

Ammonia as a marine fuel

Creating the business case

Ammonia Energy Association Conference

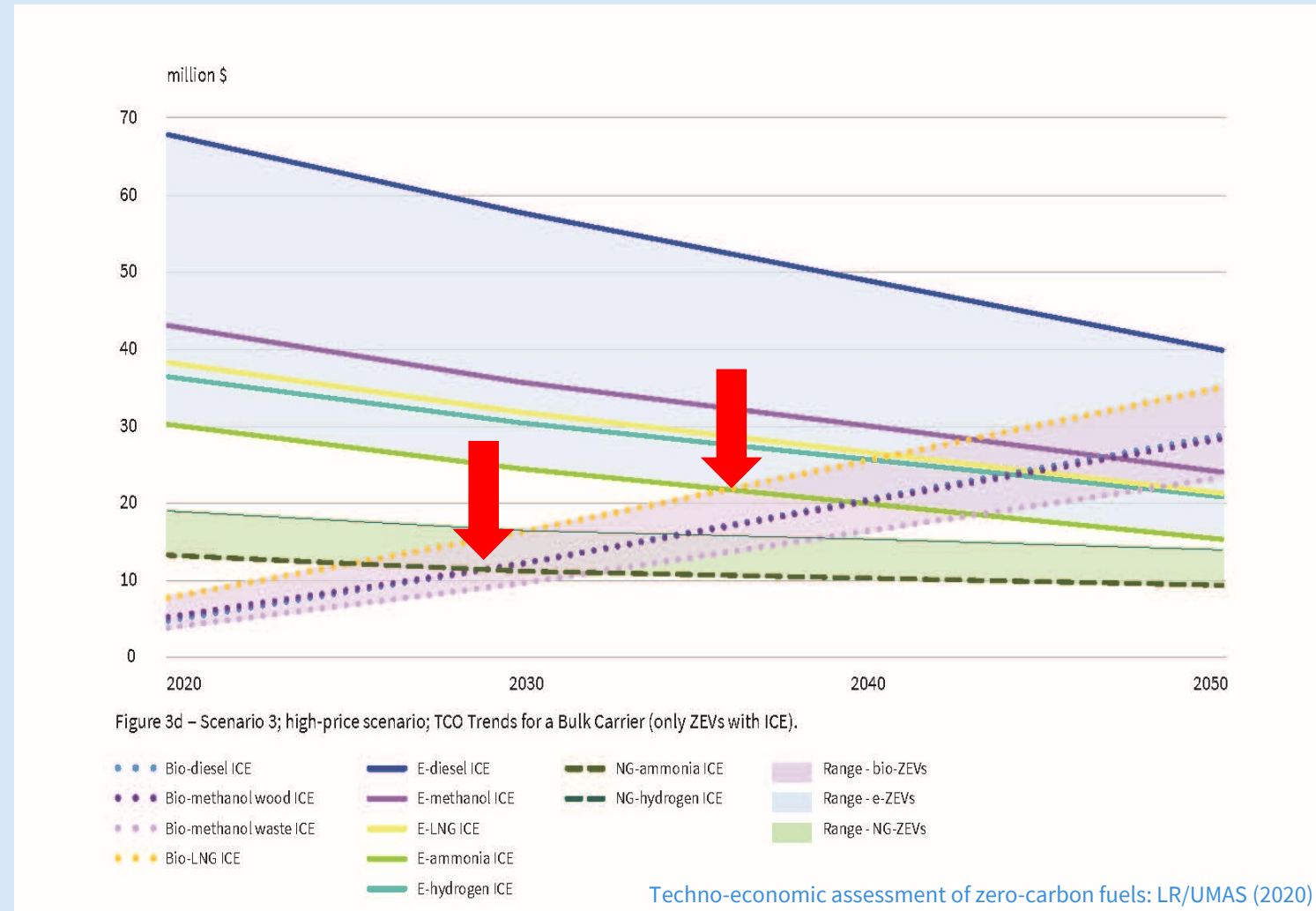
19th November 2020



Total cost of operation

The cost of e-ZEVs have a decreasing trend over time.

- Biofuels maybe more competitive in the short-term
- But lose this advantage as prices are expected to increase
- NG-ammonia is as competitive today as the most expensive biofuel
- Overall e-fuels become more competitive in the 2040s



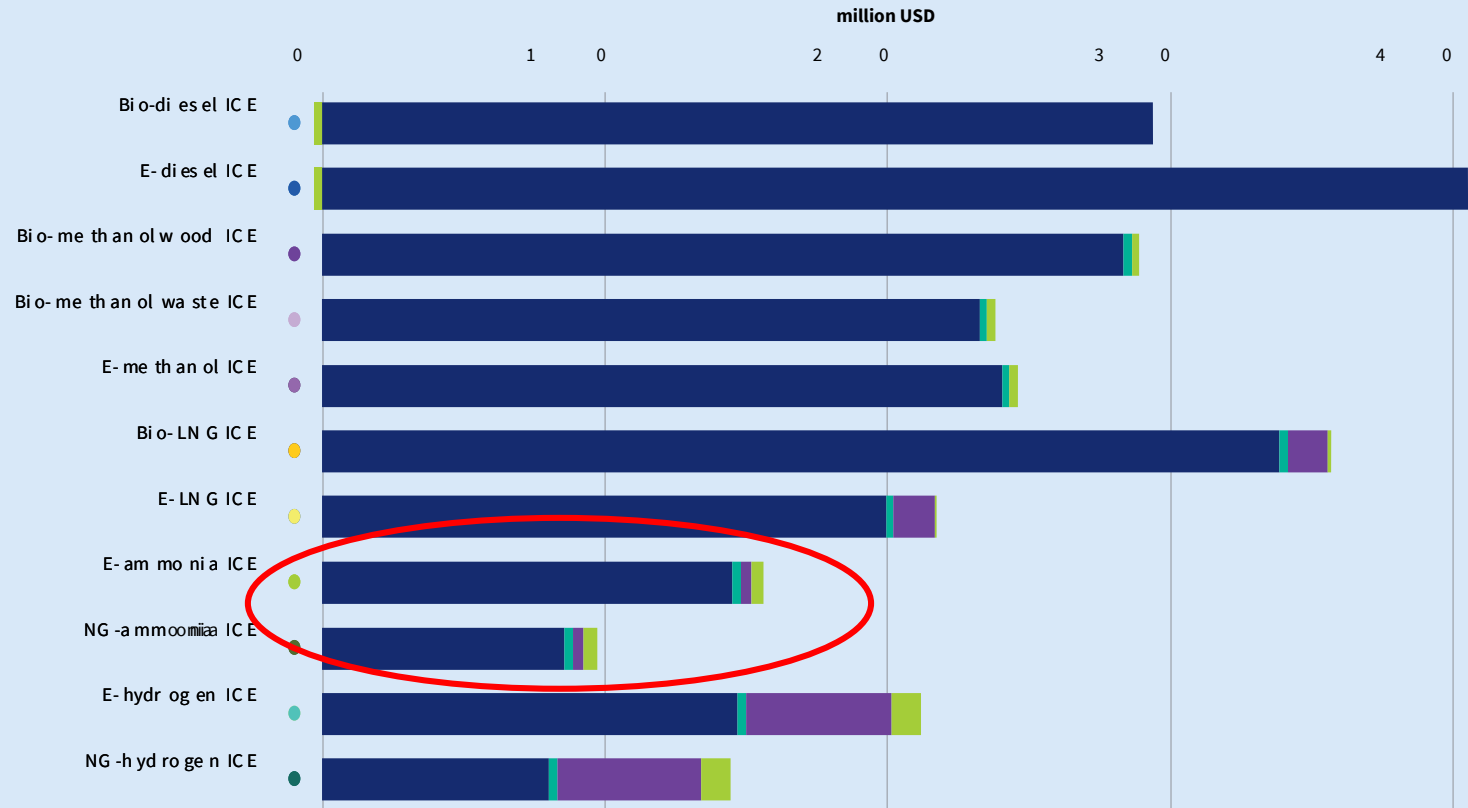
Techno-economic assessment of zero-carbon fuels: LR/UMAS (2020)

Voyage-related costs

Fuel cost is a significant proportion of the overall TCO.

- The main cost driver is fuel price
- Hydrogen has a high capital cost of storage and a loss of cargo-carrying capacity which impacts revenue
- E-ammonia is lower than e-hydrocarbons because the production processes are still under development and energy intensive
- A carbon price is essential to close the gap with fossil-based fuels

2050 (high price scenario)



Figures 4b – Relative cost implications of ZEV technologies for bulk carrier under high-price scenario and no carbon price.

■ Voyage ■ Engine ■ Storage ■ Storage impact

Techno-economic assessment of zero-carbon fuels: LR/UMAS (2020)

Technology Readiness of Ammonia as a marine fuel

	Bunkering	Containment	LFSS & FGSS	Consumers	Safety
Current Status	<ul style="list-style-type: none"> loading and unloading in terminals as a cargo procedures for loading as a fuel do not exist 	apply same as LNG as a fuel	apply same as LPG and or LNG as a fuel	none proven at marine full scale	<ul style="list-style-type: none"> Toxicity Corrosivity Precluded as a fuel by IGC code
Technology readiness challenge	<ul style="list-style-type: none"> vapour handling handling of leaked ammonia structure protection (Low temperature) 	environment control (e.g. inerting, dry air) of hold spaces	supply system to be developed for liquid and gas	ICE and Fuel cell under development	<ul style="list-style-type: none"> venting and ventilation system toxic safety level (gas detection) engine safety concept (probability of leakage, purging) prevent gas release into atmosphere

38 ports export & 88 ports import ammonia globally

Ammonia is currently shipped by 71 LPG tankers.

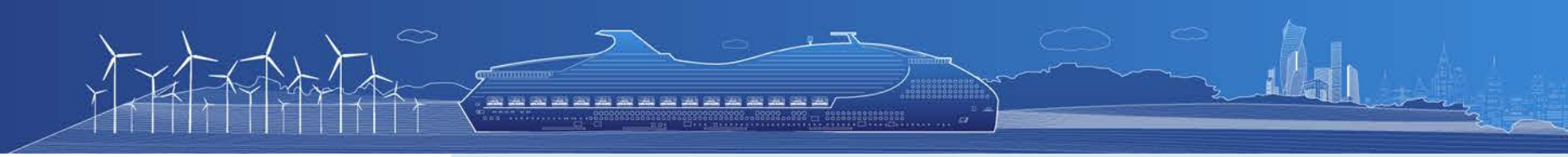


Regulatory readiness of Ammonia as a marine fuel

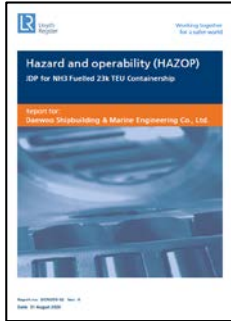
Safety & infrastructure		Tank to Wake Emissions Regulations						Carbon Pricing	Lifecycle GHG emissions		
Safety (SOLAS, IGF, IGC, MARPOL Annex VI)	Infrastructure	EEDI	EEXI	CII	Methane regulation	NOx regulation	SOx & PM	Based on operational carbon factor	Depends on how Ammonia is produced and primary energy source to reduce carbon intensity of the product		
									Gas & Coal for example	Gas with CCS for example	Renewable electricity



Progress



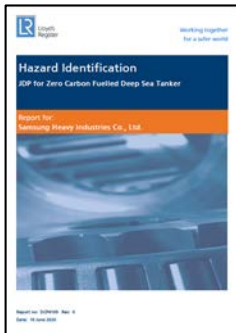
Approvals



HAZID for NH3 fuelled 23k TEU Containership



Approval in Principle NH3 23k TEU Containership



HAZID for NH3 fuelled Aframax tanker



Approval in Principle NH3 fuelled Aframax tanker

Lloyd's Register – Creating sustainable pathways to zero

Collaborations



Partnership

