MAN Energy Solutions
Future in the making

Ship Operation Using LPG and Ammonia As Fuel on MAN B&W Dual Fuel ME-LGIP Engines

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

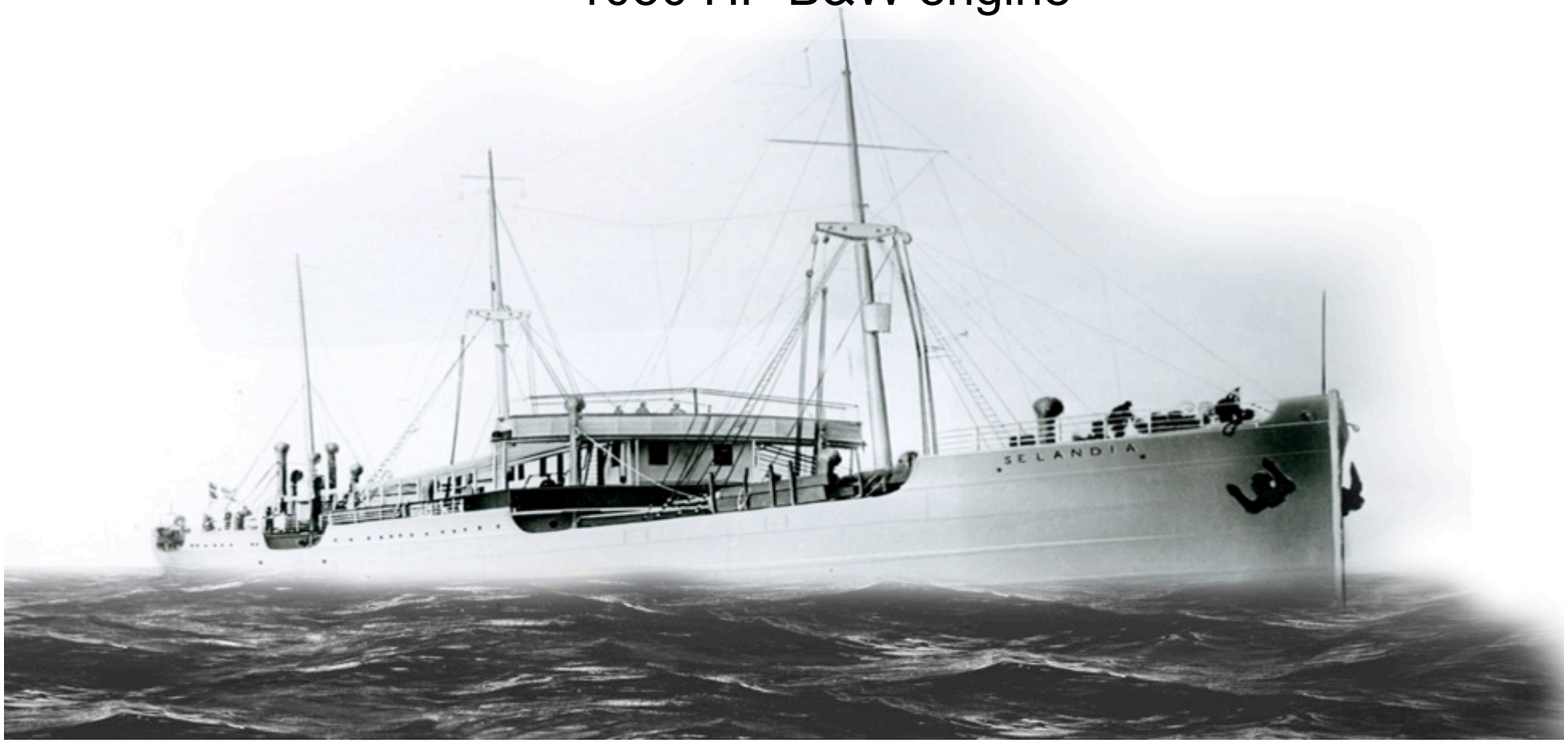
R&D Center

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

Ammonia, NH3 as green fuel produced with renewable energy

Ammonia is the logic option

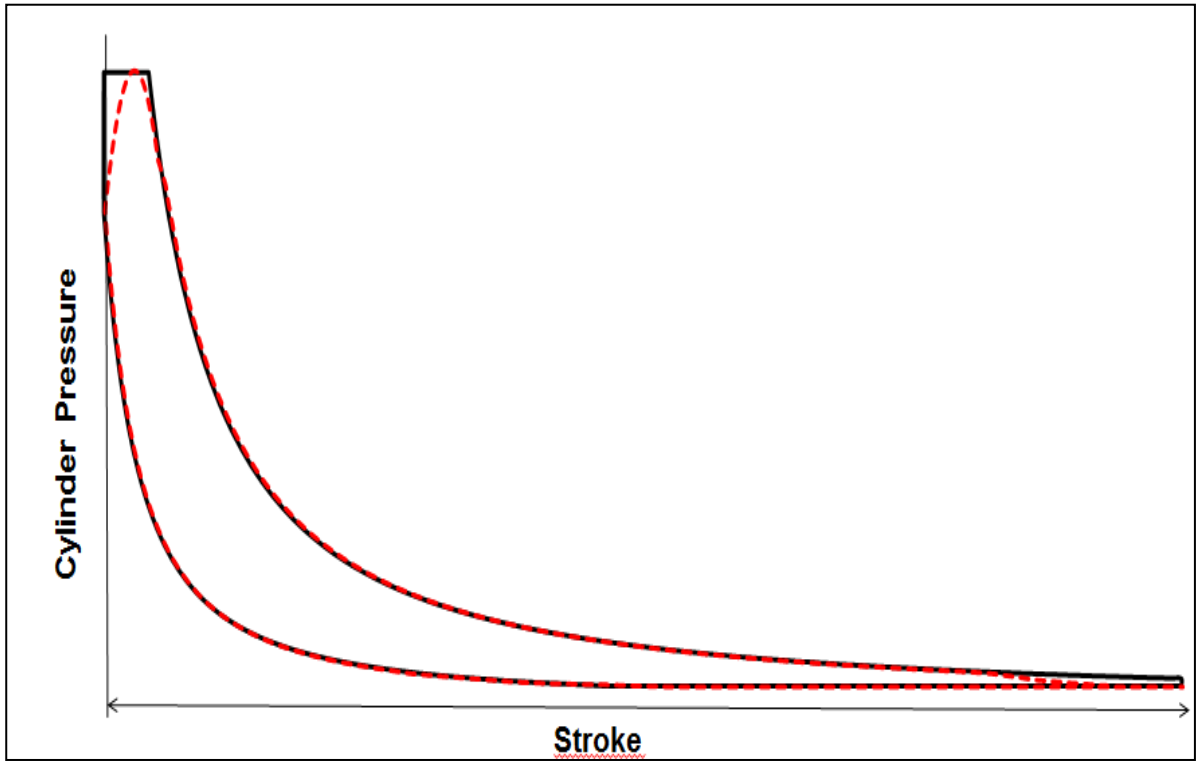
SIEMENS Gamesa
RENEWABLE ENERGY

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

The new MAN B&W ME-LGIP engine

Two-stroke market – Dual fuel contracting of total contracting



- Highest thermal efficiency
- Lowest unburned hydrocarbons
- Largest range of available fuel types
- Best controlled combustion under all dynamic and ambient conditions

The New MAN B&W ME-LGIP Engine

LGIP Technologies Confirmed at RCC - LGIP Injection Concept

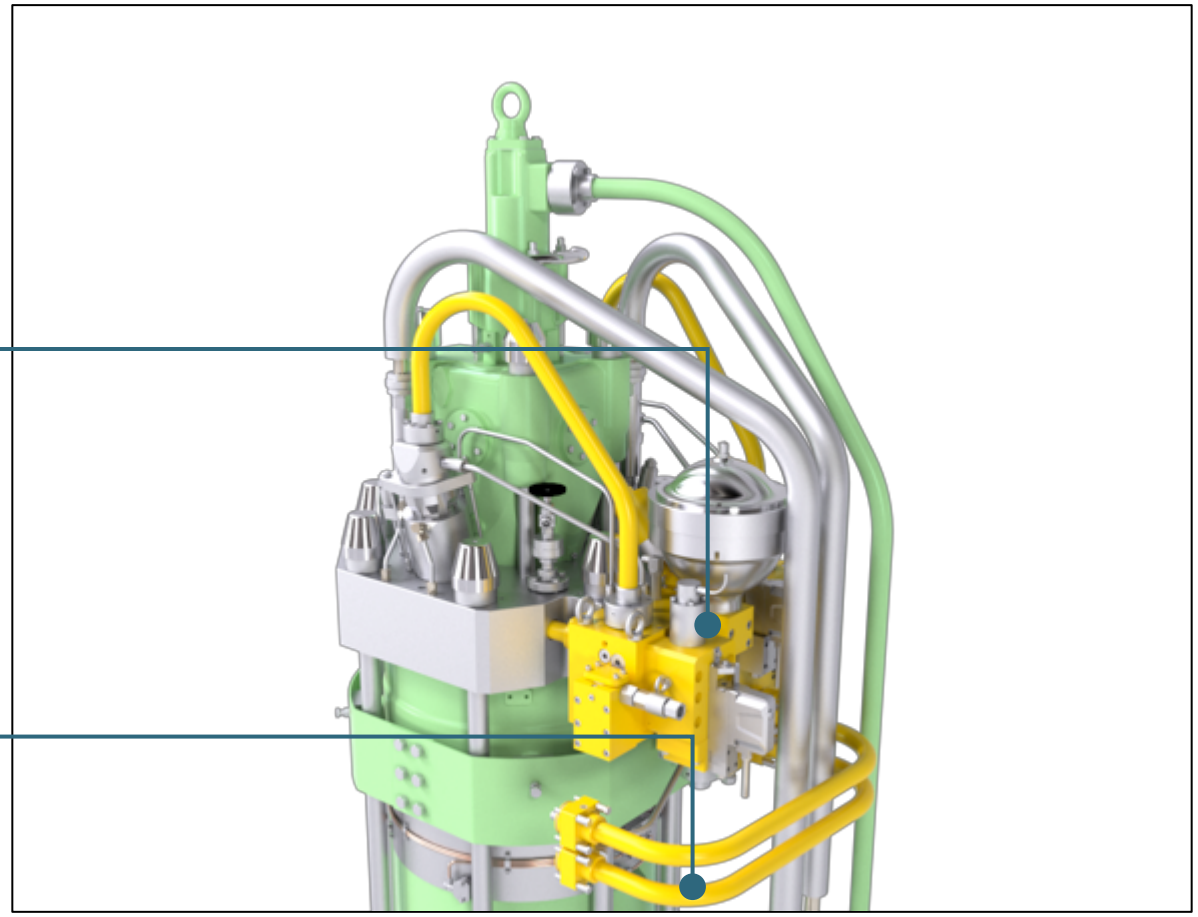
Cylinder cover with LPG injection valve and gas block – same system to be used for NH3

Valve control block:

- ELWI-valve (fuel pressurization)
- ELGI-valve (injection timing)
- Hydraulic accumulator
- Hydraulic and sealing oil connections

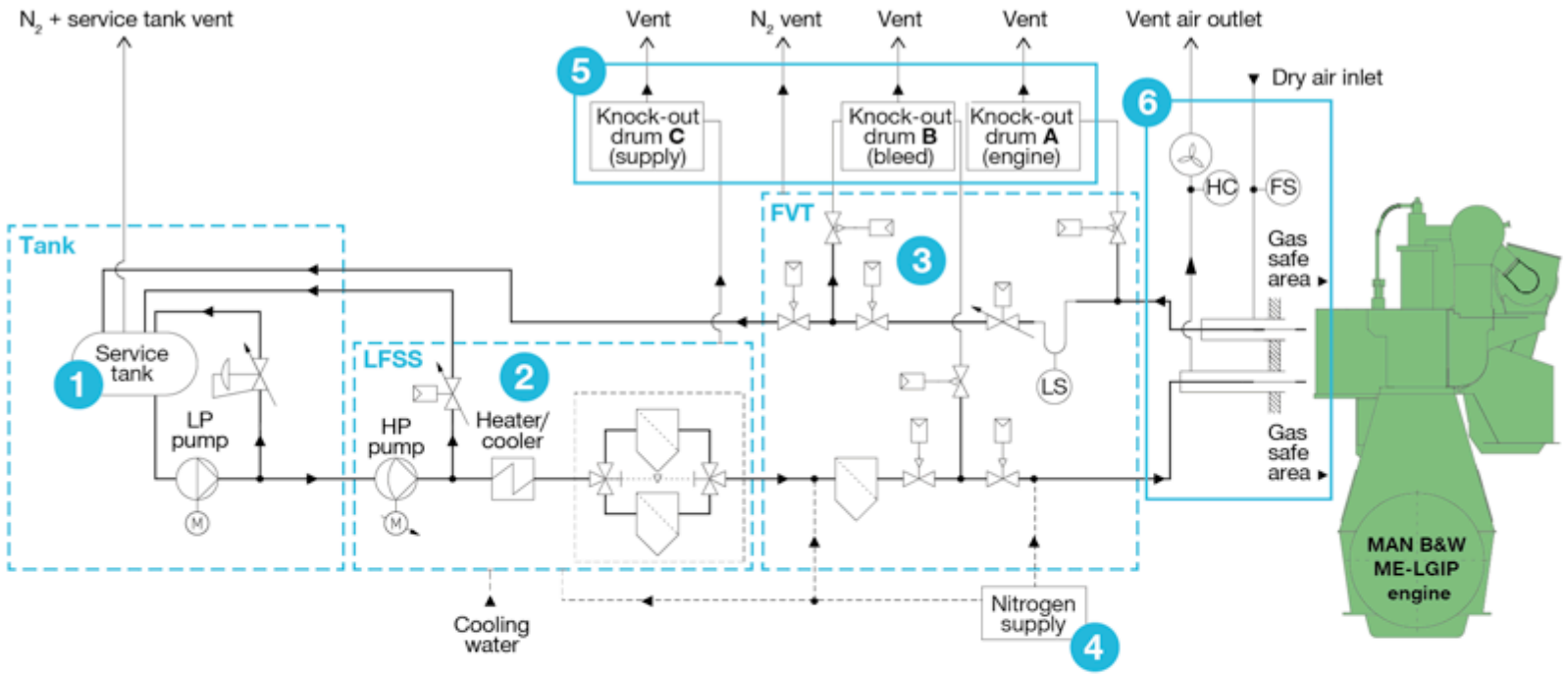
Double wall gas piping:

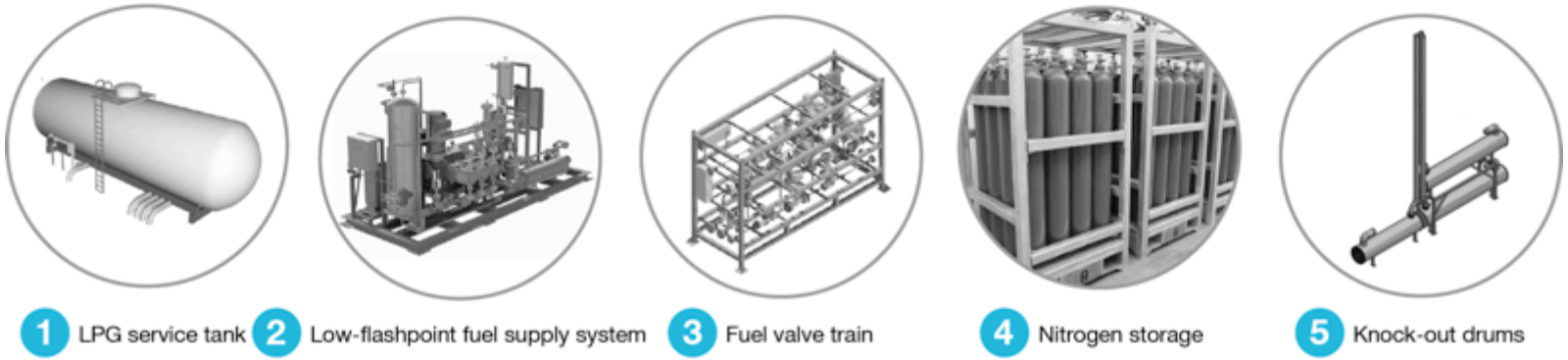
- LPG inlet
- LPG return



The new MAN B&W ME-LGIP engine

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

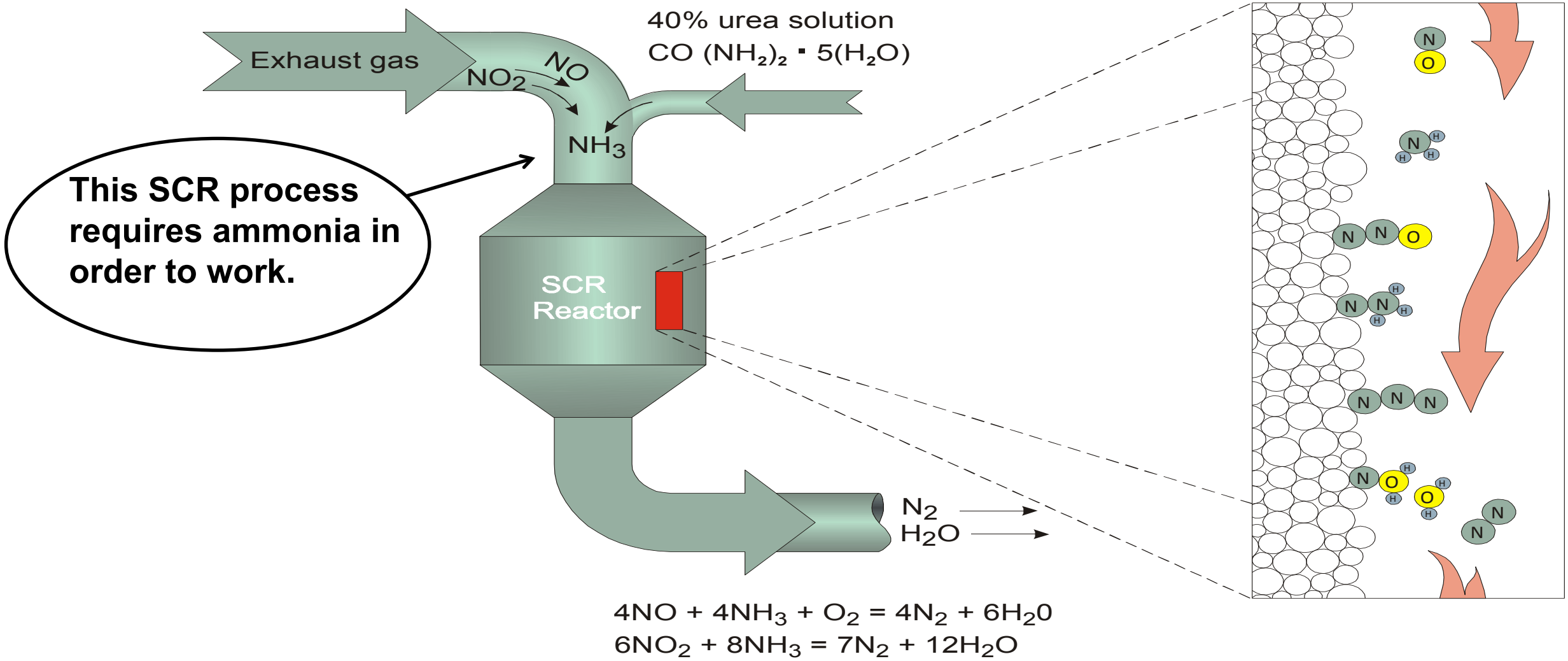




- **Development time of an ammonia engine 2-3 years**
- **We will be ready when the market comes**
- **Efficiency 50%**

NOx emission – ammonia.

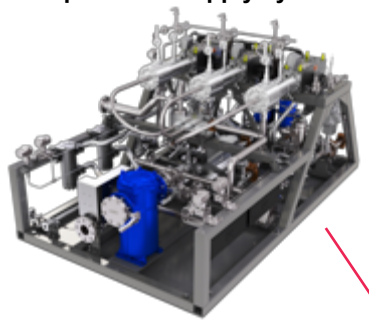
Selective Catalytic Reduction (SCR) Process – removing NOx emissions



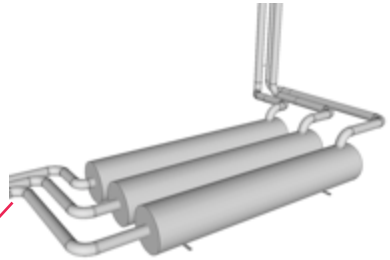
The new MAN B&W ME-LGIP engine

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

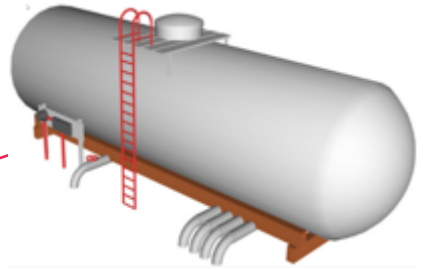
Low-flashpoint fuel supply system - PU



Knock-out drum

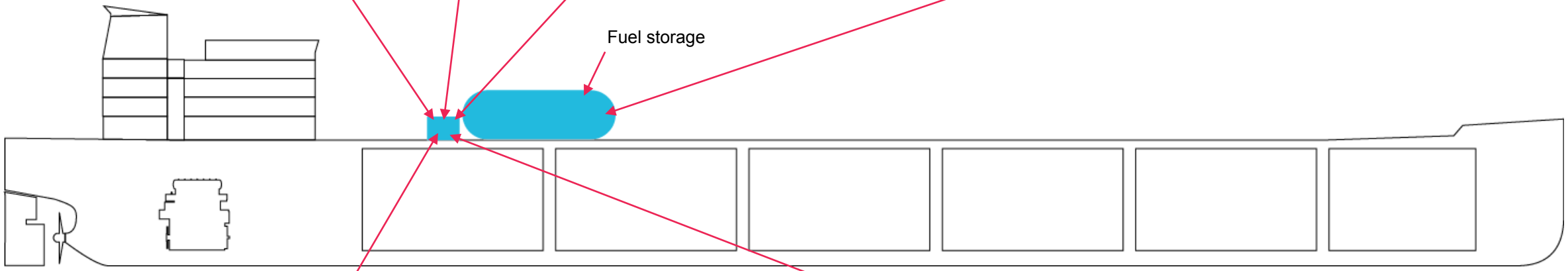


Fuel storage tank



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
- Engine Efficiency above 50% (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.

Thank you!

Do you have any questions?