Decarbonising European Shipping

Faïg Abbasov
T&E: 26 Countries
61 Members
5 National experts
Founding member of CSC
Key structure [temporary]

● State of the play
  ○ 2018, 2019, 2020 MRV emissions
  ○ Top emitters
  ○ Scope of emissions (fleet and company level)
● Our modelling results
  ○ Energy efficiency, SSE and e-fuels
  ○ Different fuels: e-fuel costs, bio-availability, LNG-limits
  ○ How much e-fuels would we need by 2030?
● Current FuelEU situation
  ○ Explain goal-based
  ○ Rational choice and price
  ○ The impact on LNG/bio of the current draft
  ○ Multiplier
● Recommendations
18% reduction in 2020 due to COVID-19 *

*preliminary

Note: data extracted from Thetis MRV using v258 for 2018, v182 for 2019 and v5 for 2020. 2020 emissions are likely to be revised upward. About 10 Mt CO2 drop in 2020 is attributable to cruise and ferry passenger ships.
<table>
<thead>
<tr>
<th>Rank</th>
<th>CO₂ Emissions (Mt)</th>
<th>Polluter Name</th>
<th>Country (Code)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30.1</td>
<td>Power Plant Bełchatów</td>
<td>PL</td>
</tr>
<tr>
<td>2</td>
<td>18.7</td>
<td>Power Plant Neurath</td>
<td>DE</td>
</tr>
<tr>
<td>3</td>
<td>13.6</td>
<td>Power Plant Jänschwalde</td>
<td>DE</td>
</tr>
<tr>
<td>4</td>
<td>11.9</td>
<td>Power Plant Niederauβem</td>
<td>DE</td>
</tr>
<tr>
<td>5</td>
<td>11.5</td>
<td>Power Plant Weisweiler</td>
<td>DE</td>
</tr>
<tr>
<td>6</td>
<td>10.9</td>
<td>Mediterranean Shipping Company</td>
<td>IT-CH</td>
</tr>
<tr>
<td>7</td>
<td>10.5</td>
<td>Power Plant Kozience</td>
<td>PL</td>
</tr>
<tr>
<td>8</td>
<td>10.3</td>
<td>Power Plant Schwarze Pumpe</td>
<td>DE</td>
</tr>
<tr>
<td>9</td>
<td>9.7</td>
<td>Power Plant Opole</td>
<td>PL</td>
</tr>
<tr>
<td>10</td>
<td>8.7</td>
<td>Power Plant Boxberg WerkIV</td>
<td>DE</td>
</tr>
</tbody>
</table>

Source: Estimates by T&E based on the EU shipping MRV (2020 - v5), EU ETS emissions (2020) and Alphaliner containership database (2020).
Decarbonising EU Shipping

Majority of emissions fall on extra-EU voyages

MSC: 34% (66%) CO₂ emissions on voyages between European and non-European ports, 66% (34%) CO₂ emissions on voyages within Europe

Maersk: 21% (79%) CO₂ emissions on voyages between European and non-European ports, 79% (21%) CO₂ emissions on voyages within Europe

CMA CGM: 35% (65%) CO₂ emissions on voyages between European and non-European ports, 65% (35%) CO₂ emissions on voyages within Europe

COSCO Group: 26% (74%) CO₂ emissions on voyages between European and non-European ports, 74% (26%) CO₂ emissions on voyages within Europe

Hapag-Lloyd: 23% (77%) CO₂ emissions on voyages between European and non-European ports, 77% (23%) CO₂ emissions on voyages within Europe

Total emissions: 10.9 Mt CO₂

Source: Transport & Environment (2021)
T&E Roadmap for decarbonising European shipping
"Fair share" decarbonisation of EU shipping

EU shipping would need to slash 90Mt CO$_2$ by 2030.

Note: "Fair share" trajectory envisages a -55% 2030 target (vs 1990) & -100% by 2050, compatible with the EU's overall climate goals. "Fair share" assumes that shipping’s share in the overall EU emissions/decarbonisation remains constant.
## Scenarios and input main assumptions

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scenario 1</strong></td>
<td>No energy efficiency/High e-fuel penetration</td>
</tr>
<tr>
<td>2025+</td>
<td>All new vessels co-combust 70:30 ratio of Nh3-diesel</td>
</tr>
<tr>
<td>2030-2040</td>
<td>Old vessels progressively retrofitted for 50:50 Nh3-diesel co-combustion</td>
</tr>
<tr>
<td>2040-2050</td>
<td>Remaining fossil diesel eliminated from the fleet via mono-fuel technologies or Nh3 co-combustion with e-diesel/biofuel/hydrogen</td>
</tr>
<tr>
<td></td>
<td>New vessels improve their energy efficiency as larger new vessel with better EEDI enter the fleet</td>
</tr>
<tr>
<td></td>
<td>ZE berth standard</td>
</tr>
<tr>
<td><strong>Scenario 2</strong></td>
<td>High energy efficiency/High e-fuel penetration</td>
</tr>
<tr>
<td>2025+</td>
<td>All new vessels co-combust 70:30 ratio of Nh3-diesel</td>
</tr>
<tr>
<td>2030-2040</td>
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<td>2040-2050</td>
<td>Remaining fossil diesel eliminated from the fleet via mono-fuel technologies or Nh3 co-combustion with e-diesel/biofuel/hydrogen</td>
</tr>
<tr>
<td></td>
<td>All vessels improve their technical (wind-assist, hull-lubrication, etc.) and operational (slow steaming) efficiency and carry out regular vessel maintenance.</td>
</tr>
<tr>
<td><strong>Scenario 3</strong></td>
<td>Low energy efficiency/Low e-fuel penetration</td>
</tr>
<tr>
<td></td>
<td>Half the fuel penetration of Scenario 1</td>
</tr>
<tr>
<td></td>
<td>Half the energy efficiency penetration of Scenario 2 (but includes ZE berth from 2025+ &amp; 2030+)</td>
</tr>
</tbody>
</table>
Up to a 1/3 of EU ship CO2 can be cut with energy efficiency

Trajectory compatible with EU's 2030-2050 objectives

Source: Transport & Environment
Fleet-wide energy efficiency can improve by 41% between 2018 and 2030.

Note: Vessel energy efficiency are expressed as: for RoRo/Ro-pax - kWh/GT-nm; for passenger (cruise) ships - kWh/pax-nm; for container ships - kWh/cargo_tonne-nm; for all other ship types - kWh/DWT-nm; Passenger (cruise) ships use different units and are thus not included in the graph above.

T&E analysis based on EU MRV and IMO 4th GHG Study.
Higher energy efficiency would save the industry about €12 billion/yr in transport costs in 2050.

Cost-effectiveness of EU ship CO₂ abatement

Note: T& analysis based on MAC curves of the 4th IMO GHG study. For e-fuels, we assumed ships use green e-ammonia with production costs of €501/tonne in 2030 and €429/tonne in 2050 (Ricardo EAE, 2020). Energy efficiency includes, inter alia, wind-assist and slow steaming. Analysis excludes ship machinery and infrastructure costs.
E-fuels such as e-ammonia can reach up to 7% of EU shipping’s energy demand by 2030, if coupled with efficiency measures.
What are the realistic & sustainable technologies?

**Battery-electric**
- Inland barges & short-sea ferries; power supply at berth

**Hydrogen fuel-cells/ICE**
- Inland & short-sea ferries, tomorrow larger vessels

**Green ammonia**
- Deep-sea vessels, typically containerships
How much would e-fuels cost to EU shipping?

*Ricardo EAE e-fuel cost estimations*

**e-Ammonia & e-Hydrogen**

**cheapest** e-fuels to decarbonise maritime transport

Source: T&E estimations based on fuel consumption projections for EU shipping (full MRV scope) and cost of e-fuel production with high DAC from Ricardo EAE, 2020.
What do the shipyards say?

**Dalian Shipbuilding Industry** (China) - world’s largest shipyard

- Ammonia - *The Closest Alternative to an Ideal Fuel*
- Even the largest vessels can be powered - 23 000 TEU
- Enough autonomy for a single trip from S. Korea to Poland
- Multiple refueling can be realised along the route - already existing ammonia discharge/loading ports

**Daewoo Shipbuilding & Marine Engineering** (S. Korea)

- Ready to commercialise 23 000 TEU container ship by 2025

**Hyundai Mipo & Samsung Heavy Industries** (S. Korea)

- Ready to commercialise 50000-125000 DWT tankers by 2024/2025
Investment needs in H2 production for ships & new Jobs

€603 billion

1.9 million jobs (2030-2050)

€799 billion

H2 production
Ammonia synthesis from H2

Note: T&E estimations based on UMAS (2020), Aggregate investment for the decarbonisation of the shipping industry and European Commission (2020), Hydrogen generation in Europe: Overview of costs and key benefits. Analysis includes only CAPEX needs for H2 production and excludes electricity generation & ammonia synthesis.

Economic Recovery via Technological Transition
What if half of global fleet were to switch to LNG by 2050? Here is why it is a dead-end fuel.

How can LNG be a transitional fuel if emissions go in the opposite direction?
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EU 2050 bio-methane potential not even enough for households

Notes: The chart is conservative as it compares 2050 supply with 2017 demand. This supply would only be feasible at a retail price of €6300/t (excluding taxes), which is more than 10 times higher than the current LNG prices. Energy demand for households is limited to natural gas demand only.

Recap - Key findings

1. EU shipping needs to slash 90Mt CO$_2$ in 2030 to meet -55% below 1990.

2. Almost half of it (46%) could be met by high energy efficiency alone (about 42Mt).

3. For 2050 carbon neutrality, zero emission vessels needs to be deployed from 2025, while existing vessels need to be retrofitted to run on green hydrogen(-based fuels) from 2030 on.

4. But without energy efficiency, even that would leave a 60Mt/yr CO$_2$ gap towards 2030 target.

5. Combined energy efficiency & ammonia uptake would:
   a. be 3x more cost-effective than fuels-alone approach to abate each tonne of CO$_2$ by 2030.
   b. save industry €2 billion/year in 2030 and €12 billion/year in 2050
   c. require 3 times less alternative fuels by 2030 than fuels-alone approach.
FuelEU Maritime regulation (forthcoming)
Goal-based targets in FuelEU Maritime regulation

Note: The baseline for well-to-wake emissions of CO2 equivalent per energy is calculated from the Port of Rotterdam fuel sales in 2020. Sources of fuel price in Table 1 of the Annex.
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Well-to-Wake carbon intensity of marine fuels

Fossil LNG compliant until 2039

Advanced (UCO) biodiesel until 2044

Note: T&E compilation based on the draft FuelEU Maritime Regulation. Baseline was estimated by T&E using 2020 Rotterdam fuel sales data as a proxy. Analysis assumes CH4 GWP of 36 as per IPCC SAR; however, if GWP 28 were chosen, WTW intensity of LNG in low-pressure DF 2 stroke engines would be 83.26 gCO2eq/MJ.
Simply goal-based approach provide equality but not equity.
With no safeguards, FuelEU target will drive fossil LNG and biodiesel in shipping, instead of green e-fuels.
The draft FuelEU will incentivise fossil LNG and dubious biodiesel imports.

Alternative fuel demand from shipping (Mt):
- 2020: LNG 2.4, Advanced biodiesel 2.2
- 2025: LNG 2.2, Advanced biodiesel 2.4
- 2030: EU projected demand 7.0

Supply driven by EU demand:
- 2030: EU demand 8.2 Mt, Supply 5.1 Mt (Shipping demand), 6.3 Mt (Surface transport demand), 1.7 Mt Max Domestic supply, 1.5 Mt Max Imports

This will add to EU demand for used cooking oil (UCO) in 2030, far exceeding supply.

With constrained waste-based feedstock, most biofuels supply for ships will come from **unsustainable crop-based bio**

### Table 5 Biomass feedstock consumption by type (in Mtonnes)

<table>
<thead>
<tr>
<th>Feedstock consumption</th>
<th>PO1</th>
<th>PO2</th>
<th>PO3</th>
<th>PO4</th>
<th>PO5</th>
<th>PO6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mtonnes</td>
<td>2030</td>
<td>2050</td>
<td>2030</td>
<td>2050</td>
<td>2030</td>
<td>2050</td>
</tr>
<tr>
<td>Part A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perennial crops</td>
<td>0.0</td>
<td>6.3</td>
<td>0.0</td>
<td>7.7</td>
<td>0.0</td>
<td>6.9</td>
</tr>
<tr>
<td>Annual crops</td>
<td>0.3</td>
<td>33.6</td>
<td>0.3</td>
<td>40.8</td>
<td>0.3</td>
<td>36.4</td>
</tr>
<tr>
<td>Forestry products</td>
<td>3.1</td>
<td>14.4</td>
<td>3.2</td>
<td>18.4</td>
<td>3.1</td>
<td>15.9</td>
</tr>
<tr>
<td>Forestry residues</td>
<td>1.4</td>
<td>11.7</td>
<td>1.5</td>
<td>14.7</td>
<td>1.5</td>
<td>12.8</td>
</tr>
<tr>
<td>Wood waste</td>
<td>1.8</td>
<td>6.7</td>
<td>1.8</td>
<td>8.0</td>
<td>1.8</td>
<td>7.2</td>
</tr>
<tr>
<td>Agricultural residues</td>
<td>1.5</td>
<td>15.4</td>
<td>1.5</td>
<td>18.6</td>
<td>1.5</td>
<td>16.8</td>
</tr>
<tr>
<td>Manure</td>
<td>1.2</td>
<td>2.8</td>
<td>1.2</td>
<td>3.3</td>
<td>1.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Part B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-agricultural oils</td>
<td>0.80</td>
<td>1.4</td>
<td>0.83</td>
<td>1.8</td>
<td>0.82</td>
<td>1.6</td>
</tr>
</tbody>
</table>

**Source:** PRIMES Biomass model, E3Modelling

**Estimation of biomass feedstock consumption for 2030-2050 under various policy options in European Commission’s impact assessment for FuelEU Maritime**
Compliance costs - multipliers can boost cost-effectiveness of e-fuels for operators in 2030

<table>
<thead>
<tr>
<th>Energy share for an operator to comply</th>
<th>Total fuel cost (including fuel oil)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HFO</strong></td>
<td>Non-compliant</td>
</tr>
<tr>
<td><strong>LNG (1)</strong></td>
<td>Not feasible with fleet renewal alone</td>
</tr>
<tr>
<td><strong>bio-diesel</strong></td>
<td>Compliance with one alternative fuel blend or co-combustion</td>
</tr>
<tr>
<td><strong>bio-LNG</strong></td>
<td></td>
</tr>
<tr>
<td><strong>e-ammonia</strong></td>
<td></td>
</tr>
<tr>
<td><strong>e-ammonia MULTI = 2</strong></td>
<td></td>
</tr>
<tr>
<td><strong>e-ammonia MULTI = 4</strong></td>
<td></td>
</tr>
<tr>
<td><strong>technology mix (2)</strong></td>
<td></td>
</tr>
</tbody>
</table>

**2030 target: 84.9 CO2eq/MJ WtW**

**Share of energy required to comply**

- Remaining share of fuel oil

**Price of compliance per Gigajoule (€)**

- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18

**E-fuels needs a multiplier of at least 5 to be cost-competitive**

**Note:** This graph shows how multipliers can incentivize e-fuels by boosting their cost effectiveness for compliance per operator. This simplistic approach only includes fuel costs - carbon mark-up is excluded. Price range based on the difference between conservative and optimistic cost assumptions. See Table 1 for sources.

1. LNG (DF high-pressure 2 stroke) ay 75.71 gCO2e/MJ well-to-wake (WTW). We calculate the maximum share from LNG could be 18.8% from a fleet turn-over model.
2. LNG and biofuel from Climate Disaster Scenario. See Figure 2 for LNG technology mix, resulting in 83.62 gCO2e/MJ WTW.
### T&E FuelEU Maritime recommendations

<table>
<thead>
<tr>
<th>Min. share 50% e-fuels to achieve target and/or multiplier of 5 to boost e-fuels’ cost-effectiveness</th>
<th>Credit exchange mechanism with <em>excess credit sales</em> (pooling) to ships with e-fuels only to incentivise their uptake;</th>
<th>Exclude fossil LNG and first gen. biofuels from the scope; apply RED II sustainability criteria to all advanced fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulation with <em>dissuasive fines</em> (cfr car CO2, DE REDII) - NO “pay-to-comply”</td>
<td>Beyond intra EU (ideally full MRV scope)</td>
<td>EU industrial policy (CfDs) to support uptake of zero-emission vessels</td>
</tr>
</tbody>
</table>
Faïg Abbasov  
Shipping Programme Director  
Transport & Environment  

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