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
Decarbonising EU Shipping

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 be revised upward. About 10 Mt CO2 drop in 2020 is attributable to cruise and ferry passenger ships.
Shipping giant climbs to 6th in 2020 EU top 10 polluters

1. **30.1 Mt CO₂**  |  Power Plant Bełchatów (PL)
2. **18.7 Mt CO₂**  |  Power Plant Neurath (DE)
3. **13.6 Mt CO₂**  |  Power Plant Jänschwalde (DE)
4. **11.9 Mt CO₂**  |  Power Plant Niederauβem (DE)
5. **11.5 Mt CO₂**  |  Power Plant Weisweiler (DE)
6. **10.9 Mt CO₂**  |  Mediterranean Shipping Company (IT-CH)
7. **10.5 Mt CO₂**  |  Power Plant Kozience (PL)
8. **10.3 Mt CO₂**  |  Power Plant Schwarze Pumpe (DE)
9. **9.7 Mt CO₂**   |  Power Plant Opole (PL)
10. **8.7 Mt CO₂**  |  Power Plant Boxberg WerkIV (DE)

Source: Estimates by T&E based on the EU shipping MRV (2020 - v5), EU ETS emissions (2020) and Alphaliner containership database (2020).
Majority of emissions fall on extra-EU voyages

- MSC: 34% (66% within Europe)
- Maersk: 21% (79% within Europe)
- CMA CGM: 35% (65% within Europe)
- COSCO Group: 26% (74% within Europe)
- Hapag-Lloyd: 23% (77% within Europe)

Total emissions: 10.9 Mt CO₂
6.5 Mt CO₂
5.0 Mt CO₂
3.8 Mt CO₂
3.6 Mt CO₂

CO₂ emissions on voyages within Europe
CO₂ emissions on voyages between European and non-European ports

Source: Transport & Environment (2021)
Decarbonising EU Shipping

T&E Roadmap for decarbonising European shipping
"Fair share" decarbonisation of EU shipping

EU shipping would need to slash $90\text{Mt CO}_2$ 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.
Decarbonising EU Shipping

**Scenarios and input main assumptions**

**SCENARIO 1**  
No energy efficiency/High e-fuel penetration

- 2025+ | All new vessels co-combust 70:30 ratio of Nh3-diesel
- 2030-2040 | Old vessels progressively retrofitted for 50:50 Nh3-diesel co-combustion
- 2040-2050 | Remaining fossil diesel eliminated from the fleet via mono-fuel technologies or Nh3 co-combustion with e-diesel/biofuel/hydrogen
- New vessels improve their energy efficiency as larger new vessel with better EEDI enter the fleet
- ZE berth standard | Cruise, Ro-Ro, Ro-pax (2025+), container, oil tanker, ref-bulk (2030+), others (2035+)

**SCENARIO 2**  
High energy efficiency/High e-fuel penetration

- 2025+ | All new vessels co-combust 70:30 ratio of Nh3-diesel
- 2030-2040 | Old vessels progressively retrofitted for 50:50 Nh3-diesel co-combustion
- 2040-2050 | Remaining fossil diesel eliminated from the fleet via mono-fuel technologies or Nh3 co-combustion with e-diesel/biofuel/hydrogen
- All vessels improve their technical (wind-assist, hull-lubrication, etc.) and operational (slow steaming) efficiency and carry out regular vessel maintenance.

**SCENARIO 3**  
Low energy efficiency/Low e-fuel penetration

- Half the fuel penetration of Scenario 1
- Half the energy efficiency penetration of Scenario 2 (but includes ZE berth from 2025+ & 2030+)
Up to a 1/3 of EU ship CO2 can be cut with energy efficiency
Decarbonising EU Shipping

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.

**Note:** The analysis is 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)

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.

e-Ammonia & e-Hydrogen cheapest e-fuels to decarbonise maritime transport
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

€799 billion

1.9 million jobs (2030-2050)

H2 production
Ammonia synthesis from H2

Analysis includes only CAPEX needs for H2 production and excludes electricity generation & ammonia synthesis.
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?
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.
Well-to-Wake carbon intensity of marine fuels

Fossil LNG compliant until 2039

Advanced (UCO) biodiesel until 2044

2020 baseline: 90.3

2030-2034 threshold: 84.9

2035-2039 threshold: 78.6

2040-2044 threshold: 66.8

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.

<table>
<thead>
<tr>
<th>Year</th>
<th>LNG (Mt)</th>
<th>Advanced biodiesel (Mt)</th>
<th>Total (Mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>2.2</td>
<td>2.4</td>
<td>4.6</td>
</tr>
<tr>
<td>2025</td>
<td>2.2</td>
<td>2.4</td>
<td>4.6</td>
</tr>
<tr>
<td>2030</td>
<td>2.2</td>
<td>2.4</td>
<td>4.6</td>
</tr>
</tbody>
</table>

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

- 5.1 Mt Shipping demand
- 8.2 Mt Missing supply
- 6.3 Mt Surface transport demand
- 1.5 Mt Max Imports
- 1.7 Mt Max Domestic supply

EU projected demand: Supply driven by EU demand

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

<table>
<thead>
<tr>
<th>Table 5 Biomass feedstock consumption by type (in Mtonnes)</th>
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<tbody>
<tr>
<td>Feedstock consumption</td>
</tr>
<tr>
<td>Mtonnes</td>
</tr>
<tr>
<td>Part A</td>
</tr>
<tr>
<td>Perennial crops</td>
</tr>
<tr>
<td>Annual crops</td>
</tr>
<tr>
<td>Forestry products</td>
</tr>
<tr>
<td>Forestry residues</td>
</tr>
<tr>
<td>Wood waste</td>
</tr>
<tr>
<td>Agricultural residues</td>
</tr>
<tr>
<td>Manure</td>
</tr>
<tr>
<td>Part B</td>
</tr>
<tr>
<td>Non-agricultural oils</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

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

<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>HFO</td>
<td>Non-compliant</td>
</tr>
<tr>
<td>LNG (1)</td>
<td>Not feasible with fleet renewal alone</td>
</tr>
<tr>
<td>bio-diesel</td>
<td>Compliance with one alternative fuel blend or co-combustion</td>
</tr>
<tr>
<td>bio-LNG</td>
<td></td>
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<tr>
<td>e-ammonia</td>
<td></td>
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<tr>
<td>e-ammonia MULTII = 2</td>
<td></td>
</tr>
<tr>
<td>e-ammonia MULTII = 4</td>
<td></td>
</tr>
<tr>
<td>technology mix (2)</td>
<td></td>
</tr>
</tbody>
</table>

Share of energy required to comply

Remaining share of fuel oil

2030 target: 84.9 CO2eq/MJ WtW

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

**T&E FuelEU Maritime recommendations**

Decarbonising EU Shipping
Faïg Abbasov

Shipping Programme Director

Transport & Environment
HOW HYDROGEN CAN HELP DECARBONISE THE MARITIME SECTOR

Jorgo Chatzimarkakakis, Secretary General
**OUR VISION**

**Where we stand**

Around half of all operating ships are more than 15 years old.

For smaller cargo ships, the average is 40 years, and it's even higher for inland ships.

*Need to act now!*

**Before 2030**

All European new-build short sea ships and inland vessels can be built to have zero emissions.

The greatest potential in the very short term lies in inland vessels and vessels active in ports.

**By 2030**

Many small ships will be running on hydrogen or e-fuels. Hydrogen and hydrogen-based fuels can already provide auxiliary power to larger ships.

**By 2050**

The majority of ships with many of them fully autonomous will run on alternative fuels such as hydrogen and hydrogen-based fuels.
The Role of Hydrogen

- Hydrogen can be used in multiple ways: fuel cells or via combustion in ICEs.
- Pure H2 is the cheapest fuel. However, other fuels that are made from H2 have a better volumetric energy density.
- For short distance ships and inland vessels, pure hydrogen is a convenient option and the cheapest one.
- For large ships, ammonia is the cheapest synthetic fuel.

Fuel trade-off dilemma: the higher the energy density of a fuel, the higher its cost!
THE ROLE OF HYDROGEN

• Alternative fuels (except biofuels) are based on hydrogen.
• Each type of vessel has its own most convenient option (Up to the shipowners to choose)
Techno-economic assessment of low-carbon hydrogen technologies for the decarbonization of shipping
The pace to decarbonize very much depends on how fast ports will be able to store sufficient amounts of green hydrogen.

Ports will become H2 hubs or “H2 Valleys” where hydrogen can be produced or imported, stored and distributed for use in different applications such as:

- H2 for trucks and rail
- H2 for inland waterways (for inland ports)
- H2 for onshore power
- H2 for the decarbonisation of terminal and cargo handling
- H2 for the industrial hinterland (refineries, chemicals...)

The revision of the directive on alternative fuels infrastructure will play a crucial role in this regard.
The role of ports
ReFuel EU Maritime

Aim is to trigger the uptake of low carbon fuels in the maritime sector.

It will have direct implications for alternative fuel infrastructure and must therefore be well-aligned with existing legislation also under review.

Through the FuelEU Maritime initiative specific targets regarding the share of hydrogen and hydrogen-based-fuels by 2030 in the total fuel demand for maritime sector will need to be set.

A recent T&E study shows that 7% of e-fuels by 2030 would kickstart the decarbonization of EU shipping.

The policy initiatives are all connected one way or another. Although there is no silver bullet to decarbonise the maritime sector, we cannot afford to have a patchwork of legislations and regulations. We need a European regulatory framework with clear and ambitious obligations for the use of hydrogen and hydrogen-based fuels by 2025 and 2030 in the maritime sector.
KEY POLICY RECOMMENDATIONS

Putting a price on carbon emissions of shipping through the EU ETS would be a welcome step in establishing a regulatory framework for the decarbonization of this sector, provided that the auctioning revenues flow back to the maritime sector through the Ocean Fund which can act as an important driver for necessary investments in sustainable fuels, innovation and retrofitting.
other POLICY RECOMMENDATIONS

**Future-proof fuels**
Solutions, (...) need to be sought among technologies that can be both sustainable and scalable.

**AFID**
(...) rapid expansion of hydrogen refueling stations. The deployment of infrastructure must occur alongside the deployment of ships.

**RED II**
(...) the Commission should provide certainty for ports on how to deal with green hydrogen imports.

**TEN-T / TEN-E**
Synergies between TEN-T and TEN-E should be further explored. When their corridors are aligned geographically, the HRS network should be strengthened.
THANK YOU FOR YOUR ATTENTION!
How to kick-start the deployment of zero-emission vessels

Online presentation at “How to decarbonise shipping by 2050?”
EU Parliament, Brussel
July 2021, Roy Campe, CTO CMB.TECH
Presentation Topics

1. Introduction CMB Group & CMB.TECH
2. Zero carbon pathway from CMB
3. Why ports can play a crucial role
4. Dual fuel combustion technology
5. Key takeaways
6. Q&A
CMB.TECH, the cleantech division of CMB

- The division’s activities can be summarized in 4 focus areas:

  **ENGINEERING**
  A fast growing highly skilled engineering team with >15y of experience with hydrogen systems

  **INDUSTRY**
  Design and retrofit of industrial applications to run on the clean fuel of hydrogen

  **MARINE**
  Design, building and operation of a future proof fleet powered by hydrogen and ammonia

  **H2 INFRA**
  Technology and infrastructure to produce and distribute the clean fuels of the future
CMB has paved the pathway towards zero emission shipping with concrete and tangible projects

- **In operation**
  - Hydroville (16pax ferry)
  - Hydrocat (CTV)
  - Hydrobingo (80pax ferry)

- **Construction phase**
  - HydroPhoenix (50TBP)
  - Coaster (3800dwt)

- **Design phase**
  - Maritime Hydrogen Refuelling Station

**H₂ Powered** (short distance)

- Hydroville
- Hydrocat
- Hydrobingo

**NH₃ Powered** (long distance)

- HydroPhoenix
- Coaster
- Maritime Hydrogen Refuelling Station

CMB.TECH is also working on large scale production of green H₂ and NH₃ in Namibia
Ports will play a key role in kickstarting zero emission ships

• Shipping is standardized, meaning what works for Antwerp will work in Rotterdam, Hamburg, Marseille, etc.

• By equipping 200 ports worldwide with H₂ technology, an unparalleled emission’s saving can be established

• Europe can be key player developing the H₂ technology:
  ➢ **Port equipment**: difficult to electrify (when vessel is in port, cargo operations do not allow long battery recharging)
  ➢ **Shore power solutions**: CMB.TECH developed in the JV BeHydro hydrogen powered cold ironing genets and the concept of a power barge, to provide clean power to ships.
  ➢ **Power barge**: can also be used to refuel barges or other ships: “The station comes to the vessel, instead of the vessel sails towards the refuelling station.”
  ➢ **Port vessels**: most port vessels can operate on compressed H₂ without the need for disruptive technology
Combustion engines will have a major role for heavy industries such as shipping

• There is no golden bullet that can replace diesel, but batteries, hydrogen and ammonia will have a major role as future fuels:
  ➢ Batteries for low power and short-range applications with high idling times
  ➢ H₂ for local heavy-duty equipment where quick refuelling is required
  ➢ NH₃, where H₂ storage does not offer a viable solution
• Fuel Cells (H₂ & NH₃)
  ➢ Not proven in harsh conditions
  ➢ Expensive & limited lifetime (degradation)
• Combustion engine (H₂ & NH₃)
  ➢ Reliable
  ➢ Affordable
  ➢ Known technology
  ➢ Dual fuel capability
Ships do not have that many choices to offer zero emission transport

- **Batteries**: ships require a large energy buffer, resulting in a battery size which is too large, too heavy and too expensive. There are no means to charge this battery during port call;

- **Photo-Voltaic panels**: the ship’s surface is not big enough to even provide 10% of the required power;

- **Wind energy**: more interesting for slow sailing vessels. Deck space is challenging, but with a projected saving of 10-30% the IMO limit of 50% GHG reduction can not be reached;

- **LNG**: due to methane slip during production, storage & combustion, net GHG effect saving is far from any IMO target. The high investments required are not justified in this respect;

- **Bio-fuel**: not enough biomass available and the supply is very seasonable. Should only be used locally.

- **Methanol**: DAC technology will remain a costly and an energy consuming technology;

- **E-fuels**: H₂ and NH₃ are carbonless fuels, each with its own challenges but offer the best perspective.

- The wide variety of technologies is withholding many ship owners, shipyards, OEMs and technology providers to invest massively into H₂ and NH₃ technology which could create the boost required to achieve the emission targets.

- Investments should accelerate and focus mainly on Hydrogen and Ammonia:
  - H₂ for port/local vessels (tug, pilot vessel, patrol vessel, etc), inland water vessels (barge, ferry, etc) and short sea vessels (coaster, CTV, CSOV, feeder, etc)
  - NH₃ for deep sea going ships.
Key takeaways from a ship owner’s perspective

- Hydrogen technology will be used by the early movers which will kickstart zero emission technology for local and short sea shipping.
- Dual fuel technology is key to allow the infrastructure to grow and mature.
- Combustion engines will play a key role in supplying an affordable and reliable platform for zero emission technology.
- Ammonia is regarded as the main clean fuel for deep sea shipping.
- Clean ammonia production is to be accelerated to allow the maritime sector to make the shift.
- Fossil fuel will remain cheaper, so regulatory incentives (reduced port fees, support for infrastructure) or a global carbon tax should provide an economic justification.
- Public tenders should enhance the selection of clean propulsion designs. Low emission cars/busses/ferries/ships should be ordered/chartered, despite the higher costs and unknowns.
- CMB.TECH believes that net-zero shipping is possible and necessary.
Q&A

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Decade of Wind Propulsion 2021-2030

Delivery | Optimisation | Facilitation

www.decadeofwindpropulsion.org

International Windship Association
Gavin Allwright, Secretary General
secretary@wind-ship.org
www.wind-ship.org
PARIS AGREEMENT

“All ships designed and built today must operate in a net zero emissions world at the end of their service life”
Direct Application of Wind Power

**Direct Application of Wind Power**

<table>
<thead>
<tr>
<th>Power 2 fuel concept: the long way from wind energy to driving force...</th>
</tr>
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<tbody>
<tr>
<td><strong>Wind energy</strong></td>
</tr>
<tr>
<td>$\frac{1}{2} \cdot m \cdot v^2$</td>
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<table>
<thead>
<tr>
<th>sailing ship: the short way from wind energy to driving force</th>
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<tbody>
<tr>
<td><strong>Wind energy</strong></td>
</tr>
<tr>
<td>$\frac{1}{2} \cdot m \cdot v^2$</td>
</tr>
</tbody>
</table>

```plaintext
- Pure **Zero-Emissions** Energy Source
- Abundant & Available Worldwide **Today**
- **Free** & Delivered to the Point of Use
- No New **Infrastructure** or Onboard **Storage**
- Harvesting Technology **Available** Now
- **Compatible** with All Fuels
- **Facilitates** Secondary Renewable Fuels
- **Uniquely** Available to Shipping
- Shift from CAPEX to **OPEX** possible
```

### RETROFIT

5-20% propulsive energy & optimised up to 30%

### OPTIMISED NEWBUILD

50-80%+ possible with operational changes

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![Diagram showing wind propulsion technologies](https://example.com/diagram)

**Wind Propulsion, Key Driver for Shipping Decarbonisation**

Decarbonise Shipping by 2050 - 06 Jul 2021
# Hybrid W.A.V.E.

<table>
<thead>
<tr>
<th><strong>Wind</strong></th>
<th>+</th>
<th><strong>Activity</strong></th>
<th>+</th>
<th><strong>Vessel</strong></th>
<th>+</th>
<th><strong>Eco-fuels</strong></th>
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<tbody>
<tr>
<td>Wind – assist or Primary wind power (Primary Renewable)</td>
<td></td>
<td>Operational optimisation</td>
<td></td>
<td>Vessel optimisation</td>
<td></td>
<td>Renewable energy or waste-derived fuels (Secondary Renewables)</td>
</tr>
<tr>
<td>-retrofit wind-assist (5-20% savings – possible up to 30%)</td>
<td>-newbuild primary wind 50%++</td>
<td>-today’s tech + optimise &amp; cheaper</td>
<td>-lease/OPEX approach</td>
<td>-voyage &amp; fleet management</td>
<td>-weather routing</td>
<td>-speed reduction</td>
</tr>
<tr>
<td>20-30%</td>
<td>+</td>
<td>20%</td>
<td>+</td>
<td>20-30%</td>
<td>+</td>
<td>20-40%</td>
</tr>
</tbody>
</table>

*Note: All figures are estimates. Any one measure in each category could provide a significant % of the proposed total.*
The Shipping Decarbonisation Challenge....

Could Wind Propulsion Fund the Decarbonisation Transition of the Fleet?

- **Static fleet size**: 60,000
- **Fuel**: 300mill tn/yr
- **CO2**: 1bill tn/yr
- **Price**: $500/tn (VLSFO/04 May 21)
- **Increase**: 35%/decade from 2030s
- **Wind**: 20% (inc. operation change)

**NOTE**: No IRR/Currency rates etc included

**UMAS/ETC Report**

IMO2050 (50%) = $1trill

100% Decarbonisation = $1.4-$1.9 trill

[$1.4 trill = 23 mill per ship]

**WPT cost** = $5 mill/ship = **$300bil**

+ Reduce total cost by 10-20%

**$300 bill** invested (2020s+) = **$1trillion**+ savings by 2050 + lowers total cost to $1.1-1.7 trillion

Wind Propulsion, Key Driver for Shipping Decarbonisation

Decarbonise Shipping by 2050 - 06 Jul 2021
Large Vessel Installations

2021: 20 Ocean Going Vessels with Wind Propulsion Technology (WPT) installed & 1 Wind-ready + more than 20 small sail cargo, fisheries & cruise vessels in operation

2022/3: 40-50 Ocean Going Vessels with WPT installed + Robust R&D pipeline

2030: Up to 10,700 WPT installations (10-15% of global fleet) EU commissioned report 2016/17

2050: 37,000 – 40,000 vessels with WPT (40-45% of global fleet) UK Clean Maritime Plan Research 2019

Current Installations

- **Tankers x 2**
  - (1 x pending new build)
  - 1 x VLCC, 1 x LR2 Tanker

- **Bulkers x 2 (+1)**
  - (2 x pending)
  - 1 x VLOC, 1 x Ultramax
  - 1 x Kamsarmax (wind ready)

- **RoRo x 2**
  - (1 x pending new build)

- **Ferry/Cruise x 3**

- **General Cargo x 5**
  - (2 x pending)
  - Various sizes: 2–12,000dwt

- **Fishing Vessels x 1**

**NOTE:** More large WPT vessels currently in operation than all new alternative fuelled ships combined (excluding tankers & LNG/LPG)

**Wind Propulsion, Key Driver for Shipping Decarbonisation**

Decarbonise Shipping by 2050 - 06 Jul 2021
Win-Win-Wind Propulsion....

www.wind-ship.org

Gavin Allwright
secretary@wind-ship.org
Charting a Course for Decarbonizing Maritime Transport

Edoardo Casarotto, WB Maritime and Shipping Consultant
T&E “How to decarbonize shipping by 2050?”
Tuesday, 6 July 2021
Key findings

1 Development opportunities – Major opportunities for countries in decarbonizing shipping

2 Ammonia and hydrogen – Most promising zero-carbon bunker fuel options to date

3 Role of LNG – Limited role as a fuel, more important role as a feedstock
Our journey

1. Development context
2. Emissions challenges
3. Alternative fuels
4. Development opportunities
5. Implications
Around the world: shipping as a development issue

Key enabler for developing economies

15 out of the 20 largest ports

1.2 million jobs

9 of the top 10 ship registries

Shipbreaking

Crucial lifeline for SIDS

and more...
Our journey

1. Development context
2. Emissions challenges
3. Alternative fuels
4. Opportunities for client countries
5. Implications
Forward lookout: shipping’s emissions trajectory

Source: Own graph, based on the Fourth IMO GHG Study (2020)

Our journey

1. Development context
2. Emissions challenges
3. Alternative fuels
4. Opportunities for client countries
5. Implications
On the horizon: zero-carbon bunker fuels
Navigating the shallows: the role of liquefied natural gas
Development context
Emissions challenges
Alternative fuels
Opportunities for client countries
Implications
Country with no or insignificant oil reserves, but large renewable energy resources
Setting sail: the potential for blue ammonia/hydrogen for ships
Setting sail: the potential for first blue, then green ammonia/hydrogen for ships
Setting sail: the potential for green ammonia/hydrogen for ships
“Treasure Island”: wider development benefits
Charting a course: key implications for policymakers and industry

Main findings: (1) Development opportunities - (2) Ammonia and hydrogen - (3) Role of LNG

Public policies

Full lifecycle GHG perspective

“No-regret” options

Constructive collaboration

Policymakers

Industry
Charting a course: the catalytical role of governments

Internationally

- Create a level playing field and raise revenues
  - Meaningful carbon price on bunker fuels, and strategic revenue use

Nationally

- Enhance regulation
  - Energy efficiency standards, port regulation, etc.
- Initiate pilot and demonstrator projects
  - Direct subsidies, concessional loans, guarantees, fiscal incentives, etc.
- Scale up renewable energy production
  - Feed-in tariffs, priority dispatch, etc.
- Leverage public procurement and provide offtake certainty
  - Green public tenders, offtake guarantees, etc.