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**Title: Biofuels in Maritime Sector: Technological & Economic Dimensions and Applications**

**Presenters : George Rizos & Nikolaos Christopoulos**

# Presentation outline

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**Introduction – Questions to be answered**

**Regulatory pressure for de-carbonization ( IMO & EU )**

**An Example – Emissions penalties and how they change with Biofuel use**

**Way forward to decarbonization**

**Key Takeaways**

# Introduction

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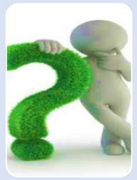

**Where do biofuels fit within the maritime industry ?**

**Which biofuels can ships use ?**

**Are ships ready ?**

**Which ships require biofuels the most ?**

# Regulatory pressure for decarbonization (IMO)

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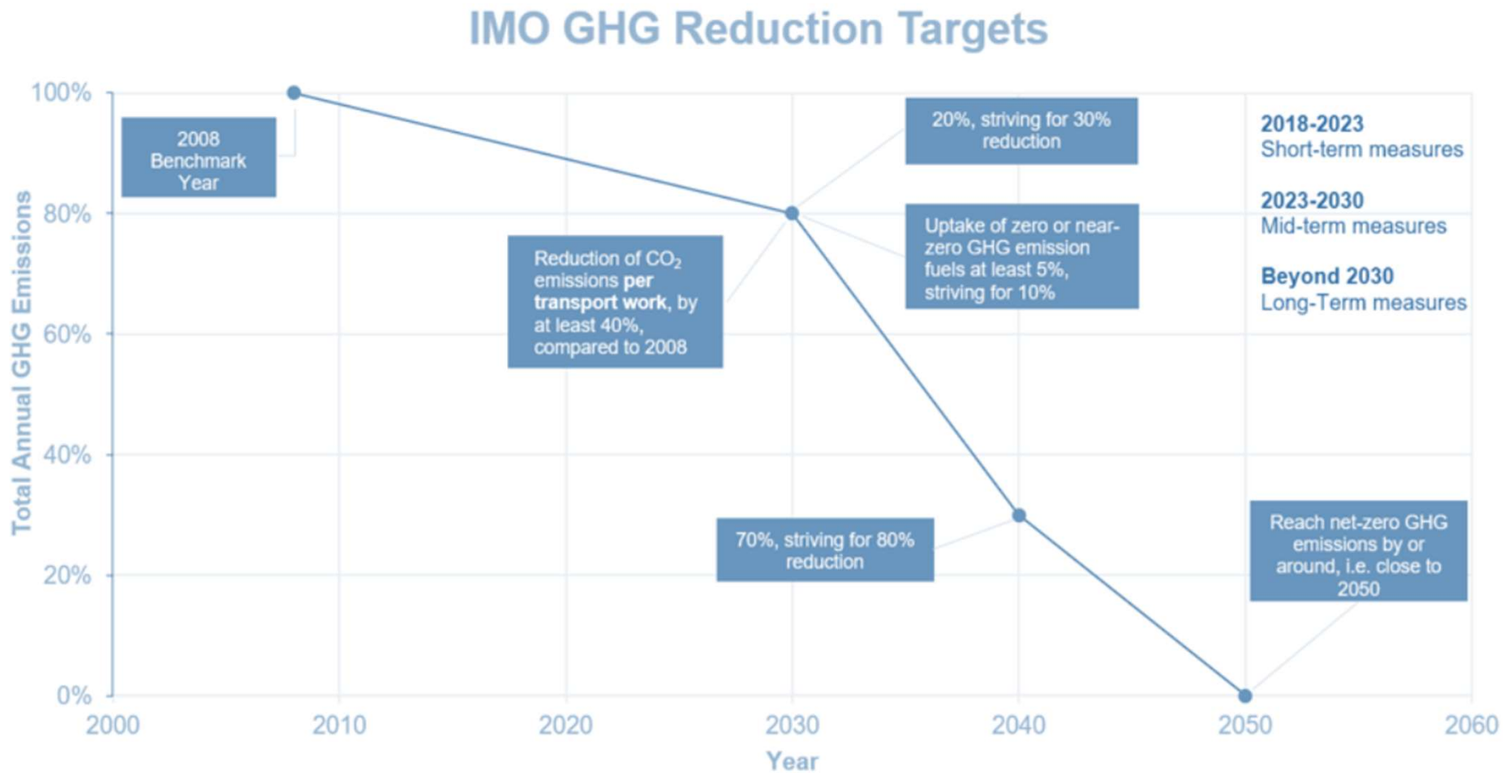
- **Carbon Intensity of International Shipping**
  - 40% reduction by 2030
- **Uptake of Zero or near-Zero GHG emission technologies/fuel**
  - 5%, striving for 10% by 2030
- **Total Annual GHG Emissions**
  - 20% striving for 30% by 2030
  - 70% striving for 80% by 2040
  - Net zero by about 2050




Source: ABS

# Regulatory pressure for decarbonization (IMO)

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**Present Development**
**GFI – a pricing mechanism on $CO_2$ emissions**

Adoption delayed (Trump effect)

**Biofuels**

## SHORT-TERM MEASURES

- ~~EEDI~~ and SEEMP
- EEXI and CII
- Methane emissions and volatile organic compounds
- Develop GHG Guidelines
- Initiate research and development for innovative technologies
- Undertake additional GHG emission study

## MID-TERM MEASURES ~~2028~~ 2029 ?

- The basket of mid-term GHG reduction measures shall be finalized and agreed by the Committee by ~~2025~~ 2026 ?
- **A technical element**, a goal-based marine fuel standard regulating the reduction of the marine fuel's GHG intensity.
- **An Economic element**, on the basis of a maritime GHG emissions pricing mechanism

## LONG-TERM MEASURES

- Pursue development and provision of low-carbon and zero-carbon fuels
- Encourage and facilitate other possible new/innovative emissions reduction mechanisms

Source: ABS

# Regulatory pressure for decarbonization (IMO – Short term measures – EEXI & CII)

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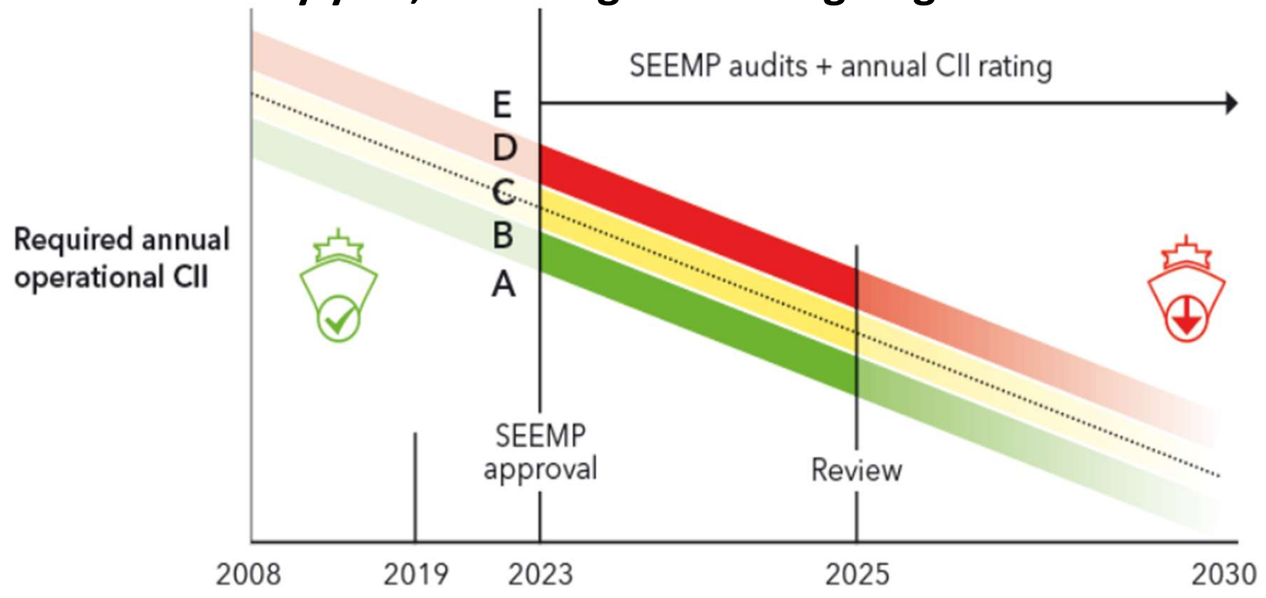
- **EEXI – Energy Efficiency Existing Ships Index**
  - **Design measure – Limits max speed/power output of ships → Reduced fuel Consumption**

- **CII – Carbon Intensity Index**
  - **Operational measure → Ships are to improve their emissions every year, following a declining target**

| Year | % Reduction factor relative to 2019 |
|---|---|
| 2023 | -5 |
| 2024 | -7 |
| 2025 | -9 |
| 2026 | -11 |
| 2027 | -13.625 |
| 2028 | -16.25 |
| 2029 | -18.875 |
| 2030 | -21.5 |




- **Biofuels consumption contributes to a reduced CII**

Source: DNV

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- Pursue development and provision of low-carbon and zero-carbon fuels
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Source: ABS

# Regulatory pressure for decarbonization (IMO – Mid-term measures - GFI - Expected)

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**Ships pay penalties depending on:**

- **Type of fuel used (in two tiers)**
- **Fuel quantity used**

**Fuel Lifecycle emissions**

**Attained GFI must be below the target**

**Below** direct compliance **target**
→ **Surplus units** → Banked or balancing other ships

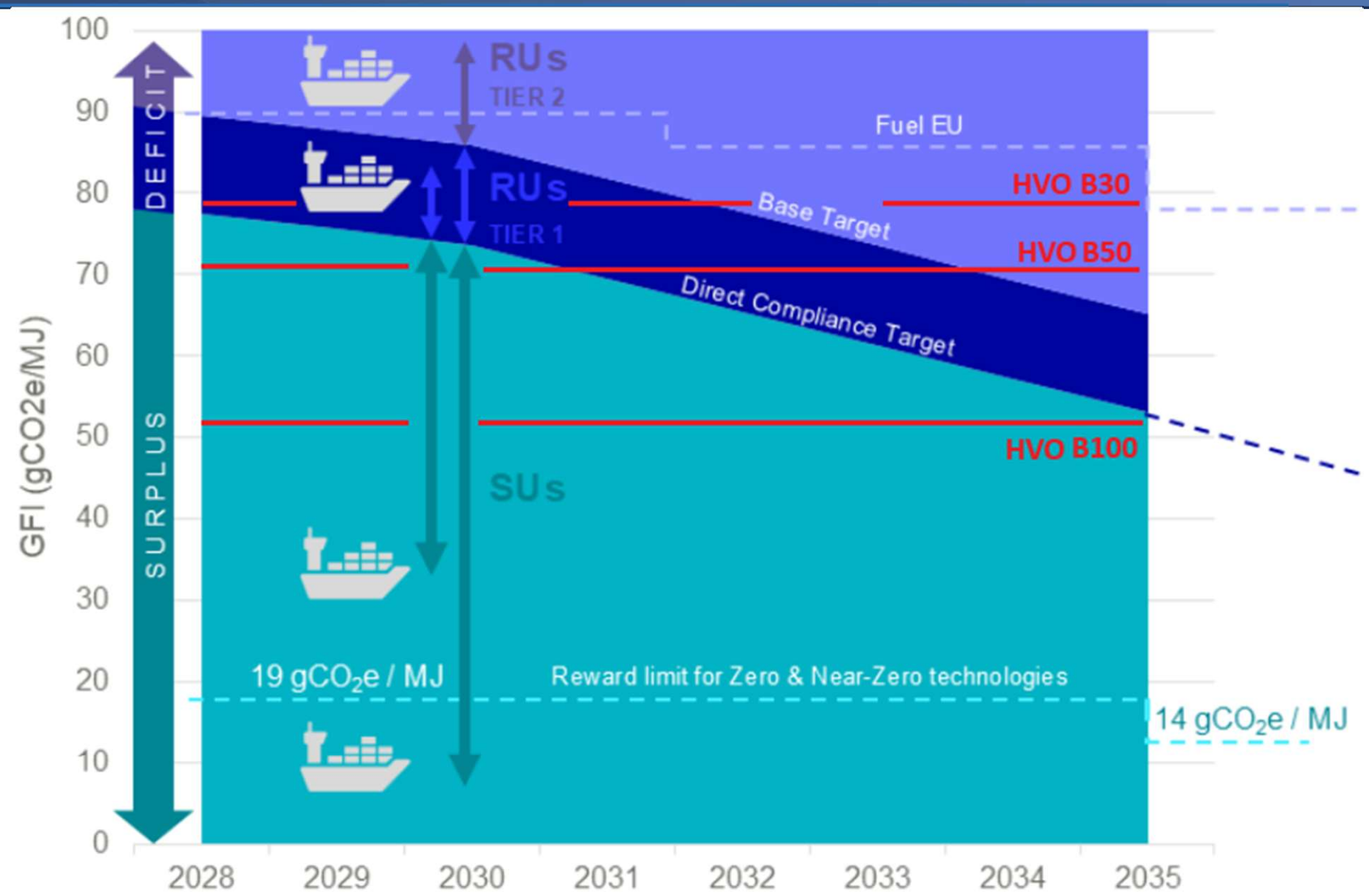
**Above** direct compliance **target**
→ **Remedial units** to comply

**Remedial Unit cost**

- **100$ / ton CO2eq – Tier 1**
- **380$ / ton CO2eq – Tier 2**

**Biofuels usage contributes to compliance**

- **B30** → Tier 1 until ≈ 2033
- **B50** → Direct Compliance to 2030
- **B100**→Direct Compliance to 2035




| | Reference | 2028 | 2030 | 2035 | 2040 |
|---|---|---|---|---|---|
| IMO Tier 1 | 93.3 | 4 % | 8 % | 30 % | 40 % |
| IMO Tier 2 | | 17 % | 21 % | 43 % | TBD |
| Fuel EU | 91.16 | 2 % | 6 % | 14.5 % | 31 % |

Source: BV

# Regulatory pressure for decarbonization (EU – ETS)

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**EU ETS – European Union – Emissions Trading System**

**Ships ≥ 5000GT calling EU ports & Covers CO2, CH4 and N2O emissions**

**Ships pay for EUAs (allowances) for each ton of CO2eq emissions**

**1x EUA ≈ 80 € - Price changes in stock market**

- **1 ton of fuel ≈ 3.2 EUAs ≈ 256 €**
- **100% emissions between EU ports**
- **50% emissions between EU and non-EU ports**

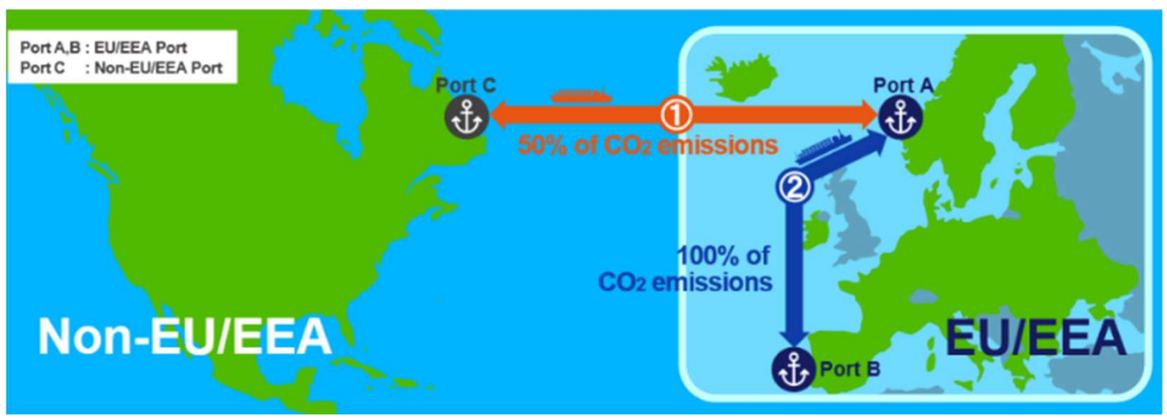
**EUAs**

- **Sold by the EU**
- **Total quantity reduced per year**

**Islands with less than 200.000 residents exempted**

**Biofuels reduce the need for EUAs / Penalties**

**Proof of Sustainability is a pre-requisite**

# Regulatory pressure for decarbonization (EU – FuelEU Maritime)

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**FuelEU Maritime**

**Applicable to Ships ≥ 5000GT calling EU ports & Covers CO2, CH4 and N2O emissions**

**Ships pay penalties depending on:**

- **Type of fuel used (no different tiers)**
- **Fuel quantity**

**Tightens every 5 years – Reduction and penalties are (very) significant after 2035**

**Pooling options to incentivize low-/zero-GHG Fuels (including Biofuels)**

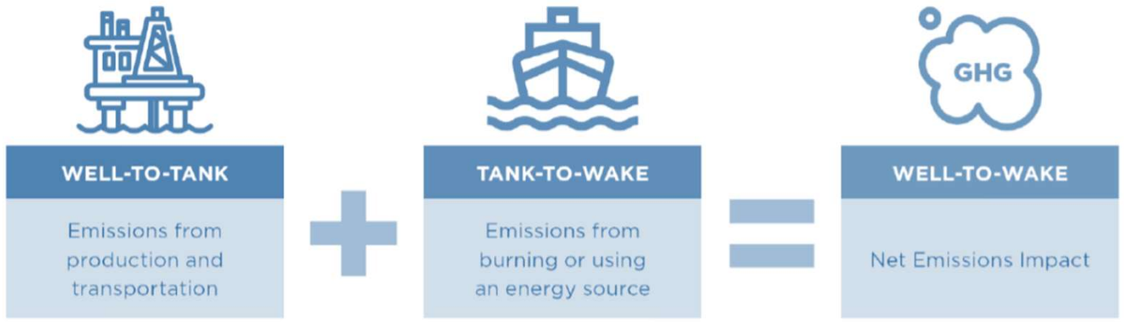
**Biofuels reduce the need for penalties**

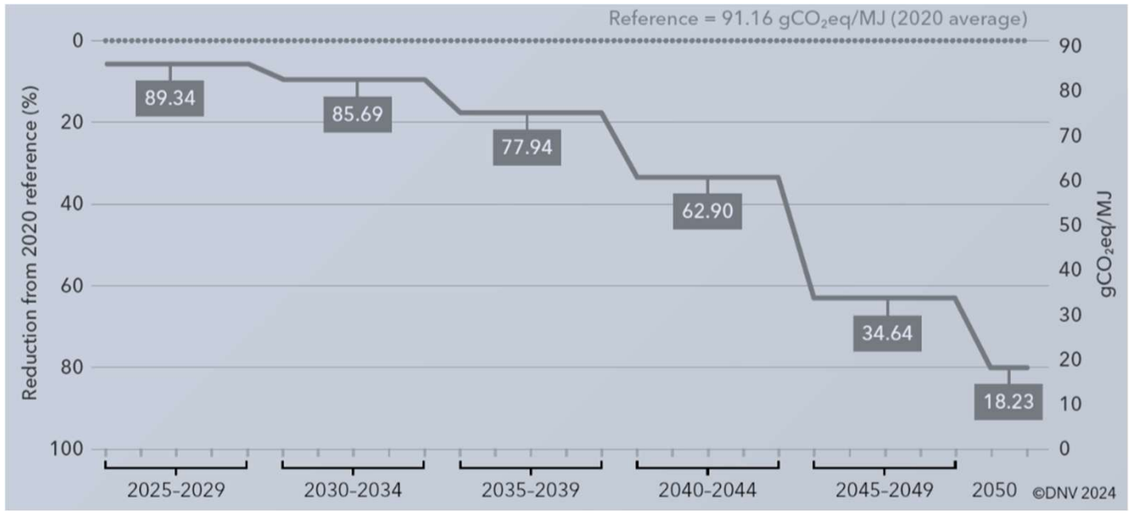
- **B30 blends → Compliance until 2034**
- **B50 blends → Compliance until 2039**

**Pre-requisites for biofuels :**

- **Proof of Sustainability and**
- **Sustainability ≥ 65% is a pre-requisite**

| Year | % Reduction factor relative to 2020 |
|---|---|
| 2025 | -2 |
| 2030 | -6 |
| 2035 | -15 |
| 2040 | -31 |
| 2045 | -62 |
| 2050 | -80 |




Sources: ABS/DNV

# An Example – Emissions Penalties in the EU

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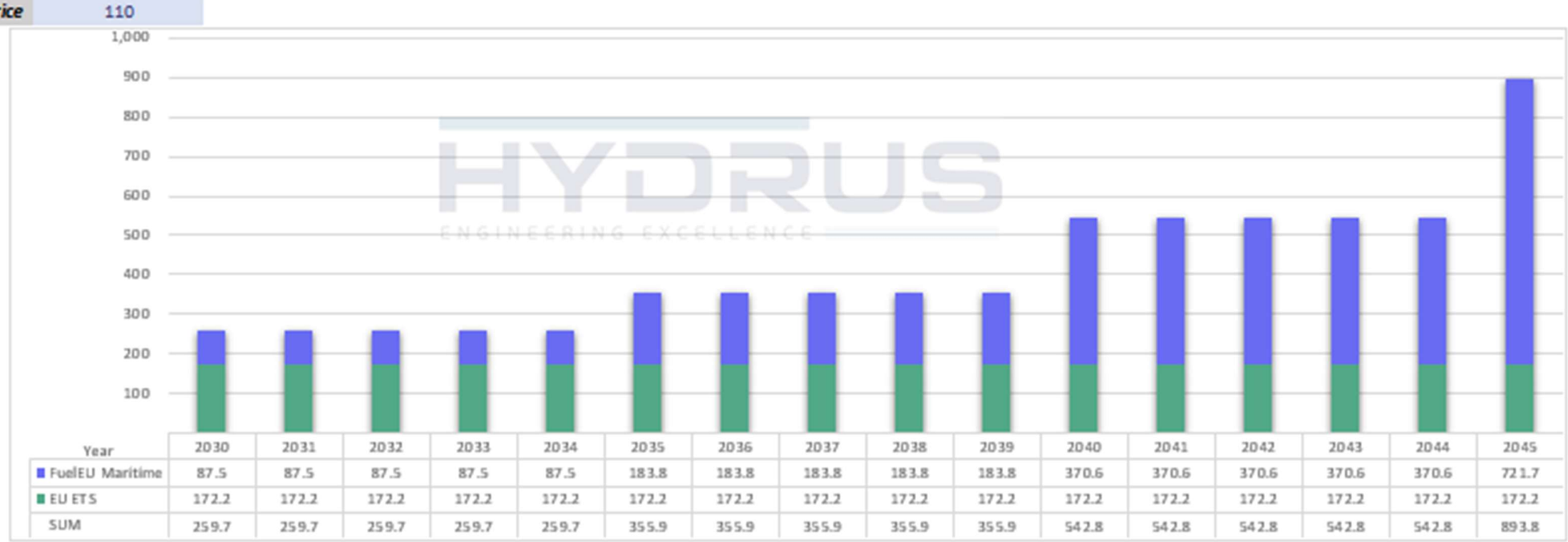
- **Kamsarmax Bulk Carrier (82k DWT)**
  - **Consumption 30t of VLSFO/day**
  - **Just one (1) trip / year from China to an EU Port – Duration 32 days**
  - **Total consumption 960t VLSFO**

| | |
|---|---|
| *Currency* | EURO [€] |
| *EUA Price* | 110 |




| Year | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FuelEU Maritime | 87.5 | 87.5 | 87.5 | 87.5 | 87.5 | 183.8 | 183.8 | 183.8 | 183.8 | 183.8 | 370.6 | 370.6 | 370.6 | 370.6 | 370.6 | 721.7 |
| EU ETS | 172.2 | 172.2 | 172.2 | 172.2 | 172.2 | 172.2 | 172.2 | 172.2 | 172.2 | 172.2 | 172.2 | 172.2 | 172.2 | 172.2 | 172.2 | 172.2 |
| SUM | 259.7 | 259.7 | 259.7 | 259.7 | 259.7 | 355.9 | 355.9 | 355.9 | 355.9 | 355.9 | 542.8 | 542.8 | 542.8 | 542.8 | 542.8 | 893.8 |

# An Example – Emissions Penalties in the EU

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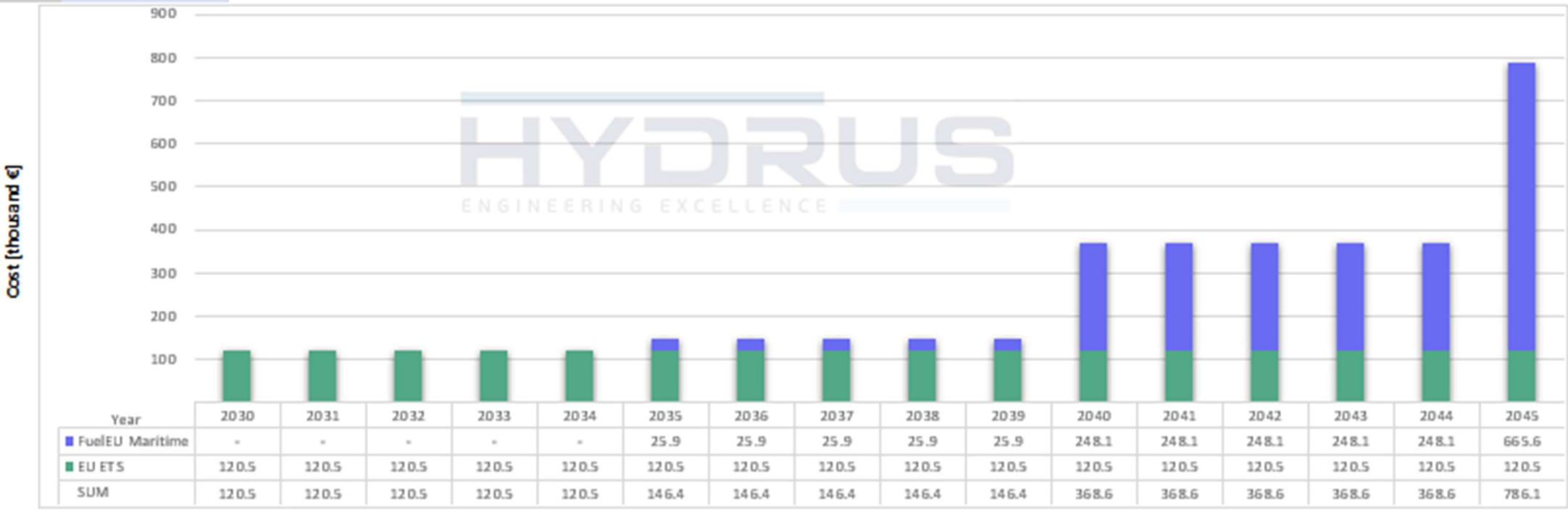
## B30 HVO

| Currency | EURO [€] |
|---|---|
| EUA Price | 110 |




| Year | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FuelEU Maritime | - | - | - | - | - | 25.9 | 25.9 | 25.9 | 25.9 | 25.9 | 248.1 | 248.1 | 248.1 | 248.1 | 248.1 | 665.6 |
| EU ETS | 120.5 | 120.5 | 120.5 | 120.5 | 120.5 | 120.5 | 120.5 | 120.5 | 120.5 | 120.5 | 120.5 | 120.5 | 120.5 | 120.5 | 120.5 | 120.5 |
| SUM | 120.5 | 120.5 | 120.5 | 120.5 | 120.5 | 146.4 | 146.4 | 146.4 | 146.4 | 146.4 | 368.6 | 368.6 | 368.6 | 368.6 | 368.6 | 786.1 |

# An Example – Emissions Penalties in the EU

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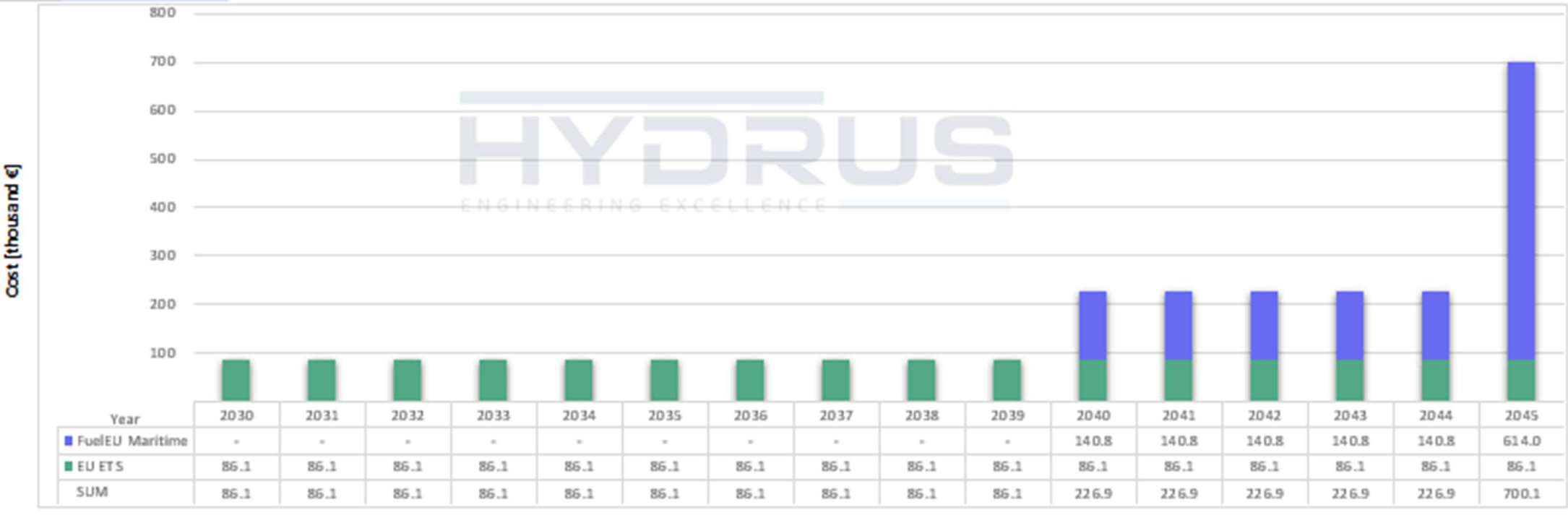
## B50 HVO

| Currency | EURO [€] |
|---|---|
| EUA Price | 110 |




| Year | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FuelEU Maritime | - | - | - | - | - | - | - | - | - | - | 140.8 | 140.8 | 140.8 | 140.8 | 140.8 | 614.0 |
| EU ETS | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 |
| SUM | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 86.1 | 226.9 | 226.9 | 226.9 | 226.9 | 226.9 | 700.1 |

# An Example – Emissions Penalties in the EU

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| Fuel Cost | | |
|---|---|---|
| Fuel Type | Price difference | Fuel Price |
| - | % | € / ton |
| VLSFO | 0 | 415 |
| B30 HVO | 15% | 477 |
| B50 HVO | 30% | 539 |
| Interest rate in fuel cost | | 3 % |
| 1x EUA Price | | 110 € |

**Emissions penalties , without considering IMO's - GFI**

| **Compliance cost for EUETS & Fuel EU** (thousand € / trip) | | | | |
|---|---|---|---|---|
| **Fuel Type** | **2030** | **2035** | **2040** | **2045** |
| **VLSFO** | 259.7 | **355.9** | **542.8** | **893.8** |
| **B30 HVO** | 120.5 | 146.4 | 368.6 | 786.1 |
| **B50 HVO** | 86.1 | 86.1 | 226.9 | 700.1 |

| **Fuel Cost** (thousand € / trip) | | | | |
|---|---|---|---|---|
| **Fuel Type** | **2030** | **2035** | **2040** | **2045** |
| **VLSFO** | 397.9 | 442.9 | 492.9 | 548.5 |
| **B30 HVO** | 457.6 | 509.3 | 566.8 | 630.8 |
| **B50 HVO** | 517.3 | 575.7 | 640.7 | 713.1 |

| **Savings from EUETS & Fuel EU** due to biofuel use **Excluding fuel price difference** (thousand €/ trip) | | | | |
|---|---|---|---|---|
| **Fuel Type** | **2030** | **2035** | **2040** | **2045** |
| **VLSFO** | - | - | - | - |
| **B30 HVO** | -139.2 | -209.5 | -174.2 | -107.7 |
| **B50 HVO** | -173.6 | -269.8 | -315.9 | -193.7 |

| **Savings from EUETS & Fuel EU** due to biofuel use **Including price difference** (thousand €/ trip) | | | | |
|---|---|---|---|---|
| **Fuel Type** | **2030** | **2035** | **2040** | **2045** |
| **VLSFO** | - | - | - | - |
| **B30 HVO** | **-79.5** | **-143.1** | -100.3 | -25.4 |
| **B50 HVO** | -54.2 | -136.9 | **-168.0** | -29.1 |

**Note: Compliance costs are significantly higher for bigger consumers – Operating in the EU**

# Way forward to Decarbonization

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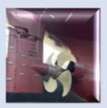
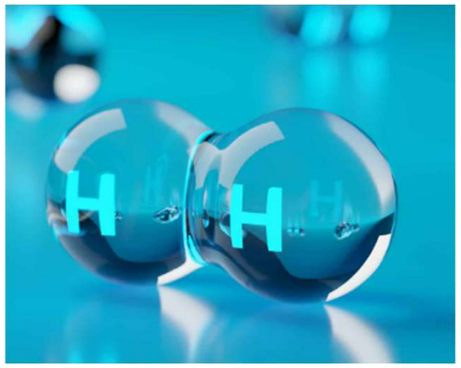
**Regulatory compliance & decarbonization will finally come with alternative fuels → Hydrogen / Methanol / Ammonia But…**

**New Engines to propel New ships by using alternative fuels are very limited**

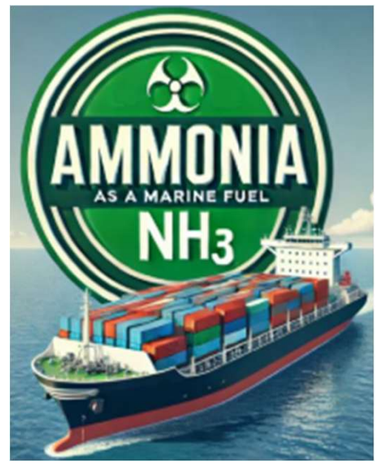


**No retrofit solutions for alternative fuels usage by existing fleet (except methanol). The costs may be overwhelming for shipowners**

**Existing ships can use Biofuels after limited modification**



# Are existing ships ready for biofuels?

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Existing ships can use blends of FAME and HVO after relatively low-cost modifications

On fuel supply, preparation, injection and storage

Up to B30 can be used with very limited changes

Higher blends (B50 / B100) require more extensive alterations but still against low cost – compared to alternative fuels (max. 10-15% of a potential methanol retrofit)

Technical limiting factors :

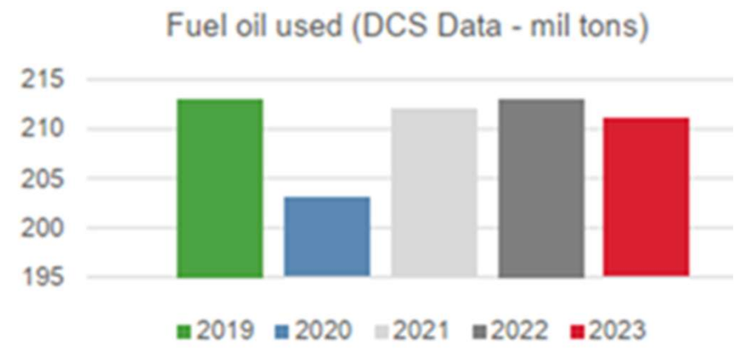
→Low viscosity - Fuel injection system wear
→Elastomer components incompatible with biofuel
→Copper valves incompatible with FAME (corrosion)

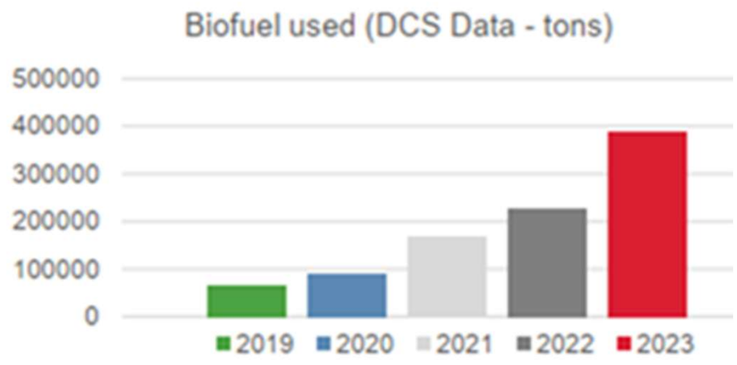
Commercial limiting factor:

→Biofuel availability is still very low

Biofuels Use

Steady increase with 73% growth in 2022 to 2023 (390,846 tonnes). Still low contribution about 0.2% of total fuel use




Source: MEPC 82/6/38

Source: ABS

# Summary - Key Takeaways

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Current EU penalties and the expected GFI become significant (2035+)
→Apply to medium/larger ships > 5000GT (min. ≈ 80m ferry)
→Regulations may be revised to include smaller ships

Biofuels (HVO and FAME) are a very good bridge until
Methanol, Hydrogen and (maybe) Ammonia can be used

→ ≥ 65% sustainability and certification by a recognized certification scheme (e.g. ISCC, RSB) are must items in the EU
→ Fuel / Blend compliance with ISO 8217:2014 is important

Target - big consumers/ships (>5000GT for now) where the operator pays for fuel & compliance costs:
→ Passenger ferries or Cruise ships doing international voyages in the EU
→ Passenger ferries operating in islands > 200.000 residents
→ Containerships trading within the EU


Life-cycle analyses of fuels and biofuels are still ongoing
→ Framework may change
(e.g. Sustainability thresholds and Indirect Land-use Change of Biofuels)

Total Global Biofuel usage by ships is ~ 400.000 tons (from 213 mil tons)
About 42.000 tons (B100) are needed to decarbonize just
the remote island ferries in Greece

There is high demand but (very) low biofuel availability
Additional quantities can be absorbed by the Maritime Industry


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# THANK YOU

Any Questions?

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