EMSA Workshop on Alternative Fuels and Power Solutions for Shipping and Ports

Ship Owner Perspective

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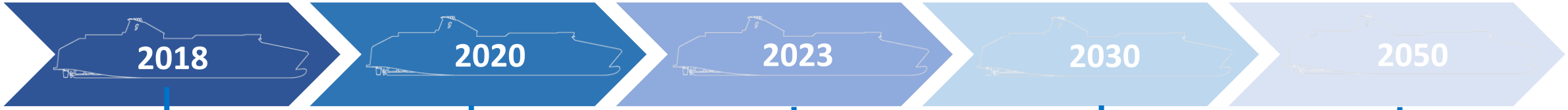
19 October 2022

SAILING TOWARD ZERO-EMISSION SHIPPING

The International Maritime Organization (IMO) road map and rules aimed at reducing harmful sulfur oxide (SO2), carbon dioxide (CO2), and other greenhouse gas (GHG) emissions from ships.



IMO adopts initial strategy to reduce GHG emissions

Sets a series of GHG emissions reduction milestones through 2050.

Low-sulfur mandate

Reduces the limit for sulfur content of fuel oil used in ships to 0.5 percent from 3.5 percent, effective Jan. 1, 2020.

Short-term decarbonization deadline

Requires finalized short-term measures to reduce CO2 emissions by 2023

Mid-term decarbonization

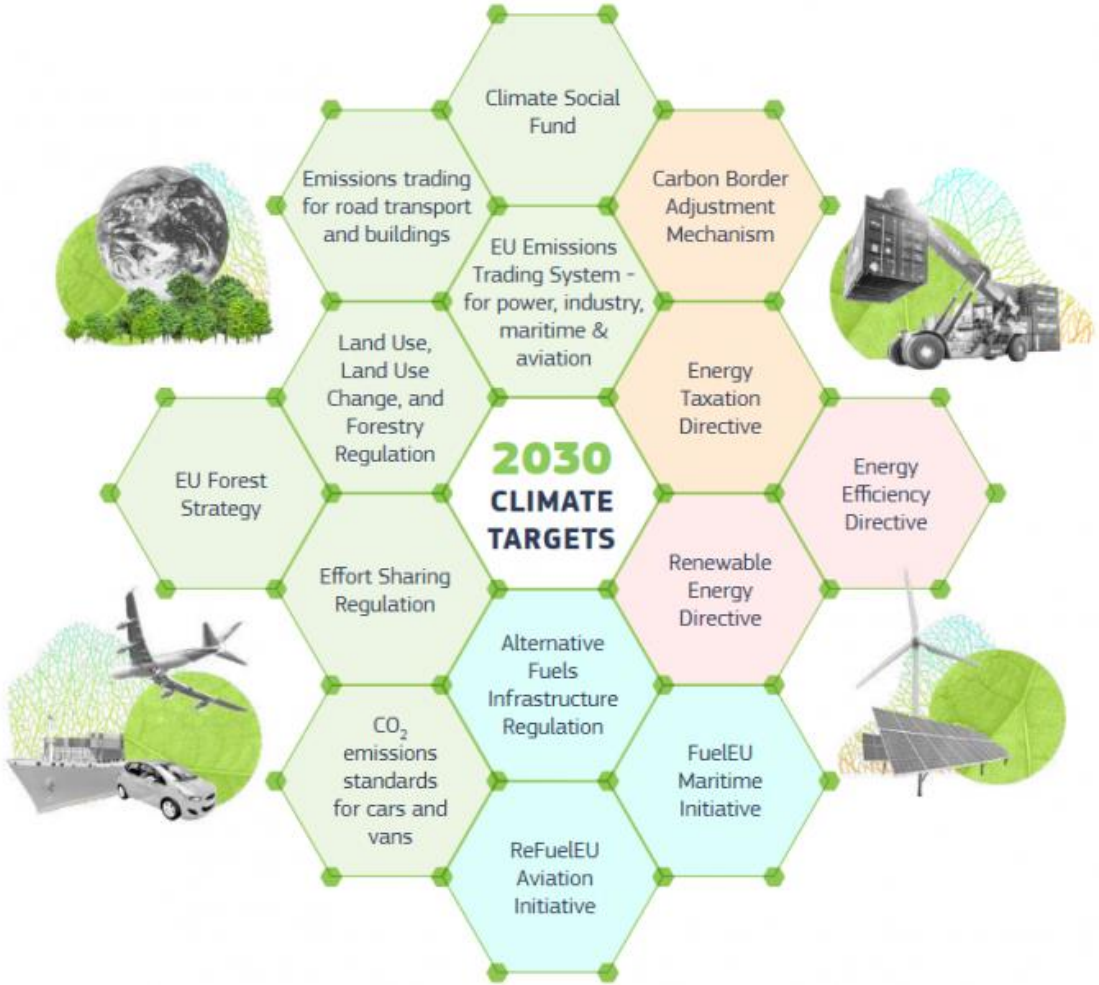
Mandates an average 40% reduction in CO2 emissions per transport work by 2030 compared with 2008 levels

Long-termGHG reduction

Requires 50% reduction in total annual GHG emissions by 2050 encouraging to phase out GHG completely

EU – FIT FOR 55% PACKAGE

The EU will reduce its net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. On 14 July 2021, the Commission presented proposals to deliver these target.



In particular for shipping sector:

1. Introduction for all ships with GT> 5000 in the Emission Trading Scheme;
2. Introduction of limits to the energy used on-board by a ship (Fuel EU Maritime)
3. Shoreside electricity supply for containerships and passenger ships.

ROAD MAP REFLECTING MEASURES TOWARDS DECARBONIZATION

	Already implemented	Upgrade in 2023 ± 2 years	Upgrade in 2028 ± 2 years
Hydrodinamics	▪ Hull optimization ▪ High-efficiency propeller ▪ Efficient coating system	▪ High-performance coating ▪ Energy-saving device	Innovative Design Air Lubrication System
Machinery	▪ Electronic engines ▪ Improved engine load	▪ Energy-efficient lighting system Variable-frequency drive-controlled pumps, fans ▪ Shaft generator PTO/PTI ▪ Waste-heat recovery ▪ Battery hybridization	▪ New, more-efficient ENGINES ▪ super after treatment ▪ fuel cell ▪ H2 and NH3 ▪ Carbon Capture
Wind	N/A	N/A	▪ Wind propulsion
Operational	▪ Wheather routing ▪ Voyage planning and execution	▪ Trim optimization	▪ Speed and route optimization ▪ JIT arrival in port
Fuel	▪ HFO (gas treatment) ▪ LSFO and MGO	▪ HFO (with gas treatment) ▪ LSFO and MGO	▪ Biofuel or synthetic fuel

ALTERNATIVE FUEL

BROWN FUEL

- Non-Renewable Energy
- High emissions

- Coal

GRAY FUEL

- Non-Renewable Energy
- Low emissions

- Diesel, Natural Gas

BLUE FUEL

- Non-Renewable Energy
- Zero emissions (Carbon Capture)

- Blue-hydrogen

GREEN FUEL

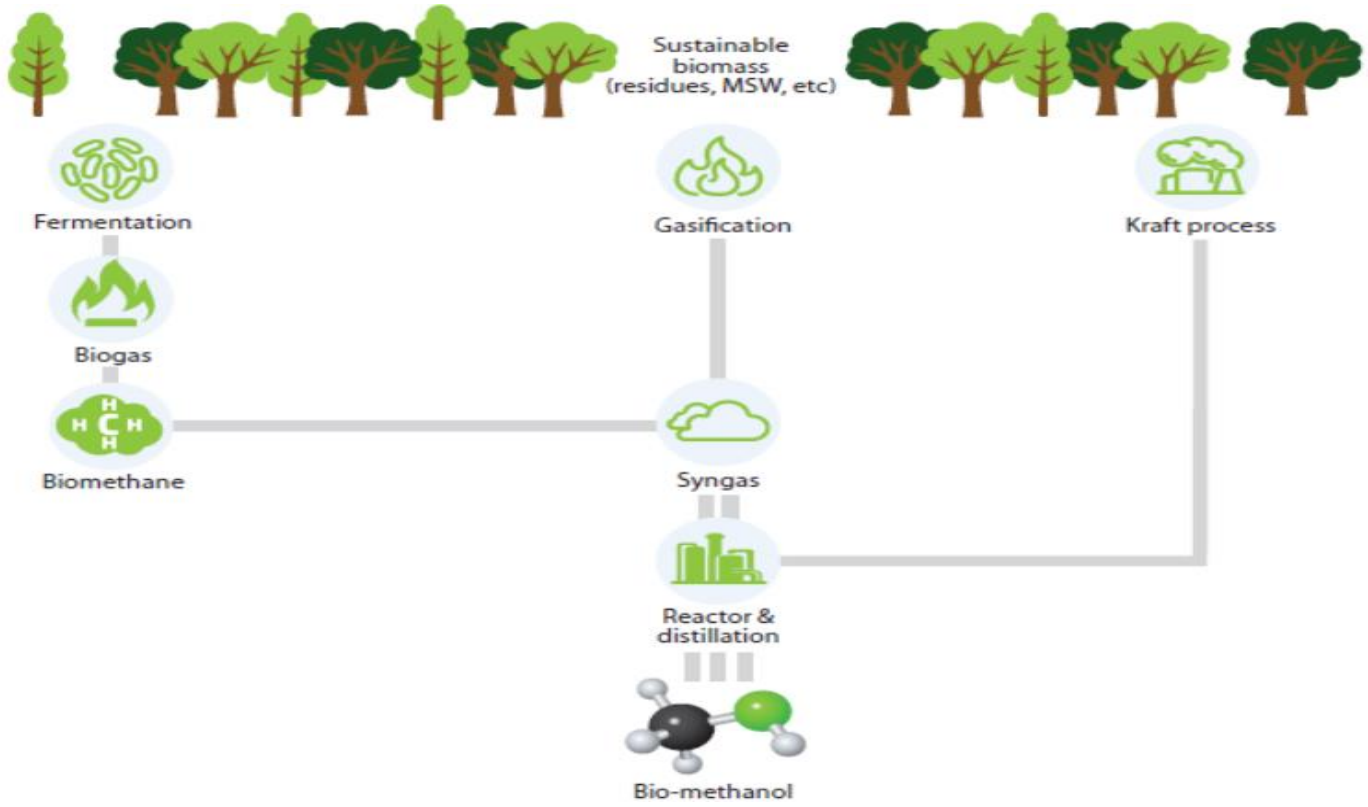
- Renewable Energy
- Zero emissions

- Green-hydrogen

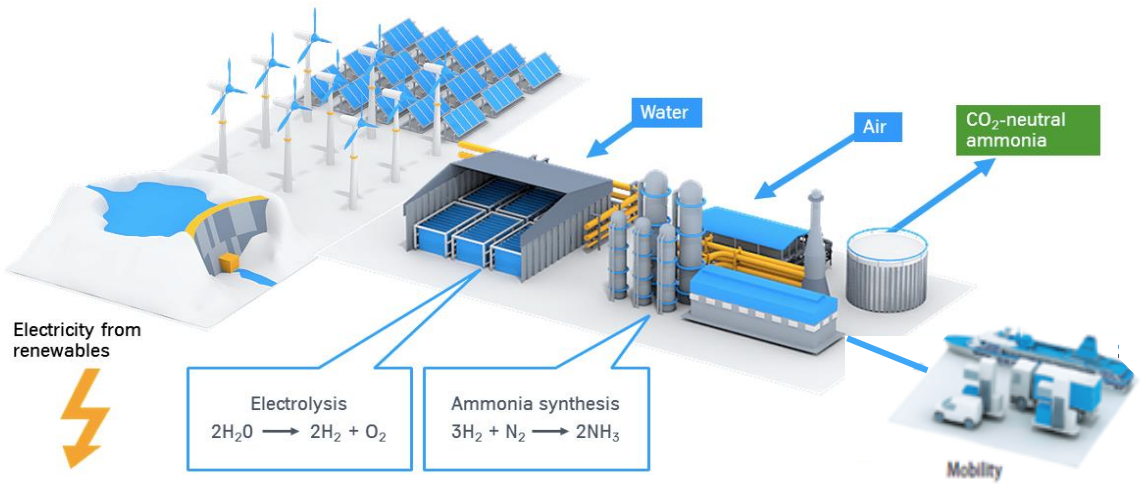
BIO-FUEL

- **Bio-fuel** produced from biomass (plant, algae, food waste)
- **Biomass fermentation** produces biogas, which is processed to produce syngas
- From **syngas** it is possible to obtain **bio-methanol** and **bio-diesel**

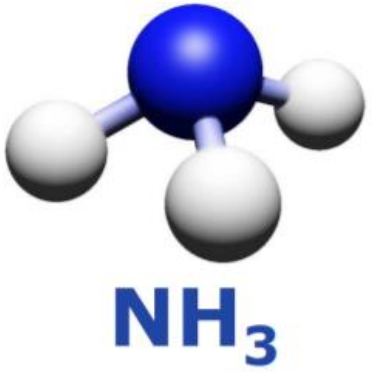
- **Barriers** to overcome:
  1. Availability
  2. Logistic chain
  3. Cost



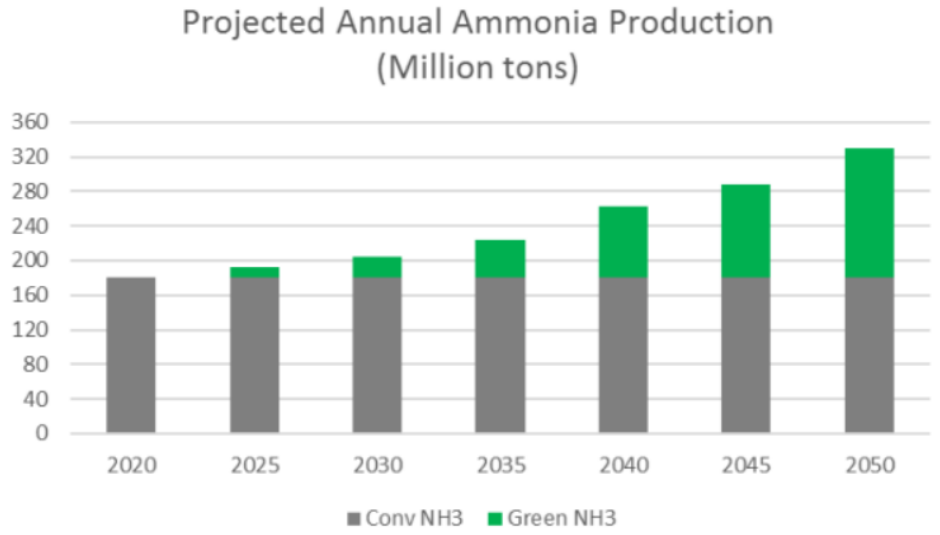
ELECTRO-FUEL ($H_2 - NH_3$)



- **Barriers** to overcome:
  1. *Availability;*
  2. *Logistic chain;*
  3. *Cost;*
  4. *Safety;*
  5. *Health impact;*
  6. *Technical issues;*
  7. *Rules requirement availability;*



- Hydrogen produced from water (H2O) electrolysis;
- Energy for this process is renewable (hydroelectric, wind, solar);
- Hydrogen combined with Nitrogen (N2) can give Green Ammonia;



FUEL PROPERTIES:

Fuel	Gravimetric LHV* (MJ/kg)	Volumetric LHV (MJ/l)	Density (kg/l)	Carrying temperature (ºC)	Carrying pressure (bar)	Carbon intensity (kg CO2/ kg fuel)	Carbon intensity (g CO2/MJ)	Deadweight requirement (mt)	Tank volume requirement (cbm)
HFO	40,6	39,1	0,87	Ambient	Ambient	3,114	76,7	870	1000
MGO	42,7	36,1	0,86	Ambient	Ambient	3,206	75,1	827	962
LPG	46,6	23,7	0,6	-42	Ambient	3	64,4	758	1263
LNG	50	20,8	0,45	-163	Ambient	2,75	55,0	706	1570
Methanol	20,1	16	0,79	Ambient	Ambient	1,375	68,4	1757	2224
Ammonia (liq)	18,6	12,7	0,68	-33	Ambient	0	0	1899	2793
Ammonia (press)	18,6	12,7	0,602	Ambient	10	0	0	1899	3155
Hydrogen (liq)	120	8,5	0,07	-253	Ambient	0	0	294	4205
Hydrogen (press)	120	8,5	0,042	Ambient	700	0	0	294	7008

Source: Alternative fuels in maritime space.

Blue Ammonia: operational considerations 1/4

Batteries 5 MWh
for Zero Emission in Port

AMMONIA READY
Notazione di Classe RINA

Solar Panel
for renewable energy

Hybrid Scrubber
SOx < 0.1% and PM < 70%

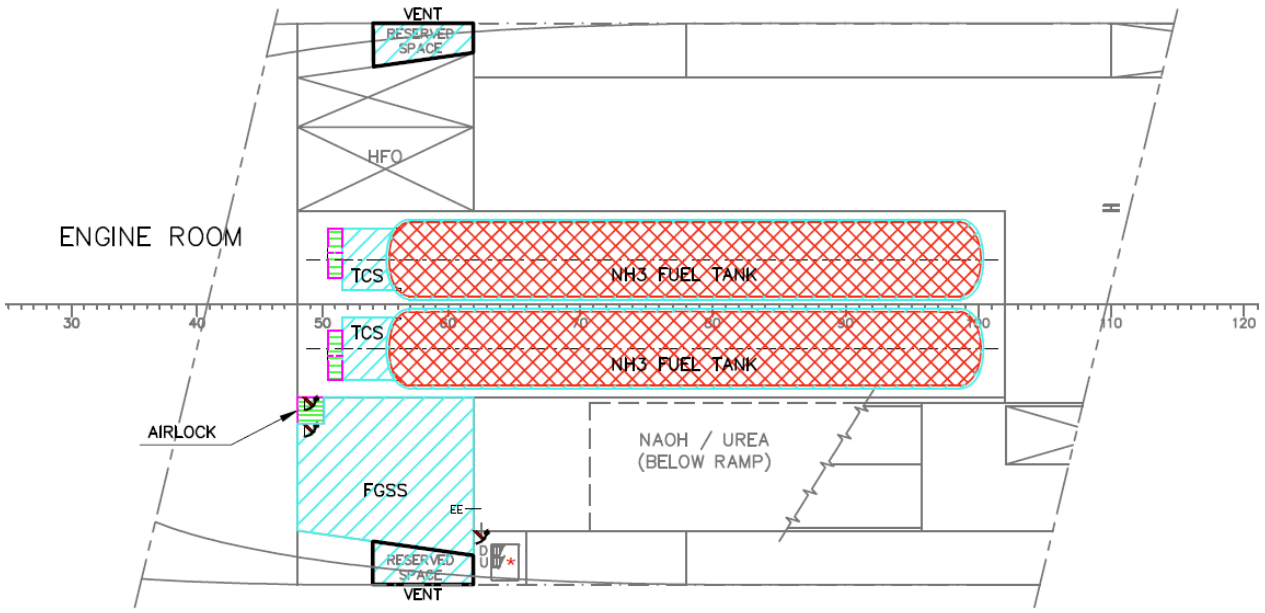
Waste Heat Recovery
Zero Boiler in port

Propulsion optimization

Air Lubrication System
To reduce viscous drag resistance thanks to a layer of micro bubbles under the bottom of the hull

Hull and appendages optimization
through CFD intensive studies

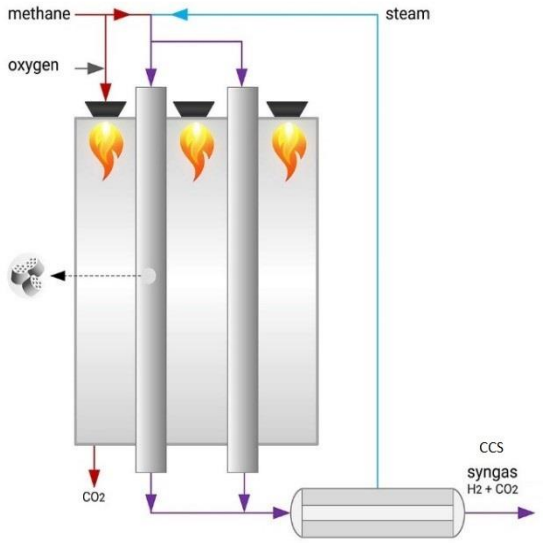
Blue Ammonia: operational considerations 2/4

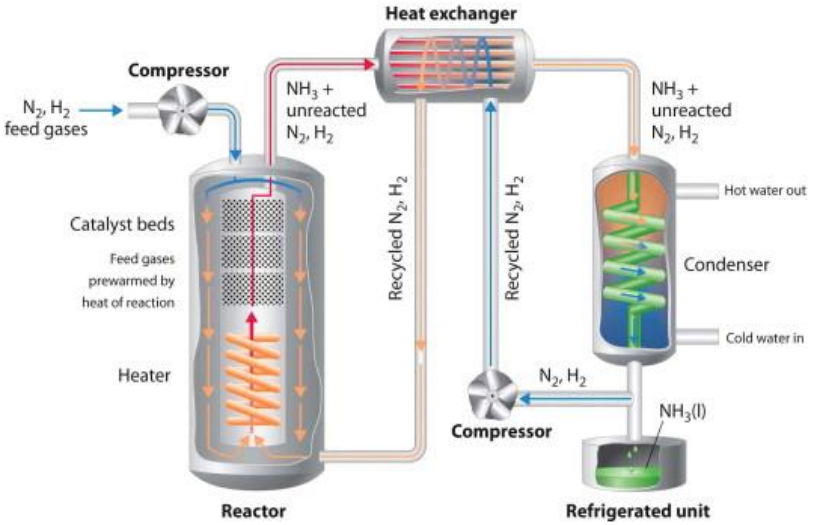


HAZARDOUS AREA DEFINITION		
ZONE 0	ZONE 1	ZONE 2
➢ NH3 Storage Tanks ➢ Pipes containing or connected to NH3 fuel ➢ Piped used for NH3 venting to bunker return, BOG system or pressure relief valves	➢ NH3 Bunkering stations ➢ NH3 Tank Connection Spaces (TCS) ➢ Spaces containing NH3 fuel stoarge tanks ➢ Space sorrounding zone, 0.0m – 1.5m from NH3 venting pressure relief valve	➢ NH3 Fuel storage hold ➢ Surrounding zone 1.5m – 3m from NH3 bunkering stations ➢ Surrounding zone 1.5m – 3m from NH3 venting pressure relief valve

AMONIA READY
Notazione di Classe RINA

Blue Ammonia: operational considerations 3/4





Steam Methane Reforming (SMR), with $\boldsymbol{CO_2}$ captured and stored *Carbon Capture*.

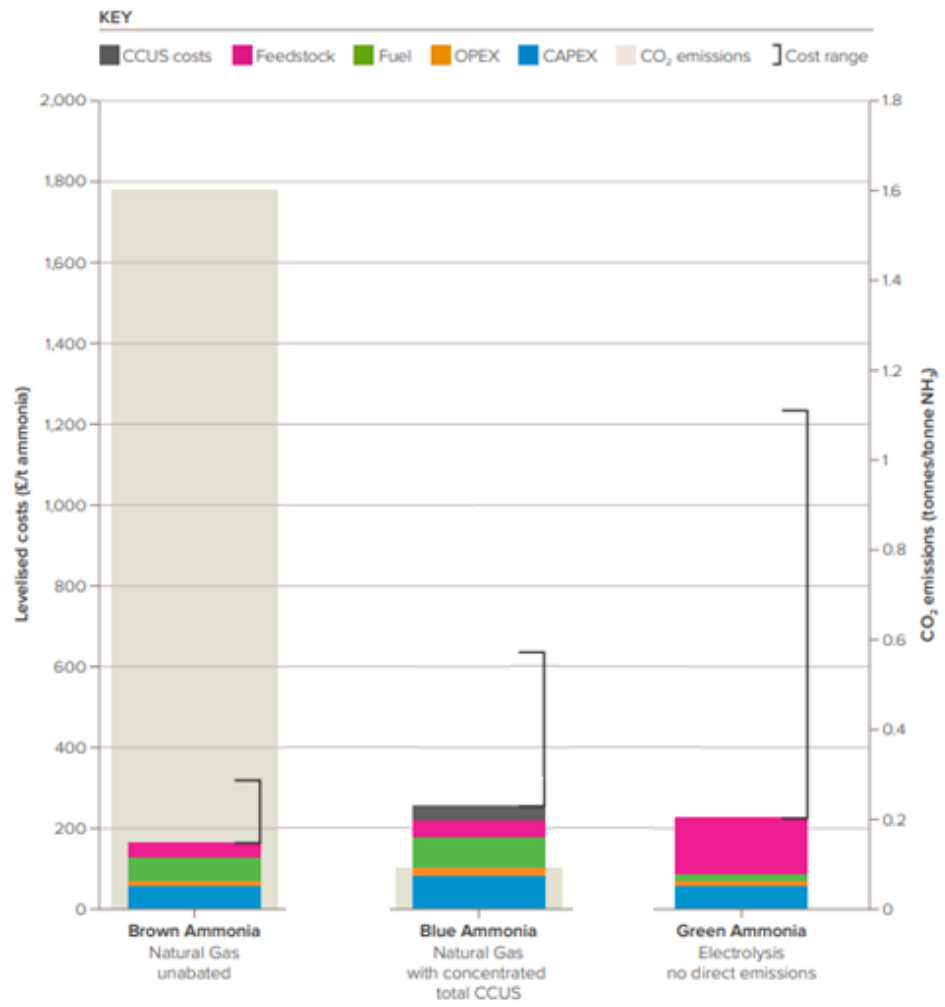
$$CH_{4\,gas} + 2H_2O_{vap} \rightarrow CO_{2\,gas} + 4H_{2\,gas}$$

The quantity of *hydrogen* produced is approximately **54%** by weight of the methane required for the *Steam Reforming* reaction: therefore approximately **540 kg** of *hydrogen* are produced from **1 ton** of *methane*.

The total energy required by the *Steam Reforming* ed *Haber Bosch* processes for the production of *blue ammonia* is approximately **20-25** GJ/ton NH_3; of this energy, the major quantity is required for the production of *hydrogen* (**16-20** GJ/tonNH_3), while the other part is used for the production and the storage of *ammonia* (**4-5** GJ/tonNH_3). The energy required for the *Carbon Capture* is instead equal to **1.2-1.4** GJ/tonCO_2 captured.

Blue Ammonia: operational considerations 4/4

Cost comparison of ammonia production via different methods[26].

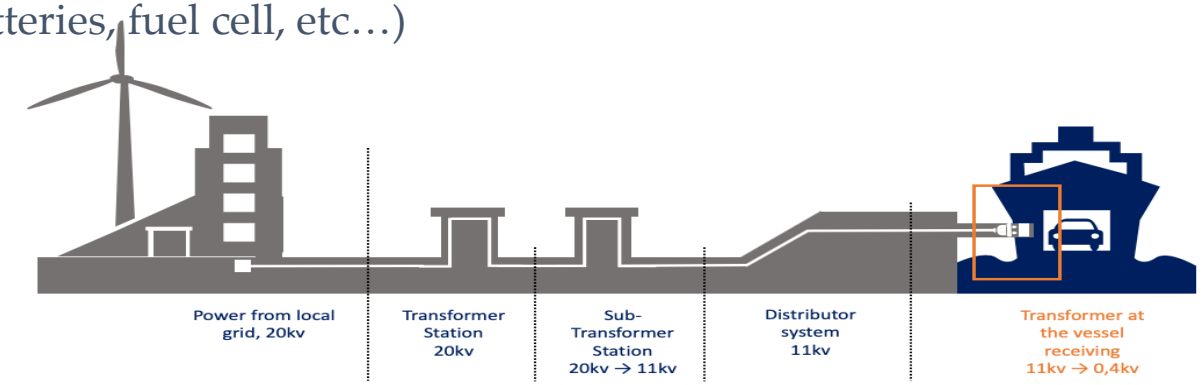


For a comparison with HFO the *cost range* must be multiplied by **2.5**, since due to different energy densities it would take about **2.5** tons of $\boldsymbol{NH_3}$ to cover the same miles that are covered with **1** ton of HFO. Furthermore, the cost in *Figure 3* relates to *ammonia* for land use (fertilizer), the costs of logistics (barge, storage, etc.) for naval use are not yet included.

PILOT PROJECT FOR COLD-IRONING

Despite of the obligation in 2030 for passenger vessels, shore connection can be an opportunity for ports, citizen, operators and shipowners:
Trasmed part of the Grimaldi Group will start in 2023 the pilot project for Cold-ironing in Barcelona Terminal and (to be finalized) in Palma de Majorca but in general for a broad uptake:

- Energy should be produced from Green sources;
- Energy provided from shore should be competitive;
- First the ships which require lot of power or pollute a lot should be addressed for OPS;
- Funding: both terminal and ship owners have to be supported in infrastructure installation;
- Incentives has to be foreseen for all ships that zero the emission with both Shore connection and other way (i.e. batteries, fuel cell, etc…)



Thanks for your attention