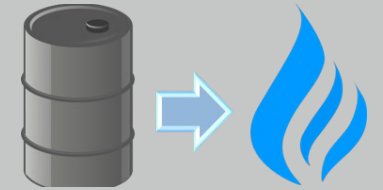


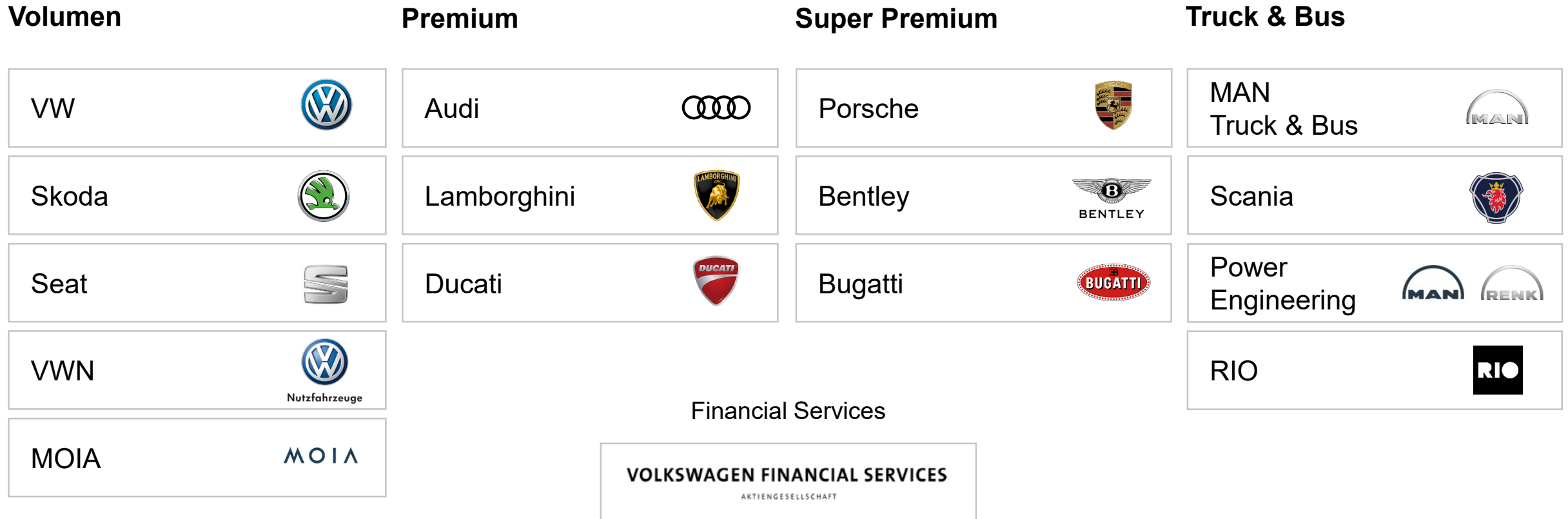
LPG as future bunker fuel



Klaus Rasmussen
SEACR
15, 05, 2019

Member of the Volkswagen Group

MAN Energy Solutions is part of a brand family



Our design and production network

Sites across Europe and Asia

11

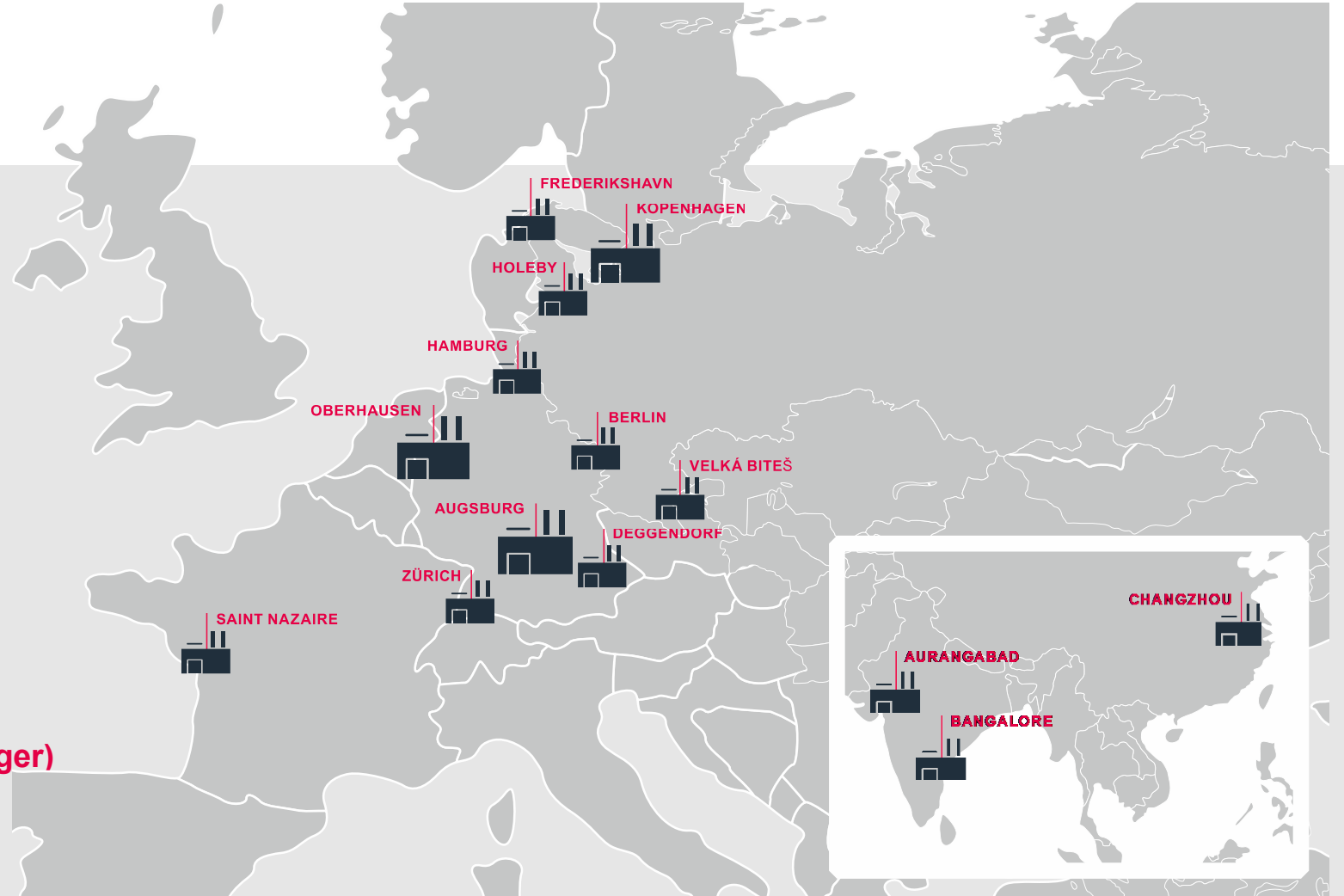
Production sites
in Europe

3

Production sites
in Asia

30

Licensees in 7 countries
(two- and 4-stroke, turbocharger)

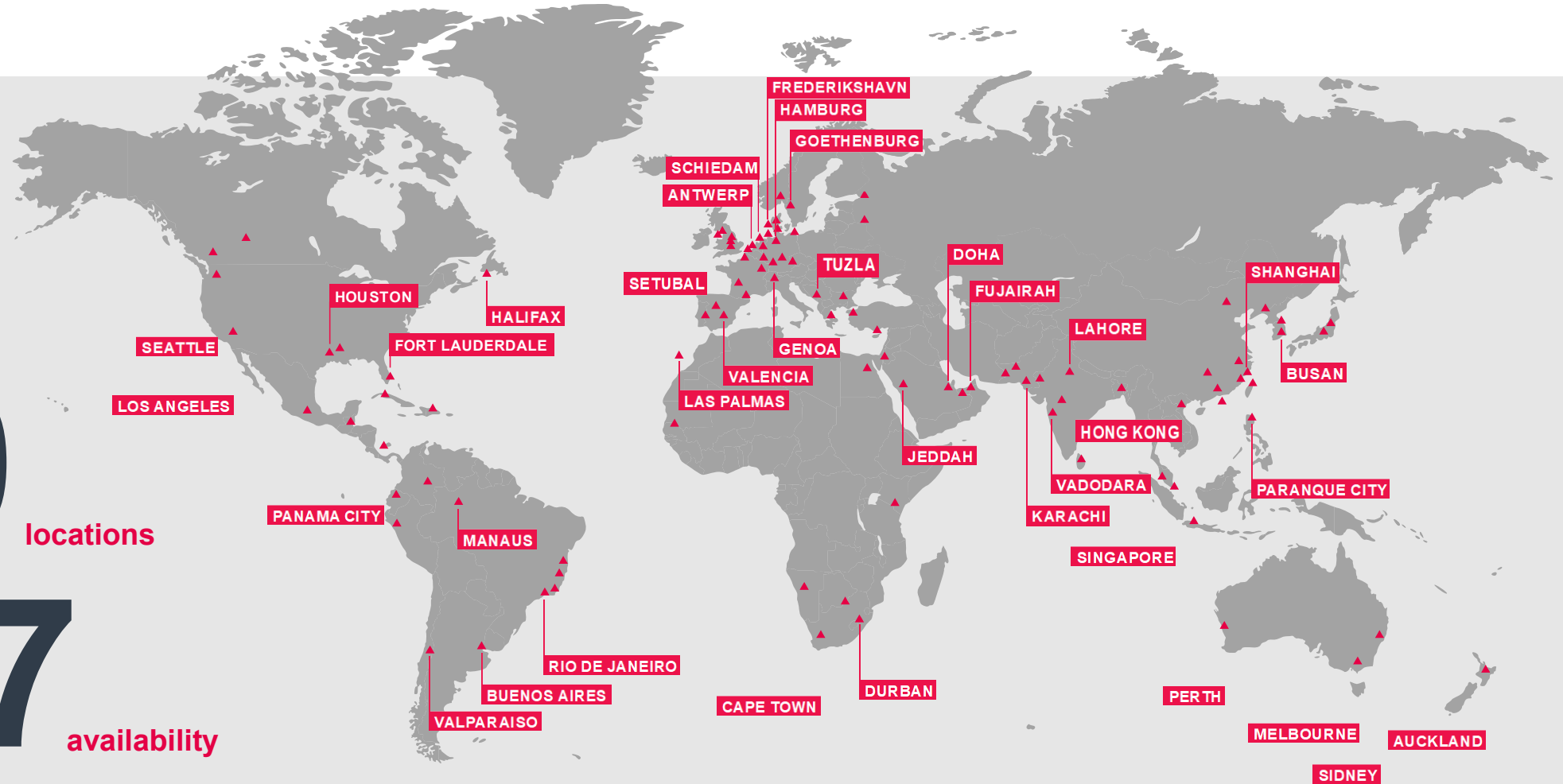


Our global aftersales network

MAN PrimeServ

120 locations

24/7 availability



2020 Opportunities



How to comply with new regulations – 5 alternatives seen in the market

1 HFO with scrubber



- Can use conventional HFO
- Possible for retrofit (Not MAN)
- Reduces particulate matter as well as SOx



- Initial investment (USD 2-10 m)
- Requires space for scrubber tower and supporting systems
- Requires chemicals (closed loop)
- Higher CO2
- Negative impact on EEDI

2 LNG as fuel



- Has good environmental performance
- Lower NOx, PM, CO2
- No SOx
- Positive impact on EEDI
- Supply Chain in major hubs in place for 2020



- Investment cost (USD 3-30 mill.)
- Large regional variations in LNG price
- Requires space for tank

3 LPG as fuel



- Has good environmental performance
- Lower NOx, PM, CO2
- No SOx
- Positive impact on EEDI
- Supply Chain place World Wide (600-700 small LPG Carriers in market)



- LPG prices available World Wide
- Investment cost (USD 3-20 mill.)
- Requires space for tank

4 New compliant fuels



- Useable for most engine configurations



- Unknown fuel cost – likely higher than HFO
- Not on the market, so no track record
- Uncertain availability
- May create operational issues due to off-spec fuel or incompatibility

5 Distillate fuels



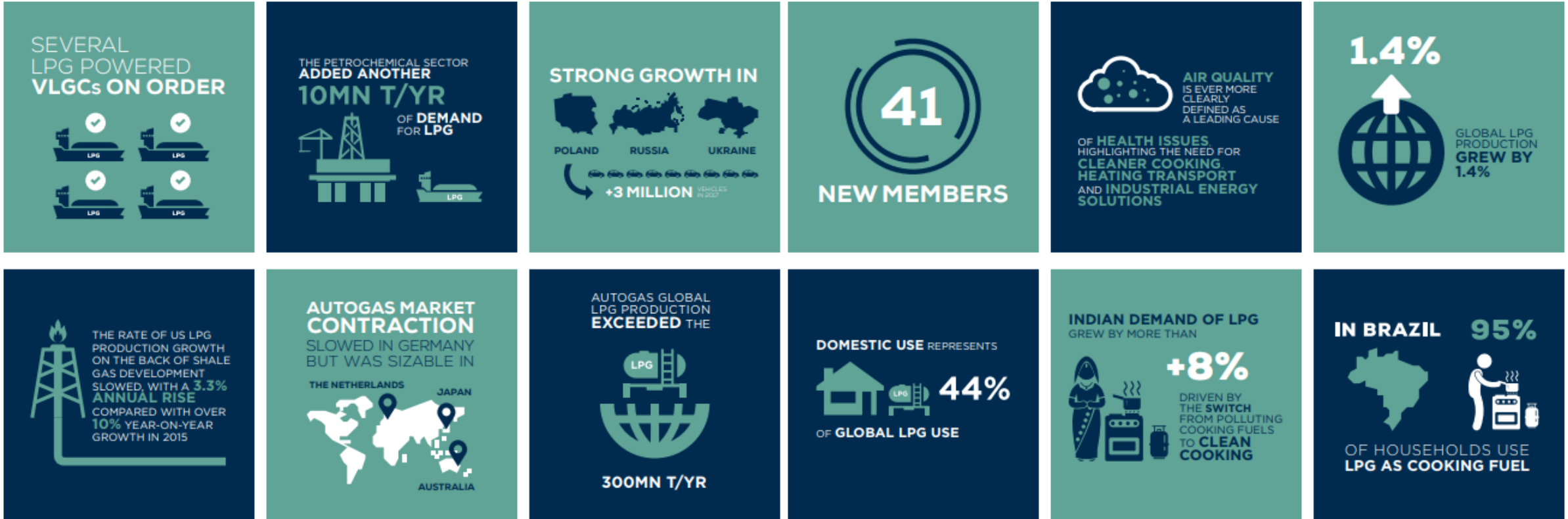
- Useable for most engine configurations



- Higher fuel cost
- May create operational issues due to low viscosity of the fuel

The world market of LPG

.....Base on input form WLPGA



LPG as bunker - supply chains benefits

.....Base on input form WLPGA



LPG IS EASIER & LESS EXPENSIVE TO STORE THAN LNG

THIS SOLVES THE LNG LOGISTICS PROBLEM, LPG IS ALREADY ACCESSIBLE IN PORTS ACROSS THE GLOBE AND NEW TERMINALS CAN BE BUILT FASTER AT LOWER COST

EASY & QUICK BUNKERING

THE SPATIAL DISTRIBUTION OF LPG STORAGE FACILITIES FAVOURS LPG OVER LNG

RELIABLE SUPPLY

GLOBAL LPG PRODUCTION GREW 5.75% EXCEEDING 300 MN T/YEAR FIRST TIME EVER

LPG CAN RELY ON AN EXTENSIVE EXISTING GLOBAL INFRASTRUCTURE - INCLUDING MORE LPG TERMINALS BUILT IN THE US TO COVER INCREASED DEMAND FOR COMPETITIVELY PRICED LPG

THE SOLUTION TO ACHIEVE GLOBAL 0.5% SULPHUR CAP

MEETS IMO EMISSION LIMITS

ECAs SECAs

- USES EXISTING SUPPLY CHAINS
- EASIER AND LOWER COSTS TO INSTALL THAN LNG
- LOW MAINTENANCE COST FOR GAS ENGINES
- NO SCRUBBER UNCERTAINTIES

REDUCES SO_x EMISSIONS BY

97%

A LOWER EMISSIONS PROFILE

COMPARED TO HFO & ULSCO

SUSTAINABLE SUPPLY CHAIN

THE LARGE NETWORK OF IMPORT AND EXPORT TERMINALS AROUND THE WORLD CAN BECOME LPG BUNKERING POINTS

=1,000 GLOBALLY AVAILABLE

EXISTING LPG FLOATING VESSELS CAN BE USED AS SUPPLY POINTS

SAFETY MANAGEMENT & MAINTENANCE

ARE SIMPLER FOR LPG THAN FOR LNG

THE PERFECT SOLUTIONS FOR VLGCs & OTHER VESSELS

SHORTER PAYBACK PERIOD

LOWER INVESTMENT COSTS

NO CRYOGENIC TECHNOLOGY REQUIRED MAKING LPG SYSTEMS LESS EXPENSIVE THAN LNG TO INSTALL

LPG IS MORE COST EFFECTIVE & LESS SENSITIVE TO FUEL PRICE SCENARIOS

IT IS MUCH CLEANER THAN HFO & ULSCO AND OTHER FUELS THAT IT REPLACES

LPG EMITS LESS

= -20%

= -97%

= -24%

= -90%

IN COUNTRIES WHERE LPG IS USED FOR OTHER APPLICATIONS

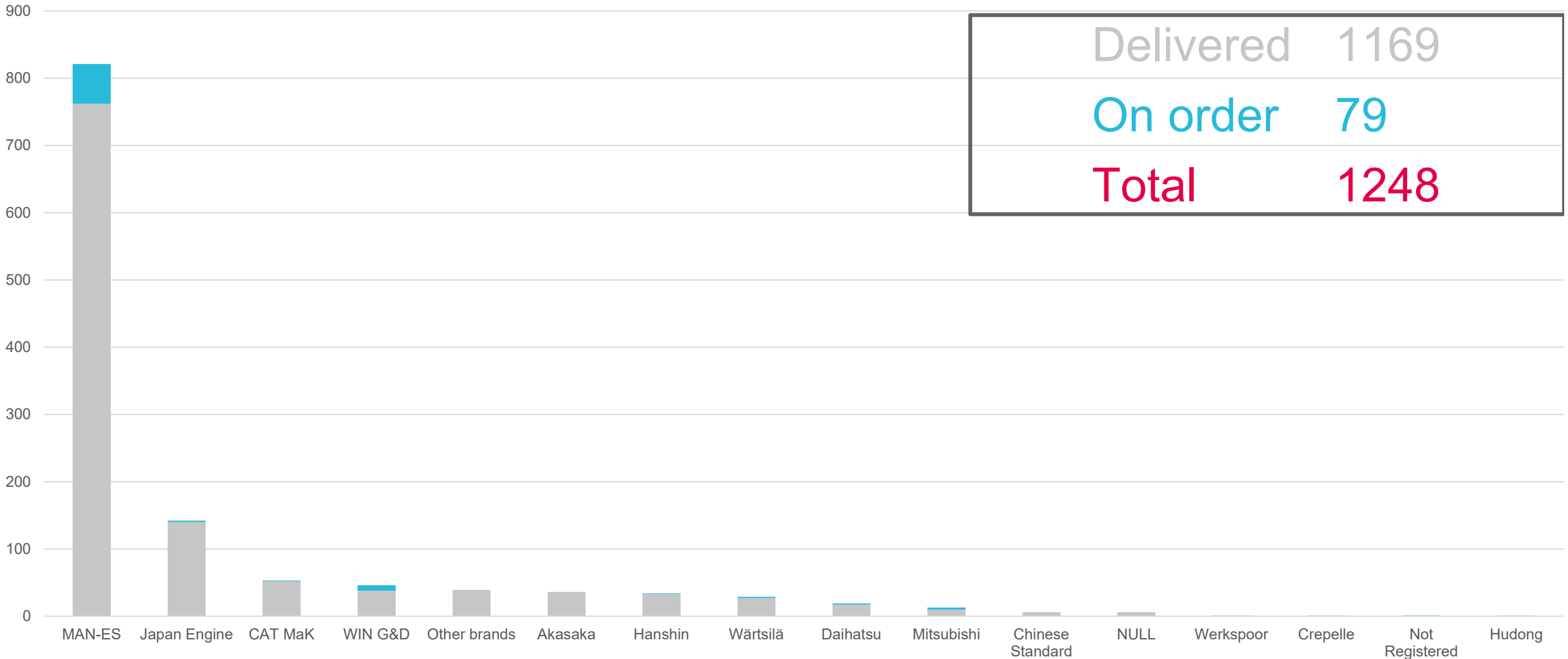
"AVAILABILITY" OF LPG MARINE ENGINES

TECHNOLOGY CURRENTLY AVAILABLE WITH TWO AND FOUR-STROKE ENGINES - GAS TURBINES CAN ALSO BE USED

LPG Carriers World Wide

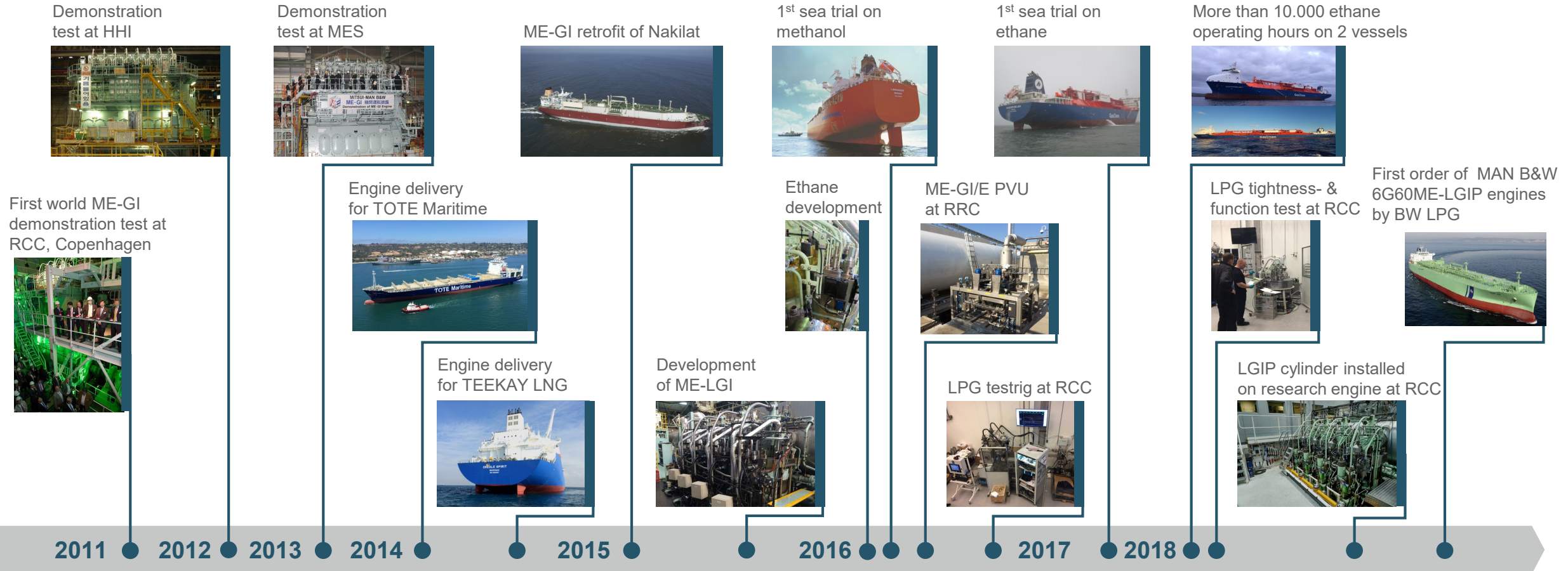


All makers & designers



The New MAN B&W ME-LGIP Engine

LGIP Technologies Confirmed at RCC - Gas Engine Technologies Development



Dual Fuel Conversion



References

New Buildings – In Service

No. of engines		Engine type			Mk.
2	G	45	ME-C-GI	9.5	
4	G	50	ME-C-GI	9.5	
5	G	60	ME-C-GIE	9.5	
87	G	70	ME-C-GI	9.2, 9.5	
1	G	90	ME-C-GI	10.5	
2	L	70	ME-C-GI	8.2	
6	S	50	ME-C-GI	9.2	
4	S	70	ME-C-GI	9.2	
2	S	90	ME-C-GI	9.2	
108					

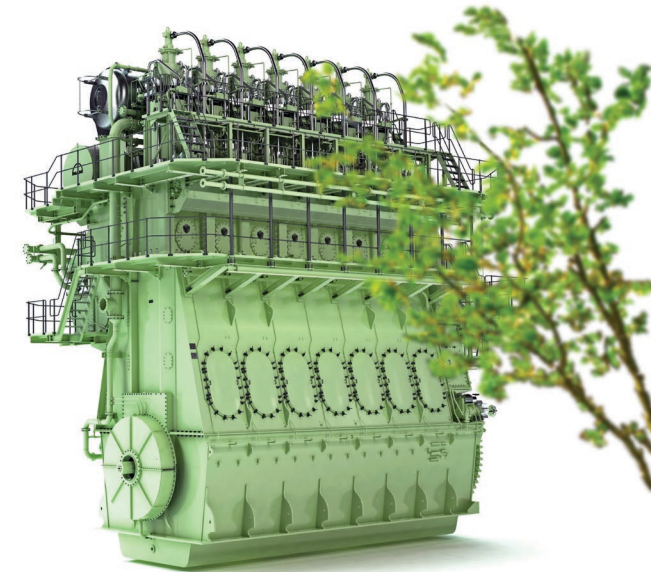
Another 55 engines on order

Updated: February 2019

The new MAN B&W ME-LGIP Engine

MAN B&W ME-LGIP engines are designed to be dual fuelled with LPG as the low-flashpoint fuel.

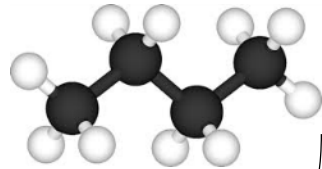
Engine is flexible with regards to fuel composition.



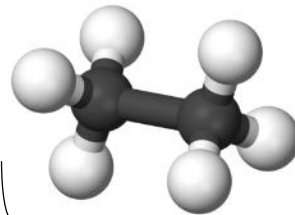
Propane C₃H₈



Butane C₄H₁₀



Ethane C₂H₆



Minimum 88%

Maximum 12%*

**Possibility to increase ethane content is under investigation*

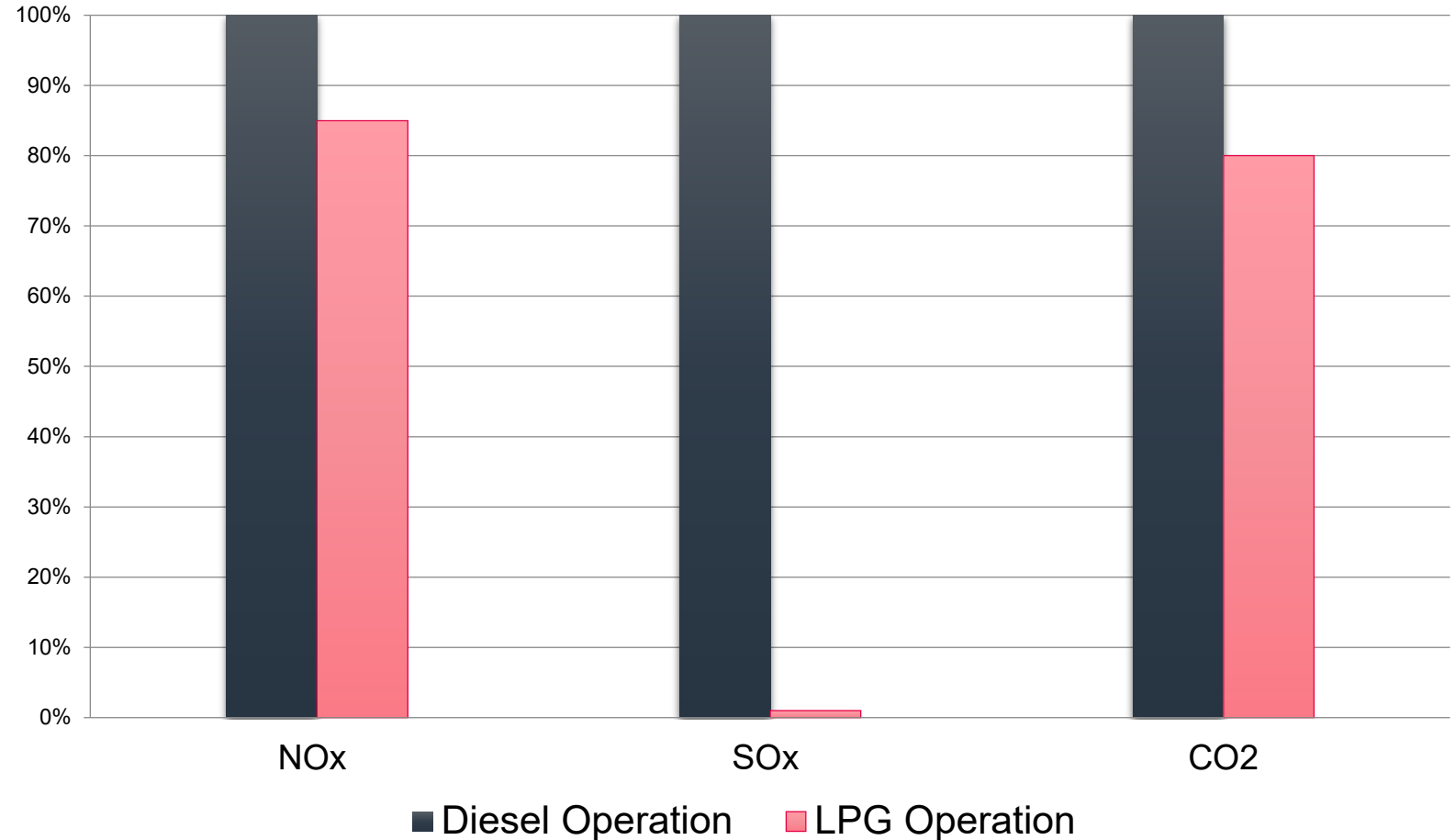
ME-LGIP Conversion



Design

Emission reductions

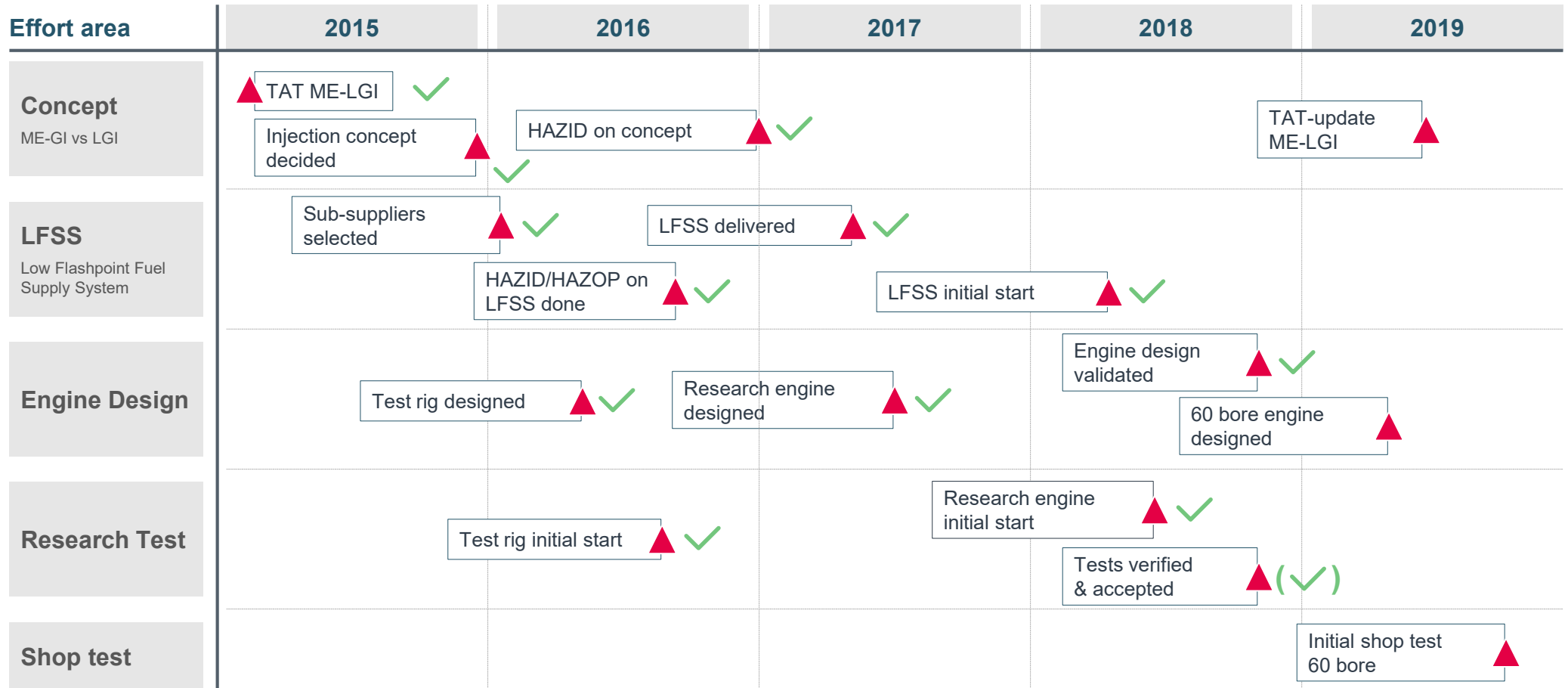
- **NOx (Nitrogen Oxide)**
 - Reduction ~ 15%
- **SOx (Sulphur Oxide)**
 - Reduction > 90%
- **CO₂(Carbon Oxide)**
 - Reduction ~ 20%



The New MAN B&W ME-LGIP Engine

LGIP Technologies Confirmed at RCC - Gas Engine Technologies Development

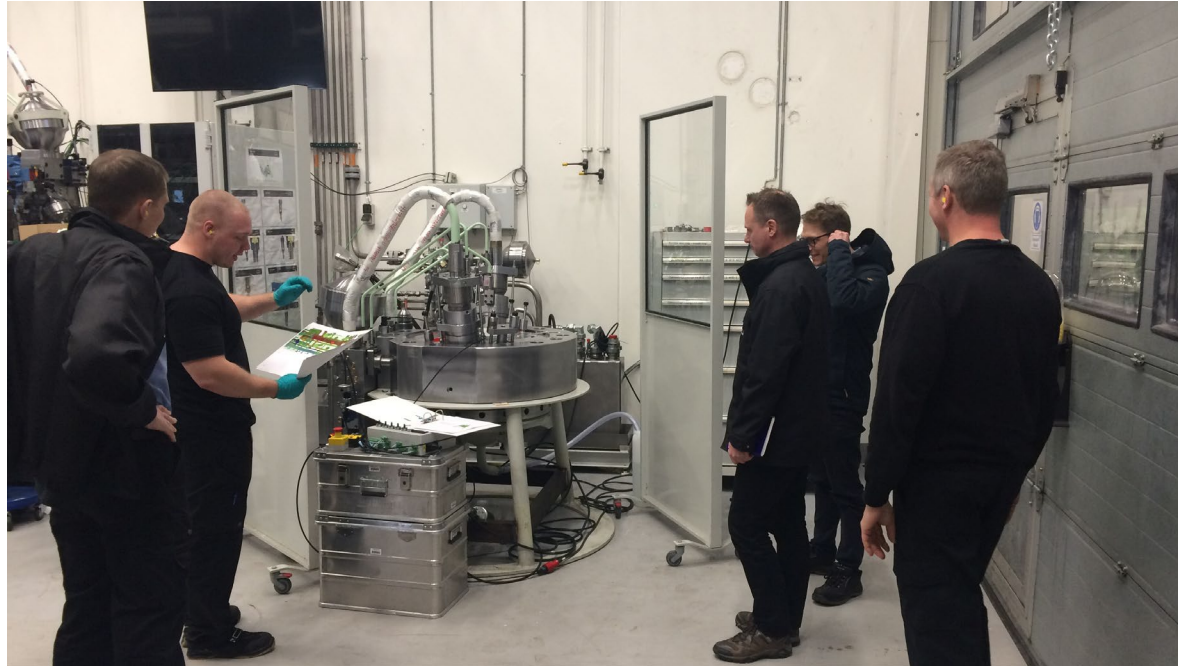
Milestone Plan



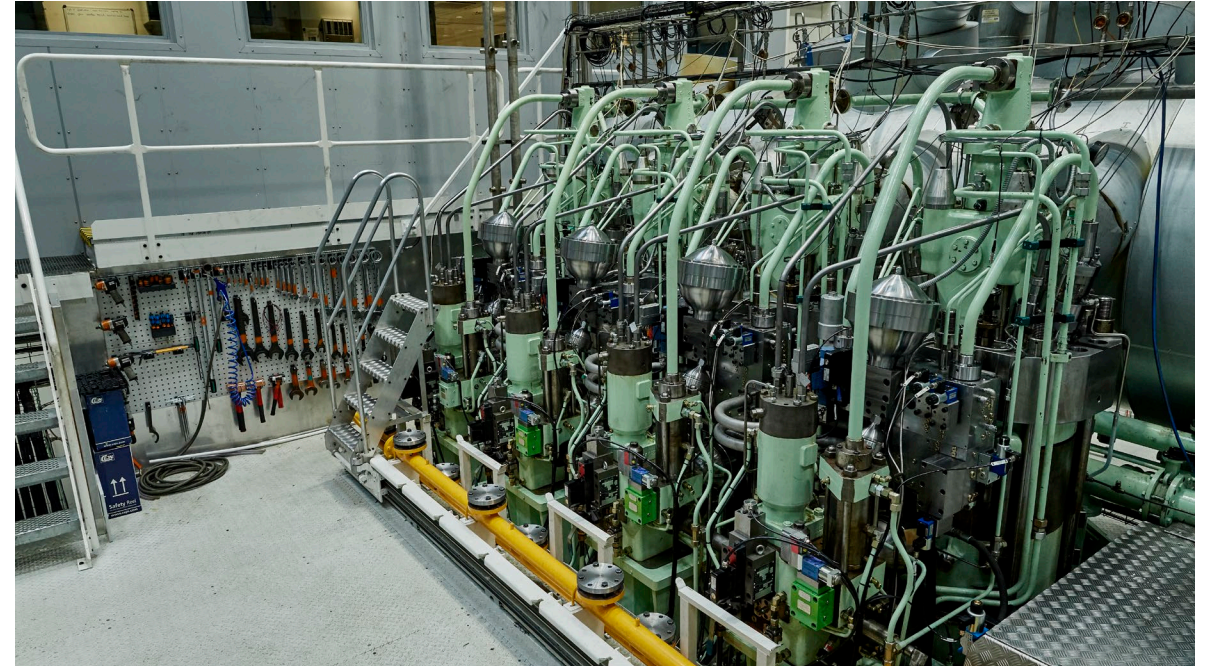
The New MAN B&W ME-LGIP Engine

LGIP Technologies Confirmed at RCC - LGIP Injection Concept

Preparations for operation on LGP at Research Centre Copenhagen



Tightness- & function test on each cylinder unit at Research Centre Copenhagen



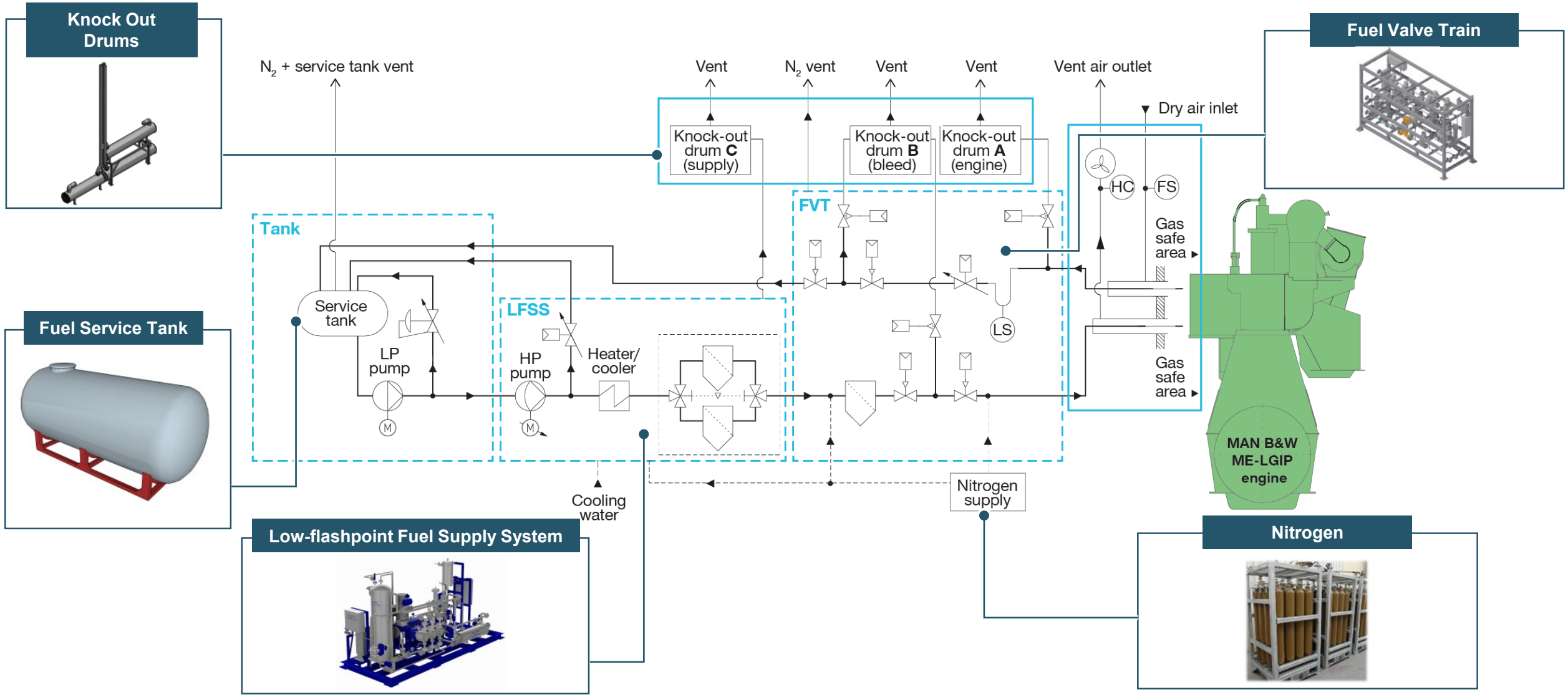
Research engine at Research Centre Copenhagen equipped for LPG operation

ME-LGIP K.O. drums and vents in DRC



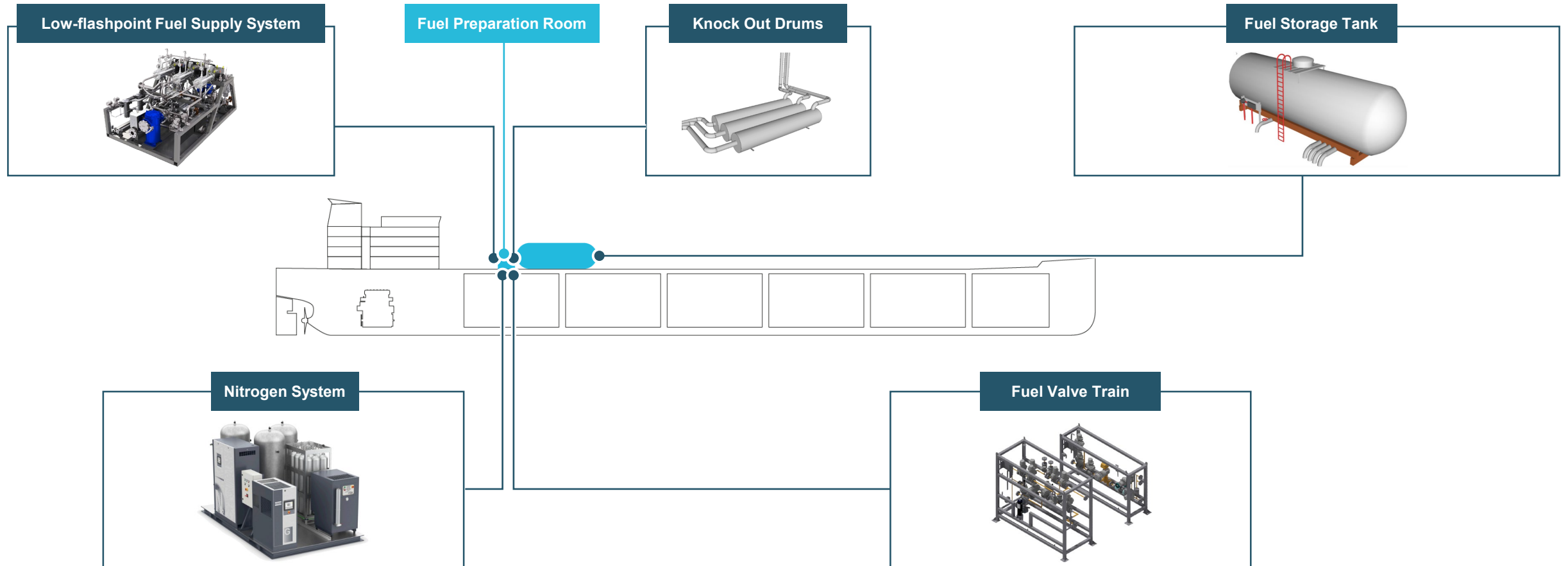
The new MAN B&W ME-LGIP Engine

ME-LGIP auxiliaries – Test centre setup – Research Centre Copenhagen



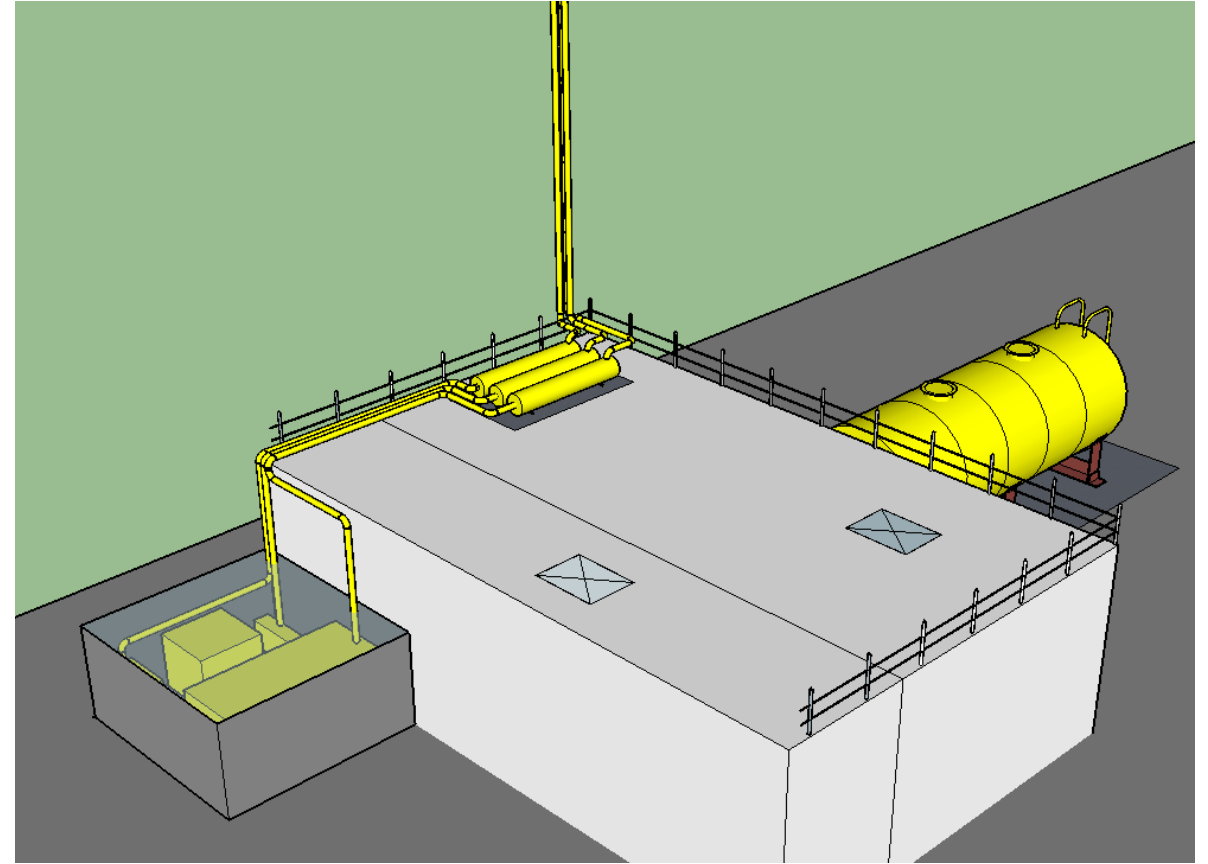
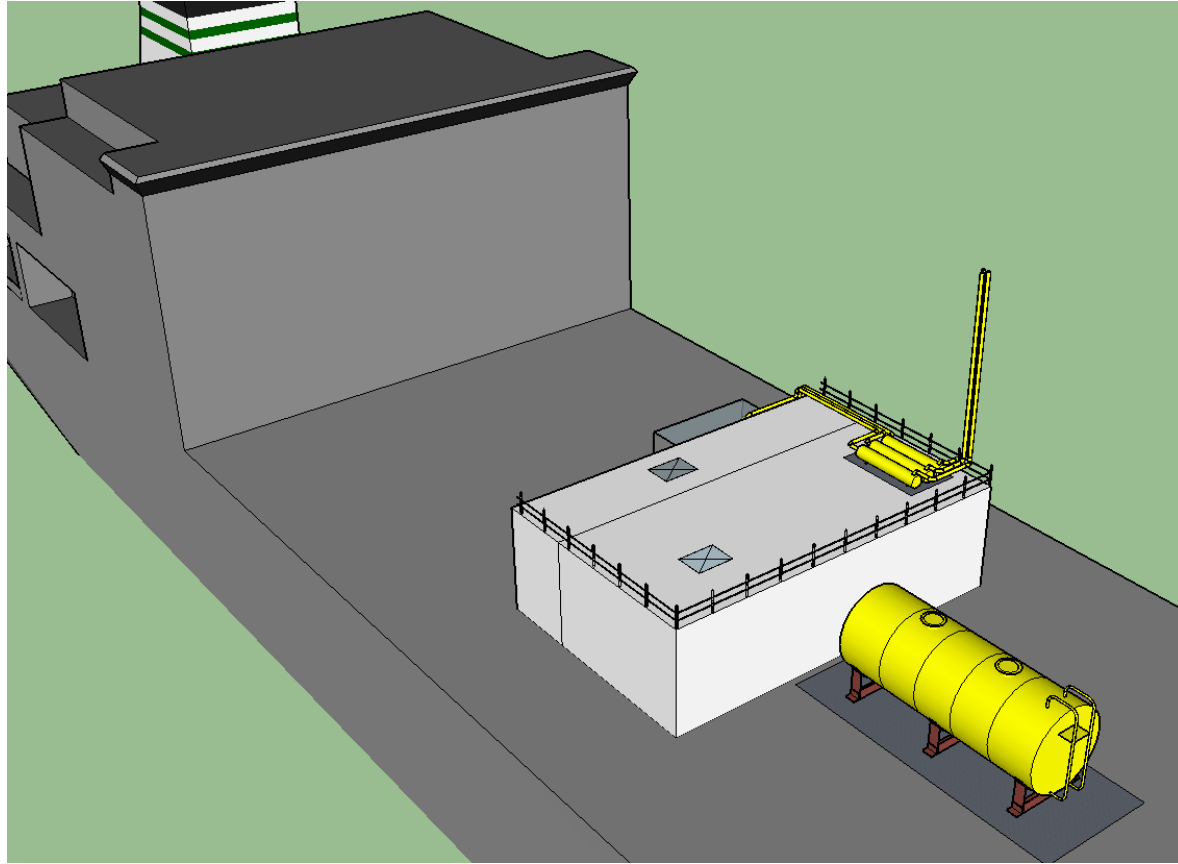
The new MAN B&W ME-LGIP Engine

ME-LGIP auxiliaries – LR1 Tanker – with large capacity fuel storage tank(s)



The new MAN B&W ME-LGIP Engine

ME-LGIP auxiliaries – VLGC – with fuel service tank

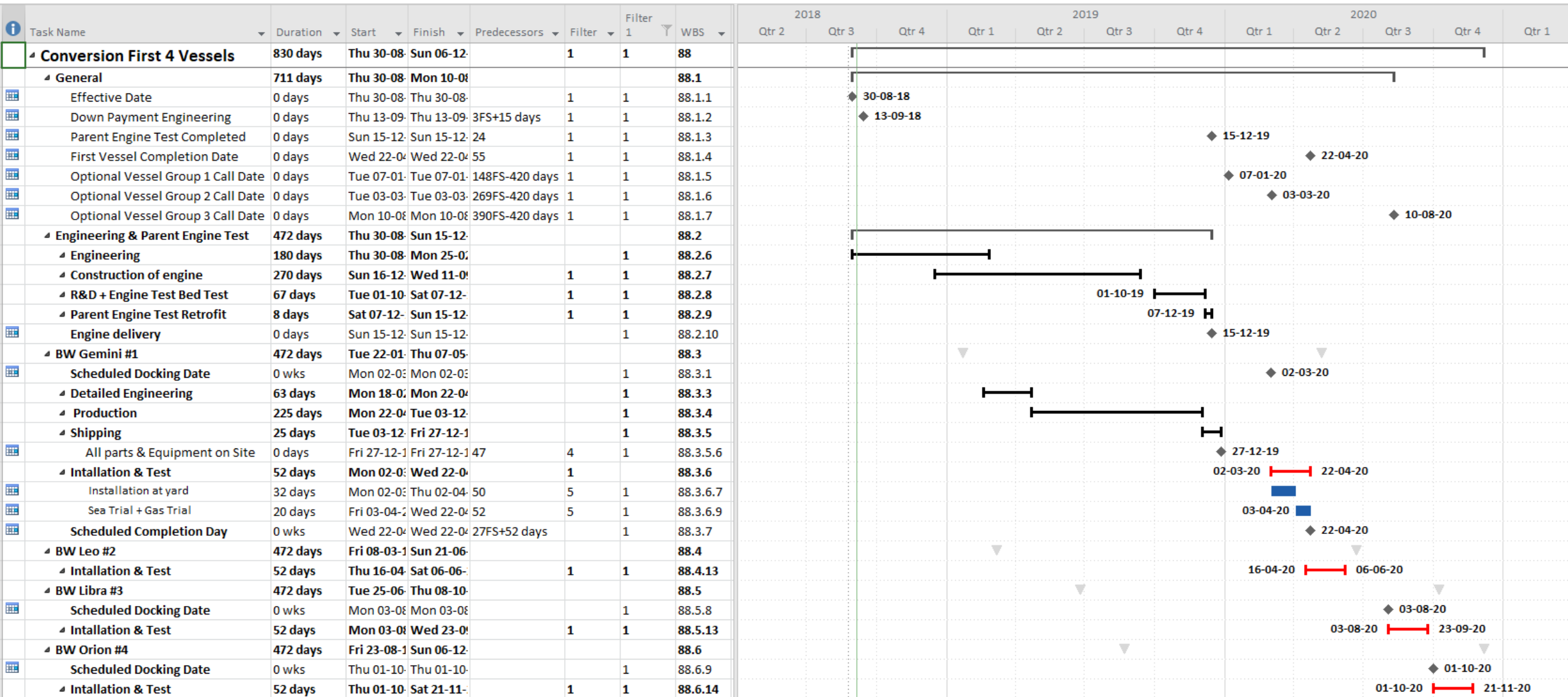


The vessels



Vessel Type:	VLGC's (17 pcs.)
ME:	6G60ME-C9.2
LGIP Conversion contract:	Firm 4, Opt. (4+4+3)

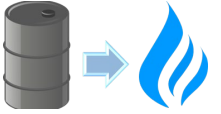
Master Project Schedule



Scope of supply

Main points

- R&D, Engineering
- Site Survey – Project management
- Engine hardware including Fuel Valve Train
- Supervision of Installation
- Test and Commissioning, (*Pre-commissioning, Sea- and gas trials*)
- Project Management and Home Office support



Scope of supply

R&D, Engineering & Site Survey



Engineering

MAN PrimeServ will engineer and design the components mentioned in section 4.1 above, as well as recertification of the main engine incl. EIAPP certificate.

Site survey on board

MAN PrimeServ will prior to engineering carry out inspection, measurements, and photo documentation etc. of a selected number of vessels. This is required for the engineering of the retrofit solution. Two (2) engineers in five (5) days is included in the price

Scope of supply



Engine hardware including Fuel Valve Train

- a) Cylinder Cover Complete incl. protection shields
- b) Cylinder cover studs and tools
- c) Piston Crowns
- d) Piston Rings
- e) New Hydraulic Cylinder Unit Distributor Blocks
- f) New fuel booster top covers
- g) New exhaust valves
- h) Hydraulic pipes for exhaust valves
- i) Exhaust gas compensators
- j) New Hydraulic Power supply Pumps
- k) Gas Control Blocks incl. Adaptor Blocks
- l) Fuel Valve modification
- m) Low flashpoint Fuel Injection Valves
- n) High Pressure Fuel oil Pipes
- o) HP. hydraulic control oil pipes
- p) Low flashpoint fuel pipes on engine (Chain Pipes)
- q) Sealing and Cooling Oil system
- r) Cabling on engine
- s) LP oil system on engine
- t) Various pipes (fuel oil, starting air, control- and safety air)
- u) Gallery and platform arrangements (material and fabrication is yard scope)
- v) Pneumatic Components
- w) LGI Engine Control system
- x) Cylinder Pressure Measuring Equip.
- y) Tools
- z) MAN PrimeServ manuals for the Low flashpoint fuel injection system
- aa) Fuel Valve Train (FVT) for low flashpoint fuel
- bb) HC sensors, Flow switches

Dual Fuel Conversion



References

New Buildings – In Service

No. of engines		Engine type		Mk.
2	G	45	ME-C-GI	9.5
4	G	50	ME-C-GI	9.5
5	G	60	ME-C-GIE	9.5
87	G	70	ME-C-GI	9.2, 9.5
1	G	90	ME-C-GI	10.5
2	L	70	ME-C-GI	8.2
6	S	50	ME-C-GI	8.2
4	S	70	ME-C-GI	7.1, 8.2
2	S	90	ME-C-GI	10.5
108				

Updated: February 2019

Dual Fuel Conversion



References

New Buildings – On Order

No. of engines	Engine type			Mk.
4	G	50	ME-C-LGIM	9.5
6	G	60	ME-C-GIE	9.5
2	G	60	ME-C-LGIP	9.5
27	G	70	ME-C-GI	9.5, 10.5
6	G	90	ME-C-GI	10.5
2	S	50	ME-C-GI	9.6
2	S	60	ME-C-GI	10.5
2	S	70	ME-C-GI	10.5
2	S	70	ME-C-LGIP	10.5
2	S	80	ME-C-GI	9.5
55				

Updated: February 2019

Thank you very much!

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