Possible ways to decarbonize maritime transport: Broad tracks, narrow paths and potential dead ends

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# Possible ways to decarbonize maritime transport

## Presentation outline

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The challenge

The dimensions of the problem


source: DNV GL: Energy Transition Outlook 2018
The challenge
The dimensions of the problem, cont.

Paris agreement scope:
• Nationally determined contributions to address climate change

Out of scope:
• Contributions from international transport from shipping as well as aviation

source:
IMO: Third IMO Greenhouse Gas Study 2014
The challenge

Initial GHG Emissions Reduction Strategy of the International Maritime Organization (IMO)

Relevant text from IMO Resolution MEPC.304(72): Levels of ambition

1. **carbon intensity** of the ship to decline through implementation of further phases of the energy efficiency design index (EEDI) for new ships to review with the aim to strengthen the energy efficiency design requirements for ships with the percentage improvement for each phase to be determined for each ship type, as appropriate;

2. **carbon intensity of international shipping** to decline to reduce CO$_2$ emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008; and

3. **GHG emissions from international shipping** to peak and decline to peak GHG emissions from international shipping as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008 whilst pursuing efforts towards phasing them out as called for in the Vision as a point on a pathway of CO$_2$ emissions reduction consistent with the Paris Agreement temperature goals.
The challenge

Global shipping traffic density

Data for the full year 2017,
- All marine traffic
- Tracking of vessel positions by satellite based on automatic identification system (AIS) signals

source: [https://www.marinetraffic.com/](https://www.marinetraffic.com/)
The challenge

Vessel types and their contributions

Passenger and recreational vessels
- Cruise vessels
- Car ferries
- Pass. ferries
- Superyachts

Fishing vessels
- Large
- Medium-size
- Small

Cargo vessels and their contribution along the value chain
- raw materials, energy carriers
- finished, consumer goods

- Oil tankers
- LNG carriers
- Bulk carriers
- General cargo vessels
- Chemical / product tankers
- Container vessels
- Reefers
- Car carriers
- Pass. ferries
- Superyachts
The challenge

Vessel types and their contributions – cont.

source: IMO: Third IMO Greenhouse Gas Study 2014
The challenge
Vessel types and their contributions – cont. 2

source: Johansson et al., Atmospheric Environment 167 (2017)

Global assessment of shipping emissions 2015,
• Tracking of vessel positions by satellite based on automatic identification system (AIS) signals
• Route reconstruction modelling approach
• Evaluation based on Ship Traffic Emission Assessment Model (STEAM3)
The challenge

Requirements towards fleet development and possible steps

Projections of CO2 emissions from shipping:

Potential contributions:

source: ICCT: Policy Update – The International Maritime Organizations Initial Greenhouse Gas Strategy, 2018

source: DNV GL: Energy Transition Outlook 2019, Maritime – Forecast to 2050
History of fuels used in maritime transport

The long-term perspective

Source: https://www.marineinsight.com/tech/
History of fuels used in maritime transport
The mid- to short-term perspective

Bunker demand evolution, in million tons


source: Meech et al., IBIA, 2014
History of fuels used in maritime transport

The history of the LNG business

source: Poten & partners
History of fuels used in maritime transport

The history of the LNG business – impact on LNG-fuelled fleet

**LNG carriers**

![Graph showing the development of LNG-fuelled fleet](source: IGU: World LNG Report, 2017)

**Other LNG-fuelled vessels**

![Graph showing development of LNG-fuelled fleet](source: Tellkamp, DNV GL, 2015)

Possible ways to decarbonize maritime transport
History of fuels used in maritime transport

LNG bunkering infrastructure – 2017 status

source: https://www.dnvgl.com/lnqi
Future marine fuel candidates

Aspects related with fuel production

Production from different sources / feedstock:
• From (solid) biomass (right)
• Using excess electrical power (PtX, below)

source: p2x4a.vdma.org

source: www.vertoro.com
Future marine fuel candidates

Grouping on basis of production pathway

Biomass-based:
- Residual fuels from refinery of «bio-crude»
- Bio-diesel
- Bio-ethanol
- Biogas

PtX-based:
- Hydrogen
- Synthetic methane
- Ammonia
- Synthetic methanol
- Synthetic higher molecular hydrocarbons
- DME, OME, synthetic diesel, ...
Future marine fuel candidates
The energy density challenge of replacing conventional fuel

Using LNG instead of HFO:
- Tank volume 1.6 times higher
- + insulation on top

From LNG to Hydrogen (cryogenic):
- Tank volume >2 times higher
- + additional insulation on top

Ammonia and Methanol:
- Challenge on tank volume increase
- Challenge in weight increase
- ...and both are toxic!

Batteries compared to HFO:
- Storage volume min 8 times higher
- Weight more than 20 times higher

source: DNV GL: Energy Transition Outlook 2019, Maritime - Forecast to 2050
Key criteria and preliminary assessment

With focus on maritime market specific aspects

Drop-in capability:
- As a surrogate
- For blending into present fuels

Storage and handling on board:
- Cargo capacity impact
- Health and operational safety implications

Business maturity and perspectives:
- Market existing
- Proximity of production capacities and major shipping routes
- International trade existing
- Intersectoral competition
### Key criteria and preliminary assessment

With focus on maritime market specific aspects

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Discussion

Key hypotheses

- Decarbonization of maritime transport will only be possible if low net carbon fuels are either made economically attractive or the phase-out of traditional fuels is enforced.
- Drop-in capable fuels are the fastest way to decarbonize maritime transport.
- New fuels need to be made available worldwide.
  - Production, transport, storage and bunkering infrastructure has to be put in place, in a first stage for serving the main sectors (container vessels, bulk carriers) along their shipping routes.
  - A global market for any candidate fuel is a key enabler for its adoption in the maritime sector.
  - Dedicated vessels for shipping such fuels are a prerequisite for establishing such global market, at the same time, they facilitate the introduction of propulsion / ship energy systems using these fuels.
- The regulatory framework needs to be updated before any new fuels associated with health or operational safety implications can be introduced.
- High-quality, high energy-density fuels will not be a viable solution for marine applications as other sectors will be more prepared to pay the price premium associated.