

EMSA 18-20 Oct. 2022 in Lisbon



Future fuels and engine design

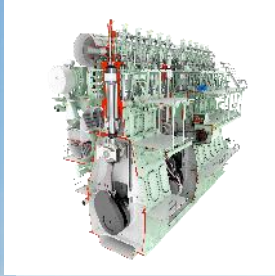
Special attention Biofuels and Ammonia



MAN Energy Solutions
Future in the making

Kjeld Aabo
Director New Technologies
Two stroke sales and promotion

The world's leading designer of two-stroke Diesel engines



**Design of
two-stroke engines**



**Production of
spare parts**



PrimeServ Academy



R&D Centre



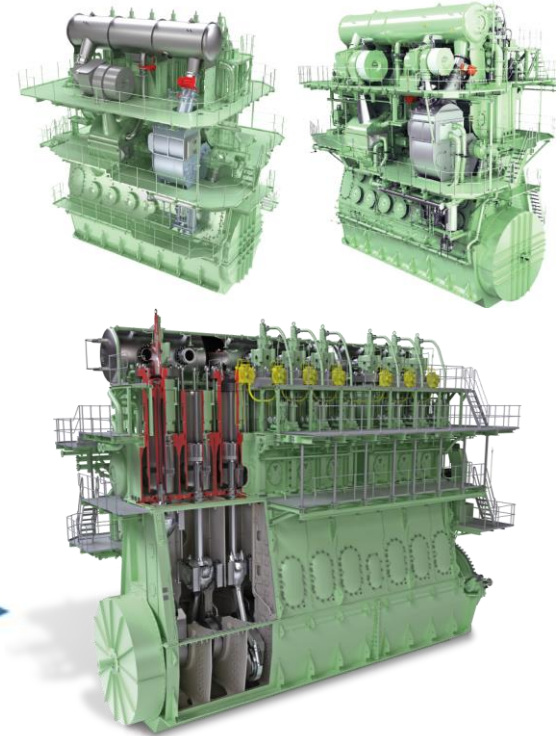
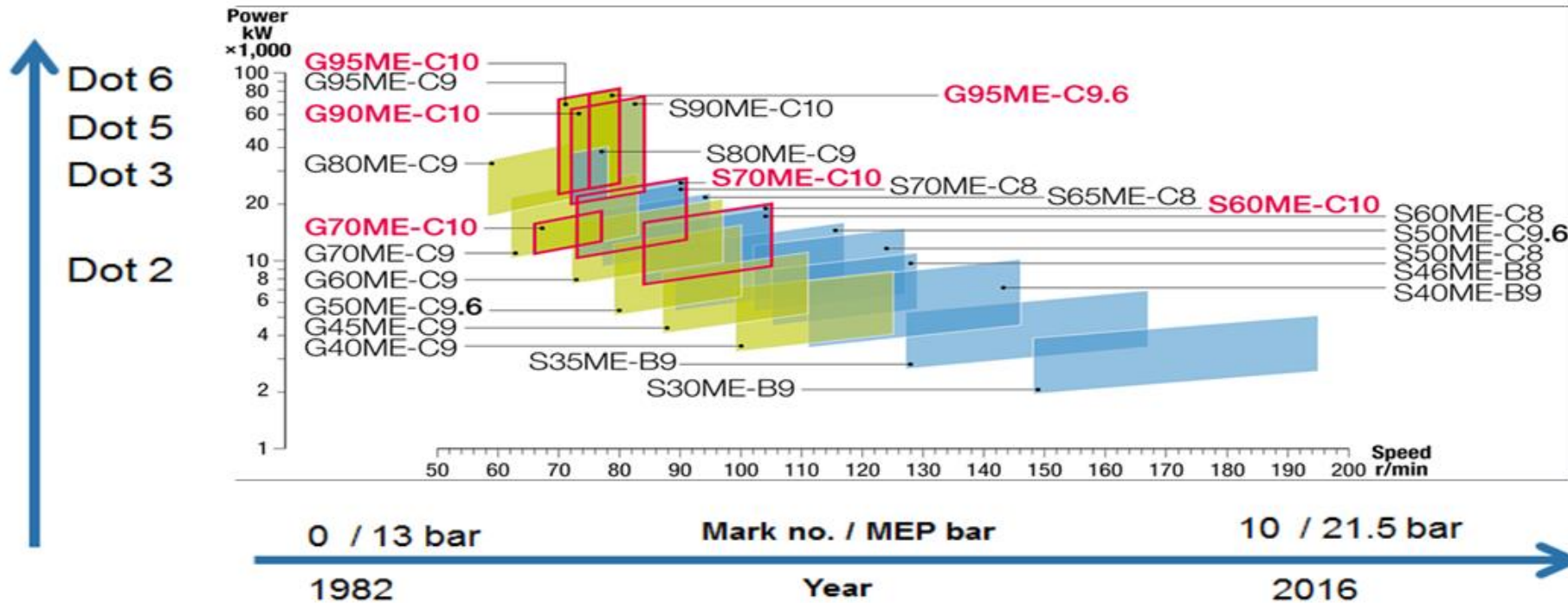
Diesel House



80-90% of global freight is
transported by sea.

~ 50 % of global freight
are transported by a MAN
ES engine.

Engine Programme Development



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

Biofuel in large two-stroke engines



Why biofuel in marine?

- Current focus on reducing greenhouse gas emissions from shipping.
- No need for extensive re-builds.
- Customers seem to be willing to pay a premium for the transport if a "green" fuel can be used.

There is not enough biofuel for everyone - but biofuel can play its part in the marine world

Challenges

1. Fuel standards / ISO 8217
2. Technical and operational challenges
3. Emissions and NOx compliance
4. Sustainability and net CO₂ savings of the biofuel.



Biofuel today

Making biofuel a marine fuel



MAN ES has published

- Technical guidance
- Evaluation of NOx emissions

Biofuels covered by MAN ES guidelines

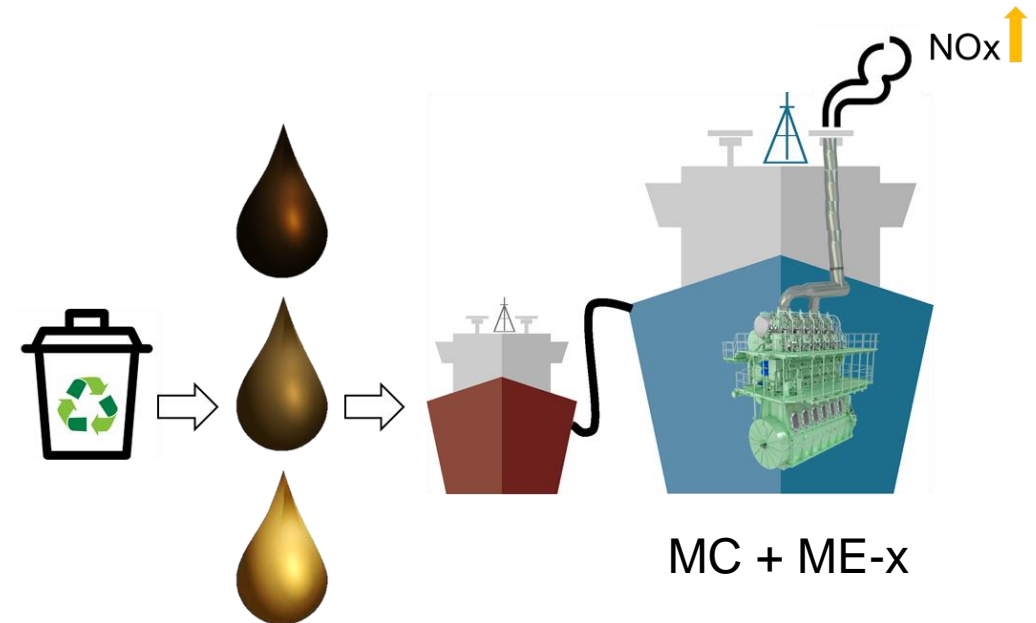
- Fatty acid methyl esters (FAME)
 - Blends with ISO 8217 compliant DM and RM-grades
- Similar FAME-type fuels
- Hydrotreated vegetable oil (HVO)

Sustainability of the biofuels should be considered.



IMO

- IMO approved biofuel as fossil fuel regarding NOx compliance.



Powering sustainable **shipping** by opening clear routes

MAN Energy Solutions

LNG

Ethane

Methanol

LPG

Ammonia

ME-GI
459
engines

ME-GA
192
engines

ME-GIE
31
engines

ME-LGIM
72
engines

ME-LGIP
124
engines

→ **2024**

2011

2019

2016

2015

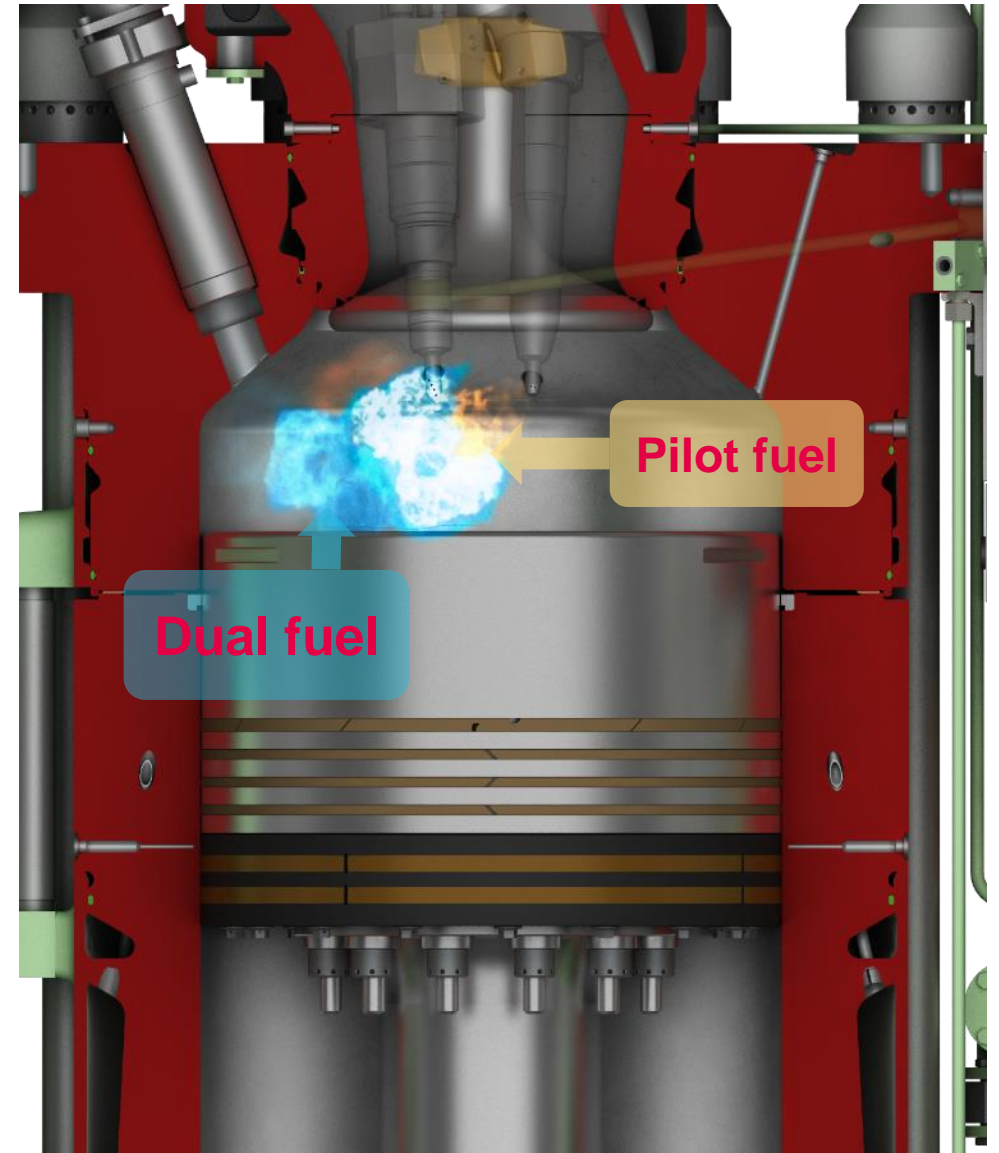
2018

The Diesel combustion principle

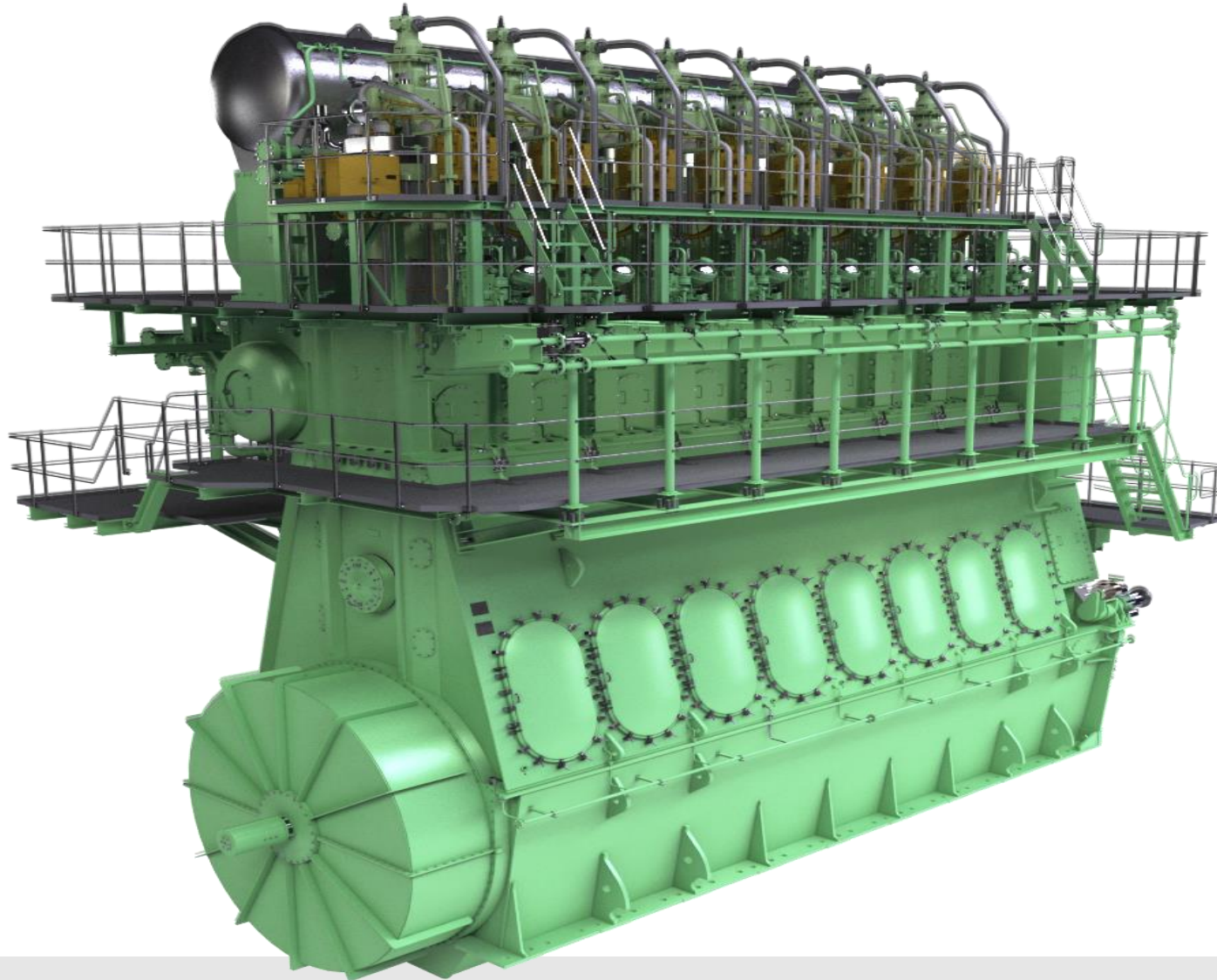
ME-GI and ME-LGI

2 running modes

1. “Dual fuel mode”:
 - Small pilot flame (hydrocarbon fuel)*.
 - Dual fuel ignited by the pilot flame.
2. “Liquid fuel mode”:
 - Identical performance as conventional fueled Diesel engine.

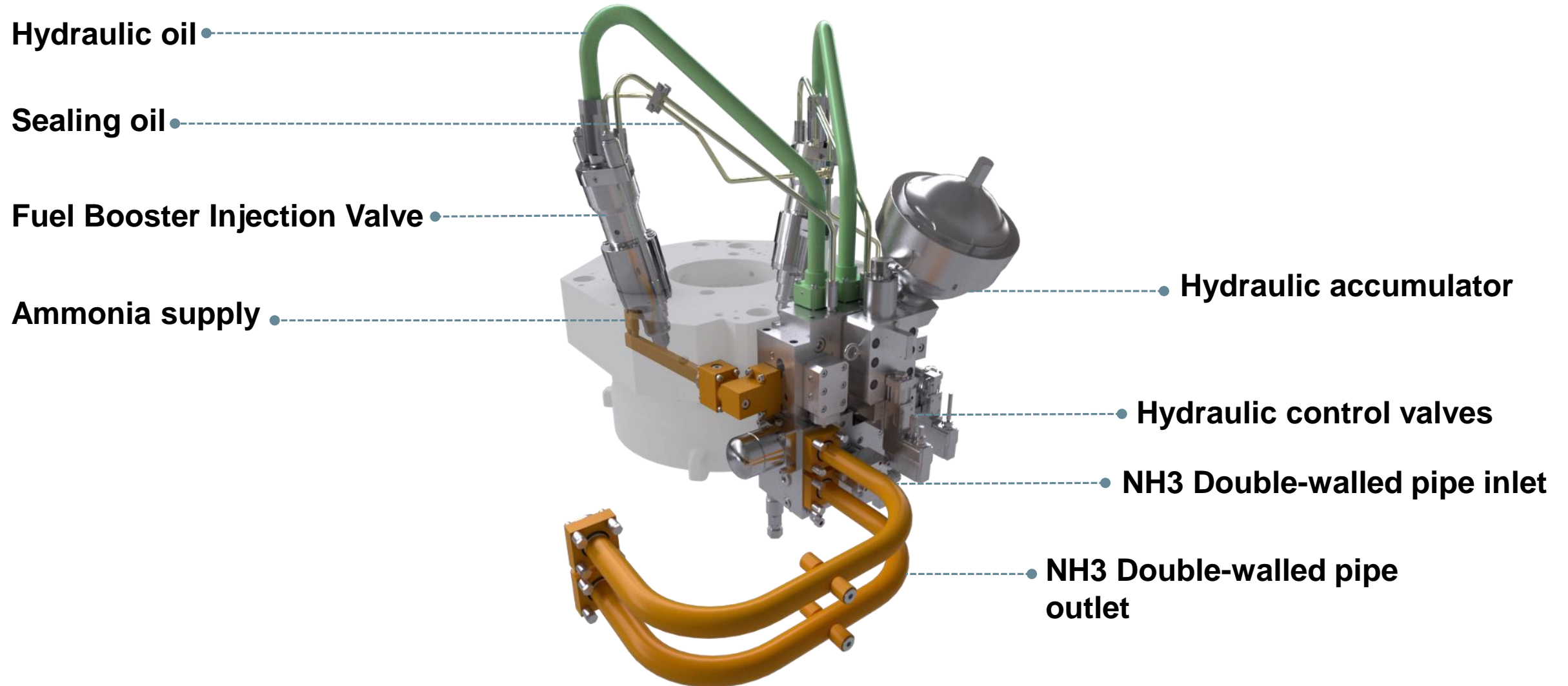


ME-GI and ME-LGI engines for future fuels



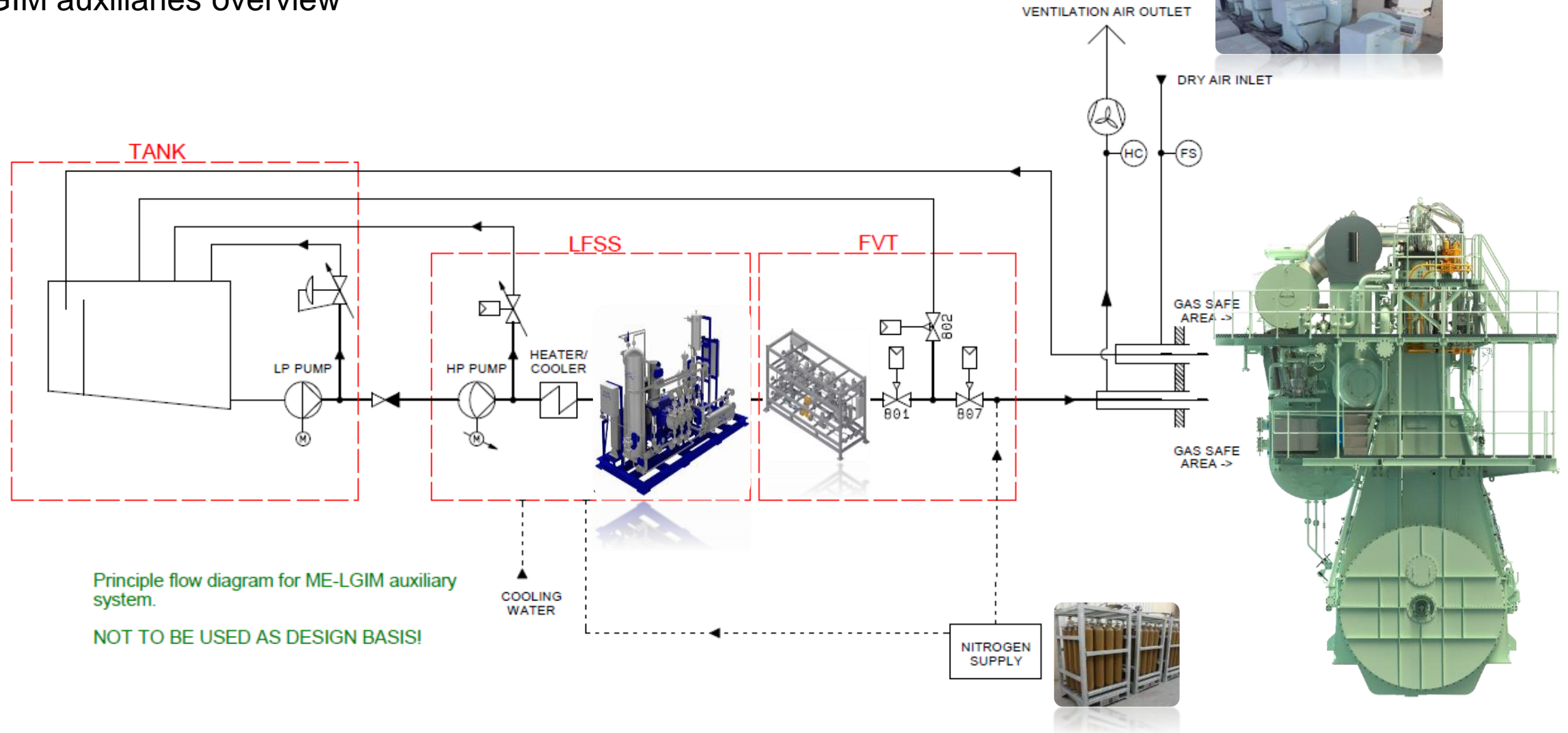
Ammonia engine development

The LGI injection system



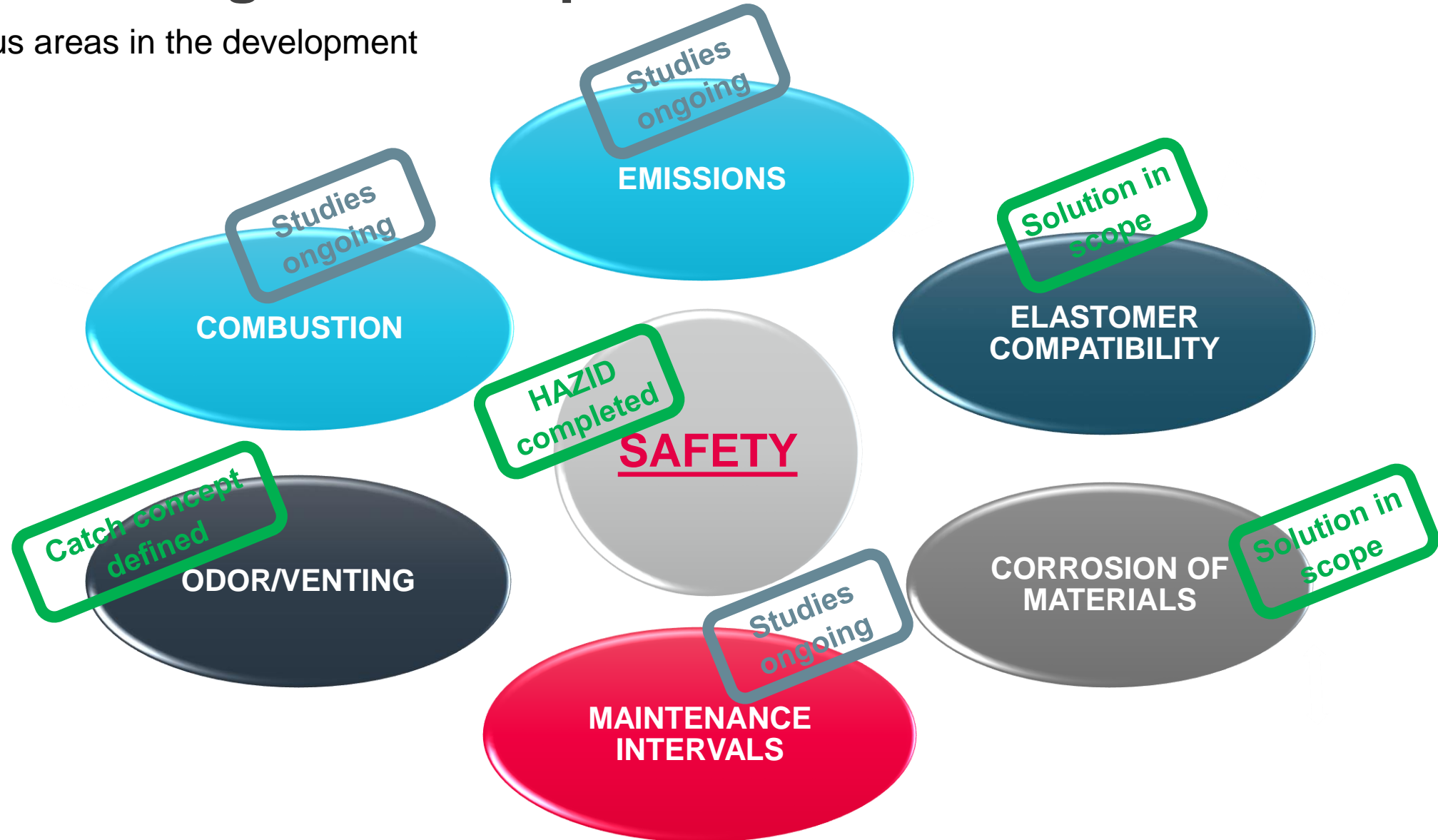
Fuel supply system

ME-LGIM auxiliaries overview

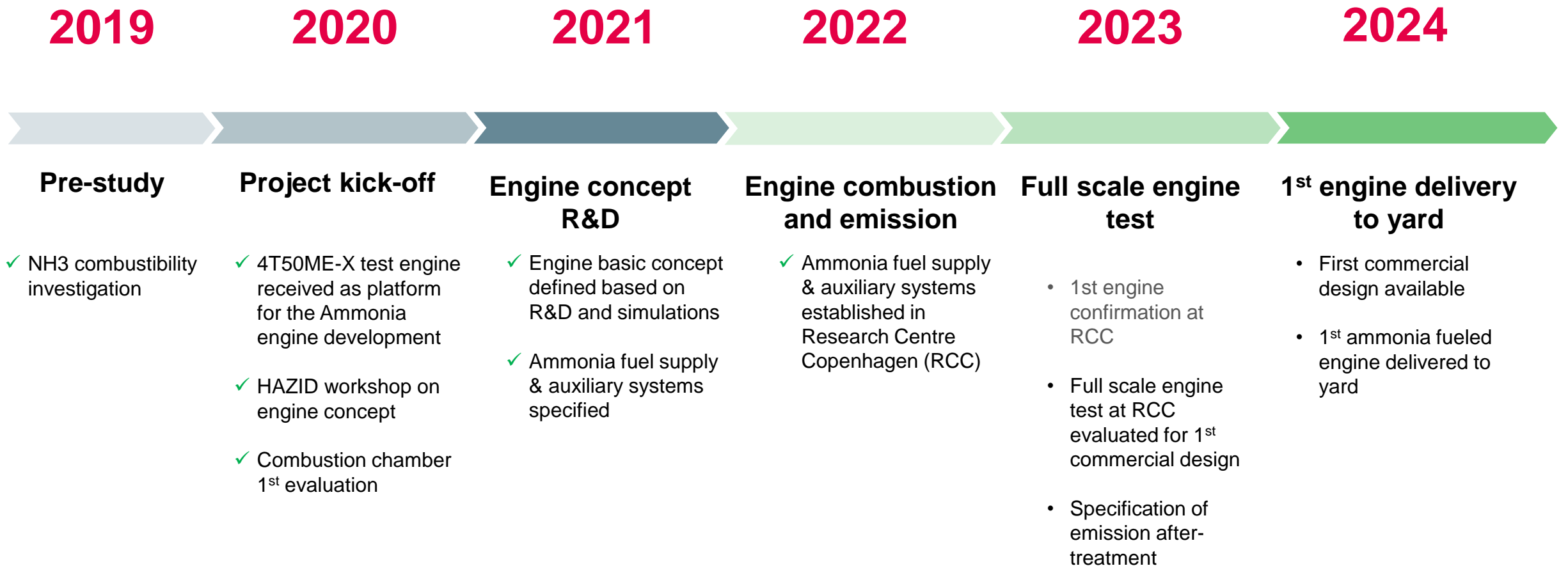


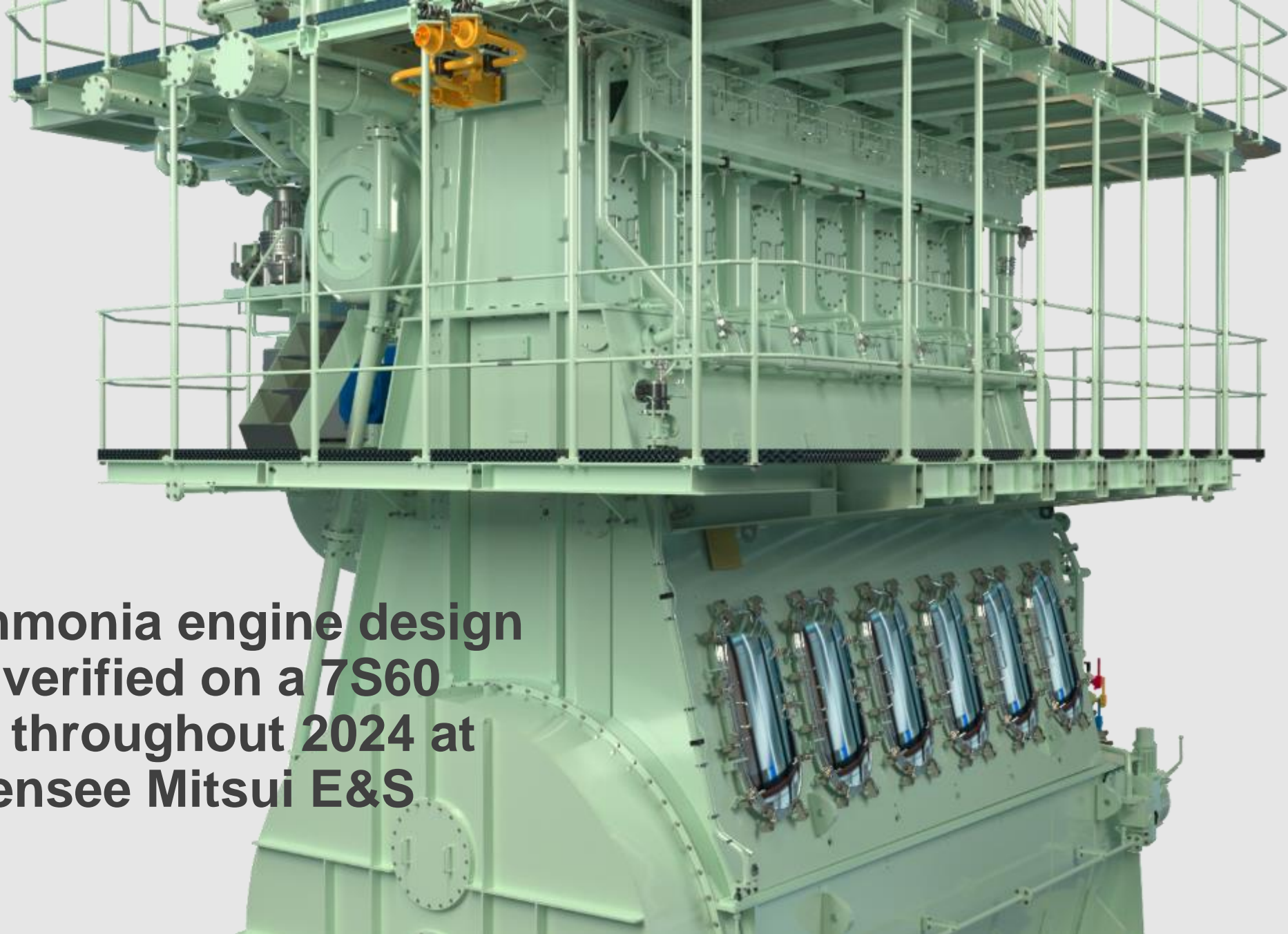
Ammonia engine development

Main focus areas in the development



Two-stroke ammonia engine development schedule





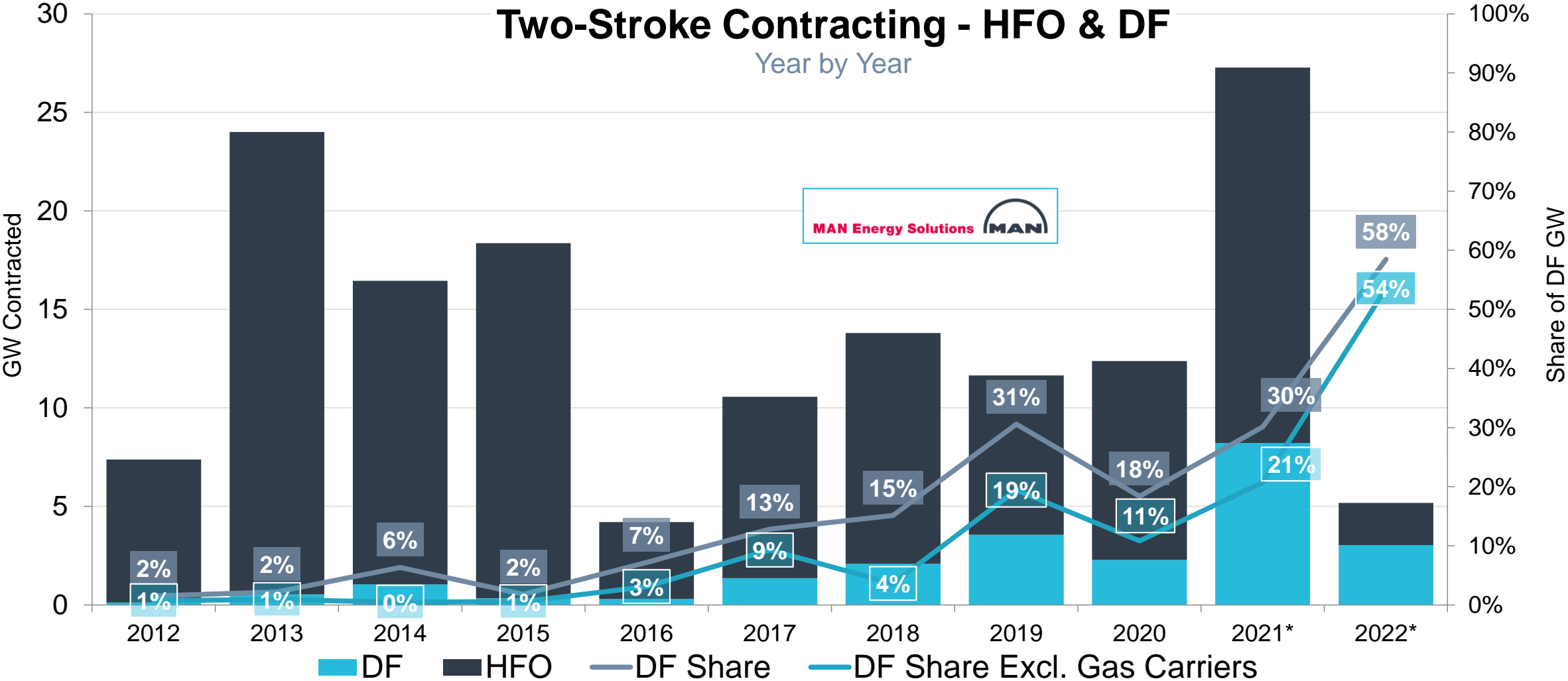
**The ammonia engine design
will be verified on a 7S60
engine throughout 2024 at
our licensee Mitsui E&S**

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

Conventional and dual-fuel two-stroke contracting

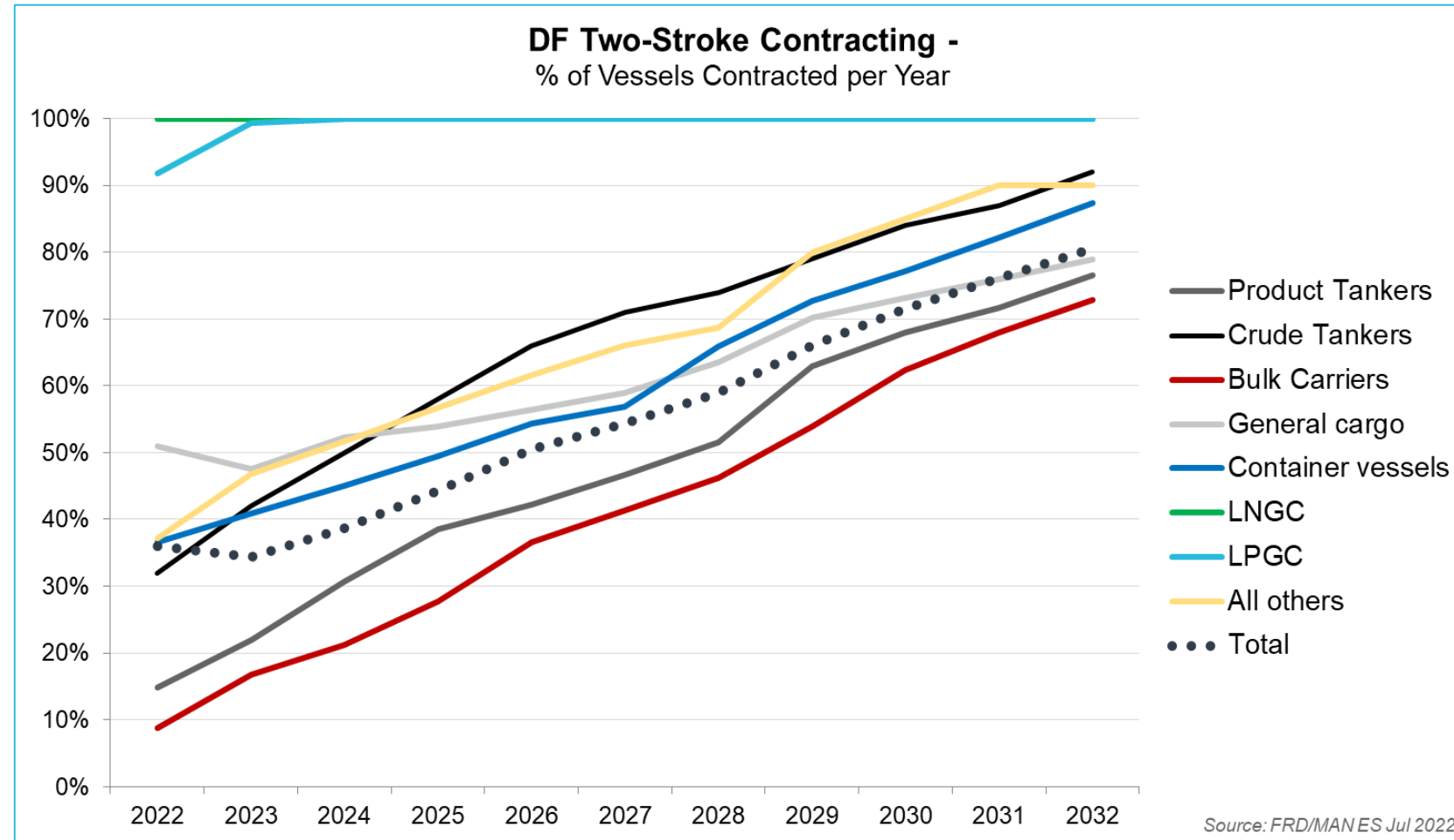


* Preliminary Year to Date (end Mar 2022)

Source: IHS Markit & FMS MAN ES

Two-Stroke Dual Fuel Forecast

Number of Vessels



Comments:

- Greater DF % uptake for bigger vessels, i.e., the DF % increases faster in kW compared to number of ships
- DF % in 2025 = 44%
- DF % in 2030 = 72%
- DF % in 2032 = 81%

Category II 40 BN Cylinder oils - Explained



What is Category II 40 BN?

- Excellent overall performance with a special focus on cleaning ability.
- Aim: 40 BN cylinder oil that performs equal or better than a 100 BN oil in regards to cleaning.

Why

1. Some lubricants aimed for low Sulphur applications were not adequately able to prevent and manage the deposit formation in especially newer engines types.
2. Operation on low Sulphur fuels is the most predominant way of operating.
3. Fuel-efficient engines with higher pressures and temperatures require lubricants with matching performance.
4. Clean piston rings, lands and grooves and crowns are important in order to secure an acceptable time between overhaul of the cylinder units.



**Reliable and Clean
Engine!**

Where to use Category II 40 BN oils



Applicable for All engines mean that

A Cat II 40 BN may also be advantageous for engines such as mark 8 and lower.

Fuel

- 0.50% S fuel
- 0.10%S fuel
- LNG
- Methanol
- LPG
- Ethane

MAN ES recommends using a 40 BN Cat II cylinder oil for the ME-GA engine.

A few examples of engines that could benefit of 40 BN cat II

ME-GI 8.2



ME-C9



ME-GI9.5



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.

Thank you very much



Orders Including Options

No. of engines		Engine type			Mk.
499 180*	48	G	95	ME-C-GI	10.5
	3	S	90	ME-C-GI	10.5
	29	G	90	ME-C-GI	9.5, 10.5
	84	G	80	ME-C-GI	9.5, 10.5
	2	S	80	ME-C-GI	9.5
	8	S	70	ME-C-GI	7, 8.2, 10.5
	215	G	70	ME-C-GI	9.2, 9.5, 10.5
	2	L	70	ME-C-GI	7, 8.2
	15	G	60	ME-C-GI	9.5, 10.5
	72	S	60	ME-C-GI	10.5
	7	S	50	ME-C-GI	8.2, 8.5, 9.5
	7	G	50	ME-C-GI	9.5, 9.6
	2	G	45	ME-C-GI	9.5
	5	S	35	ME-C-GI	9.7
192	192	G	70	ME-C-GA	10.5
31 14*	24	G	60	ME-C-GIE	9.5
	3	G	50	ME-C-GIE	9.5
	4	S	50	ME-C-GIE	8.2
72 17*	18	G	95	ME-C –LGIM	10.5
	31	G	50	ME-B/ME-C –LGIM	9.3, 9.5, 9.6
	23	S	50	ME-B-LGIM	9.3, 9.6
126 41*	92	G	60	ME-C-LGIP	9.2, 9.5, 10.5
	7	S	60	ME-C-LGIP	10.5
	21	G	50	ME-C-LGIP	9.6
	6	S	35	ME-C-LGIP	9.7

*** in service**

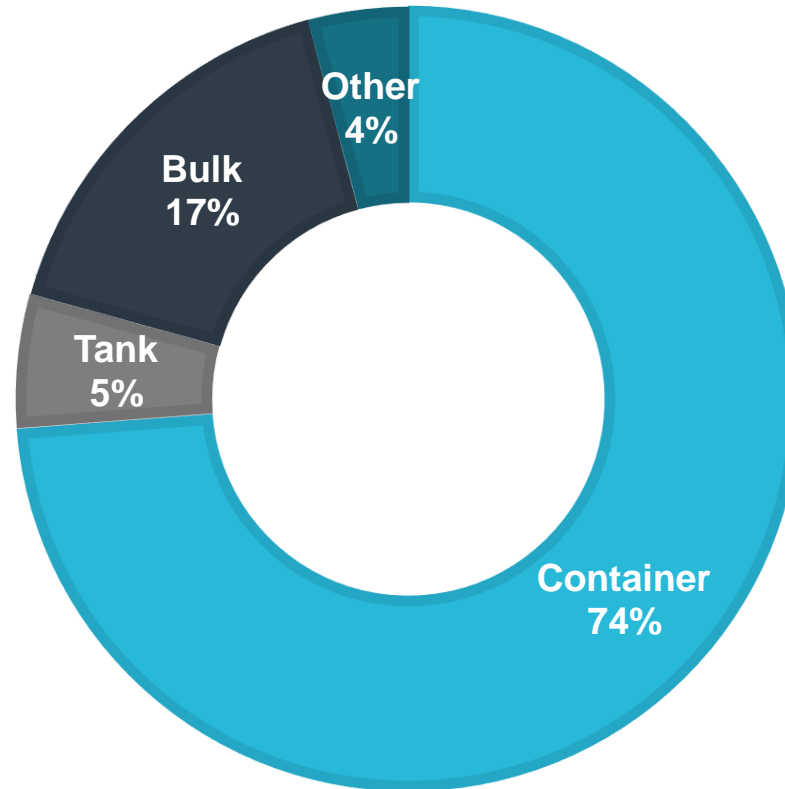
Totals	
Total dual fuel engines including options	920 engines
Total power main engine	19.76 GW
Total dual fuel engines in service	242 engines

Methane
Ethane
Methanol
LPG

The main driver: Container vessels

Requests for MAN B&W ME-LGIM engines are increasing significantly

Main drivers: Large and ultra large container vessels – Midsize container vessels – Container feeders
Increasing interest from bulk carrier segments, tankers, RoRo and PCTCs.



The maritime industry is the backbone of global trade

The background of the slide is a photograph showing the silhouettes of several large ships, including a container ship and a tugboat, on the water. The scene is captured at sunset or sunrise, with a warm orange glow across the sky and water. The ships are dark against the bright, shimmering water and sky.

~ **80-90%** of
global freight is
transported by
sea.

Shipping is
responsible for ~ **3**
% of the global
CO2 emissions.

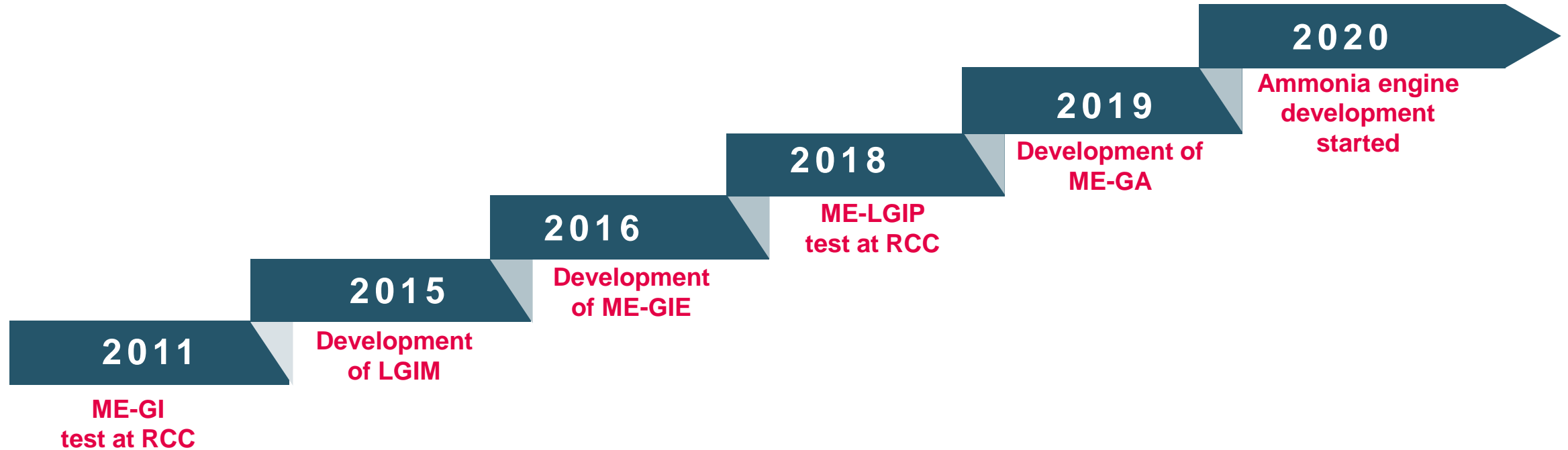
~ **50 %** of global
freight are
transported by a
MAN ES engine.



Components at RCC for ammonia engine development

MAN B&W two-stroke engines for alternative fuels

ME-GA Methane; Ammonia



Extensive experience in the development of dual-fuel engines