EMSA study
Potential of Ammonia as Fuel in Shipping

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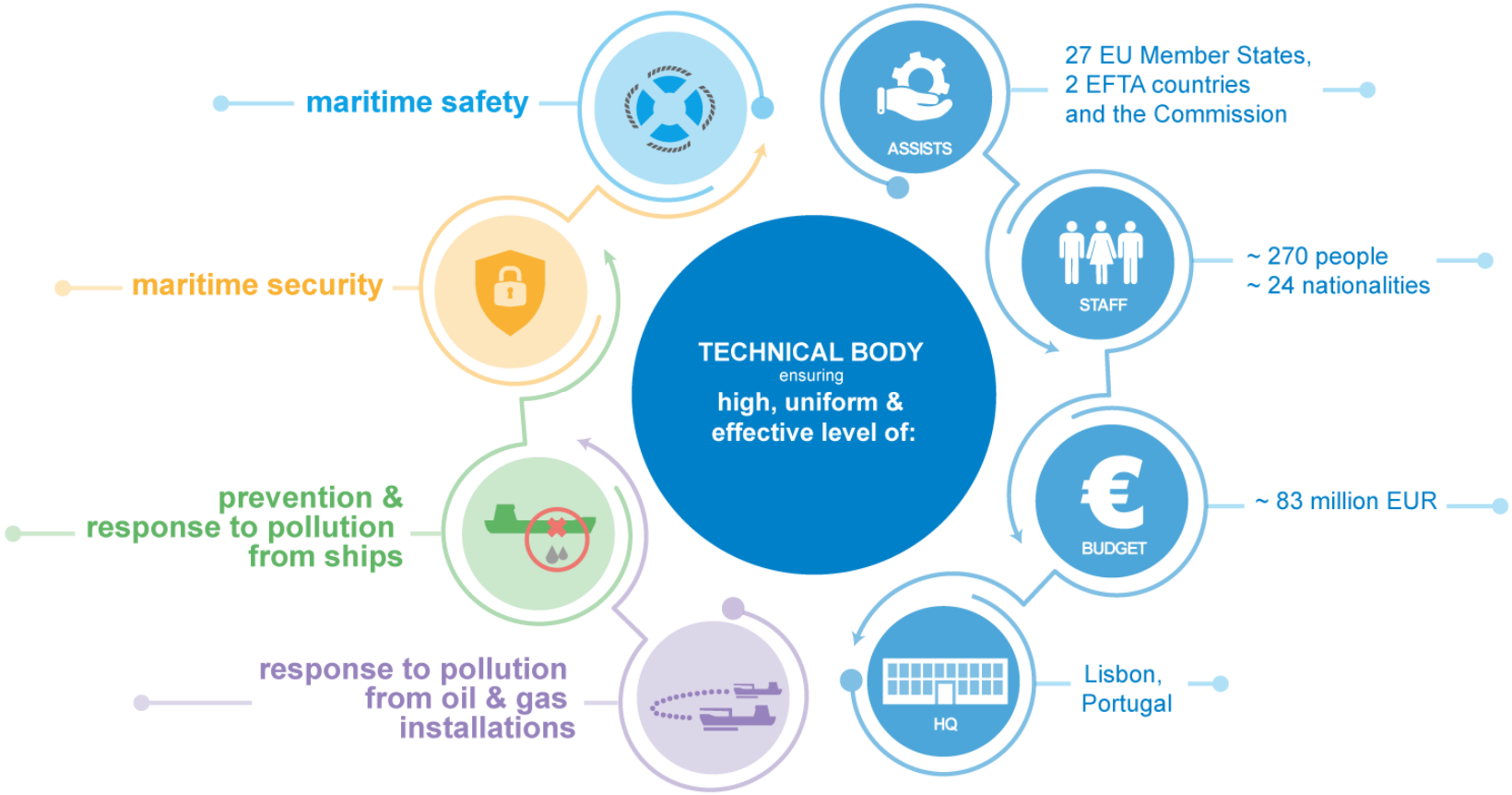
APEC Symposium Pursuing Decarbonization of Fossil Fuels

Kobe, 11 October 2023

EMSA
European Maritime Safety Agency

EMSA in a nutshell



EU ETS extension to maritime

Cap-and-trade' system: puts a price on GHG emissions to harness economic forces

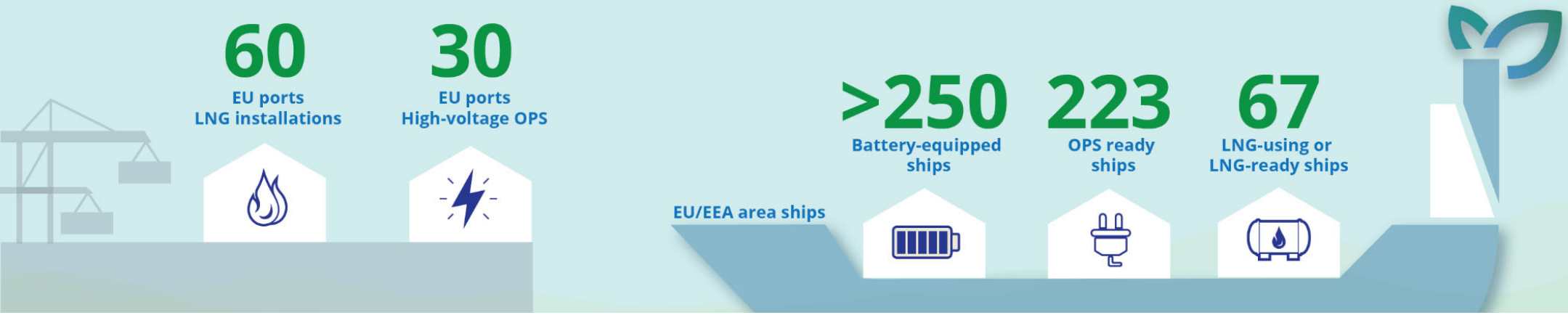
Covering around **2/3 of CO_2** emissions related to EU maritime transport

Applicable **to large ships** (above 5000 gross tonnage) regardless of the flag they fly

ETS-funded Innovation Fund for ships and ports

FuelEU Maritime - overview

- Limits the GHG intensity of the energy used on-board
- Obligation to use OPS or zero-emission technology from 2030
- Targets established in 5-year intervals from 2025 until 2050



EMSA Studies on Alternative Fuels and Power Solutions

- Part of EMSA's work in the area of sustainability and in support of the European Green Deal
- Previous studies conducted on: **Biofuels** (2012), **LNG** (2013), **Methanol/ethanol** (2016), **Fuel Cells** (2017), **Batteries** (2020)
- **Framework contract signed in 2021** and for a period of **4 years** and up to a total of **6 studies**
- Consortium integrated by:

ABS CE Delft ARCSILEA A Specialist Maritime Consultancy

- New studies on **Biofuels** and **Ammonia** released in **October 2022**
- **1st Workshop** on Alternative Fuels (biofuels and ammonia) and Power Solutions for Shipping and Ports held **18-20 October**
- Link to the studies:

  Technical Reports - EMSA - European Maritime Safety Agency (europa.eu)

EMSA Studies Project Organisation

Key Numbers

- **6** Alternative Fuels / Power
- **3** Partners + Industry/Authorities
- **20** Team members
- **6+12** Dedicated HAZID workshops

Tasks

Task 1 – State of Play
Production pathways, scalability, availability, sustainability, suitability, cost analysis

Task 2 – Standards/Regulations/Guidelines
IMO, IGF code, SOLAS, IACS, ISO, ISM, Regional Regs, Guidelines, SIGGTO, SGMF
Regulatory Gap Analysis

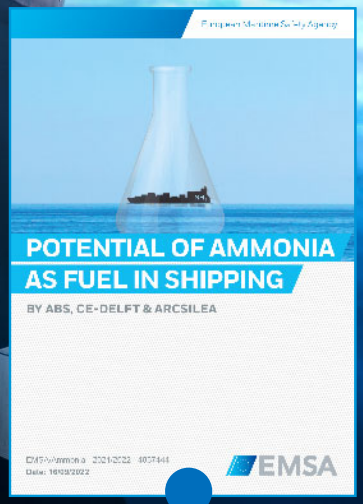
Task 3 – Safety Assessment
Selected 3/4 Designs
HAZID workshops
Suggestions for improvement

Progress

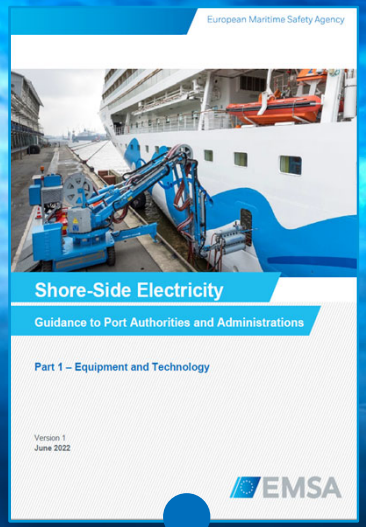
- 2021/2022 – Biofuels Ammonia
- 2022/2023 – Hydrogen
- 2023 – *Wind assisted propulsion*
- 2023/2024 – *Synthetic Fuels*

Studies released

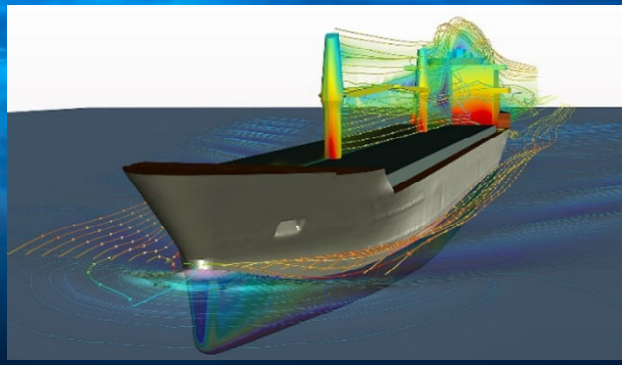
Update on potential of Biofuels in shipping



Potential of Ammonia as fuel in shipping

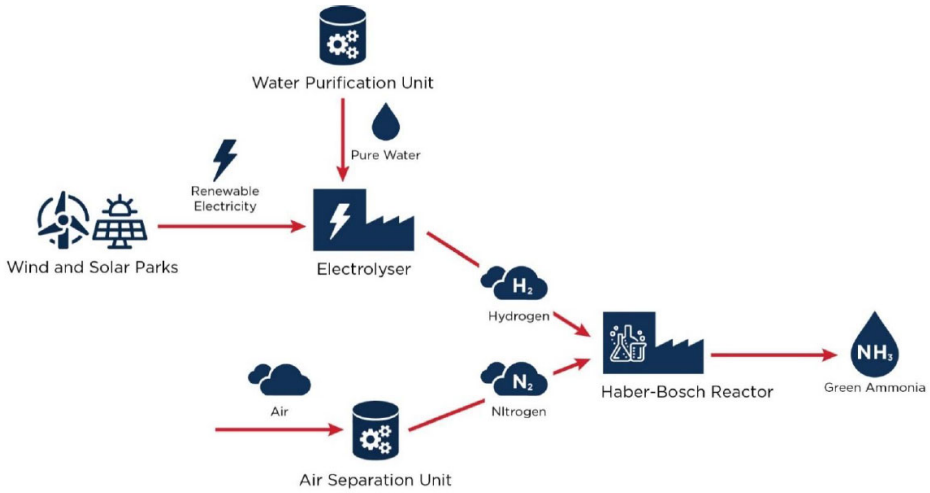


Guidance on Shore-Side Electricity



Availability and Scalability

HB is the most mature process



Process Type	Expected Efficiency [up to]
Pathway 1 Electrolysis and Haber-Bosch synthesis	~72%
Pathway 2 Direct solar hydrogen production	9% [up 70%]
Pathway 3 Biogenic hydrogen production	~57%
Pathway 4 Non-thermal plasma synthesis	12-37% [up to 45%]
Pathway 5 Electrochemical ammonia synthesis	14-62% [up to 90%]

Grey NH3 Production

235

Mtons/year

2019

Green NH3 Announced

>133

Mtons/year

*annouced blue and green ammonia production

What are the challenges?

- Many sectors will have demand for green or blue ammonia.
- Green electricity will also be in high demand
- Demand depends on policy, many of which are not yet confirmed
- Green production needs to be efficient, utlized at maximum capacity and this poses challenges:
  - Location, pipelines, access to ports
  - Connection to grid (sustainable?)
  - Potentially oversized

Sustainability

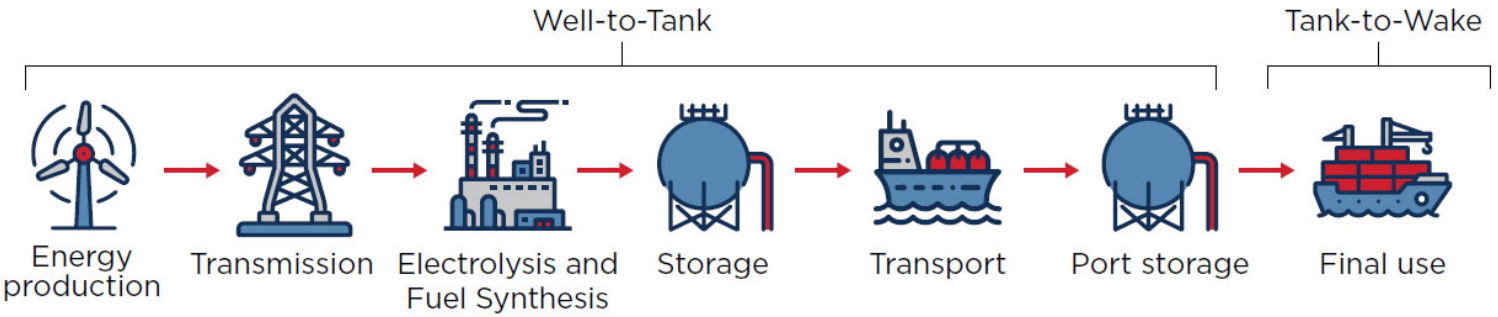
The challenge is green electricity

- Certification mechanisms
- If connected to the grid, need to ensure the source of that energy
- Transportation, if not decarbonised, may lead to increased footprint

Engine still under development

- NOx & N2O slip uncertain
- Pilot fuel usage

Pollutant	HFO, MGO	LNG	Ammonia (combusted in engines)
SO_2 and metals	Present	Not present	Not present
Carbon monoxide and hydrocarbons	Present	Present or increased	Not present
VOCs and PAHs	Present	Reduced	Not present
NO_x **	Needs SCR for Emission Control Area	Otto engines meet Emission Control Area without SCR	Needs SCR for Emission Control Area
Direct particulate matter	Present	Reduced	Reduced
Ammonia (NH_3) ***	Low	Not present	Unknown
N_2O	Present	Present	Present or increased****
CH_4	Low	Present at Otto engines	Not present
CO_2*****	Present	Present	Not present



Sustainability (2)

Other Environmental Impacts (production)

- Production of hydrogen requires pure, deionized water. The amount of (fresh) water can increase water scarcity. Desalination and rejection of brines can be detrimental to ocean biodiversity and marine life;
- Generating green electricity will require land (solar or onshore wind);
- Production of Solar should avoid using land used for crops;
- Inland transportation has been ongoing for many decades. Accidents happened and handling of ammonia is known;
- Ammonia spills can be harmful for marine life, need for further evaluation.

Where Solar ?

- Western Australia
- Northern Chile
- Parts of China and US
- Northeast Brazil
- Northern Africa

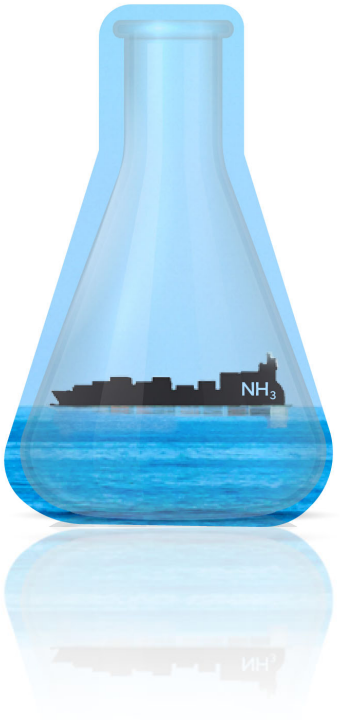
Where Wind ?

- Avoid land used for crops (Australia, Chile, etc)
- Using offshore may be an option in Western Europe and USA

Sustainability (3)

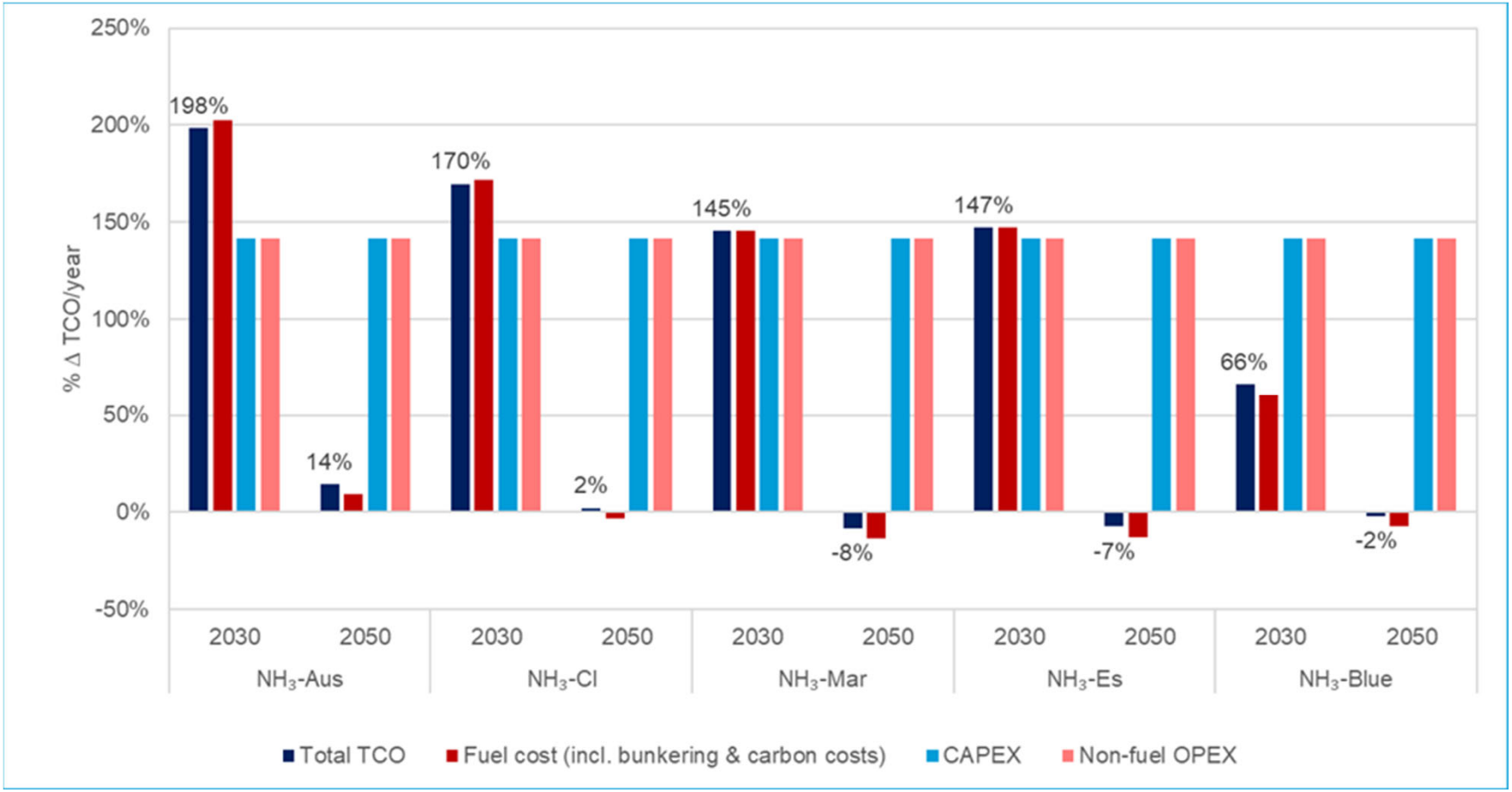
Other Environmental Impacts (bunkering/onboard)

- Ammonia spills may cause more sever harm:
  - Ammonia dissolves partly into water (towards an equilibrium of NH3, NH4+ and NH3 (g))
  - At pH of 8, NH3(aq) ranges from 0.8% to 7.4% (higher pH, higher percentages)
  - Toxicity depends on bio-sphere, from 17 mg/L to 510 mg/L in toxicity limit for Ammonia exposure
- Ammonia spills may be a threat to the marine life, also quality of the water, nutrients on the water, stimulate noxious blooms of algae.
- Stricter safety for bunkering or when vessel enter and leave ports (similar to LNG, but for different reasons)



Total Cost Ownership (TCO) - Ammonia fuelled vessel

Containership 14,500-20,000 TEU – TCO difference to VLSFO vessel

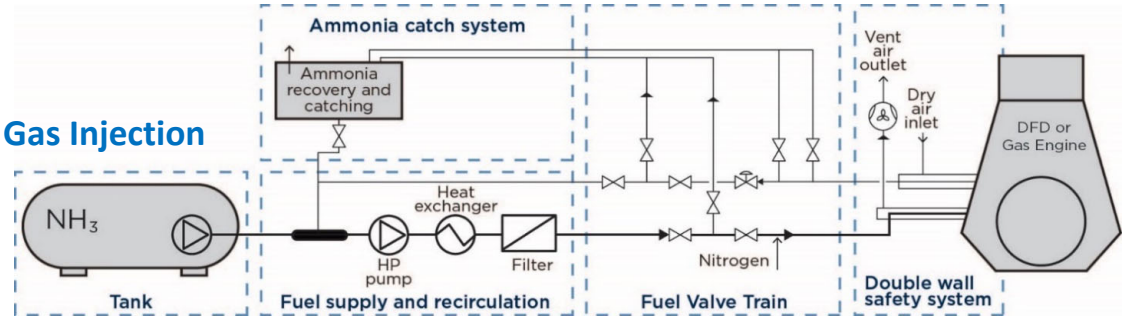


Suitablility

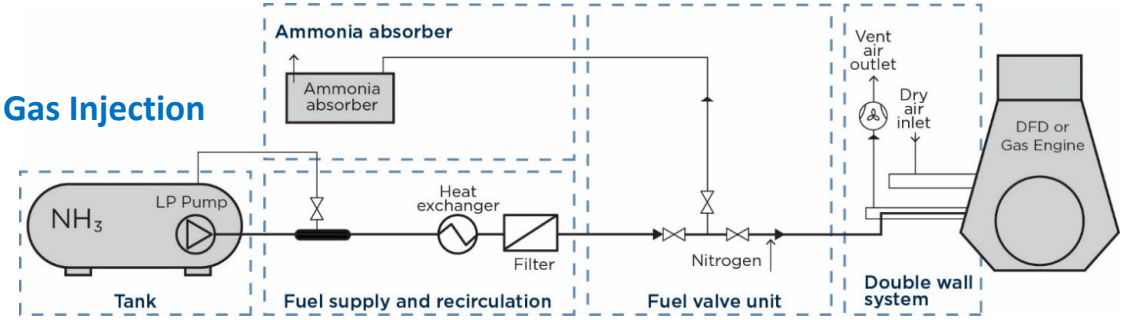
What is needed ?

1. Tanks, either Type A or Type C
2. Ammonia supply pumps
   I. High pressure ~ 80 bar
   II. Low pressure~ 5-15 bar
3. Temperature control
4. Filters
5. Double block and bleed
6. Vent system incl. a collection & treatment system for ammonia vapor
7. Double wall pipe system

High Pressure Gas Injection



Low Pressure Gas Injection



Conclusions

Ammonia as a fuel is likely to take place. It presents a series of advantages and is a promising fuel:

- Known and well-estabilished production process
- Naturally carbon-free, although attention is to be given to NOx, N2O and Pilot fuel and trully green production pathways
- It is known to shipping as a cargo (IGC covers it), and poses many challenges to be used as a fuel
- There are challenges to overcome to handle its corrosivity and toxicity: bunkering, engine, fuel supply systems.
- However, it has been used for many decades and there is substantial knowledge available

Main challenges:

- Ensure availability of green energy and competition with other sectors
- High costs associated with green ammonia production
- Safety and Regulations concerns: need to accelerate awareness and regulatory framework developments
- Need more knowledge on spillage and other environmental aspects
- IMO Guidelines to be ready by 2025

Thank you for your attention

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