPS/ intra-EU	7 HFO+UCO/ OPS/extra-EU	8 E-MeOH/ intra-EU	9 LNG/ Low-Speed DF/ extra-EU	10 LNG/ High-Speed DF/ Intra-EU	11 LNG-LBM/ High-Speed DF/ Intra-eU
Intra/Extra	Intra	Intra	Intra	Intra	Intra	Intra	Extra	Intra	Extra	Intra	Intra
Main (tonnes)	12,000 HFO	12,000 HFO	12,000 HFO	12,000 HFO	12,000 HFO	12,000 HFO	12,000 HFO	-	20,000 LNG	20,000 LNG	18,000 LNG
Aux (tonnes)	1,400 MDO	1,000 MDO	1,000 MDO	1,000 MDO	-	-	-	1,000 MDO	2,200 MDO	2,200 MDO	2,200 MDO
Energy (million MJ)	546	546	546	564	546	546 (588)	546 (281)	546	1080	1080	1080
OPS (million kWh)	-	4,74	2,37	4,74	4,74	4,74	4,74	-	-	-	-
Biofuel/RFNBO	-	-	-	-	1,220 HVO/UCO	1,000 FTD	1,220 HVO/UCO	25,276 e-MeOH	-	-	2000
F_{wind}	-	-	0.97	-	-	-	-	-	-	-	-
CO_{2eq} WtW (tonnes)	$5x10^4$	$4,85x10^4$	$4,92x10^4$	$4,85x10^4$	$4,86x10^4$	$4,79x10^4$	$2,43x10^4$	$4,06x10^4$	$3,53x10^4$	$9,29x10^4$	$4,06x10^4$
GHG Intensity 2025 (tCO2	**91,62**	**88,79**	**90,20**	**86,12**	**88,98**	**81,34**	**86,37**	**38,75**	**59,69**	**86,37**	**83,81**
Compliance balance (tonnes)	-1247	300,58	-473,42	1754,3	194,13	4708,8	833,64	55062,5	17528,7	3191,8	5941,79
Penalty (k€)	796	-	307,2 (720 – OPS)	-	-	-	-	-	-	-	-

Questions to:

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Ask questions at

slido.com

#FuelEU

Center Presentations

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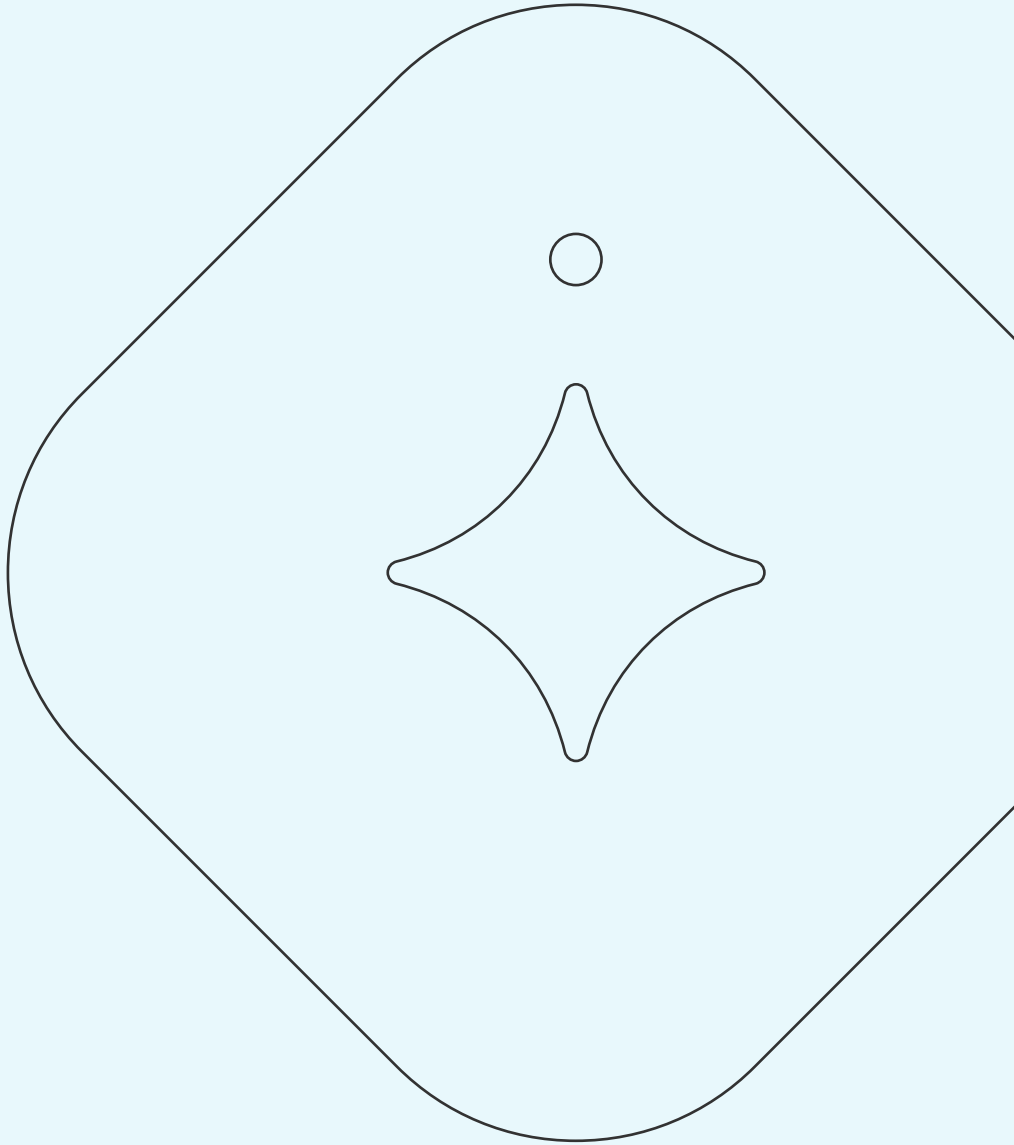
Certification of Fuels

Ratna Nataliani



Why is Certification becoming more and more important?

MEPC 80 Outcome

Measurement of onboard carbon intensity

Short-term

+

Mid-term

Measurement of lifecycle GHG intensity

Technical measure

Economical measure

IMO LCA Guidelines

Sust. Criteria

Feedstock

Production

Bunker

Use

Well

Tank

Wake

Short-term measures

Mid-term measures

IMO CII + GHG Fuel Standard

GHG Pricing

Fuel Lifecycle Label demands "Sustainability (Certification)"

The **FLL** is a technical **tool to collect and convey the information** relevant for the lifecycle assessment of marine fuels and energy carriers (e.g., electricity for shore power) used for **ship propulsion & power generation onboard** in the context of IMO LCA Guidelines.

8.2 The FLL consists of five main parts, as illustrated below:

Part A-1	Part A-2	Part A-3	Part A-4	Part A-5
Fuel type (blend)	Fuel Pathway Code	Lower Calorific Value (LCV, MJ/g)	share in fuel blend (%$MJ_{(LCV)}$ / $MJ_{(LCV)}$)	WtT GHG emission factor (GWP100, $gCO_{2eq}/MJ_{(LCV)}$)

+

Part B-1	(Part B-2)[15]
Emissions credits related to biogenic carbon source (e_c, in gCO_2/g fuel based on GWP100)	Emissions credits related to source of captured carbon (e_{ccu}, in gCO_2/g fuel based on GWP100)

+

Part C-1	Part C-2	Part C-3
Value 1 (carbon source NOT taken into account): TtW GHG emission factor (GWP100, $gCO_{2eq}/MJ_{(LCV)}$)	Value 2 (carbon source taken into account): TtW GHG emission factor (GWP100, $gCO_{2eq}/MJ_{(LCV)}$)	Energy Converter

+

Part D	Part E
WtW GHG emission factor (GWP100, $gCO_{2eq}/MJ_{(LCV)}$) Note: Part D = Part A-5 + Part C-2	Sustainability (Certification)[16]

Part E of the FLL indicates the sustainability performance of the fuel as per Section 7 of these guidelines.

?

How do we safeguard these sustainability aspects?

7. SUSTAINABILITY

The sustainability of **marine fuels** should be assessed considering the following themes/aspects on a **life cycle basis**.

- Greenhouse gases (GHG) — EMISSION GENERATION
- Carbon source
- Source of electricity/energy
- Carbon stock – DLUC
- Carbon stock – ILUC — SUSTAINABLE SOURCING
- Water
- Air
- Soil — GOOD MANAGEMENT
- Waste and chemicals
- Conservation

Other social and economic sustainability themes/ aspects may be considered at a later stage.

European Sustainable Shipping Forum (ESSF)

Led by MOVE – DG Mobility and Transport

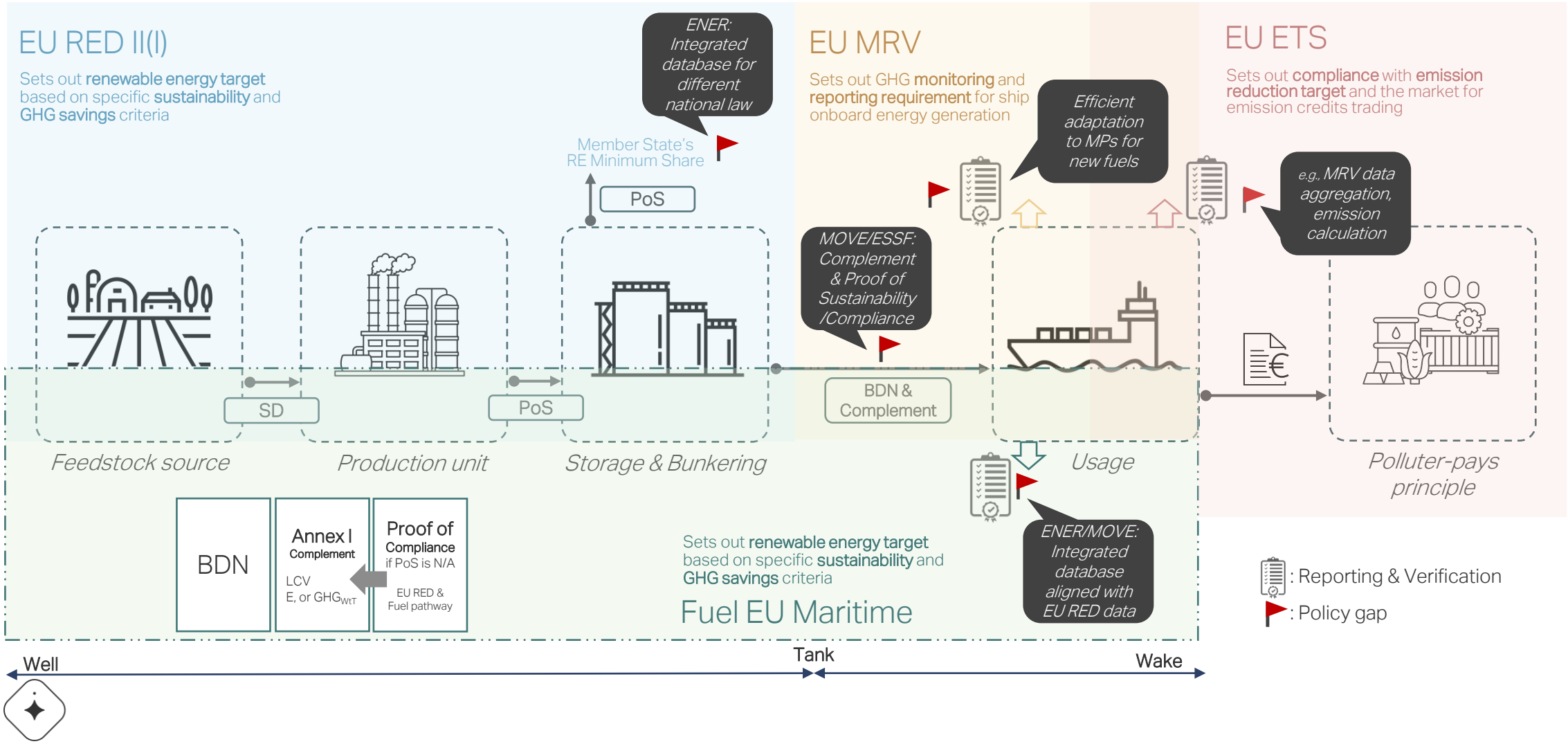
Platform for a structural dialogue, exchange of technical knowledge, cooperation, and coordination amongst relevant maritime industries' stakeholders and the Commission and its services to better address the environmental sustainability challenges confronting the EU maritime transport sector.

Work Stream #2 Certification is part of the **Subgroup** Sustainable Alternative Power for Shipping- Mid- to Long-Term Solutions for Maritime GHG Emissions Reductions.

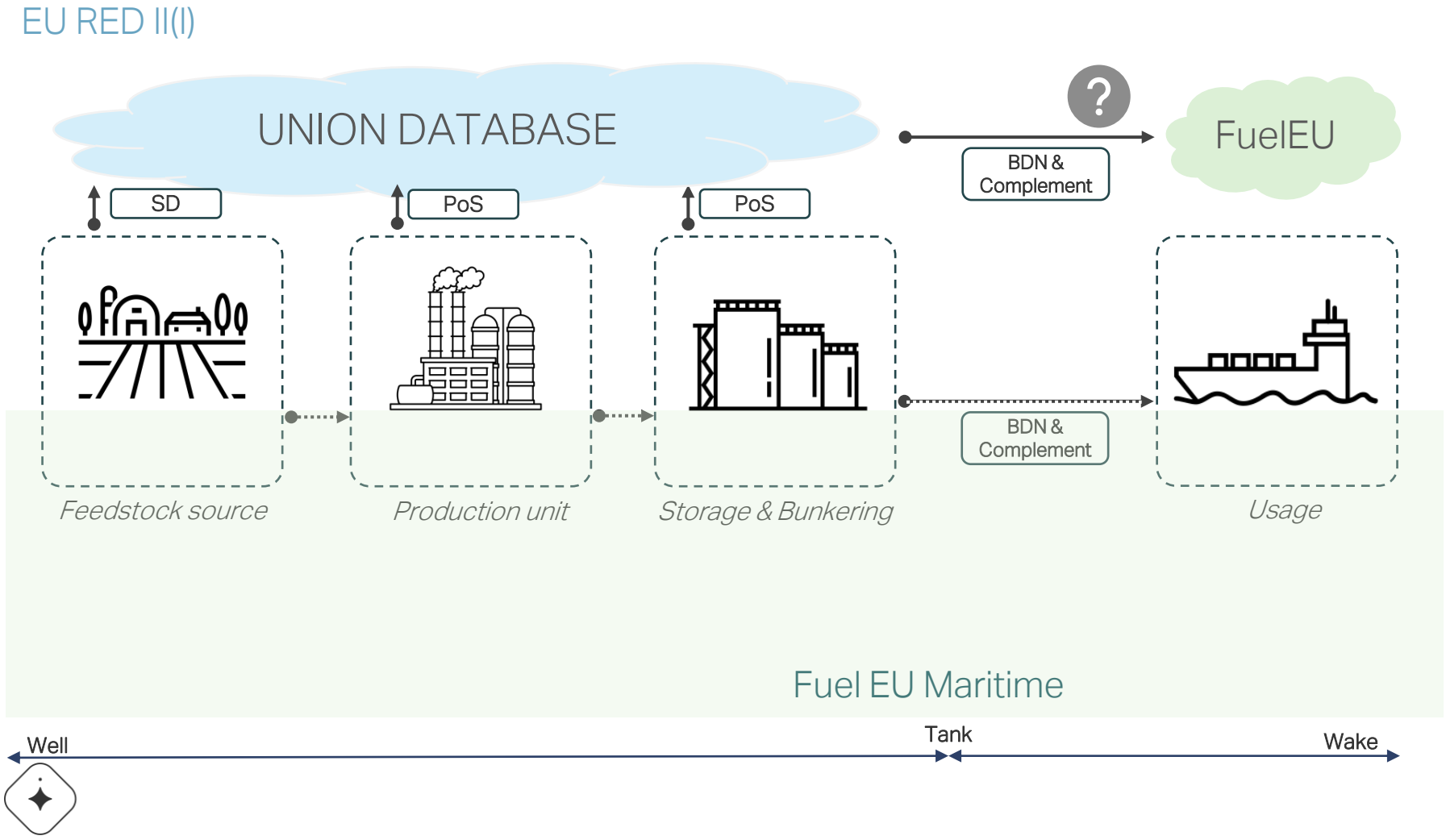
- ✓ **Analyze certification gaps** for Fuel EU Maritime and the maritime inclusion into the EU ETS implementations
- ✓ Review relevant processes and **exchange views among economic operators** along the marine fuel supply chain
- ✓ **Develop guidance document** to be proposed to the Commission with the objective of **smooth adoption** by economic operators and especially compliance subject (shipping companies) **to achieve compliance** efficiently

How do European laws [Fitfor55] affect shipping?

Context: EU territory/port



UDB: *Key solution to traceability (and efficient compliance)?*



Status

Liquid fuels: Operational, EOs have uploaded transactional documents

Gaseous fuels: Currently in discussion with national gas registries in the EU

What can we expect from **Union Database** (UDB)?

1. Sustainable feedstock and fuel traceability
2. Anti-fraud measure
3. Synergy with MS' law
4. Compliance evidence supporting e.g., FuelEU and EU ETS

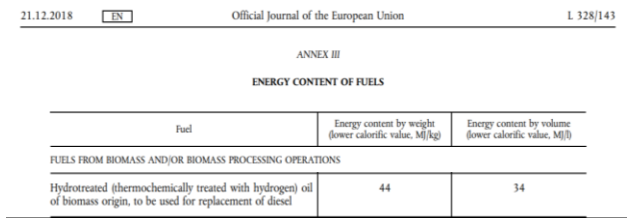
Example: GHG intensity calculation for sustainable HVO (UCO-based)

Main reference: Annex II to Fuel EU

1	2	3	4	5	6	7	8	9
			WtT	TtW				
Fuel Class	**Pathway name**	$\left[\frac{LCV}{g}\right]$	$\left[\frac{CO_{2eq\ WtT}}{MJ}\right]$	**Fuel Consumer Unit Class**	$\left[\frac{C_{f\ CO_2}}{gFuel}\right]$	$\left[\frac{C_{f\ CH_4}}{gFuel}\right]$	$\left[\frac{C_{f\ N_2O}}{gFuel}\right]$	C_{slip} **As % of the mass of the fuel used by the engine**
Biofuels	**Hydrotreated Vegetable Oil (HVO) Production Pathways of Directive (EU) 2018/2001**	**Value as set out in Annex III of Directive (EU) 2018/2001**	$E - \frac{C_{fCO_2}}{LCV}$	**ALL ICEs**	**3,115**	**0,00005**	**0,00018**	**-**

E values extracted from Complement doc

Annex III - EU RED II



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ANNEX III

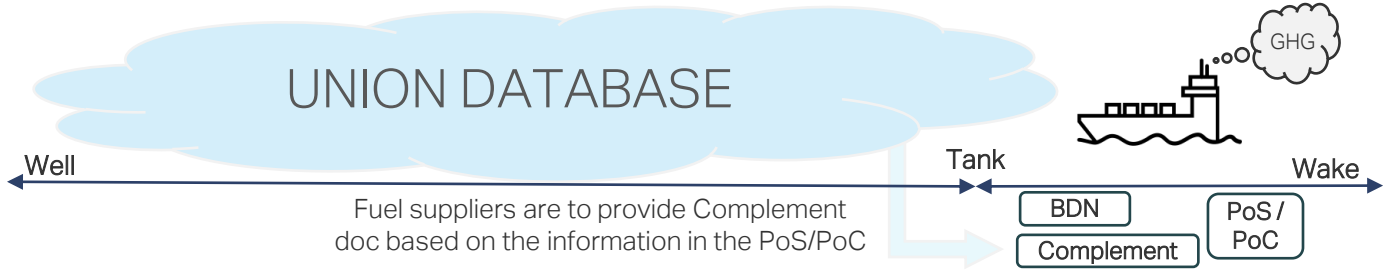
ENERGY CONTENT OF FUELS

Fuel	Energy content by weight (lower calorific value, MJ/kg)	Energy content by volume (lower calorific value, MJ/l)
FUELS FROM BIOMASS AND/OR BIOMASS PROCESSING OPERATIONS		
Hydrotreated (thermochemically treated with hydrogen) oil of biomass origin, to be used for replacement of diesel	44	34

Annex IX – Implementing Regulation 2022/996

STANDARD VALUES OF EMISSIONS FACTORS

		parameter:	
		unit:	gCO_{2eq}/g
Global warming potential			
	CO_2		1
	CH_4		28
	N_2O		265



Fuel suppliers are to provide Complement doc based on the information in the PoS/PoC

Assume HVO is produced from waste cooking oil. What is the default GHG intensity?

$$WtW\left(\frac{gCO_{2eq}}{MJ}\right)$$

$$= WtT\left(\frac{gCO_{2eq}}{MJ}\right) + TtW\left(\frac{gCO_{2eq}}{MJ}\right)$$

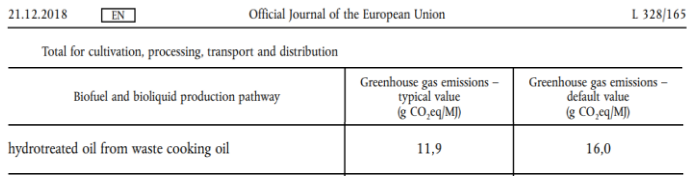
$$= \left[E - \frac{CfCO_2}{LCV}\right] + \left[\frac{CfCO_2}{LCV} * GWPCO_2 + \frac{CfCH_4}{LCV} * GWPCH_4 + \frac{CfN_2O}{LCV} * GWPN_2O\right]$$

$$= \left[16 - \frac{3.115}{0.044}\right] + \left[\frac{3.115}{0.044} * 1 + \frac{0.00005}{0.044} * 28 + \frac{0.00018}{0.044} * 265\right]$$

$$= 16 - 70.79 + 70.79 + 0.0308 + 1.084$$

$$= 17.11\ \frac{gCO_{2eq}}{MJ}$$; equivalent to **81.27% savings** against 91.16 $\frac{gCO_{2eq}}{MJ}$.

Annex V - EU RED II→ for HVO, waste cooking oil



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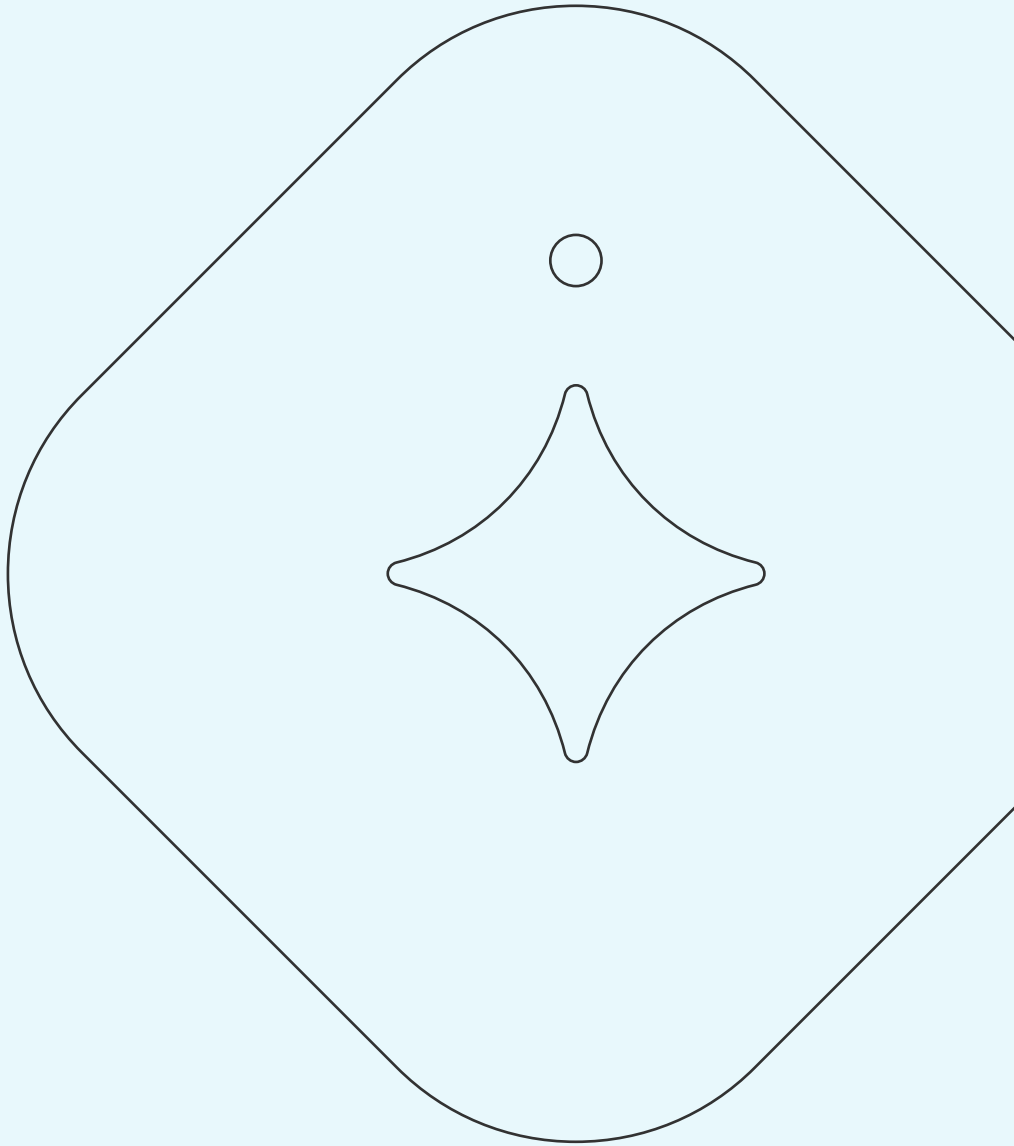
Total for cultivation, processing, transport and distribution

Biofuel and bioliquid production pathway	Greenhouse gas emissions – typical value ($g\ CO_2eq/MJ$)	Greenhouse gas emissions – default value ($g\ CO_2eq/MJ$)
hydrotreated oil from waste cooking oil	11,9	16,0

For reference only. All figures shall be provided by fuel suppliers.

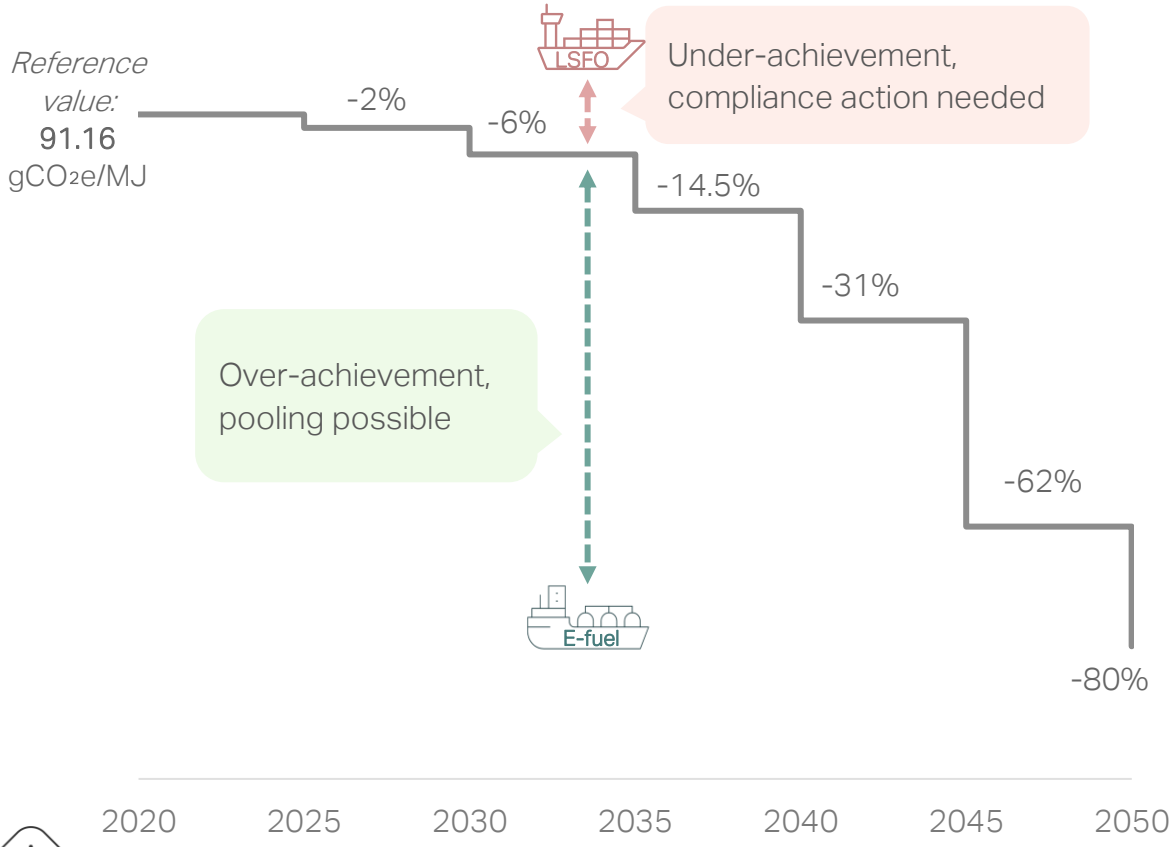
FuelEU Pooling

Joe Bettles

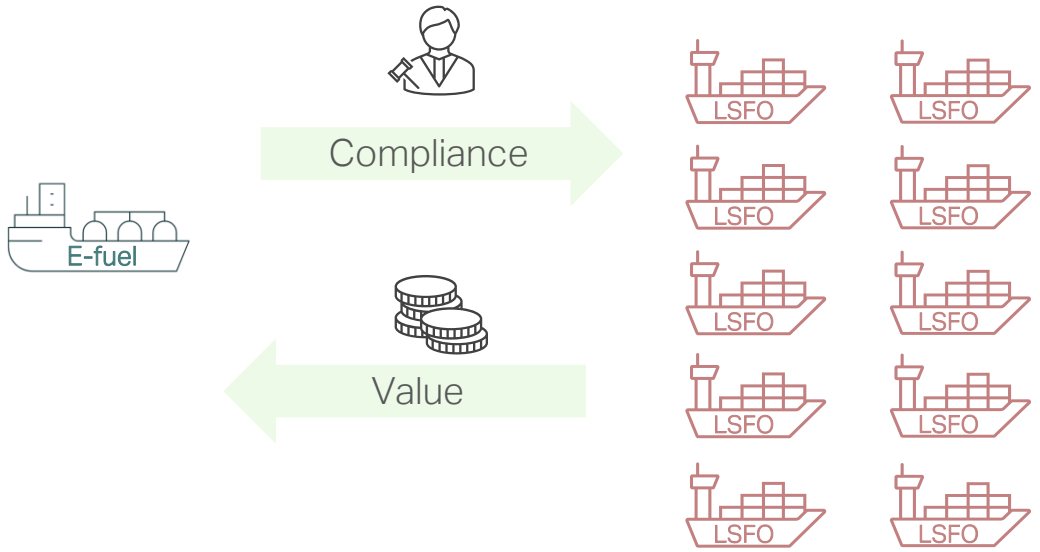


FuelEU Pooling | Companies that overachieve on their targets can use pooling to share overachievement

Pooling is possible when overachieving on targets



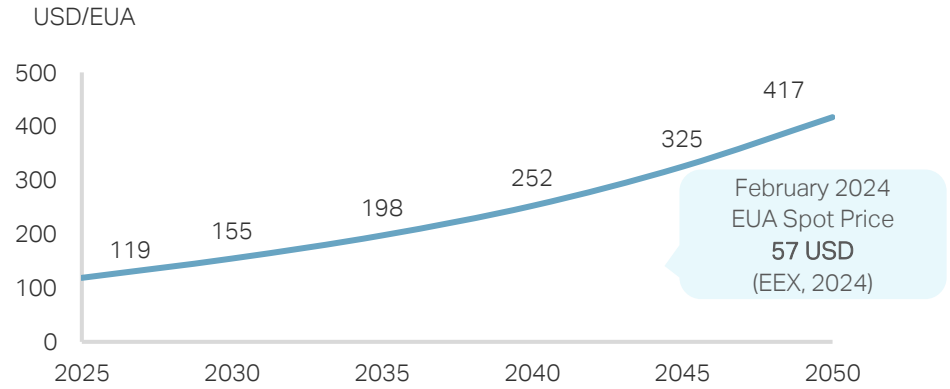
Pooling exchange



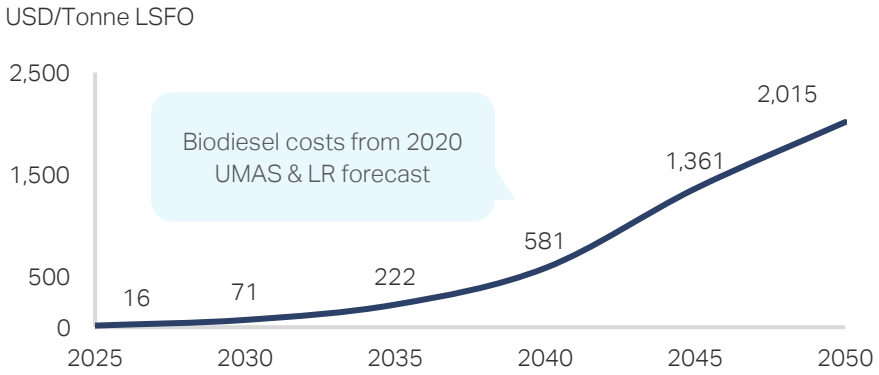
Sources: FuelEU

FuelEU Pooling | Estimated combined impact of EU ETS and FuelEU are expected to significantly drive-up the cost of conventional fuel

Pietzcker et al., 2022 Forecasted ETS Allowance Price



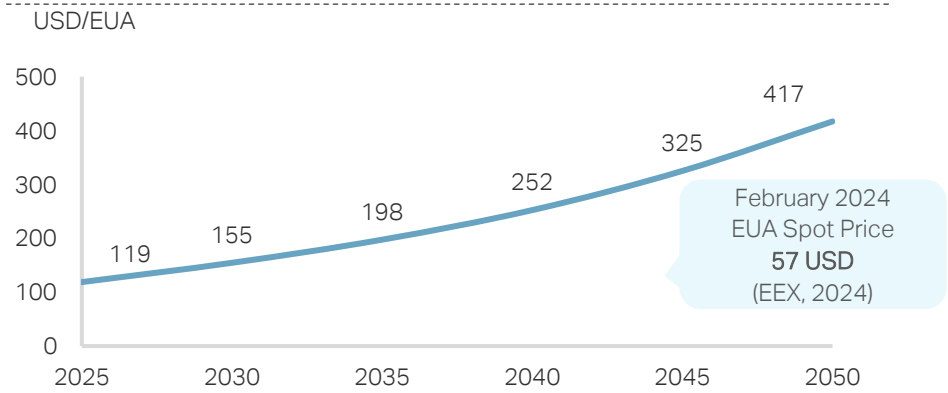
Biofuel Blend Costs for FuelEU Compliance (LSFO + FAME)



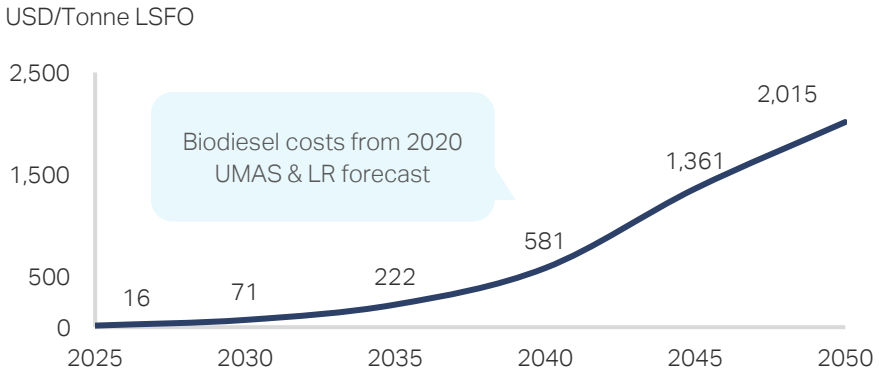
ETS forecast based on 'ambitious scenario' in which EU policymakers withdraw allowances to meet a 55% GHG reduction by 2030 and net-zero by 2050 (Pitetzcker et al., 2021)
Biodiesel forecasts is the average of low and high projections from a 2020 Lloyd's Register and UMAS Report (LR & UMAS, 2020)
Note: Figure shows estimates for LSFO vessels sailing exclusively in the EU

FuelEU Pooling | Estimated combined impact of EU ETS and FuelEU are expected to significantly drive-up the cost of conventional fuel

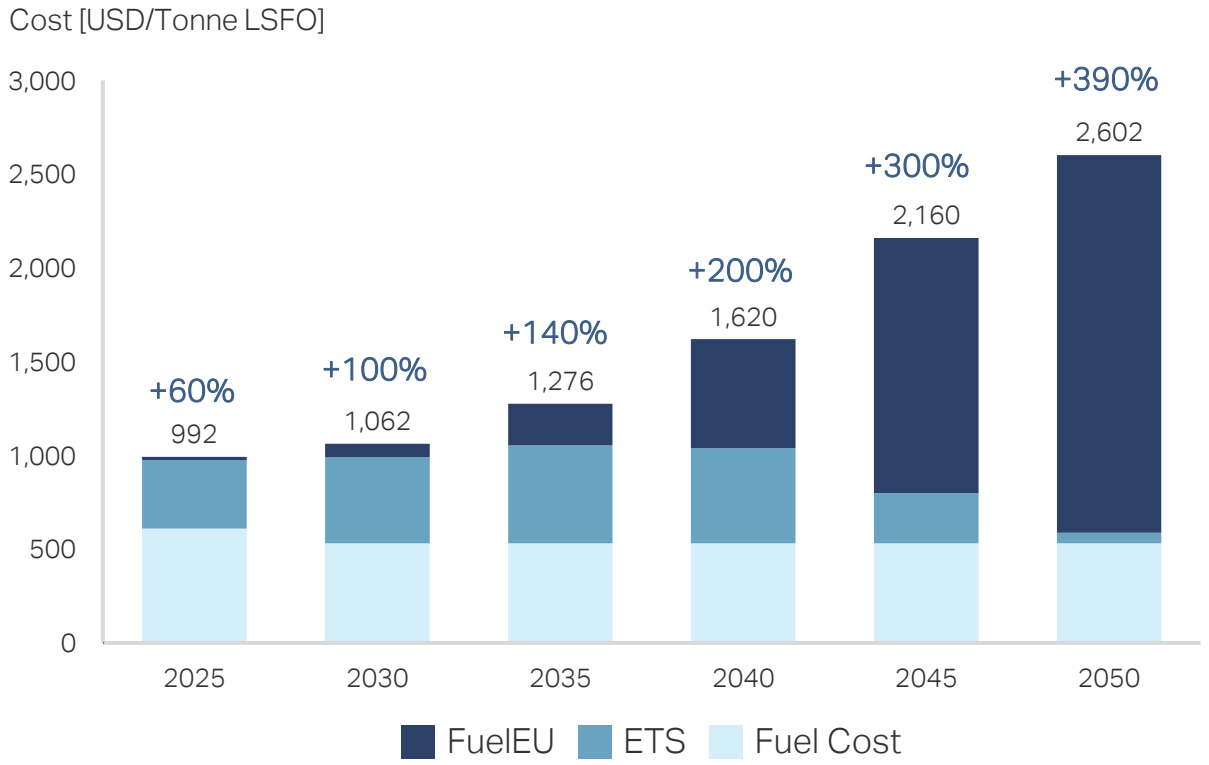
Pietzcker et al., 2022 Forecasted ETS Allowance Price



Biofuel Blend Costs for FuelEU Compliance (LSFO + FAME)



Impact of FuelEU and EU ETS on LSFO Fuel Cost



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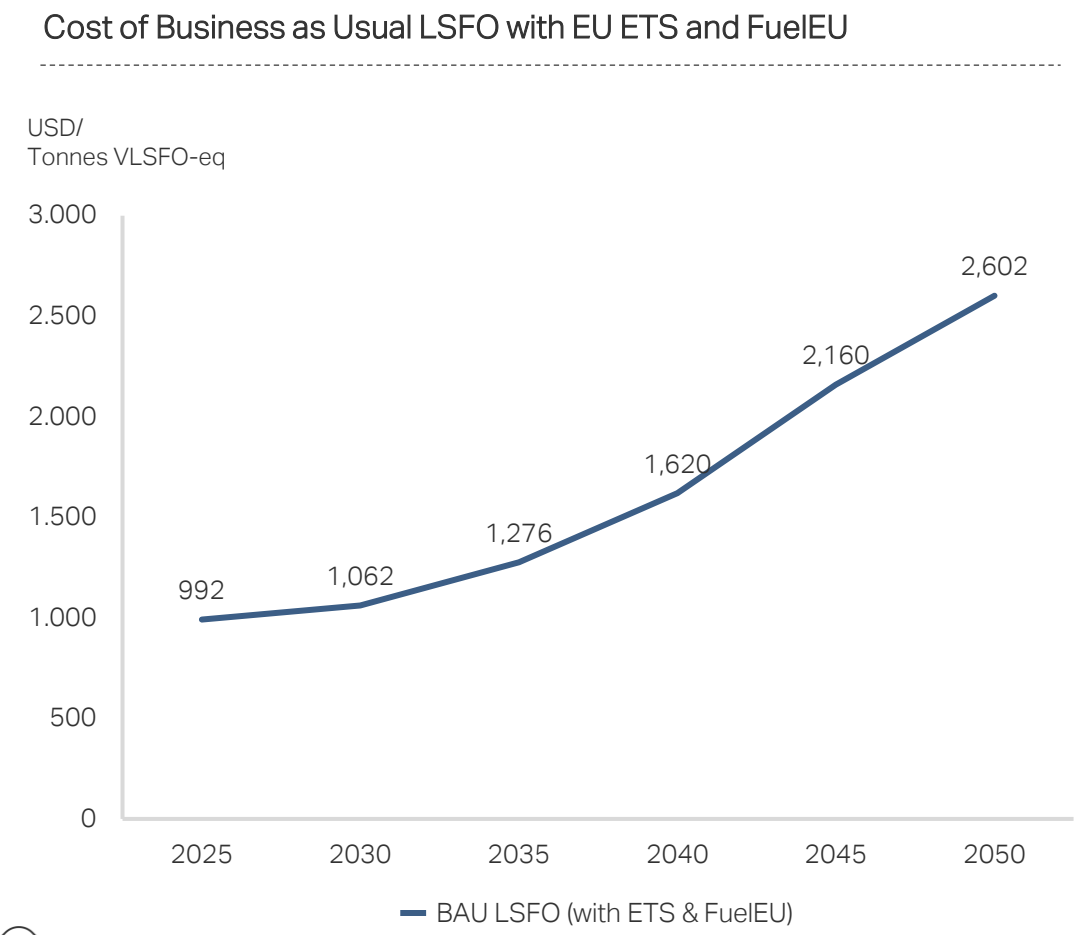
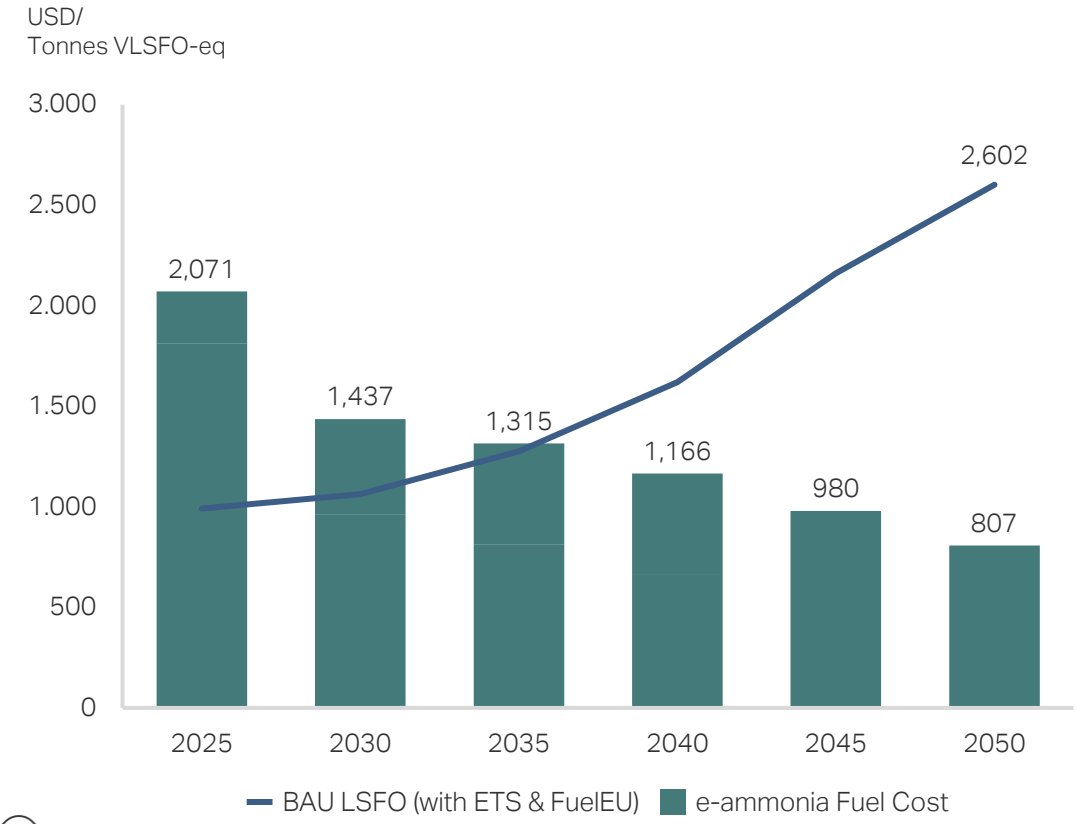
FuelEU Pooling | Vessels sailing on e-ammonia or e-methanol can achieve cost parity with rising LSFO costs by 2035 or earlier with pooling



Note: VLSFO-equivalent units are a standardized measure used to compare the energy content of Very Low Sulfur Fuel Oil (VLSFO) with alternative maritime fuels like ammonia and methanol, enabling a direct comparison of cost. This is needed because these fuels have varying energy densities per tonne.

FuelEU Pooling | Vessels sailing on e-ammonia or e-methanol can achieve cost parity with rising LSFO costs by 2035 or earlier with pooling

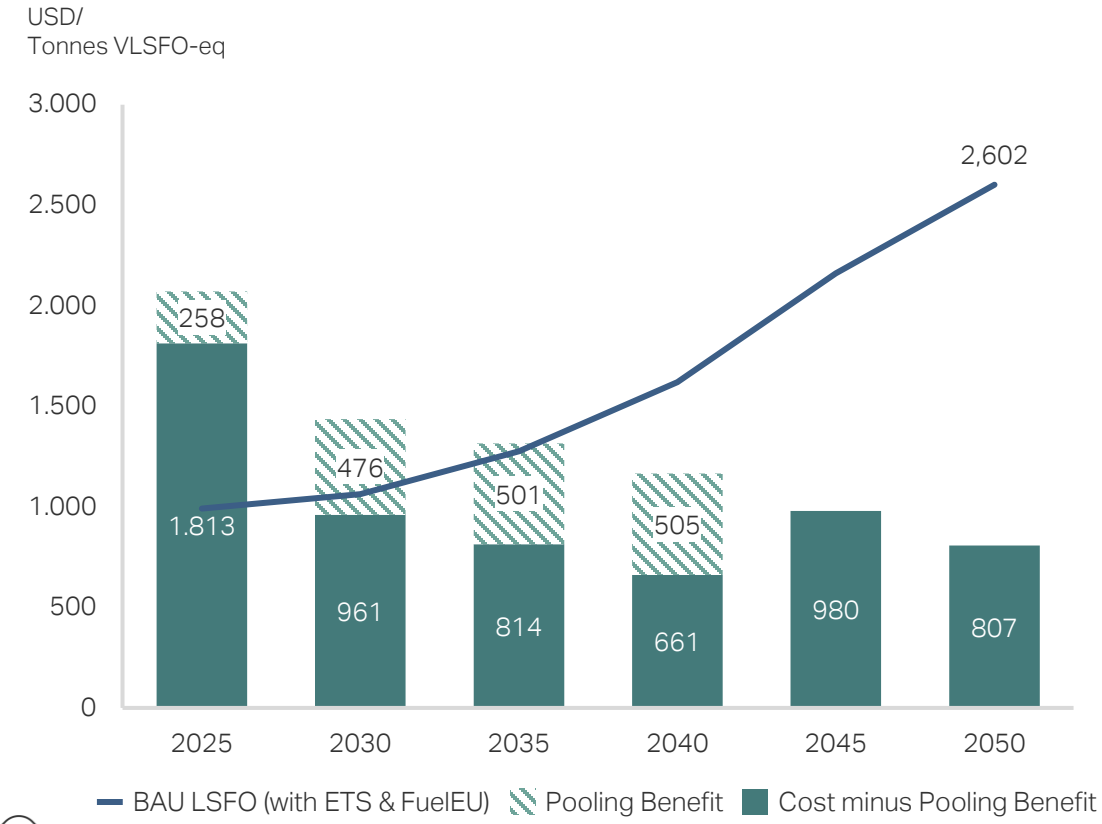
Fuel Cost of e-ammonia vs Business as Usual LSFO



Note: Cost projections are from MMMCZCS's in-house transition modeling tool NavigaTE, which is based on knowledge and insights from in-house experts and partner organizations. Cost projections can be found by acquiring access to the MMMCZCS' open source TCO model.

FuelEU Pooling | Vessels sailing on e-ammonia or e-methanol can achieve cost parity with rising LSFO costs by 2035 or earlier with pooling

Fuel Cost of e-ammonia with Pooling vs Business as Usual LSFO



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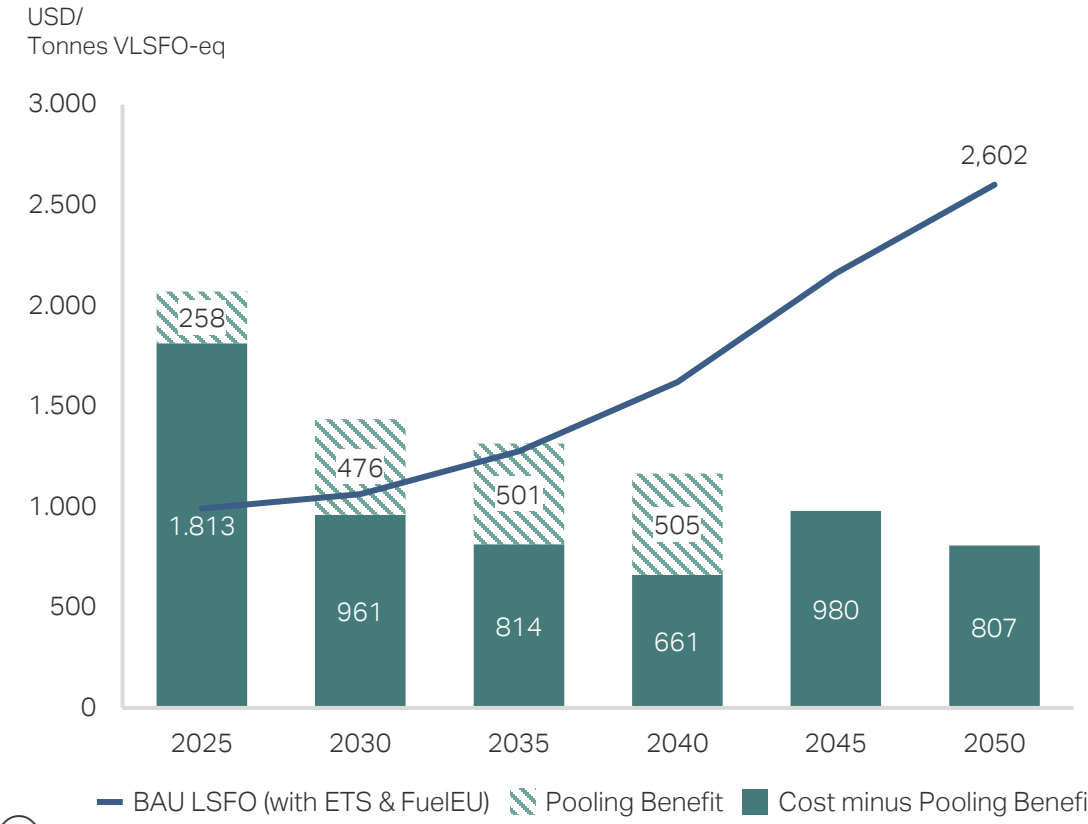
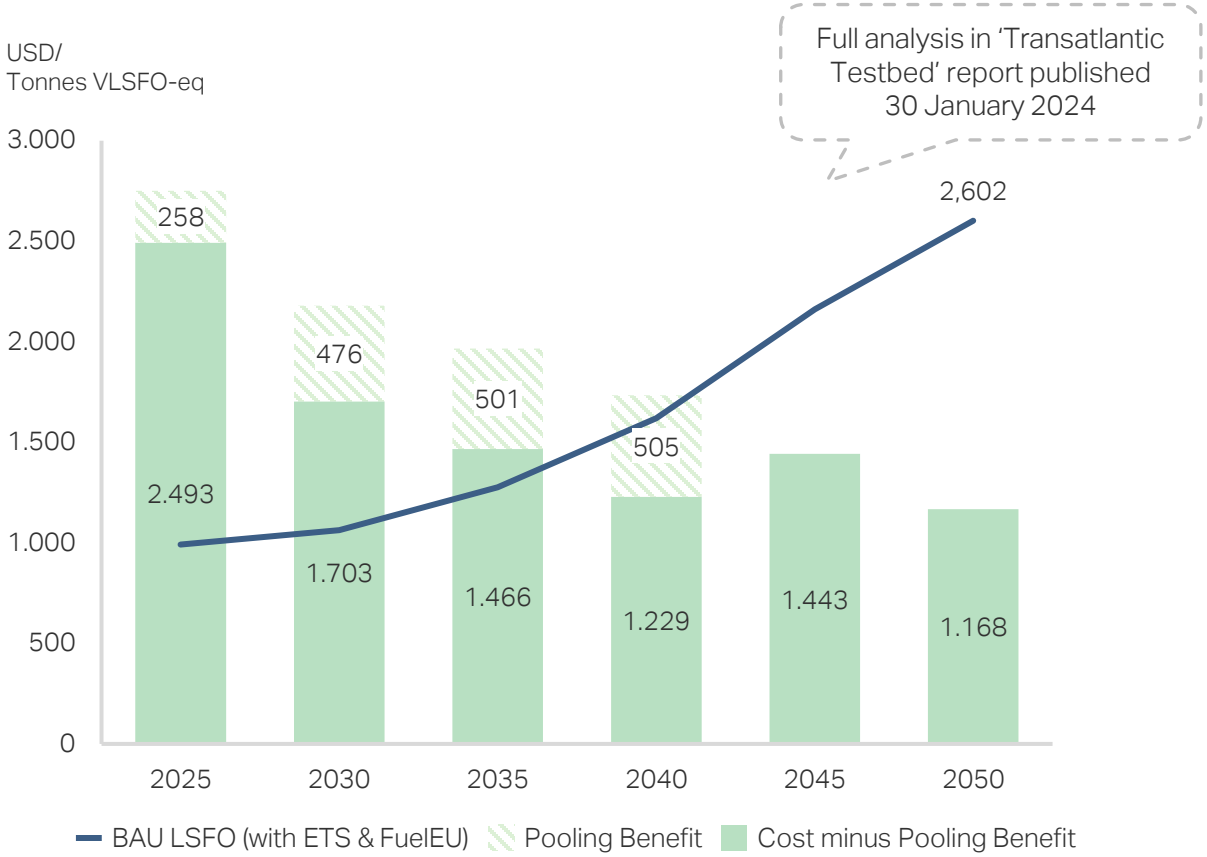
Fuel Cost of e-ammonia with Pooling vs Business as Usual LSFO



Fuel Cost of e-methanol with Pooling vs Business as Usual LSFO



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New FuelEU Pooling Project | Uncertainty prevents the industry from making investments based on potential benefits

Motivating feedback

"FuelEU Pooling could be a big deal. We just haven't been able to figure out how it will work in practice"

Constraining Uncertainties

Uncertainty with value of pooling

Uncertainty with how the first of a kind policy works in practice

Project Outputs

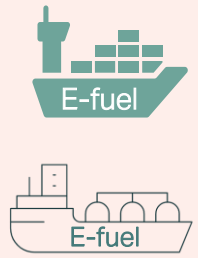
Value proposition: the value of FuelEU pooling for alternative fueled vessels

Playbook: operating procedures that show how to set up and operate a pool

Project Outcome

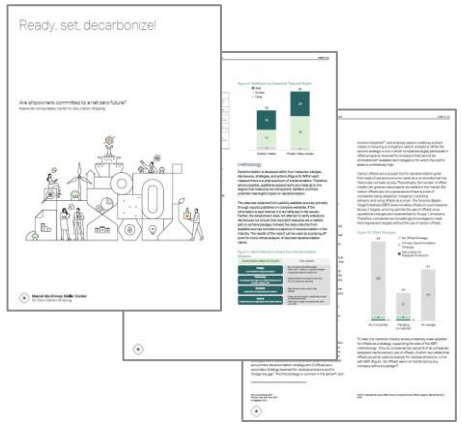
Address uncertainty and show value to drive investment

Investment



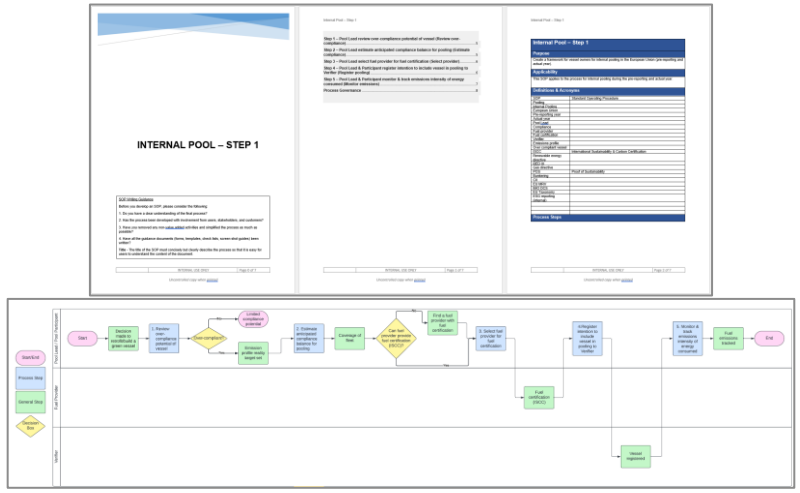
New FuelEU Pooling Project | Goal is to increase certainty on the value and practicalities of pooling

Value proposition



Commercial viability of alternative fuels with pooling using real world case studies

Operating procedures for pooling

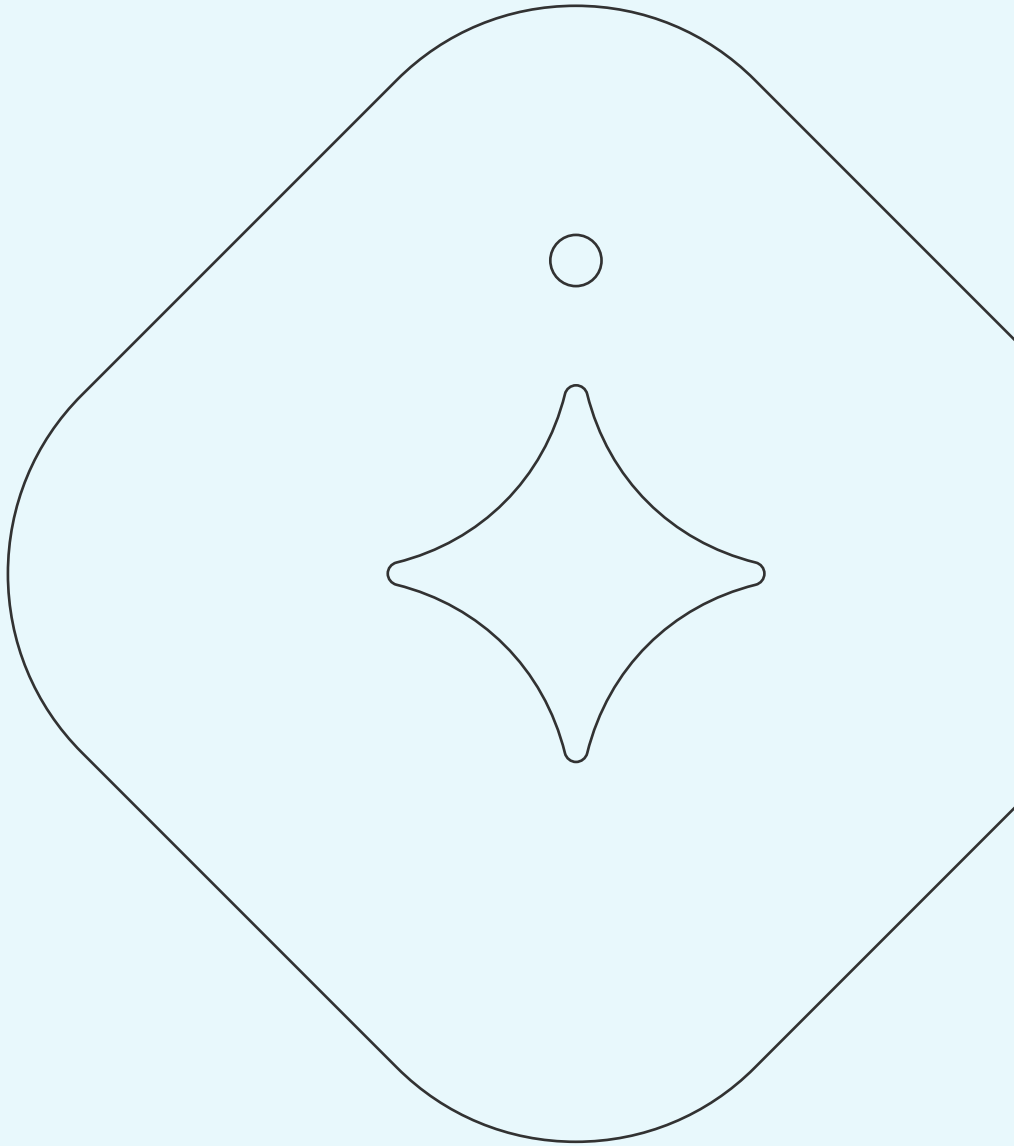


Set of instructions that describes the step-by-step process to create and operate a pool

Thoughts or questions? Reach out:
joe.bettles@zerocarbonshipping.com

Commercial Contracts for FuelEU

Pernille Palmelund Sørensen



Ongoing work of a BIMCO subcommittee will develop FuelEU maritime clauses and contracts

Ongoing work at BIMCO

- Group of legal experts from the shipping and fuel industry
- Analyzing the FuelEU Maritime Regulation with a few to develop standard clauses and contracts on elements to be covered by commercial contracts
- Will be made available through the course of 2024

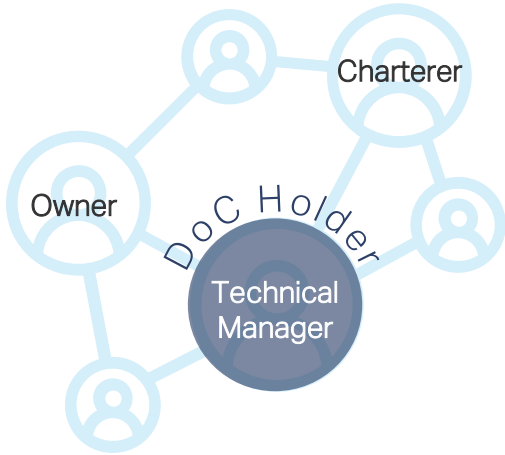
Contracts will be needed because the regulated entity in the FuelEU often does not have responsibility for the fuel

FuelEU Definition of Regulated Entity

- The obligations apply to ships individually.
- The regulated entity is the company, which is defined in line with the ISM Code

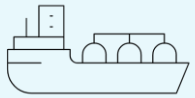
> "'company' means the shipowner or any other organisation or person such as the manager or the bareboat charterer, which has assumed the **responsibility for the operation of the ship** from the shipowner and has agreed to take over all the duties and responsibilities imposed by the International Management Code for the Safe Operation of Ships and for Pollution Prevention;" (FuelEU, Art 3(13))

- Thus, the DoC holder will generally be responsible, since the majority of shipowners delegate ISM Code responsibilities.

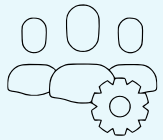


BIMCO subcommittee plans for standard clauses and contracts

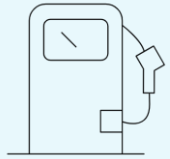
Standard Clauses Covering Relationships



- Owner and time charterer
  - Art. 4: general obligations on overall targets with which to comply
  - Art 10(3): certification of fuels
  - Art. 23(8): penalty 'pass on' clause from shipping company to commercial charter party

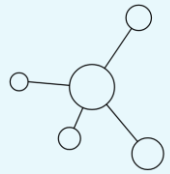


- Owners and ship managers
  - Art. 7, 8, 9, 11, 13, 15, 16: Monitoring and reporting obligations



- Fuel buyer and fuel supplier
  - Art. 23(9): penalty 'pass on' clause from shipping company to fuel supplier

Standard Contract



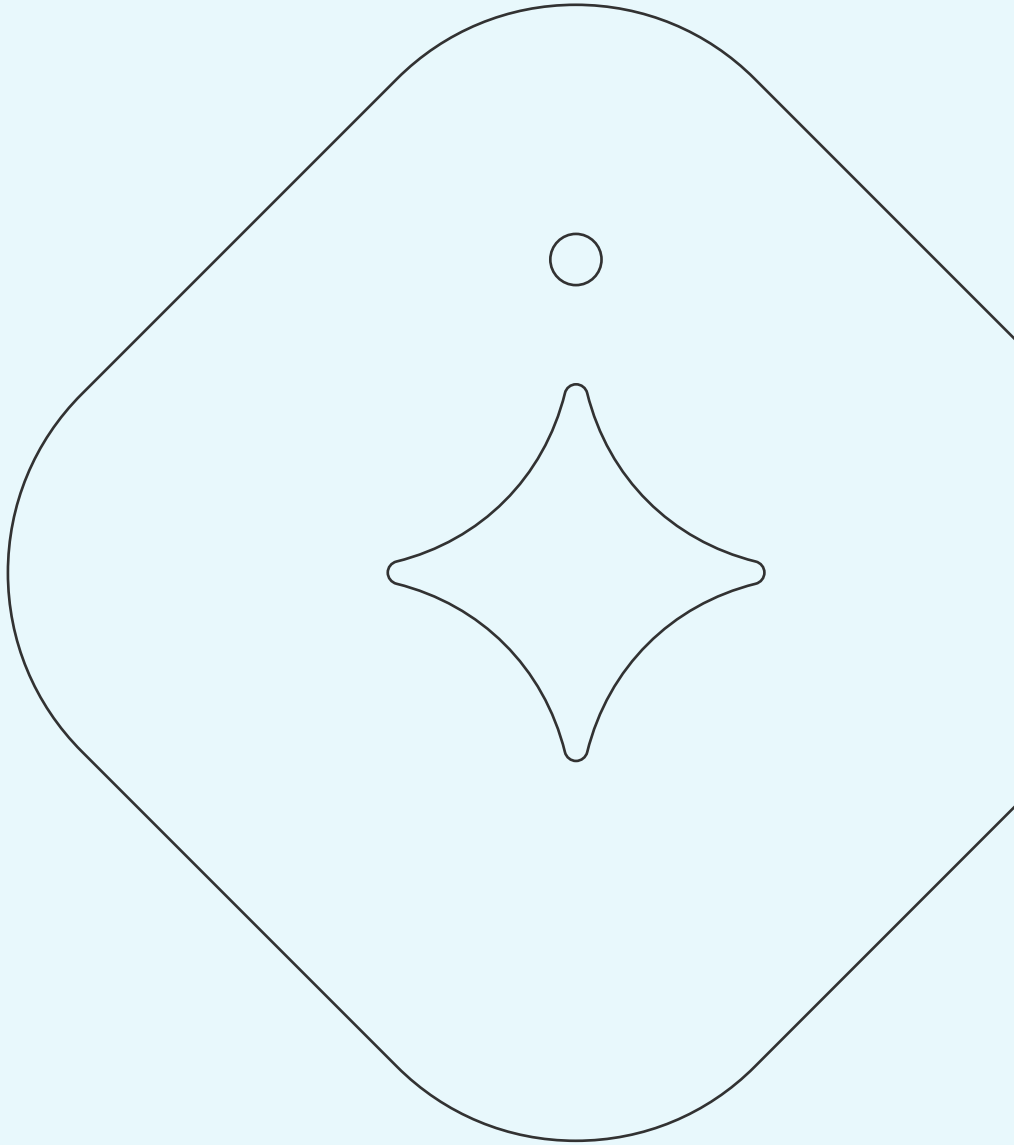
- Pooling
  - Art. 21: pooling

Answer polls at

slido.com

#FuelEU

Panel Q&A



Ask questions at

slido.com

#FuelEU

Questions? Submit at slido.com using code #FuelEU

Thank you!

The recording will be posted on our website

Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

Visit our website www.zerocarbonshipping.com and make sure to follow us on LinkedIn to stay up to date with the latest news and events

European Commission

Send questions to:
Fitfor55@emsa.europa.eu

Related Projects

'Visit our website: https://transport.ec.europa.eu/transport-modes/maritime_en

- **FuelEU Pooling**
  Commercial opportunities for alternative maritime fuels through pooling
- **Book and Claim**
  Maritime Book & Claim System Strengthens Business Case for Green Shipping
- **IMO Mid-Measures**
  Assess and inform formulation of IMO's forthcoming mid-term measures