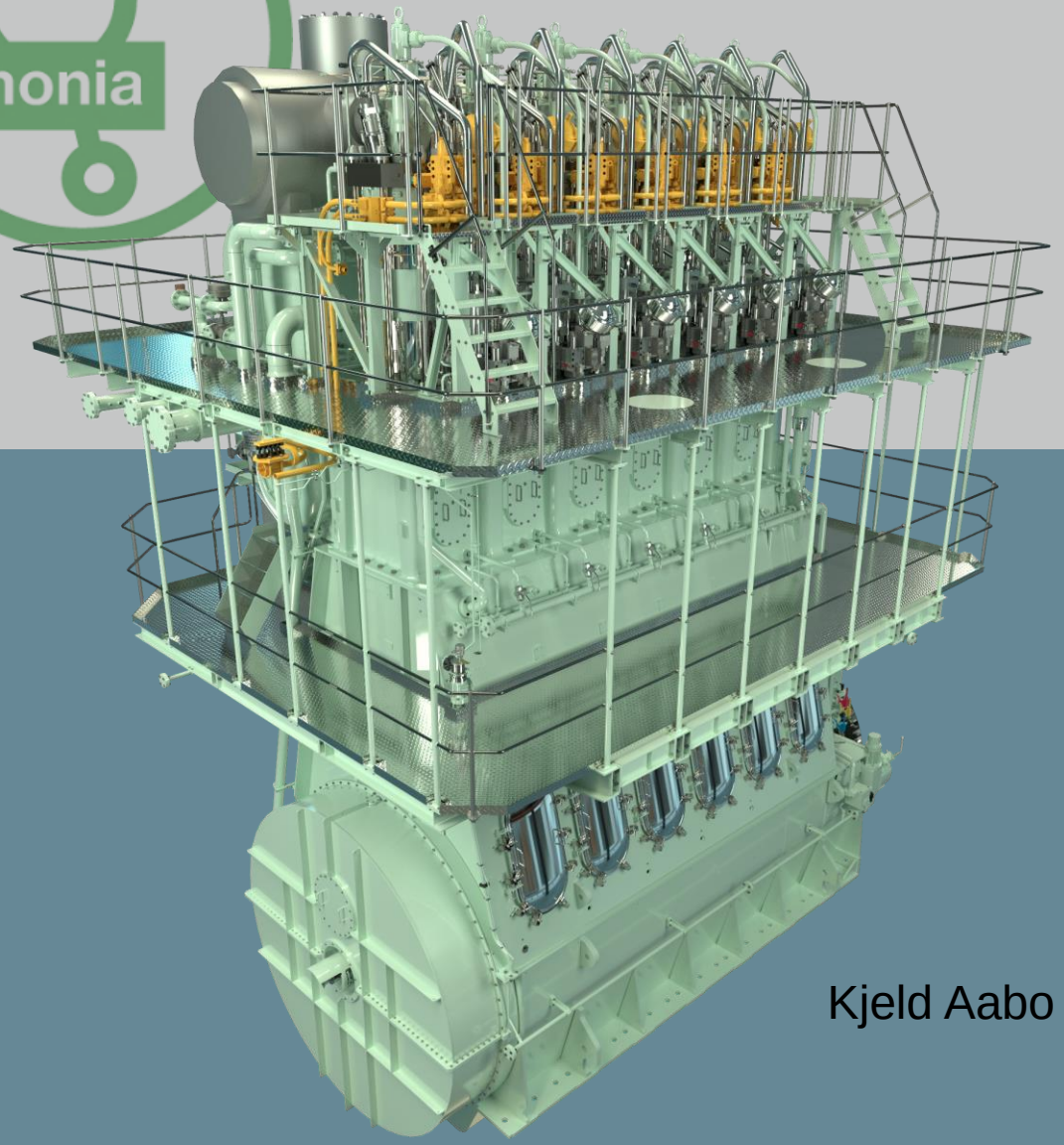
MAN Energy Solutions
Future in the making

Ammonia Energy Association

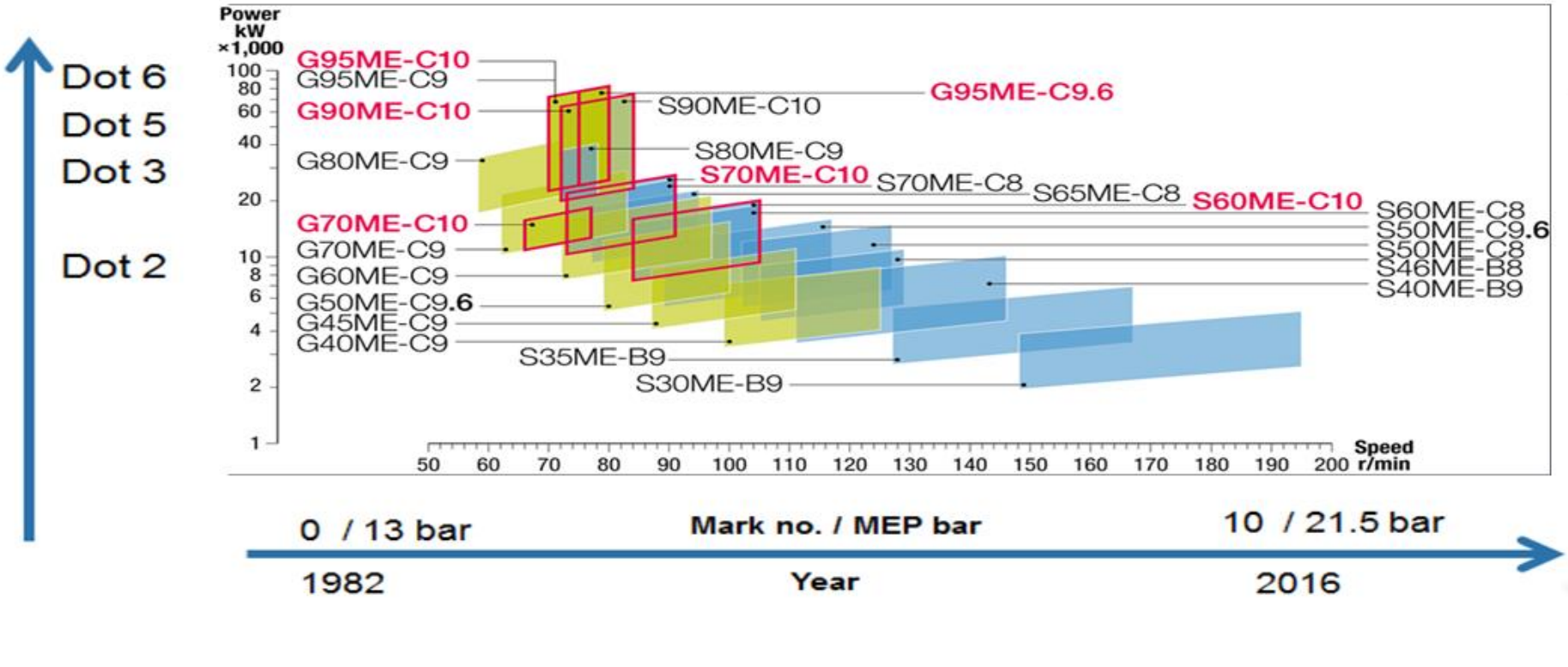
August 2022 Melbourne

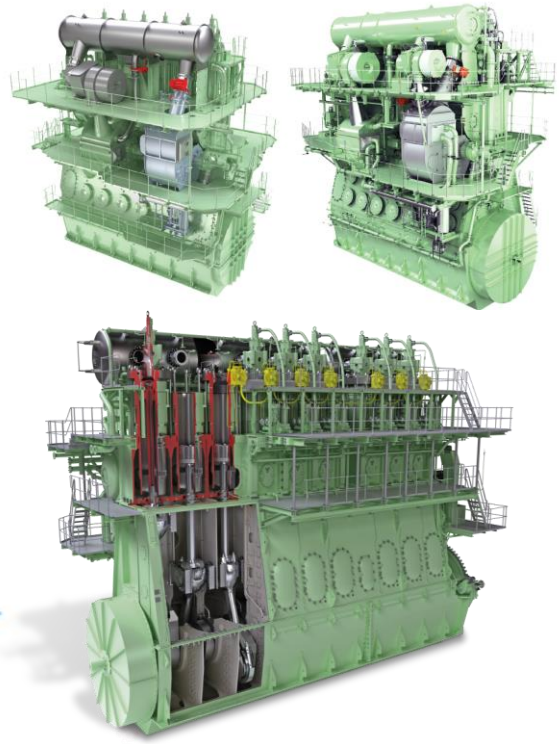
MAN B&W Ammonia engine



Kjeld Aabo

Engine Programme Development



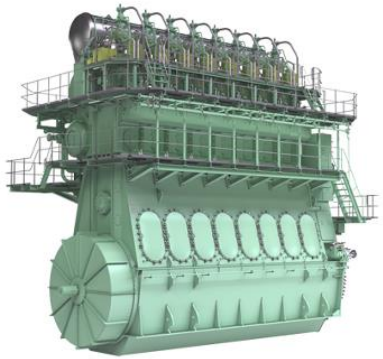
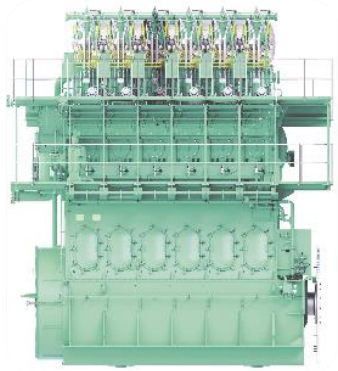
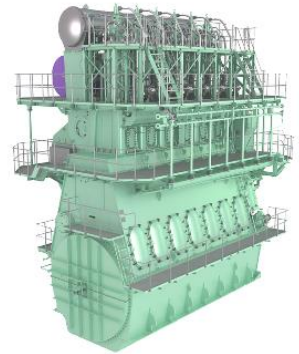


Mission: Meet any combination of propeller power and speed the naval architects will need

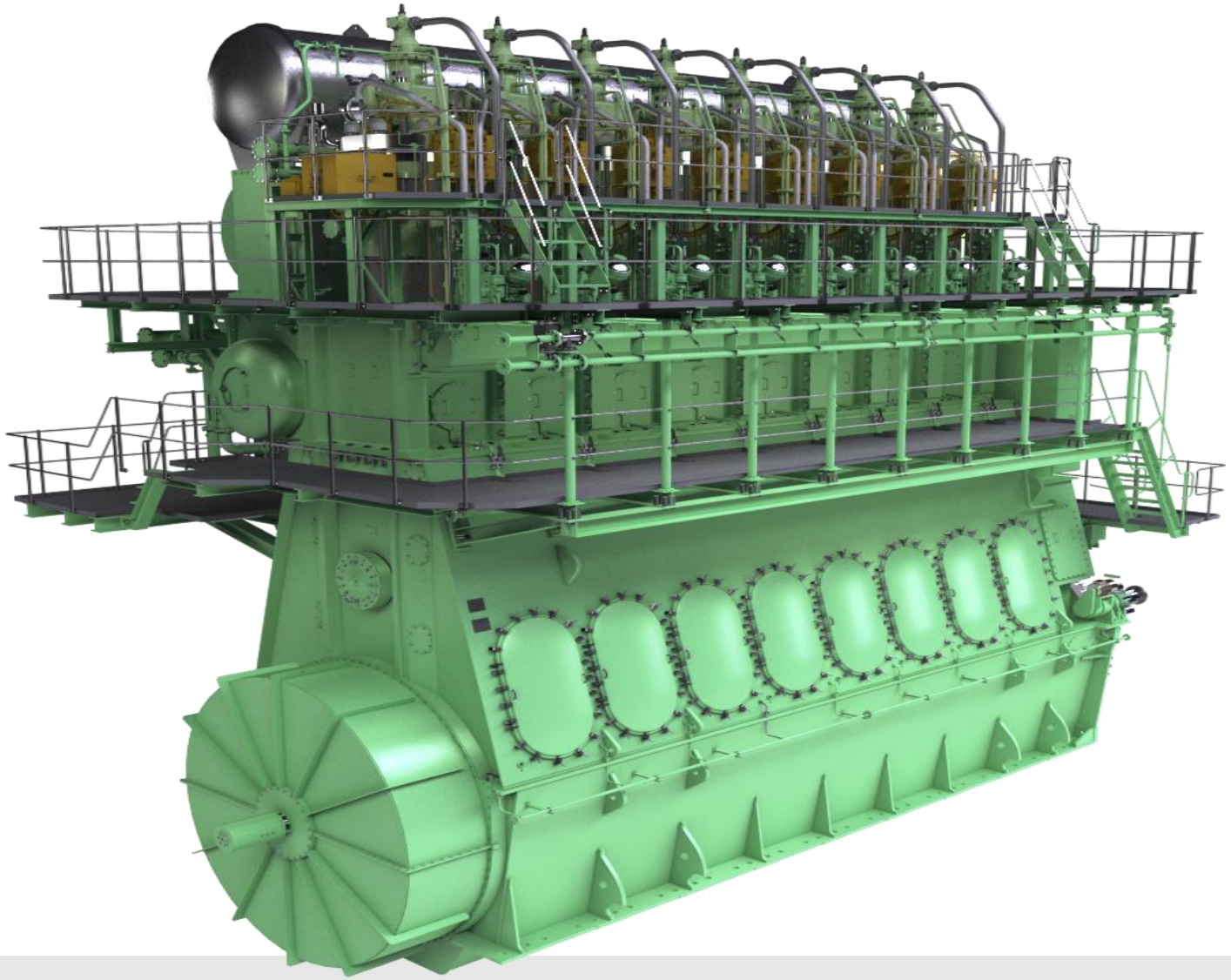
MAN B&W two-stroke engines for alternative fuels

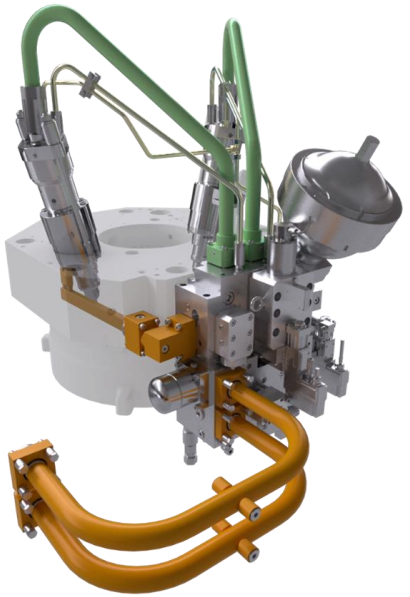
Extensive experience in the development of dual-fuel engines

MAN B&W dual fuel portfolio based at the “diesel principle”. (and not Otto Cycle)

LNG	Ethane	Methanol	LPG	Ammonia
ME-GI	ME-GIE	ME-LGIM	ME-LGIP	→ 2024
				
459 engines	71 engines	56 engines	124 engines	

ME-GI and ME-LGI engines for future fuels





Ammonia engine development

The LGI combustion principle

Ammonia combustibility

- Ammonia is not a hydrocarbon.
- It doesn't burn like hydrocarbons.
- It reacts much slower than hydrocarbons.

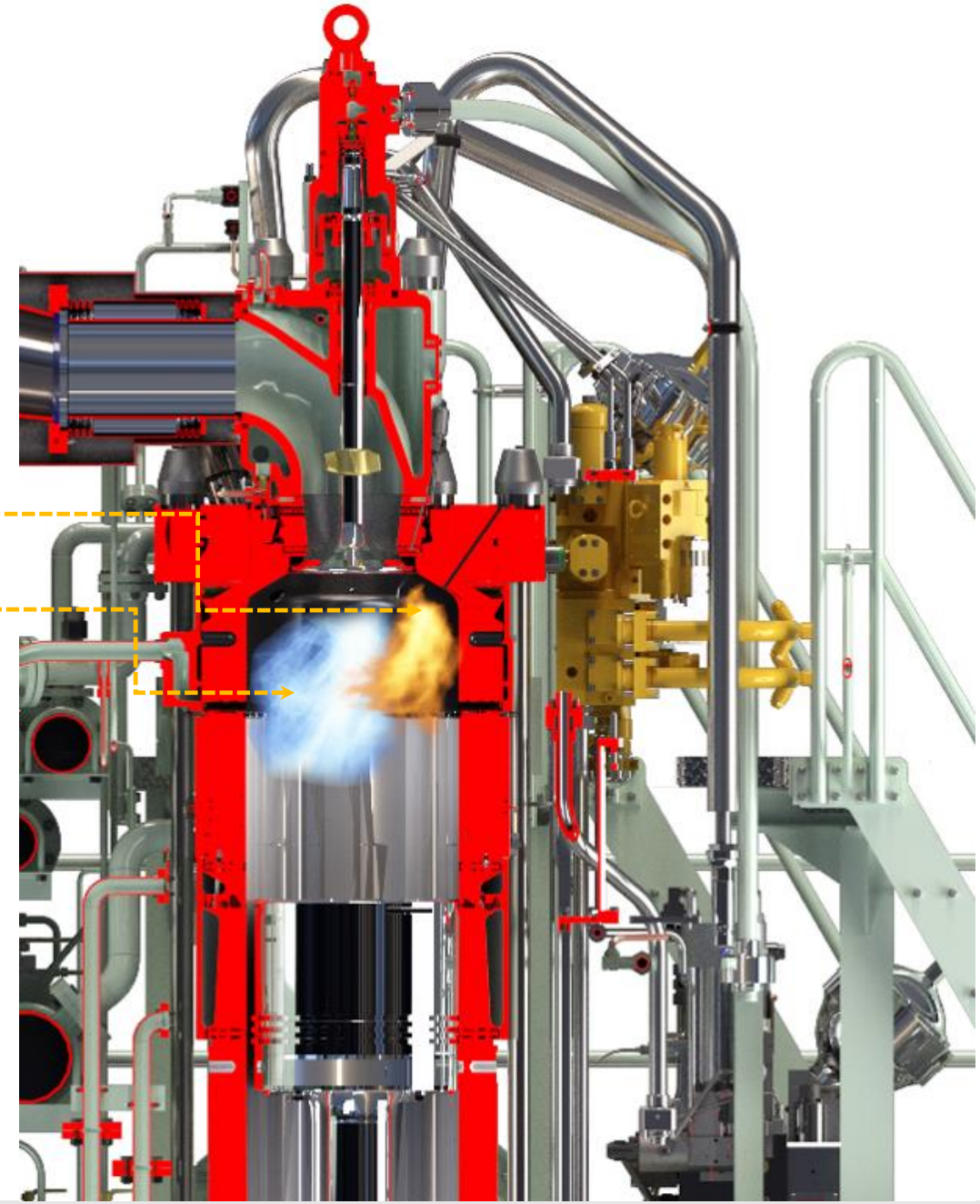
The MAN B&W ammonia engine design philosophy

"Ammonia mode":

- Small pilot flame.
- Ammonia ignited by the pilot flame.

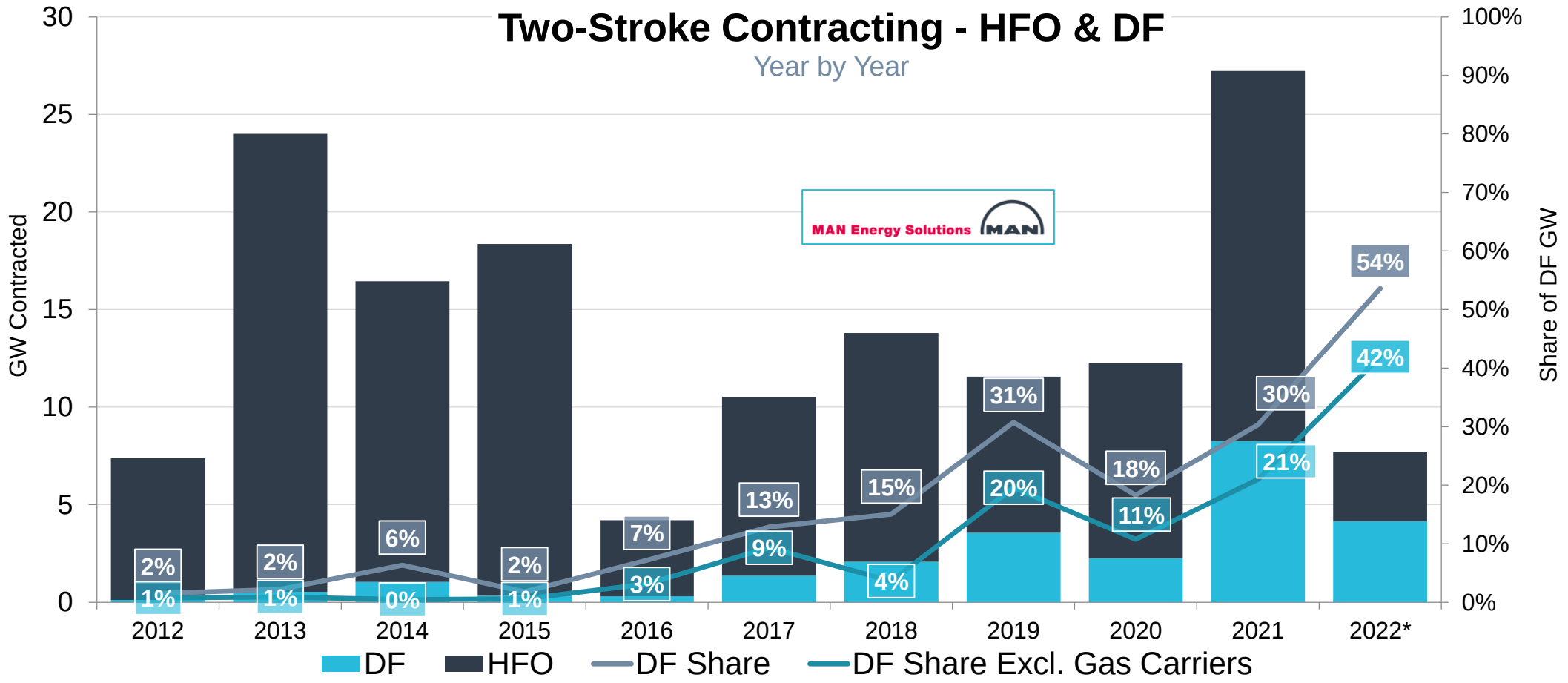
"Liquid fuel mode":

- Identical performance as conventional fueled Diesel engine.



Conventional and DF Two-Stroke Vessel Contracting

In 2021, DF contracting gained pace in a large volume market and the trend is persistent

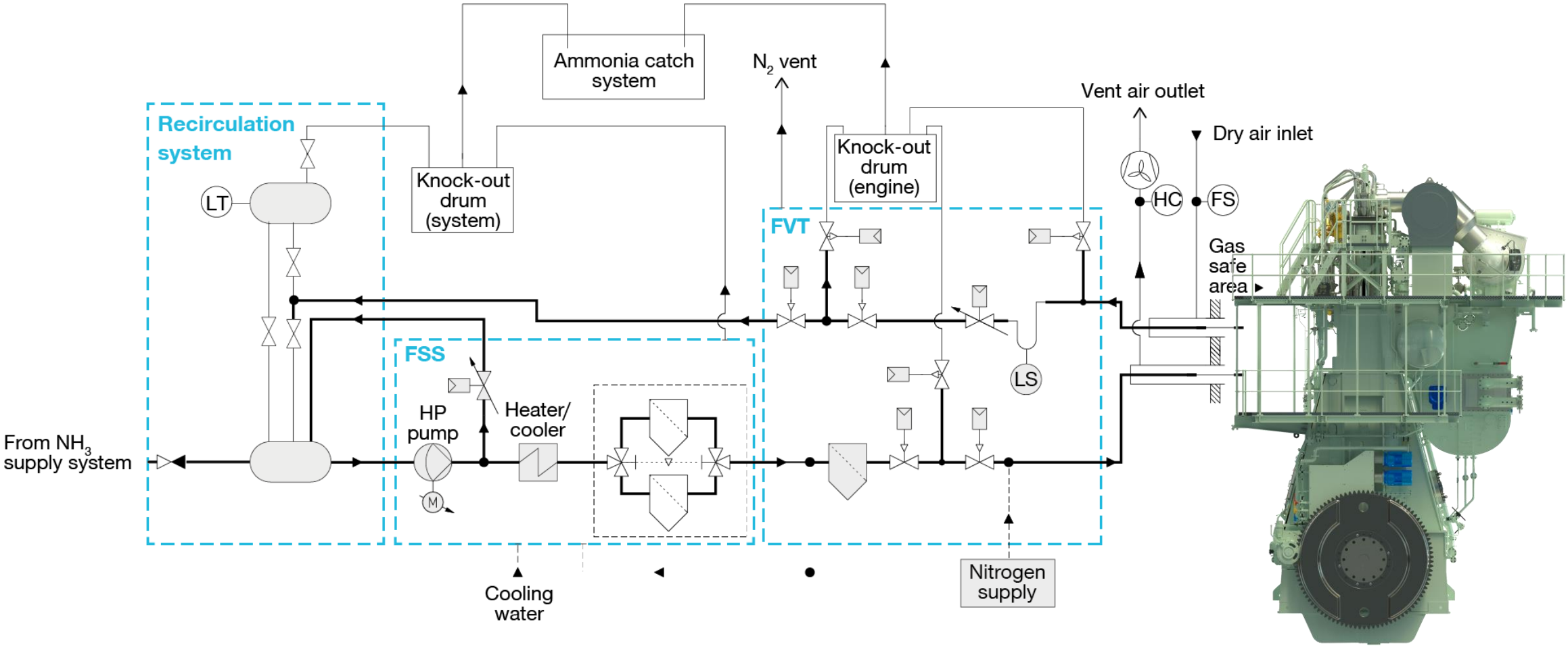


* Preliminary Year to Date (end May 2022)

Source: IHS Markit

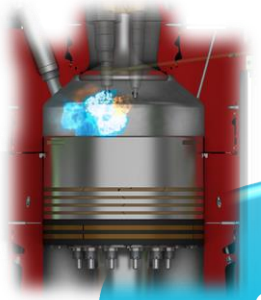
Ammonia engine development

Auxiliary systems



Ammonia engine development

Main focus areas in the development



Studies ongoing

COMBUSTION

Studies ongoing

EMISSIONS

Solution in scope

ELASTOMER COMPATIBILITY

HAZID completed

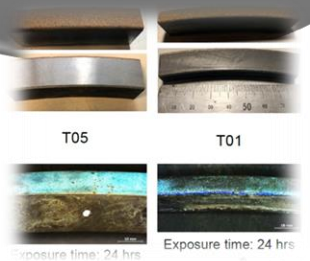
SAFETY

Catch concept defined

ODOR/VENTING

CORROSION OF MATERIALS

Solution in scope



Studies ongoing

MAINTENANCE INTERVALS

Two-stroke ammonia engine development schedule

Pre-study

- ✓ NH3 combustibility investigation

Project kick-off

- ✓ 4T50ME-X test engine received as platform for the Ammonia engine development
- ✓ HAZID workshop on engine concept
- ✓ Combustion chamber 1st evaluation

Engine concept R&D

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

Engine combustion and emission

- ✓ Ammonia fuel supply & auxiliary systems established in Research Centre Copenhagen (RCC)
- 1st engine confirmation at RCC
- Specification of emission after-treatment

Full scale engine test

- Full scale engine test at RCC evaluated for 1st commercial design

1st engine delivery to yard

- First commercial design available
- 1st ammonia fueled engine delivered to yard

Modular design enables extensive retrofit options

By ensuring full fuel flexibility and extensive retrofit capabilities with a proven record, MAN Energy Solutions future proof your investment

Fuel types	ME-C	ME-GI	ME-GA	ME-GIE	ME-LGIM	ME-LGIP
Fuel oil	✓	✓	✓	✓	✓	✓
LNG	Retrofit	✓	✓	Retrofit	Retrofit	Retrofit
LEG (Ethane)	Retrofit	Retrofit	-	✓	Retrofit	Retrofit
Methanol	Retrofit	Retrofit	-	Retrofit	✓	Retrofit
LPG	Retrofit	Retrofit	-	Retrofit	Retrofit	✓
Ammonia	Retrofit	Retrofit	-	Retrofit	Retrofit	Retrofit

Four-stroke small-bore engine development

Roadmap for future fuels

Indicative timelines of market introduction of future fuel MAN four-stroke small-bore auxiliary engines

Future fuels are not yet readily available in the quantities the maritime industry requires.
The four-stroke small-bore engine program therefore supports **transitional adoption** of future fuels.

Today
- ✓ Bio-fuel oils*
- ✓ Synthetic-fuel oils
- ✓ Methane

2023
Methanol
and diesel

~2025
Hydrogen
and diesel

Long-term
Ammonia
and diesel

* Proven reliability for bio-fuels in accordance to ISO 8217. Lot's of service experience for bio-fuels outside ISO 8217, but confirmation will need to be made per request.

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.

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Thank you very much!