Ammonia as Marine Fuel

NH3 Fuel Conference – Maritime Panel Discussion

1st Nov 2018

NH3 FUEL ASSOCIATION

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

YARA

MAN

C-JOB DEDICATED NAVAL ARCHITECTS

Panelists

- Emile Herben (Yara): Holding a Master's degree in Chemical Engineering, he has previously worked in various manufacturing positions, mostly at Procter & Gamble. He currently works at Yara in the corporate innovation department where he explores new technologies and new business models that could become important for Yara in the medium to long term. Much of his work has focused on the technical and commercial feasibility of green ammonia and (green) ammonia energy.

- René Sejer Laursen (MAN Diesel & Turbo): Mr. René Sejer Laursen holds an M.Sc. in Mechanical Engineering from the Technical University of Denmark in 1989. He joined MAN B&W Diesel in 1998 after an extensive career working on super critical and incineration technologies, and in early 2004 he started in the ME-GI project group as Product Manager. In 2010 he was promoted to Promotion Manager, looking after the market for gas fueled merchant ships and LNG carriers, including the market for engines using new fuels such as ethane, methanol and LPG.

- Niels de Vries (C-Job Naval): He finished his B.Eng. in Naval Architecture in 2014. He has worked nearly 5 years at C-Job as Naval Architect. Currently, he is doing a MSc. in Marine Technology, which he has nearly completed, on the topic: Safe and effective application of ammonia as a marine fuel, topic that he has promoted over the last couple of years in several international conferences.

- Agustin Valera-Medina (Cardiff University, Moderator): He finished his PhD in 2009 and is Associate Professor at Cardiff University. He has worked on the topic of ammonia over 5 years, leading Cardiff's contributions on the topic with 19 international publications, 5 PhD projects and various industrial/research based projects, amongst which the "Decoupled Green Energy Supply" project with Siemens, Oxford and STFC is the flagship of his program Storage of Ammonia for Energy "SAFE".

Panel Session 4

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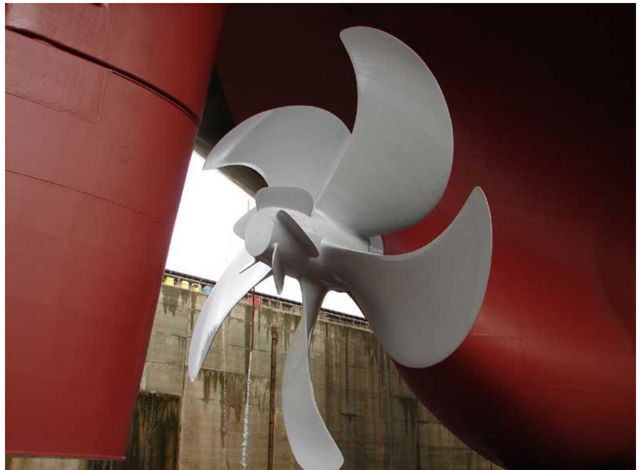
Marine Ammonia Experience

- Bulk Transport
- Cooling systems
- DeNOx (SCR)

Marine Power Generation

- Large scale
- Marine environment
- Dynamic behaviour/Load response
    - Experience natural gas
- Part load conditions
- Fuel direct & Fuel electric configurations
- Size, Mass, Efficiency and Emissions



Ammonia Power Generation

- Ammonia Power Generation
  - Steam Turbine
    - Ammonia
    - Ammonia dual-fuel
  - Gas Turbine
    - Ammonia
    - Ammonia dual-fuel
  - Internal Combustion Engine
    - Compression ignition
      - Ammonia
      - Ammonia dual-fuel
    - Spark ignition
      - Ammonia
      - Ammonia dual-fuel
  - Fuel Cell
    - Proton Exchange Membrane
      - Hydrogen (Cracking & Purification)
    - Alkaline
      - Hydrogen (Cracking)
    - Solid Oxide
      - Ammonia

Q1: Which options of ammonia power generation are most suitable for marine applications?

Safety (Rules and Regulations)

Natural Gas

- Bulk transport
  - IBC Code - International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk, Amended by Resolution MEPC.225(64)
  - 1983/2014 IGC Code - International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
- Fuel
- 2005:
  - IGF Code - International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels First draft initiated
- 2017:
  - IGF Code Adopted

  Fully developed for natural gas only

Ammonia

- Bulk transport
  - IBC Code - International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk, Amended by Resolution MEPC.225(64)
  - 1983/2014 IGC Code - International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
- Fuel
- Future:
  - ?

Safety (Rules and Regulations)

Methanol & Ethanol

- Fuel
- 2013:
  - DNV-GL: Tentaive Rules for Low Flashpoint Liquid Fuelled Ship Installations
- 2016:
  - LR: Provisional Rules for the Classification of Methanol Fuelled Ships
- 2018:
  - IGF Code - International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels Completed draft interim guidelines

Ammonia

- Fuel
- Future:
  - Pilot projects?
  - Marine demonstrators?

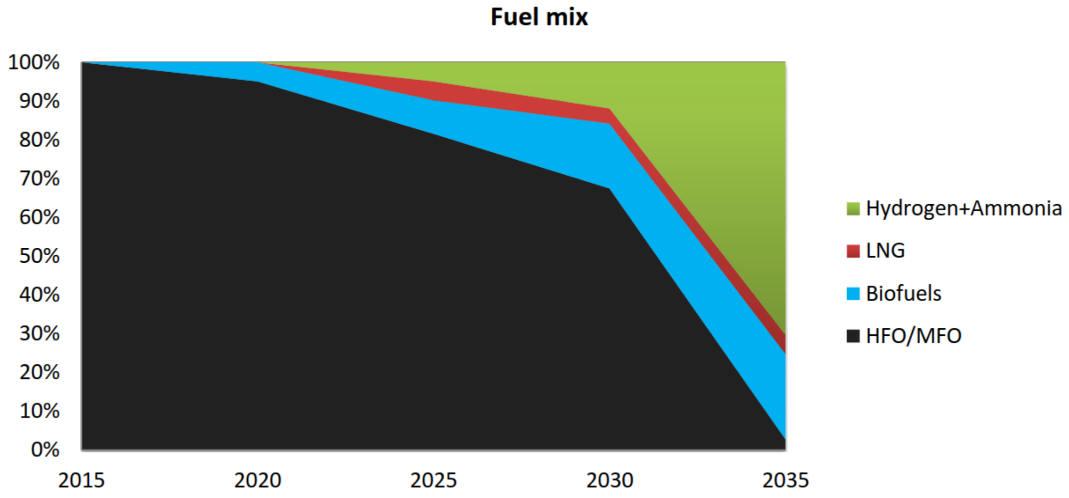
Visibility of Marine NH3

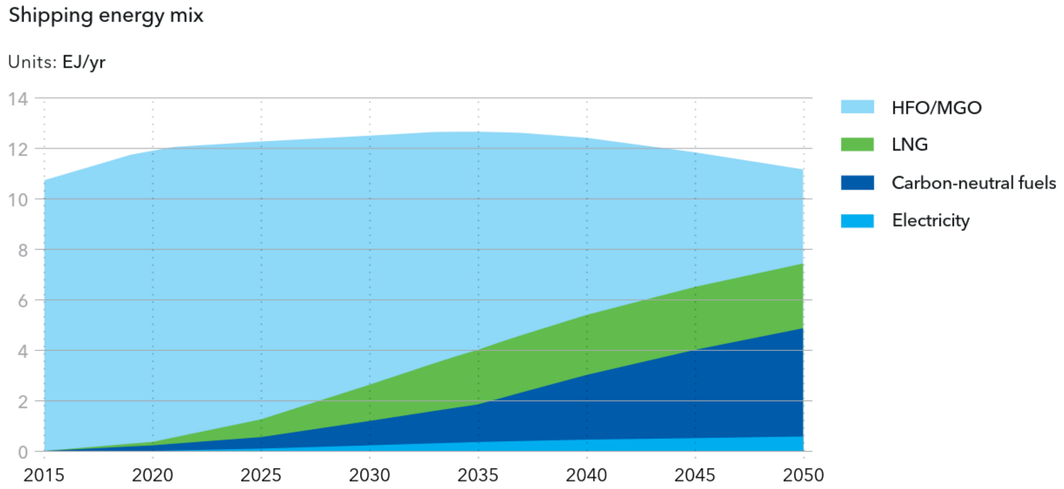
2017: Zero-Emission Vessls 2030. How do we get there?

2018: Pathways to zero-carbon shpping by 2035

2018: Maritime Forecast to 2050

All mention ammonia





Q2: What development is needed in rules and regulations to realise ammonia powered vessels?

In the USA, the NuStar Line (3,070 km long) transports ammonia from Mississippi into the heart of the corn-belt region of the central and northern States of the Union, where it can be distributed still further via the Magellan line (~1,900 km long). Both lines deliver approximately 2.9 million tons of ammonia per year.

In Eastern Europe, a pipeline runs from TogliattiAzot's plant (Tolyatti, Samara) to Odessa in the Black Sea and is one of the largest (~2,400 km long) with a capacity of 3 million tons per year.

In Western Europe, series of small lines (up to 70km long) transport ammonia to various industries.

Q3: How well developed is the current ammonia infrastructure to supply the maritime industry? What more is needed?

Q4: What is the role of the ship and cargo owner for clean transport?

Q5: How is ammonia viewed as marine fuel compared to other renewable fuel options, like hydrogen and methanol?

Fuel type:	Energy density LHV [MJ/kg]	Volumetric energy density LHV [GJ/m3]	Renewable synthetic production cost [MJ/MJ]	Storage pressure [bar]	Storage temperature [°C]
Marine Gas Oil (reference)	42.8	36.6	Not applicable	1	20
Liquid Methane	50.0	23.4	2.3	1	-162
Ethanol	26.7	21.1	3.6	1	20
Methanol	19.9	15.8	2.6	1	20
Liquid Ammonia	18.6	12.7	1.8	1 or 10	-34 or 20
Liquid Hydrogen	120.0	8.5	1.8	1	-253
Compressed Hydrogen	120.0	7.5	1.7	700	20

Q6: What are key technical improvements in order to improve the uptake of ammonia, like NOx emissions, material compatibility and others?

Q7: How does ammonia fuelling compare to current diesel/fossil-based systems in terms of economics at the moment? Have you carried out any preliminary study?

Q8: Is there any need to acknowledge the perception of the general public for the use of ammonia as maritime fuel? Shall we start basing our engagement with people on this basis, or through other technologies as well?