Pathways to Decarbonisation of Deep-Sea Shipping: Neo-Panamax Containership Case Study

MariNH3 Clean, green ammonia engines for maritime

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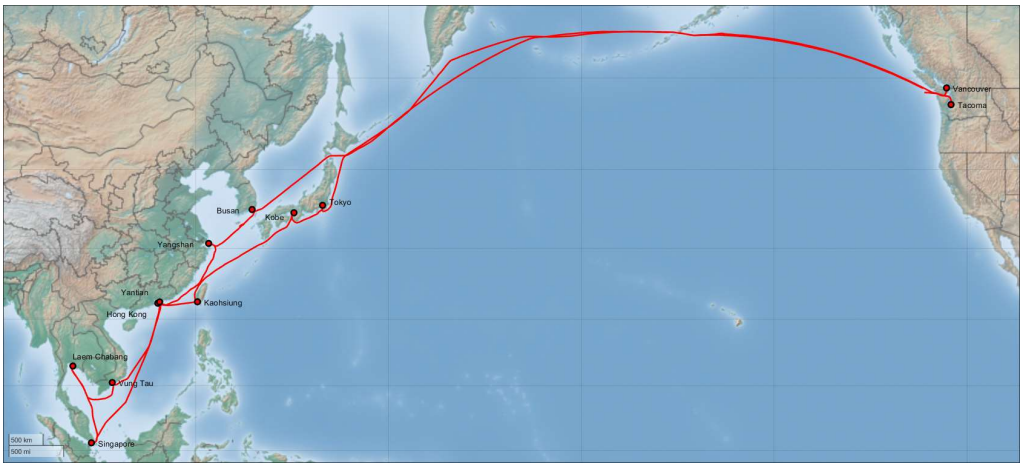

Figure 1: Case study vessel example round trip

Ship Technical Details

Neo-Panamax Containership
12,000 TEU
132,000 DWT

Base Case	NH3-ICE	NH3-FC
2 stroke main engine 42,000 kWh MCR	Matching the base case powertrain	Solid oxide fuel cells 57,000kWh combined generation
4 stroke auxiliary engines 2 x 4,000 kWh 2 x 3,500 kWh		
IFO-380 fuel oil Green e-diesel	Blue ammonia Green ammonia IFO-380 pilot fuel (5% MCR)	Blue ammonia Green ammonia

Background

- Ammonia is presented as a potential low-carbon fuel source in the marine sector, especially when produced with renewable energy sources [1].
- However, with lower volumetric energy density than the incumbent fossil fuels, compromise may be necessary in the integration with the vessel [2]. Beyond the technical feasibility for energy delivery, the mass and volume of the ammonia fuel may compete with cargo capacity.
- This study investigates the application of ammonia as an alternative fuel source for a large ocean-going containership, both in combustion and fuel cell generation, with perspectives on fuel demand and fuel-cycle emissions.

Method

- The case study ship powertrain configurations are summarised above. The *base case* represents the extant vessel. The *ammonia combustion* system is assumed to use a pilot fuel for ignition. The *ammonia fuel cell* system uses solid oxide fuel cells but needs full electrification.
- Fuel oil 3.75 $kgCO_2eq./kg$ well to wake;
  Blue ammonia 0.523 $kgCO_2eq./kg$ WTW;
  Green ammonia 0.141 $kgCO_2eq./kg$ WTW;
  E-diesel 0.25 $kgCO_2eq./kg$ WTW.
- The Trans-Pacific route is modelled from AIS data, characterised by vessel speed and location. The average round-trip voyage is 14,800 nautical miles over 72 days.

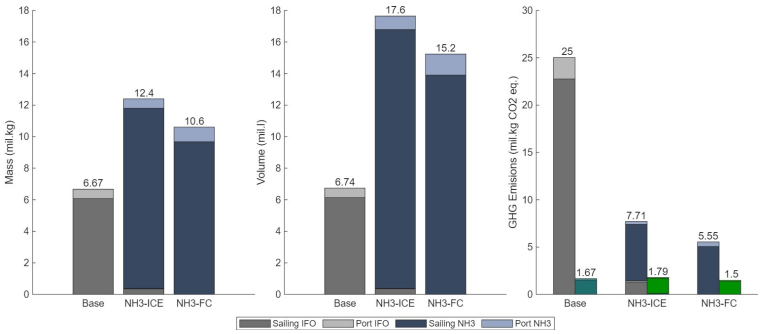

Figure 2: Round trip fuel demand: left, by mass; centre, by volume; right, fuel-cycle GHG emissions

Findings

- Ammonia fuel demand is projected to be almost twice the mass and more than 2.5 the volume of the conventional fossil fuel, for the same round-trip voyage. Fuel cell electrochemical efficiencies offer small improvements.
- This result exceeds the 11 mil litre fuel capacity expected for a ship of this size [3], compromising the cargo capacity and economic viability.
- The projected fuel demand could also need more frequent bunkering, adding hurdles to adoption for alternative fuel.
- Blue ammonia can offer a significant emissions reduction of at least 70% against the incumbent fossil fuel. Green fuels offer the greatest emissions reduction, greater than 90% in all configurations.

[1] Jamrozik et al. (2024), Experimental study on ammonia-diesel co-combustion in a dual-fuel compression ignition engine.
[2] Di Micco et al. (2024), Ammonia-powered ships: Concept design and feasibility assessment of powertrain systems for a sustainable approach in maritime industry.
[3] www.freightwaves.com

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