MAN Energy Solutions
Future in the making

Propulsion of ships towards year 2050.

Using low carbon ammonia fuel

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MAN Energy Solution in World Trade

50% of World Trade is powered by MAN-ES Engines!

3000 MAN B&W engines can eventually be converted to ammonia operation.

Center of Competence 2-stroke Low Speed Diesel

Copenhagen, Denmark

Design of Two-Stroke Engines

Production of Spare Parts

PrimeServ Academy

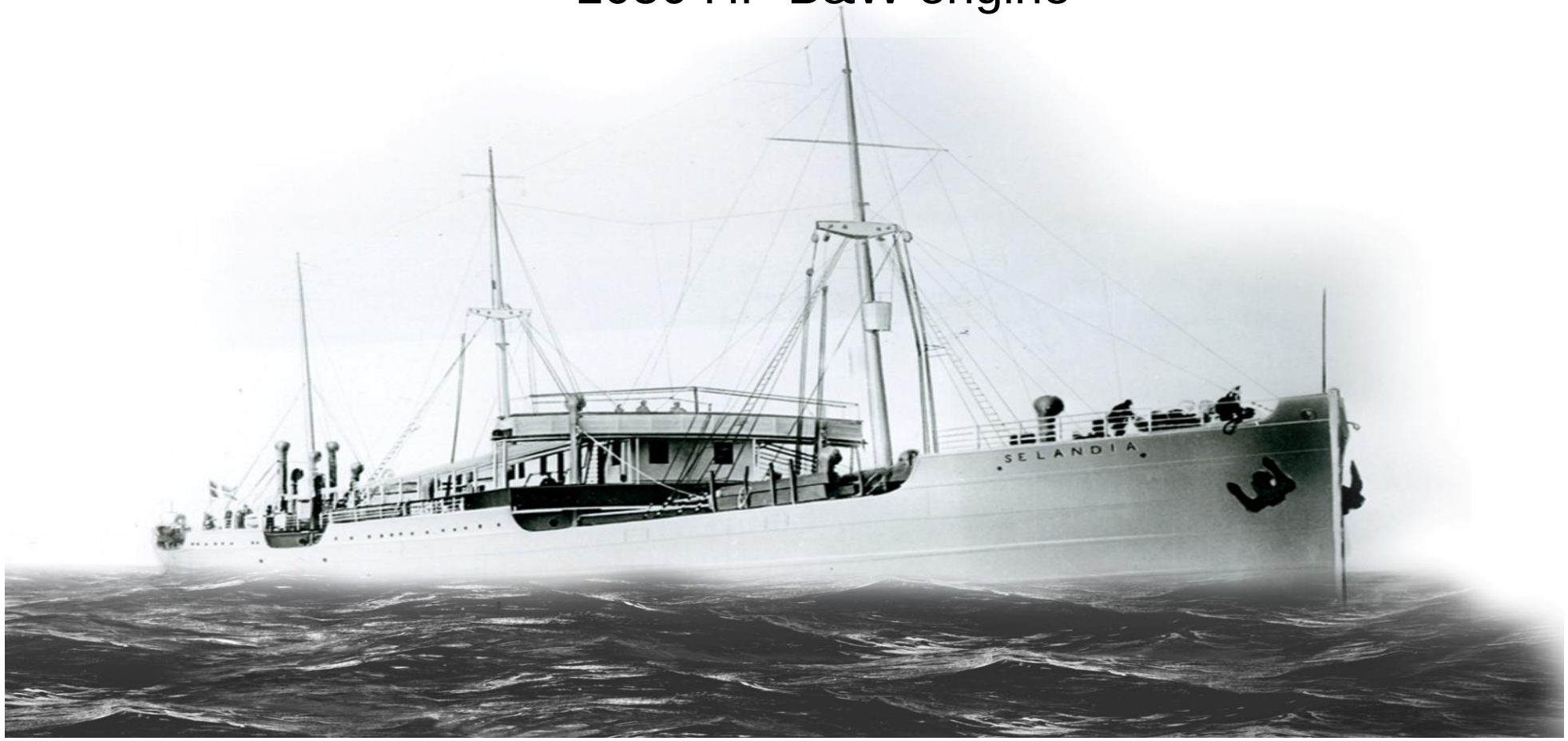
R&D Center

Diesel House

Employees (July 2017) **1,306**

Changing from Coal to Oil

In 1912 the Diesel driven MV Selandia left Copenhagen into a world with no fuel bunkering possibilities
1050 HP B&W engine



Today - The Dual Fuel success

4 x World's first duel fuel driven ships equipped with MAN B&W engines

First engine order

World's first LNG driven ocean going ship

Owner: TOTE

Ship type: Container ship

Capacity: 3,100 Teu

Dual Fuel engine type: 8L70ME-C8.2-GI

Year 2012

World's first methanol driven ocean going ship

Owner: MOL

Ship type: Methanol carrier
Capacity: 50,000 dwt

Dual fuel engine type: 7S50ME-B9.3-LGIM

Year 2013

World's first ethane driven ocean going ship

Owner: Hartmann Schifffahrt

Ship type: LEG Carrier

Capacity: 36,000 M^3
Dual Fuel engine type: 7G50ME-GIE

Year 2014

World's first LPG driven ocean going ship

Owner: Exmar

Ship type: VLGC

Capacity: 80,000 M^3
Dual Fuel engine type: 6G60ME-LGIP

Year 2018

CSSC-MES Diesel Co. Celebration

Manufacturing 10 million MAN Diesel & Turbo designed BHP

The new MAN B&W ME-LGIP engine

Regulation – a driving factor for engine development

Today, focus is on SO_x and NO_x:

- NO_x reduction is achieved with EGR and SCR
- SO_x reduction is achieved with MGO, LFSO, scrubber, LNG, methanol and LPG

In the future, we will see a growing focus on CO_2, methane slip and VOC:

- 40% reduction of carbon intensity per transport work by 2030 and 70% by 2050 compared with 2008
- 50% reduction of greenhouse gas emissions from ocean shipping by 2050 compared with 2008
- Reduction of methane slip emissions → **Diesel cycles**
- Reduction of VOC emissions → **ME-LGIP**

Carbon free fuels will be mandatory to meet the 2050 goal

Our dual fuel done right engine technology is well suited to support such goals

The New MAN B&W ME-LGIP Engine

LGIP Technologies Confirmed at RCC - LGIP Injection Concept

Cylinder cover with LPG injection valve and gas block – same system to be used for NH3

Valve control block:

– ELWI-valve (fuel pressurization)

– ELGI-valve (injection timing)

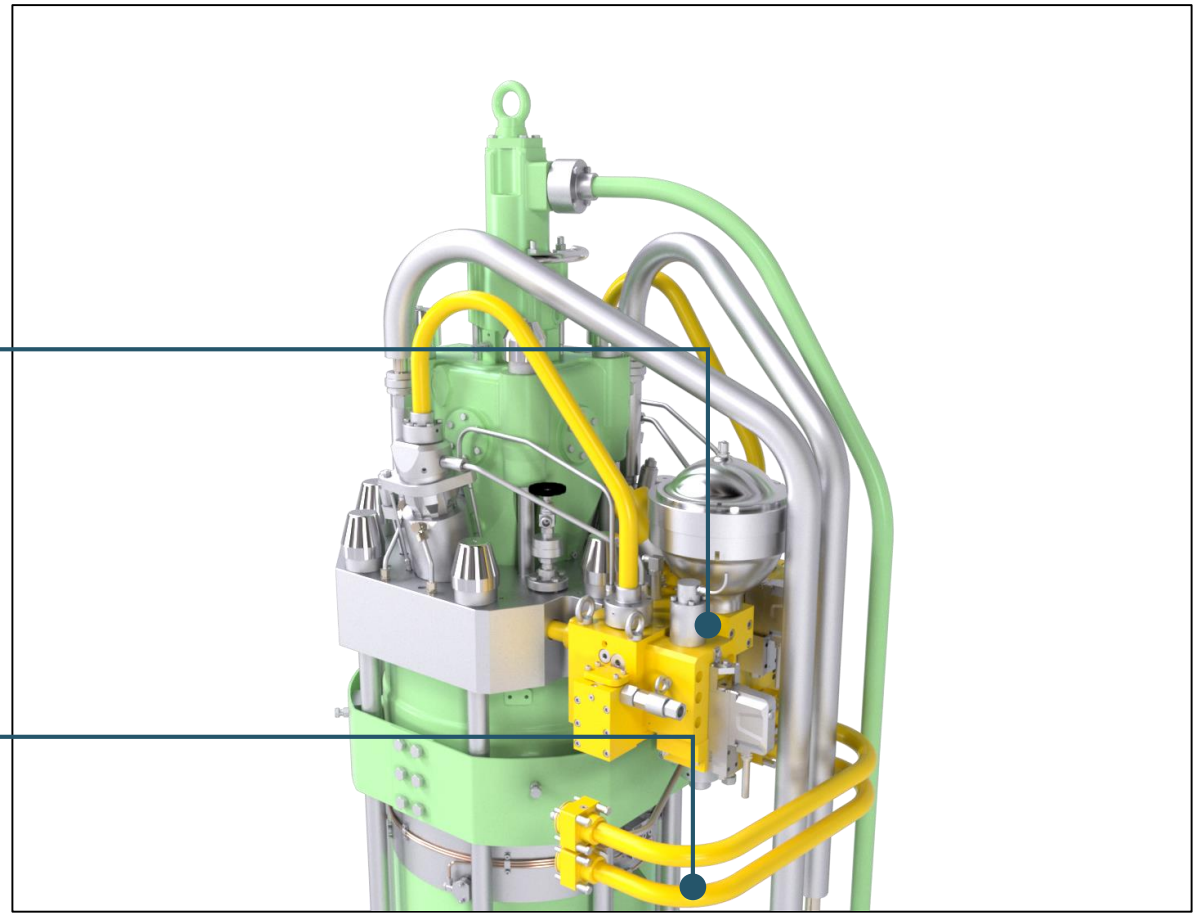
– Hydraulic accumulator

– Hydraulic and sealing oil connections

Double wall gas piping:

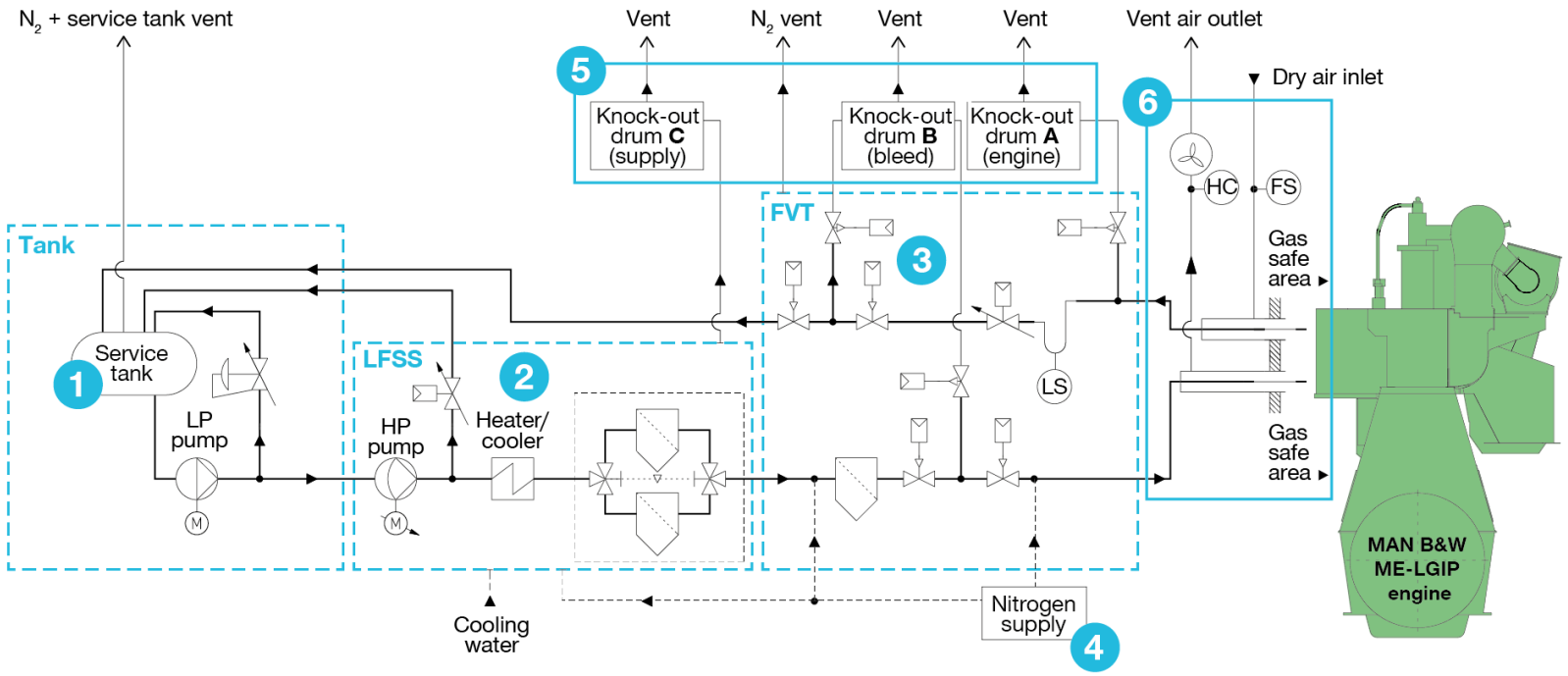
– LPG inlet

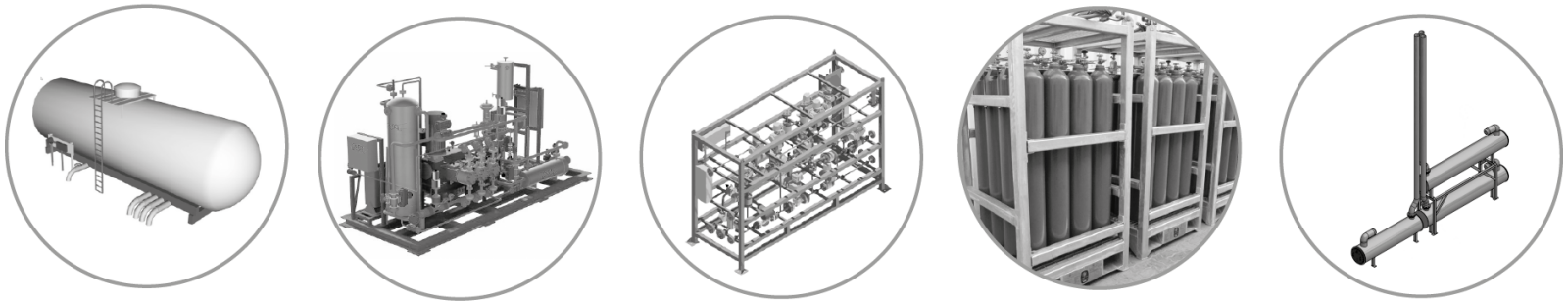
– LPG return



The new MAN B&W ME-LGIP engine

This engine type can be modified to burn ammonia as well.



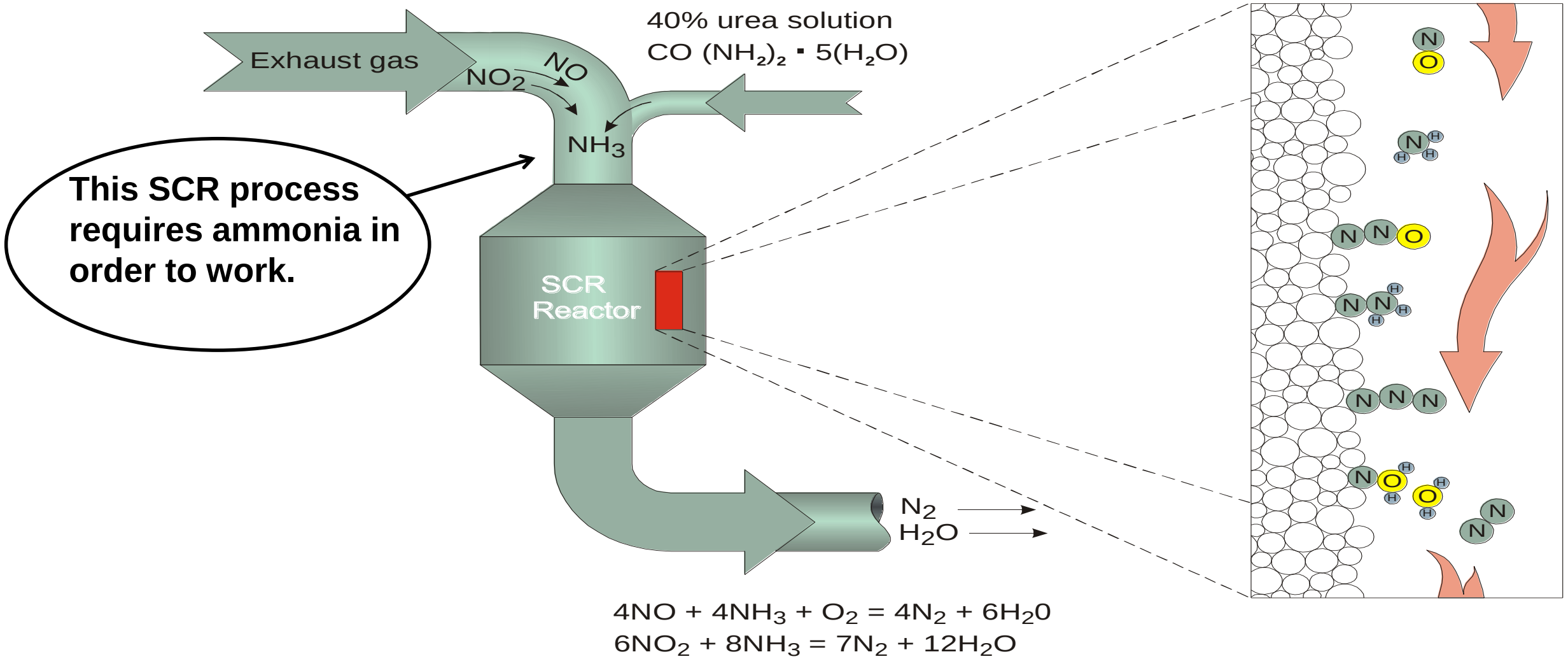


1 LPG service tank 2 Low-flashpoint fuel supply system 3 Fuel valve train 4 Nitrogen storage 5 Knock-out drums

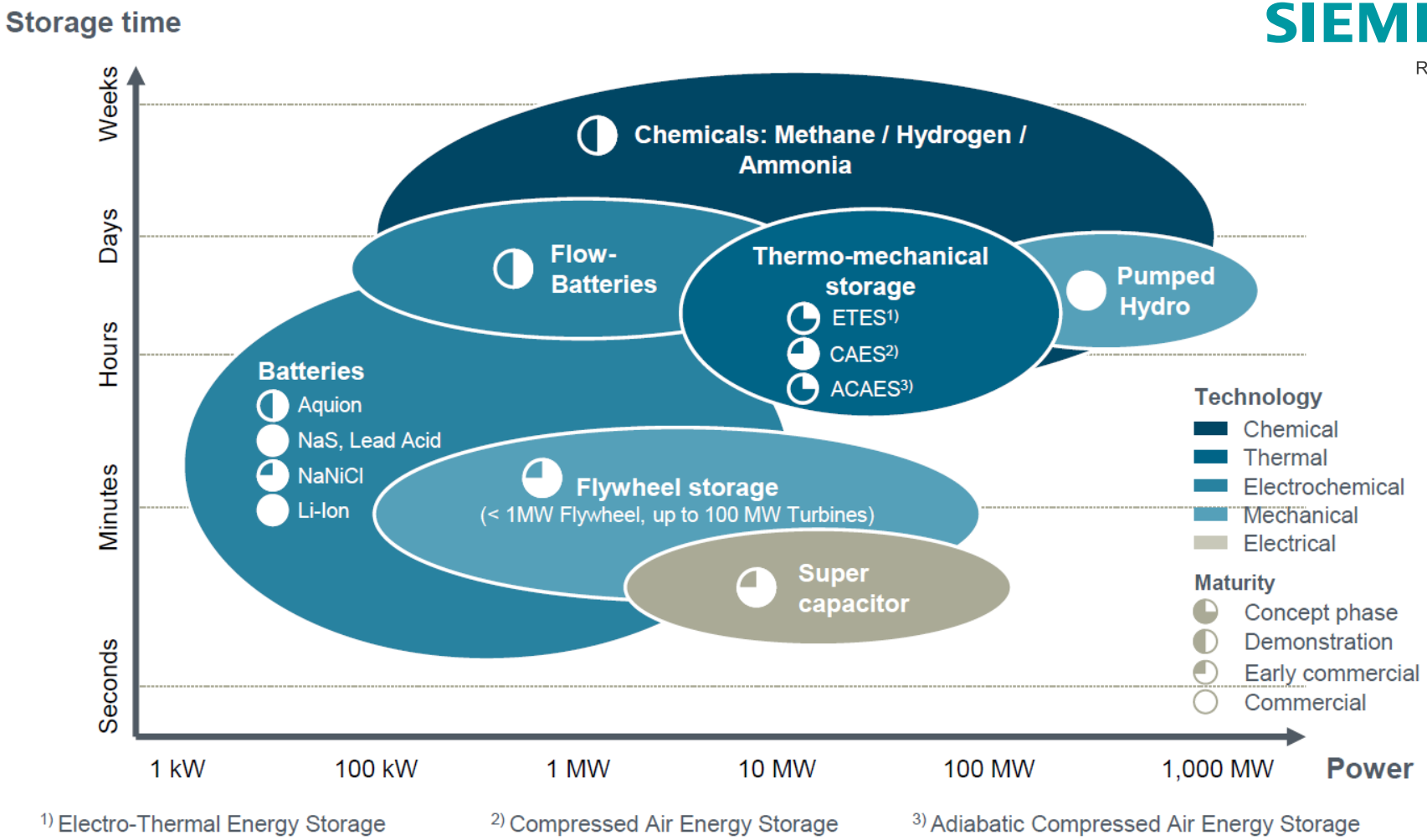
- **Development time of an ammonia engine 2-3 years**
- **We will be ready when the market comes**
- **Efficiency 50%**

NOx emission – ammonia.

Selective Catalytic Reduction (SCR) Process – removing NOx emissions



What is going to be the carbon free energy source?



1) Electro-Thermal Energy Storage 2) Compressed Air Energy Storage 3) Adiabatic Compressed Air Energy Storage

Source: Ian Wilkinson, Siemens

Ammonia, NH3 as green fuel produced with renewable energy

Ammonia is the logic option

SIEMENS Gamesa
RENEWABLE ENERGY

NH3 advantages as green fuel:

- No carbon. Clean combustion without CO2 or carbon
- Can be produced 100% by electrical energy
- Can easily be reformed to H2 and N2
- Can be stored with high energy density at < 20 bar
- Low risk of fire. Relatively specific ratio of NH3 and air (15-25%) is required to sustain combustion

Ammonia synthesis from an energy source

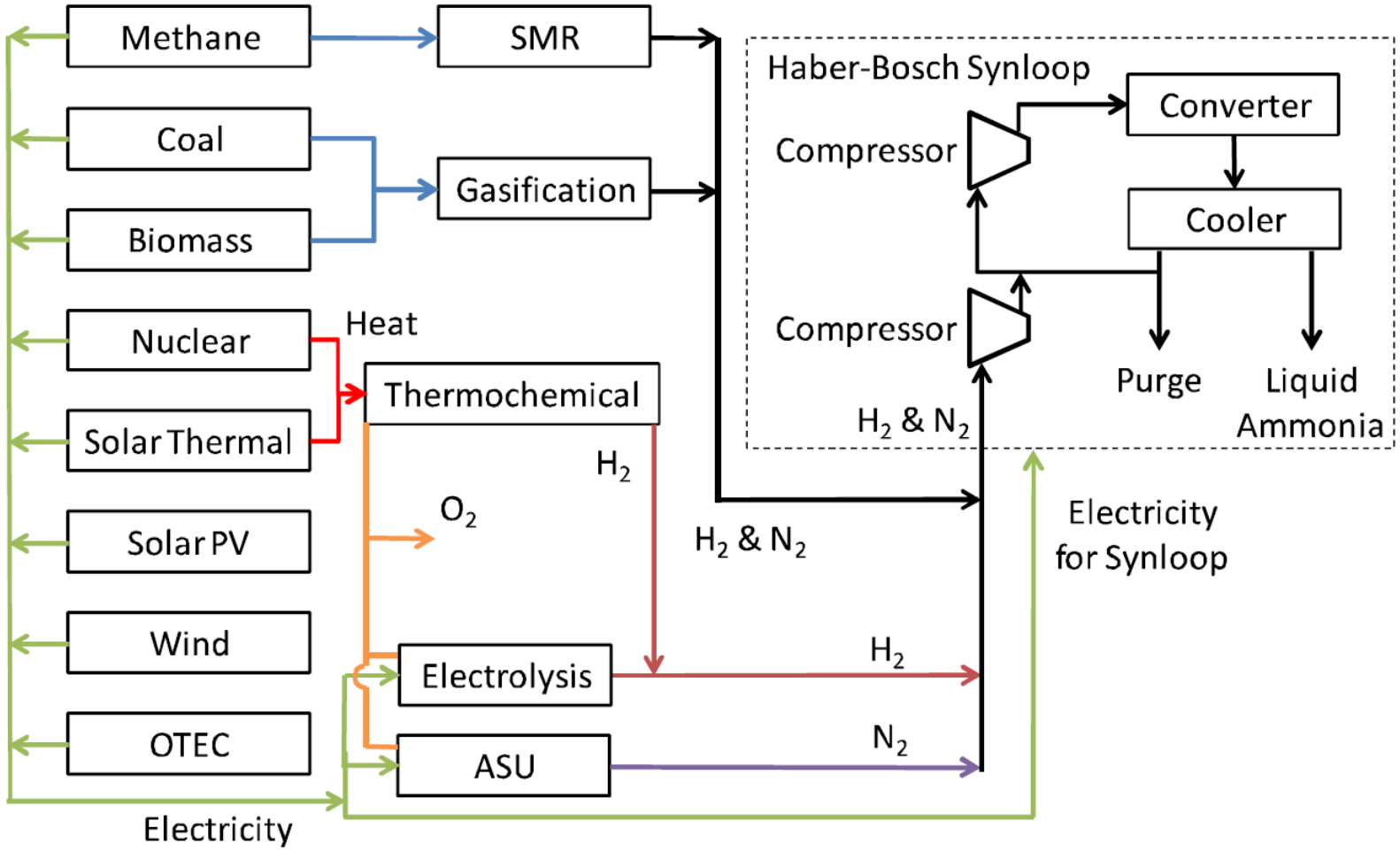
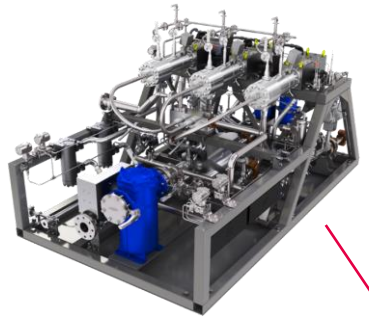


Diagram of methods to produce ammonia from several energy sources

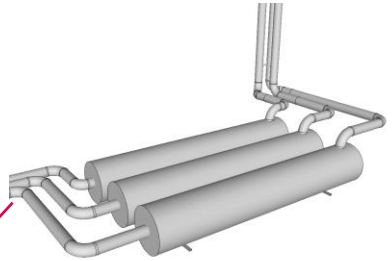
The new MAN B&W ME-LGIP engine

LR1 tanker ME-LGIP auxiliaries – for ammonia the tank size will double due to the lower energy content

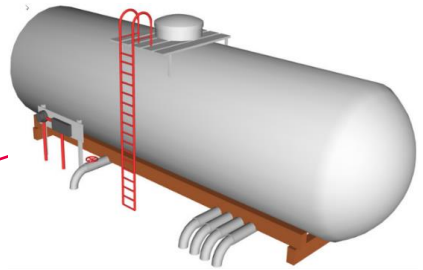
Low-flashpoint fuel supply system - PU



Knock-out drum

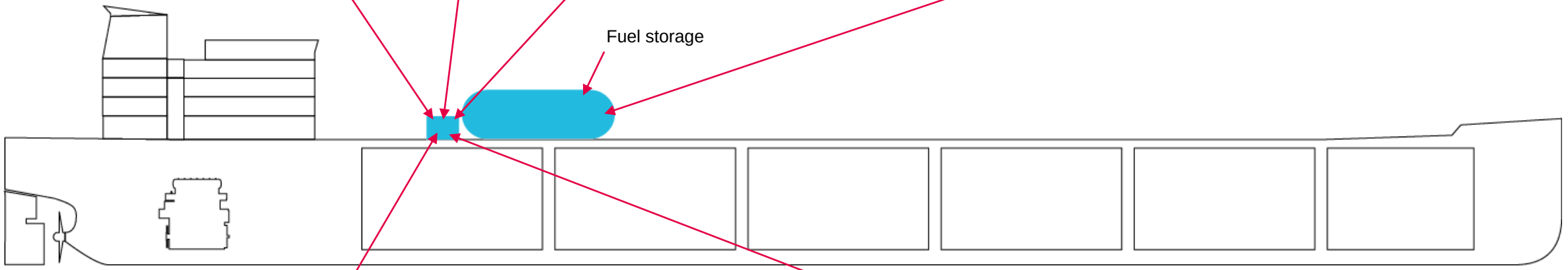


Fuel storage tank



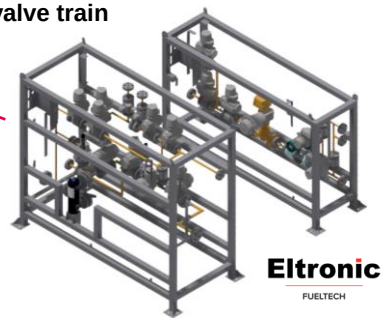
Fuel prep room

Fuel storage



Nitrogen purging system

Fuel valve train



Conclusion

Propulsion solutions on short term:

- New fuels with lower CO_2 emisson will be needed to meet EEDI
- To increase the efficiency; solutions like PTO, WHR will be more common

Propulsion solutions on long term:

- Two stroke engines will remain as the most dominating propulsion solution
- Carbon free produced methanol, ammonia, LNG and biofuels will be available
- All above fuel types can be burned in the 2-stroke ME-C, ME-GI or ME-LGI engine
- Efficiency above 60% incl. WHR & PTO

Development of an ammonia fuelled ME-LGI engine:

- History shows that ammonia works as an engine fuel.
- Engine development will be done when the market comes.
- Development time is estimated to 2-3 years.
- Development cost of an ammonia engine, estimated to 5 mill EUR.

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Future in the making

Thank you!
Do you have any questions?