Ammonia as a fuel for two-stroke powered vessels

MAN Energy Solutions
Future in the making

Unlocking the potential

Ernst Grauert Wilche
Principle Promotion Manager, Newbuildings
Ernst.wilche@man-es.com

1 Ammonia engine development update

2 Market introduction strategy

3 Summary

Unlocking the potential of ammonia as marine fuel

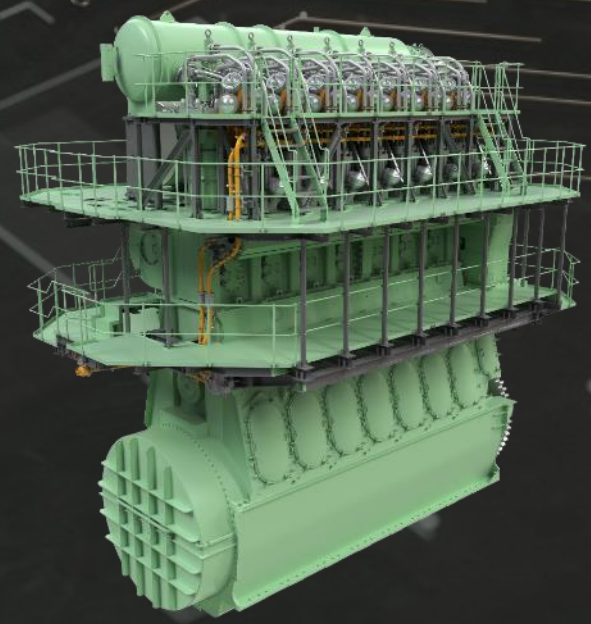
Important focus areas

Flamespeed

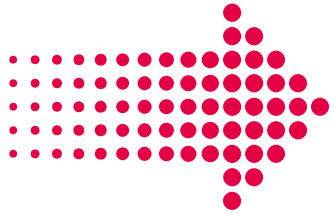
Auto ignition temperature

Combustion slip

N_2O

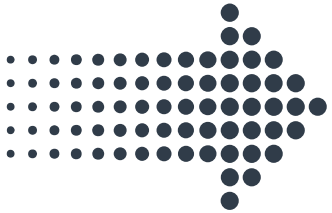


R&D timeline



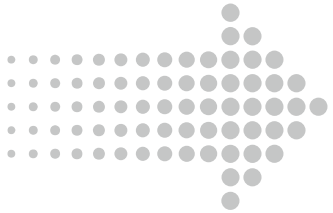
2019

- ✓ combustibility investigation.



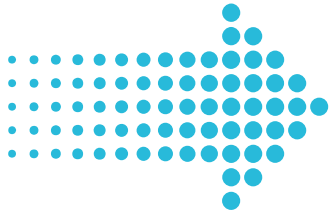
2020

- ✓ 4T50ME-X test engine received.
- ✓ HAZID on engine concept.
- ✓ Combustion chamber evaluation based on simulations.



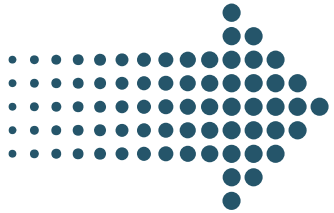
2021

- ✓ Engine concept defined based on R&D and simulations.
- ✓ Ammonia fuel supply & auxiliary systems specified.



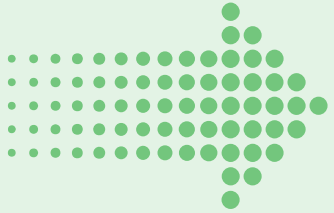
2022

- ✓ Ammonia fuel supply & auxiliary systems installed at RCC.
- ✓ 1 cylinder engine and auxiliary system preparation at RCC.



2023

- ✓ 1st bunkering of ammonia at RCC.
- ✓ 1 cylinder two-stroke ammonia combustion at RCC.
- ✓ Full scale design work. (on-going)
- ✓ Installation of emission after-treatment (HP-SCR).



2024

- Full scale engine test at RCC.
- 7S60ME-C10.5-LGIA R&D test at MES.

Two-stroke ammonia engine combustion

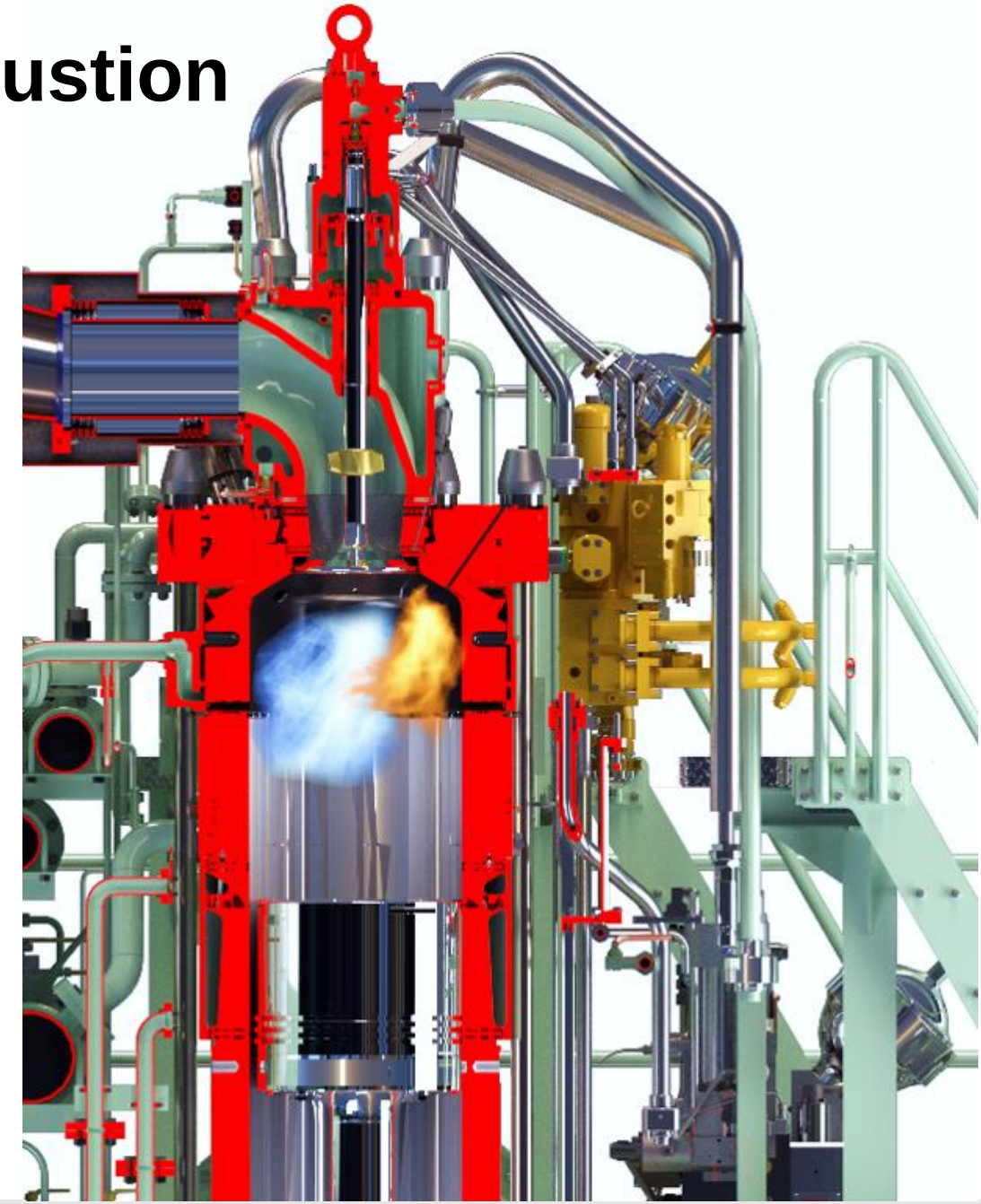
The MAN B&W ME-LGIA design philosophy

“Ammonia mode”:

- Small pilot flame needed.
- Target of 5% **S**pecific **P**ilot **O**il **C**onsumption at 100% load for L1-rated engines has been reached.
- Potential for further reductions, however 4-cylinder testing will showcase the full potential. The initial ME-LGIA engines will have 5% SPOC.
- We target to obtain same heat rate as “fuel oil mode”.

“Fuel oil mode”:

- We target identical performance as a conventionally fueled Diesel engine.



Engine emissions

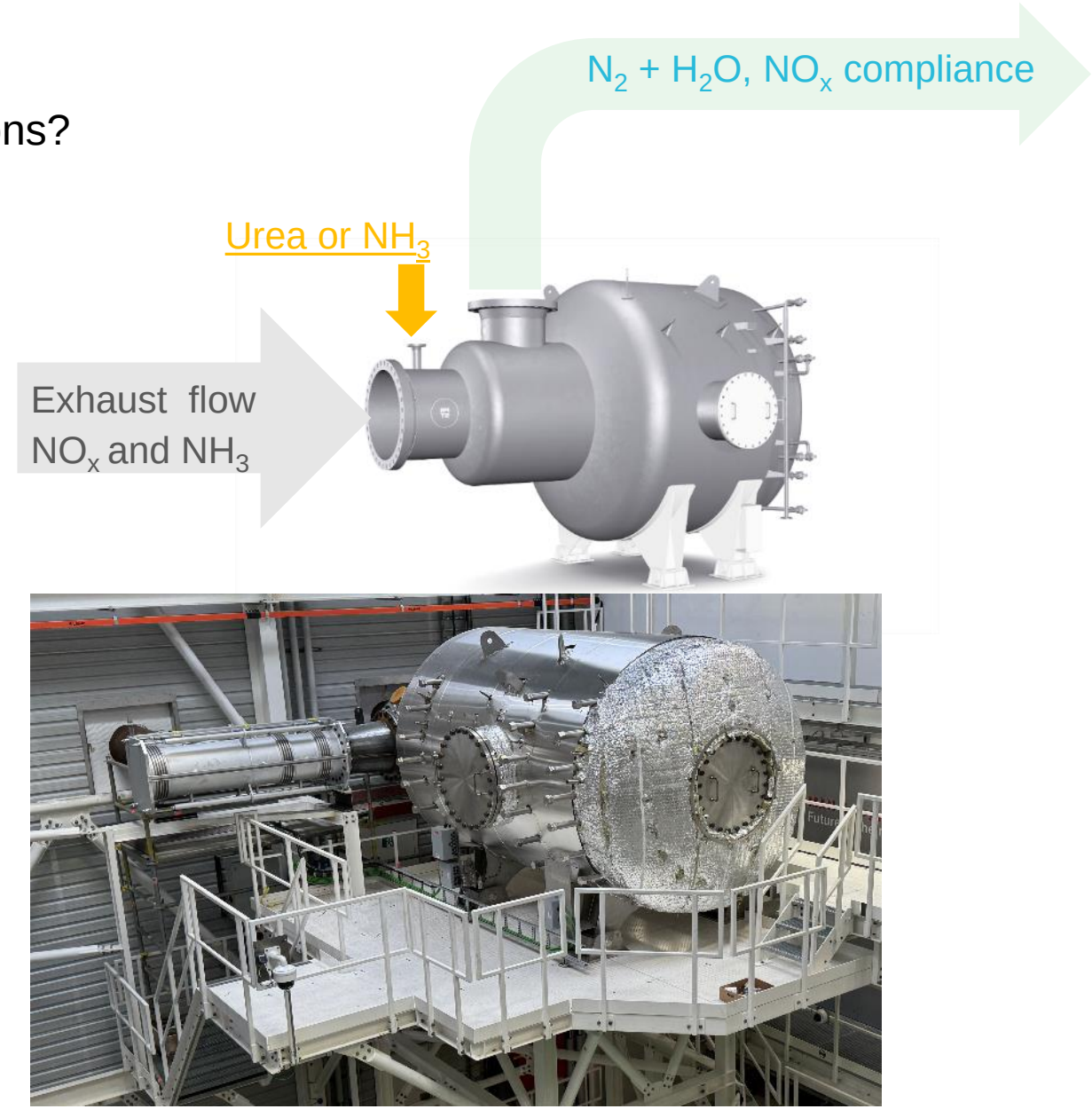
How do we handle potential Nitrous Oxide (N_2O) emissions?

N_2O is a very potent GHG with GWP of 298 and will be accounted in on-going adopted regulations

- N_2O will be removed by engine tuning alone, and emission levels are extremely low.
- Exact levels will be published to market after four-cylinder testing.

Ammonia slip and NOx emissions

- Unburned NH_3 and NO_x is removed in the SCR reactor
- Dosing of additional ammonia to SCR reaction if needed.
- Four cylinder testing will be used to find balance between NH_3 slip and NO_x



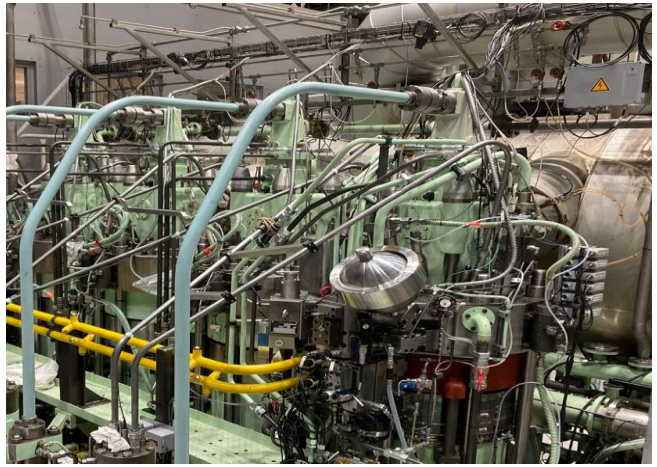
Two-stroke ammonia engine development update

The MAN B&W two-stroke ammonia engine is designated ME-LGIA

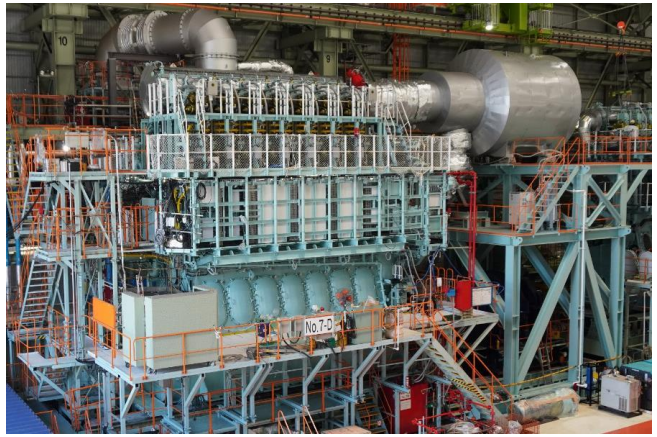
MAN B&W ME-LGIA status

- 12 months of ammonia combustion testing at **R**esearch **C**entre **C**openhagen completed on a two-stroke test engine.
- Combustion stability is very good.
- N_2O emissions are extremely low.
- NOx emissions are around 40% lower than fuel oil.
- Similar pilot oil amount as for methanol and LPG.

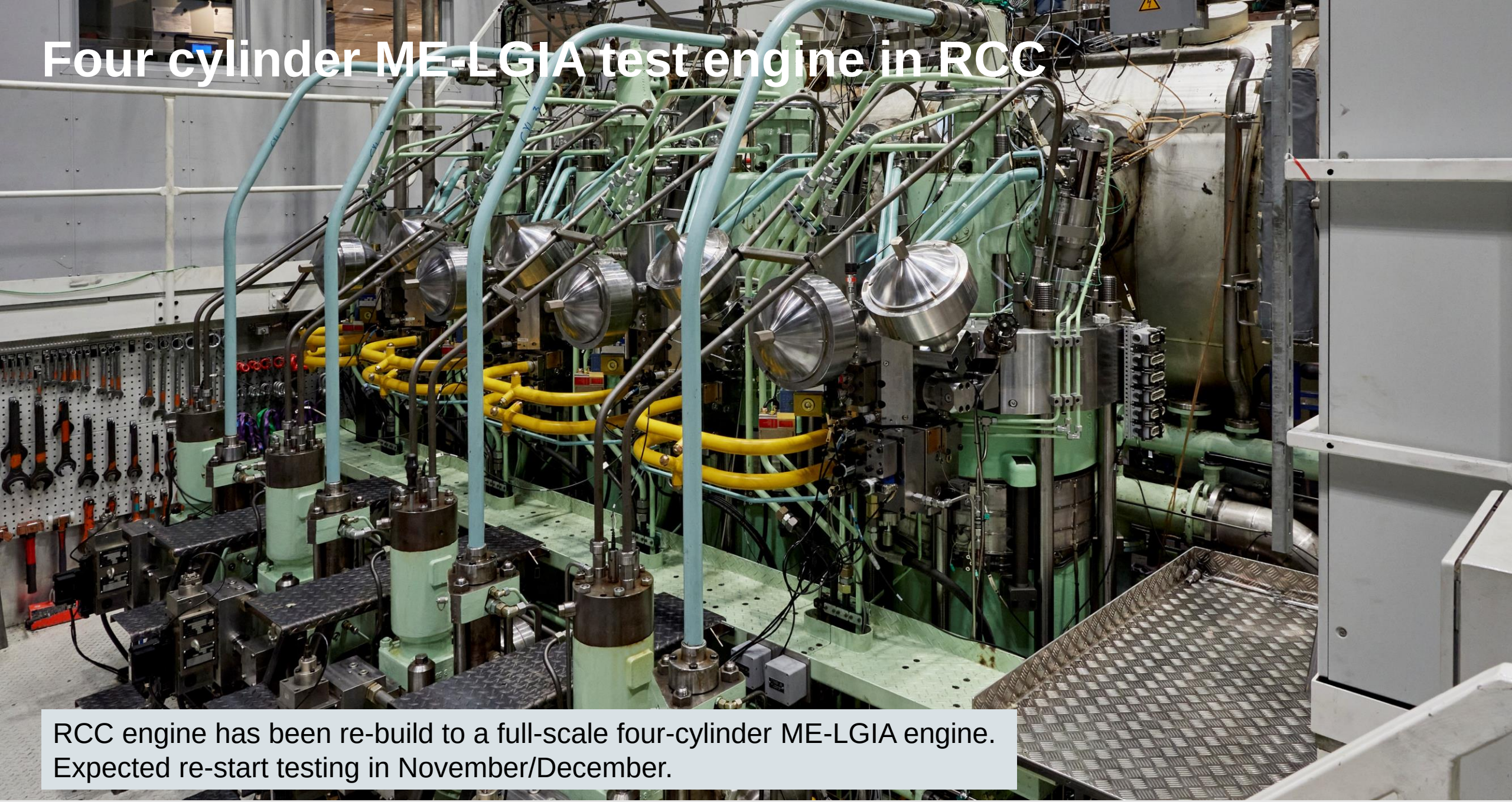
4 cylinder 50-bore test engine at RCC



7S60ME-C10.5-LGIA at Mitsui E&S Co., Ltd.



Four cylinder ME-LGIA test engine in RCC



RCC engine has been re-build to a full-scale four-cylinder ME-LGIA engine.
Expected re-start testing in November/December.

Ammonia engine auxiliary systems at RCC

Ammonia service tank

Ammonia supply and recirculation system

Fuel valve and return train

Nitrogen purging

Double wall ventilation and absorber

Ammonia catch system

7S60ME-C10.5-LGIA at Mitsui E&S Co., Ltd.

- 7S60ME-C10.5-LGIA at MES has been operated on Diesel. Currently the ammonia auxiliary systems are being finalized.

1 Ammonia engine development update

2 **Market introduction strategy**

3 Summary

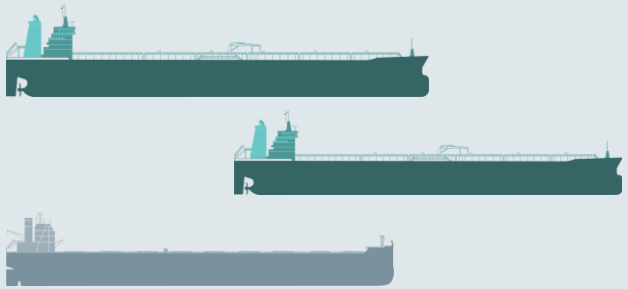
Two-stroke ammonia engine main development timeline

Pilot projects in Korea, Japan and China.

Full release of **G50**, **S60**, **G60**, **G70** and **G80 ME-LGIA** to the market as soon as the first vessel or vessels have demonstrated positive seagoing service experience operating on Ammonia. As such the actual **time schedule will be pending shipyard delivery schedule**.

A best guess time estimate for sales release of these engines is **end of 2026.**

R&D development Copenhagen



Positive seagoing experience of pilot projects 2026-2027

Full sales release

1 Ammonia engine development update

2 Market introduction strategy

3 **Summary**

Summary

MAN B&W ME-LGIA status

1. Ammonia is a **great fuel** in slow speed two-stroke engines
2. Combustion stability **similar to fuel oil**
3. N_2O emission levels are **negligible**
4. NOx emission levels **are 40% lower than fuel oil**
5. Pilot oil amount **similar to methanol and LPG**
6. Toxicity challenges of ammonia are being handled with **success** in our RCC in the middle of Copenhagen
7. **However,** in order to safeguard the uptake of ammonia as marine fuel, we have a **responsible** implementation plan with a number of pilots going into service to obtain service experience prior to full sales release to market
8. **MAN Energy Solutions is the market leading** for two-stroke ammonia engine development with dedicated two-stroke ammonia combustion on-going for more than 12 months, with a dual-fuel concept of which we have a decade of experience.

MAN Energy Solutions
Future in the making

Thank you very much!

Disclaimer

All data provided in this document is non-binding.
This data serves informational purposes only and is especially not guaranteed in any way.
Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.