International Congress on Ship's Technology 2015

Chances and risks for the use of gas-engines in Marine applications

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Mobile Gas Engines

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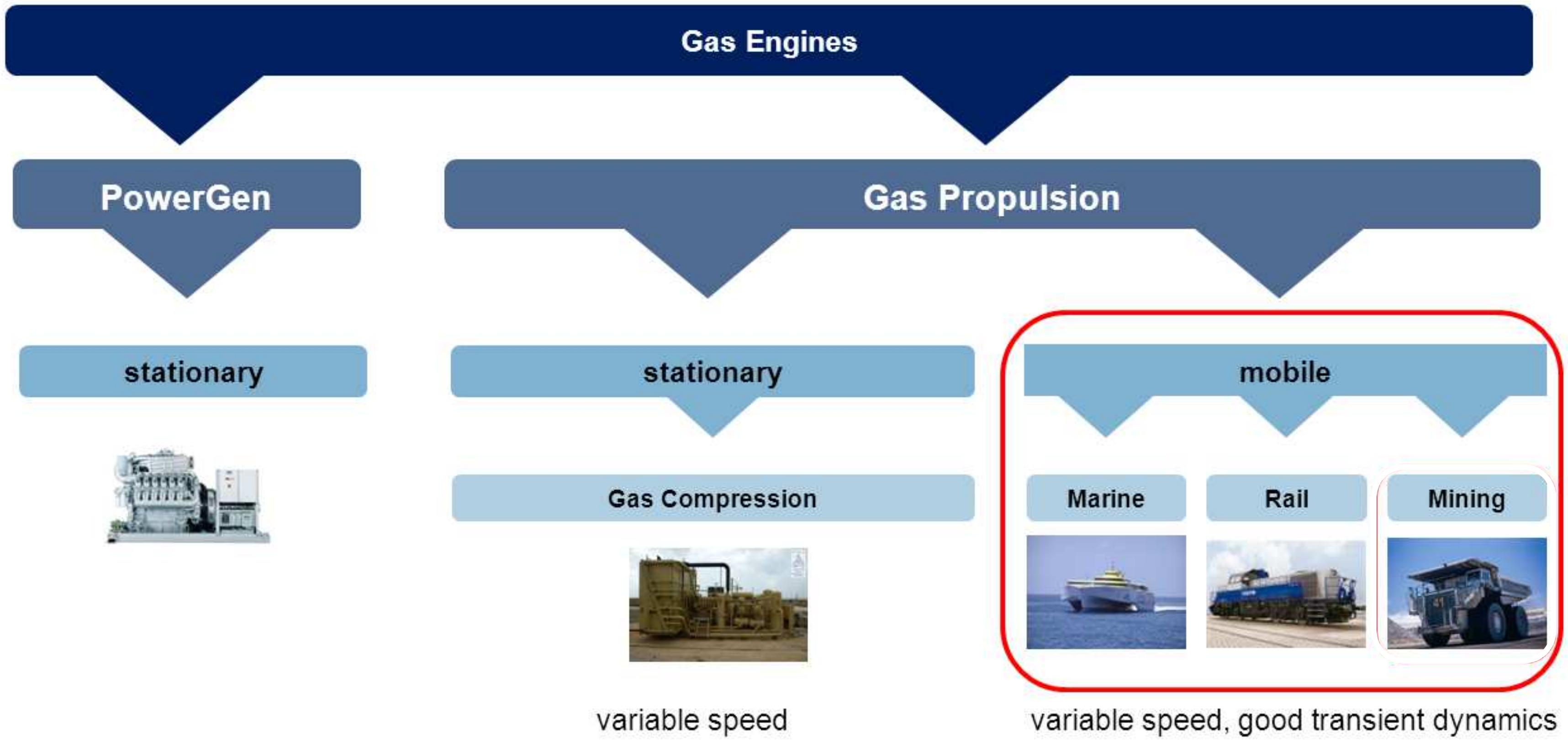
Power. Passion. Partnership.

1 Gas engine Segmentation
MTU‘s stationary and mobile applications



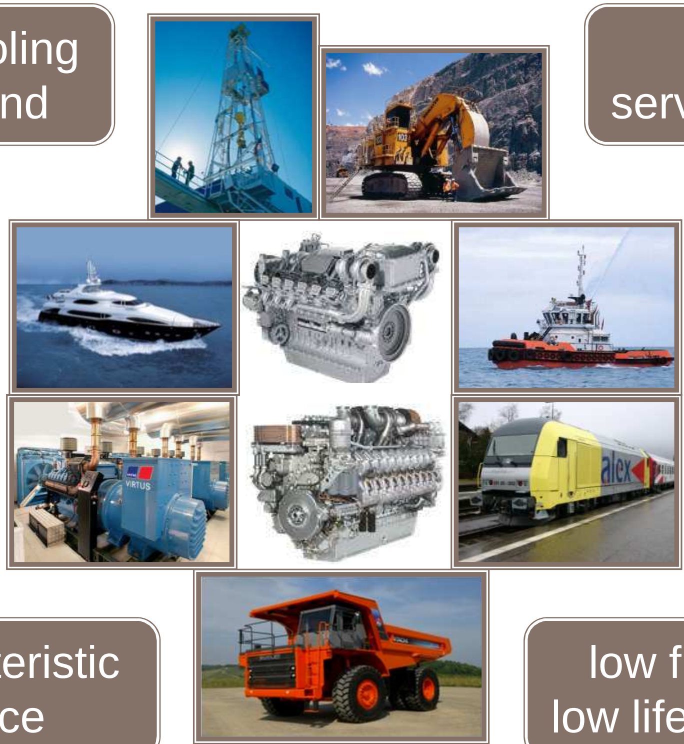
1 Off-Highway Applications Requirements

low cooling demand

good serviceability

stringent emission requirements

high availability and reliability



restricted installation space, high power to weight ratio

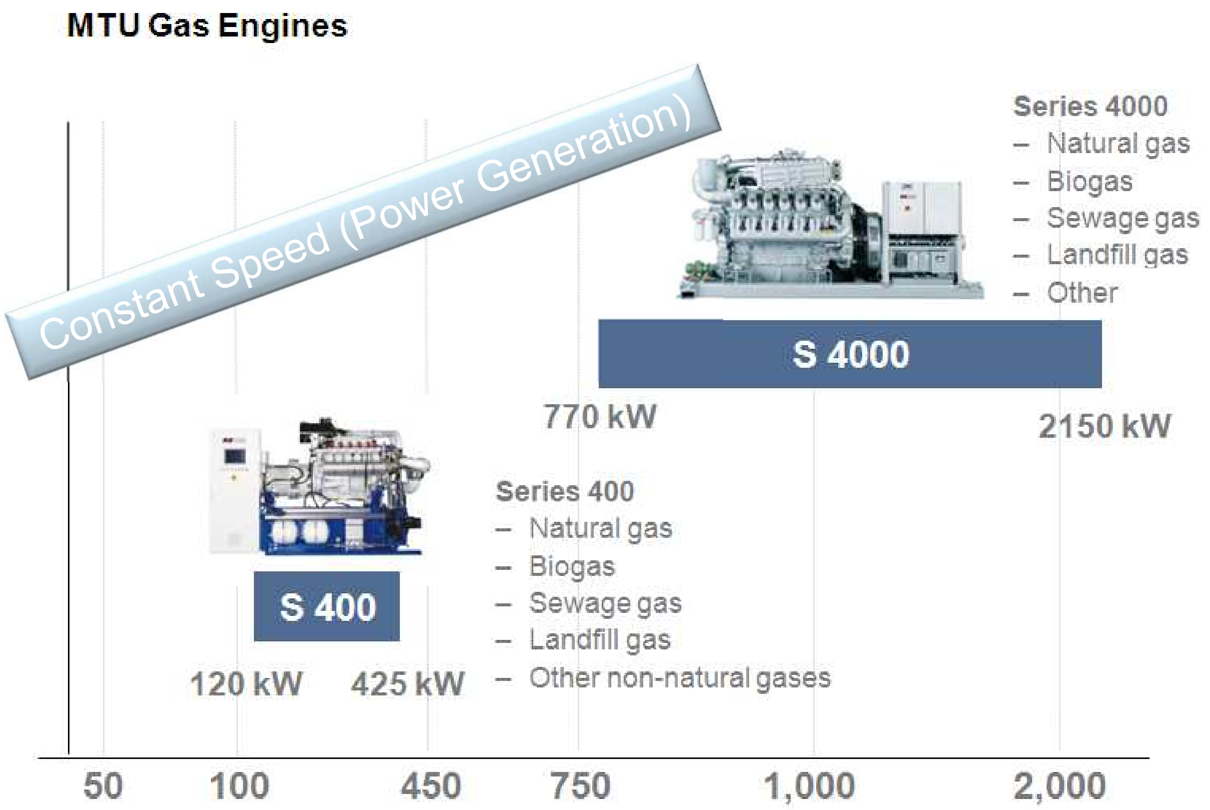
high time-between-overhaul (TBO)

good response characteristic and load acceptance

low fuel consumption, low life-cycle-costs (LCC)

➢ **Can a gas fuelled engine meet these requirements?**

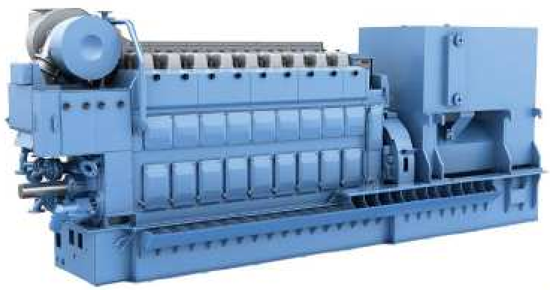
2 MTU Gas Systems and Engines
MTU Onsite Energy's Gas GenSets



2 Gas Systems and Engines
Bergen's Medium Speed Engines

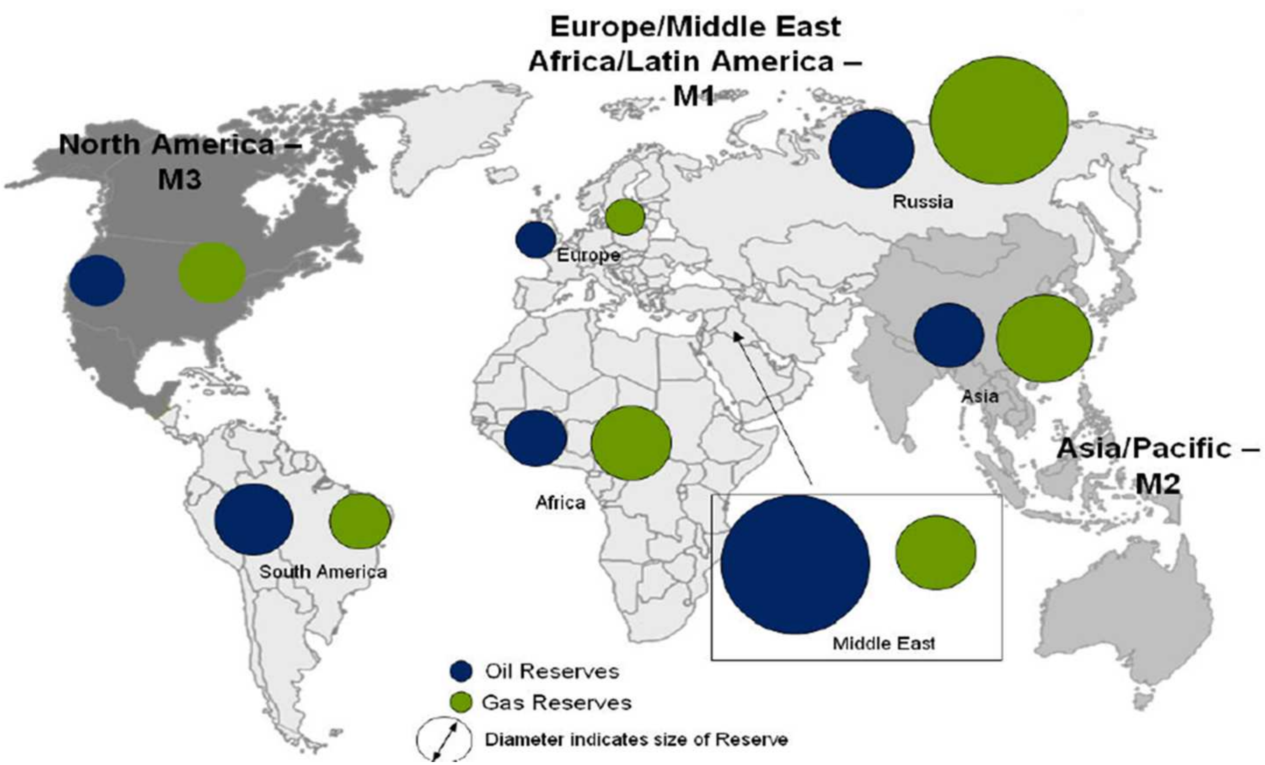
- Power generation
- Ship propulsion
- Constant speed
- Variable speed

• **Types:**	**C26:33L6-8-9**
• **Bore:**	**260 mm**
• **Stroke:**	**330 mm**
• **Power:**	**270 kW / cyl.**
• **Speed:**	**600 – 1000 rpm**
• **Power range:**	**1400 – 2500 kWmech**



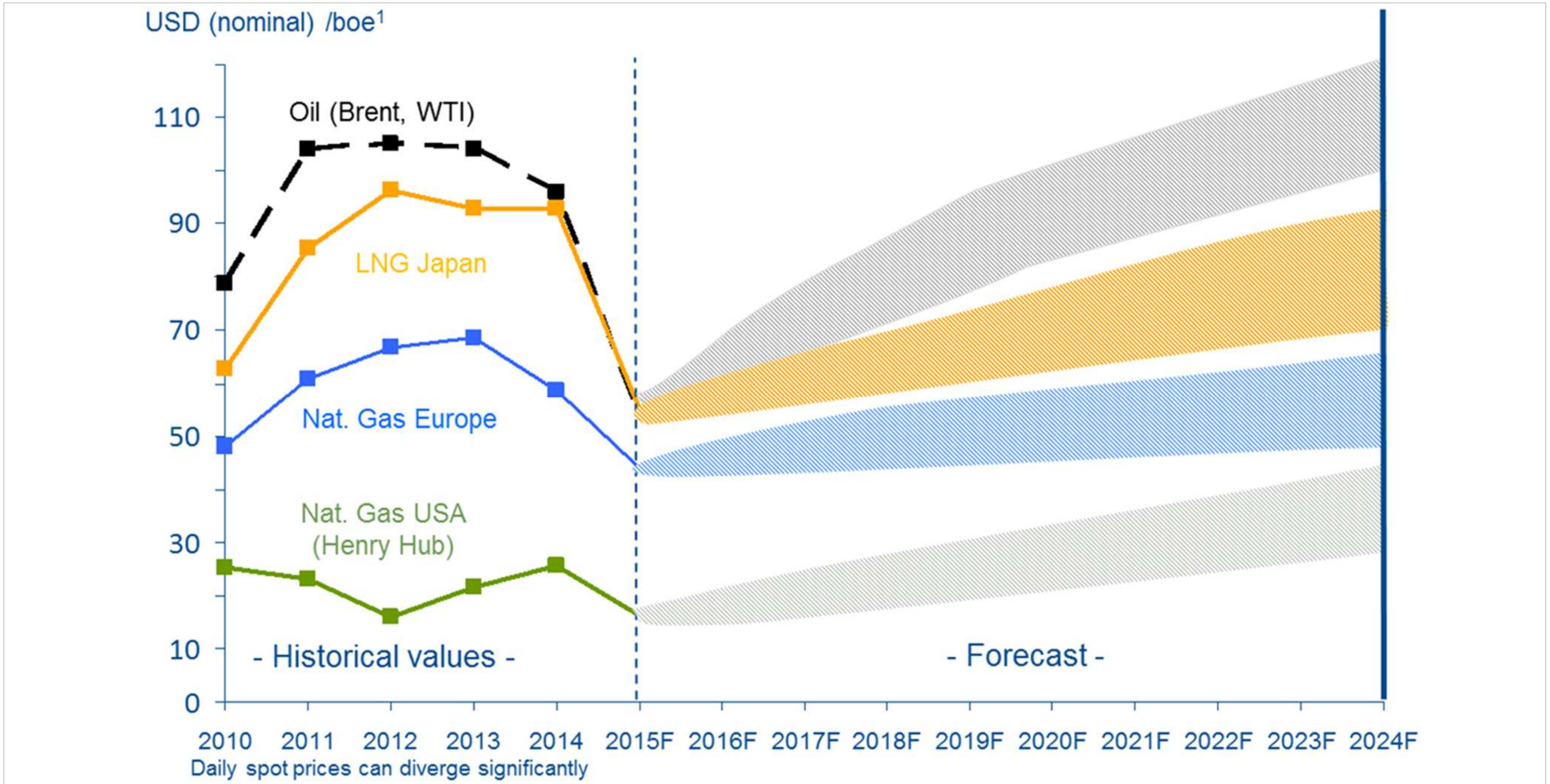
• **Types:**	**B35:40L8-9 & B35:40V12-16-20**
• **Bore:**	**350 mm**
• **Stroke:**	**400 mm**
• **Power:**	**440 - 480 kW / cyl.**
• **Speed:**	**500 – 750 rpm**
• **Power range:**	**3500 – 9620 kWmech**

3 Motivation for Gas Engines in mobile Applications
Gas Reserves



➢ **Reserves of natural gas are much larger than oil reserves.**

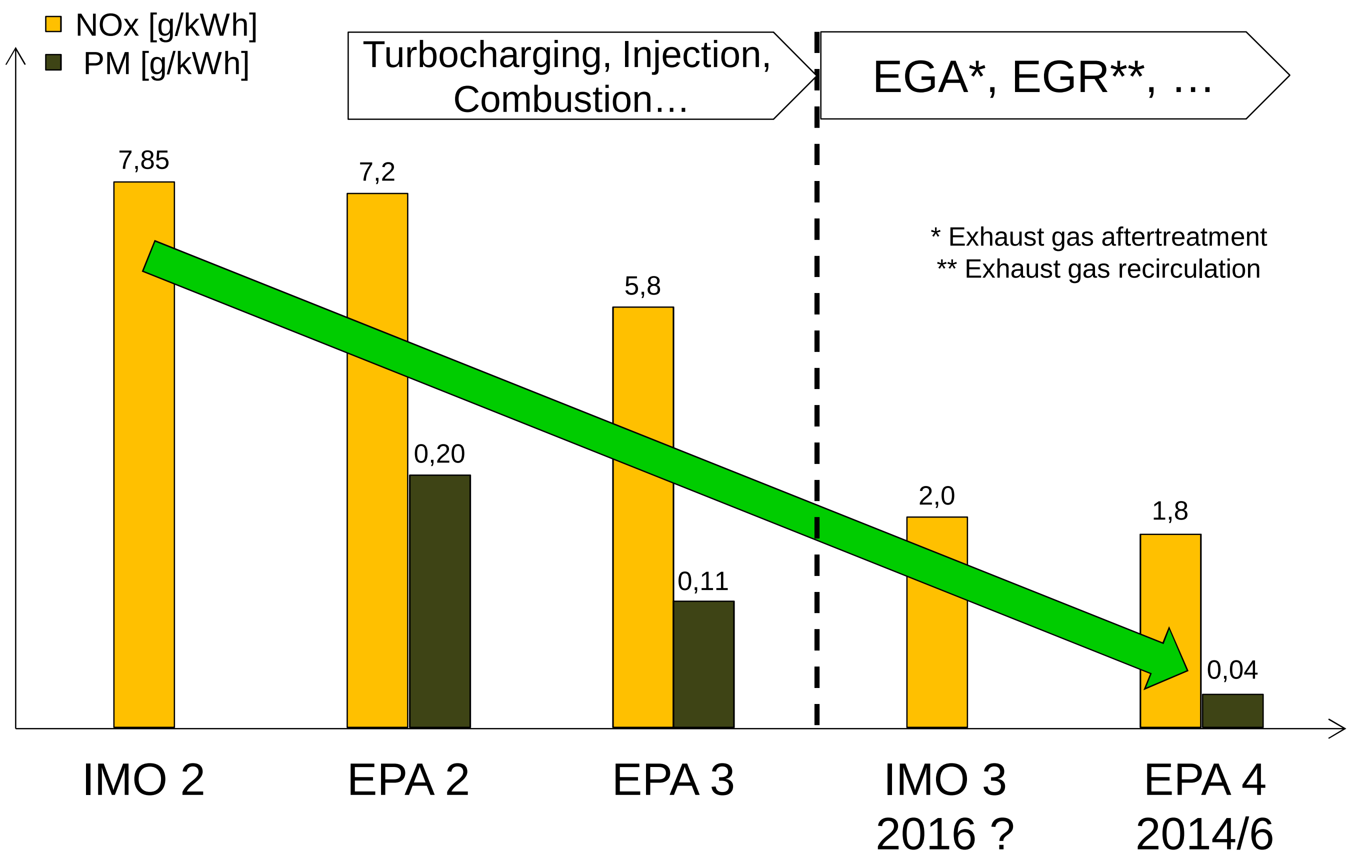
3 Motivation for Gas Engines in mobile Applications
Gas Price vs. Crude Oil – annual average prices



1) Conversions: 1 barrel = 42 gallons ; 1 boe (barrel of oil equivalent) =1x 10^6 * 5.8 BTU = 1.7 MWh = 170 m³n nat. gas

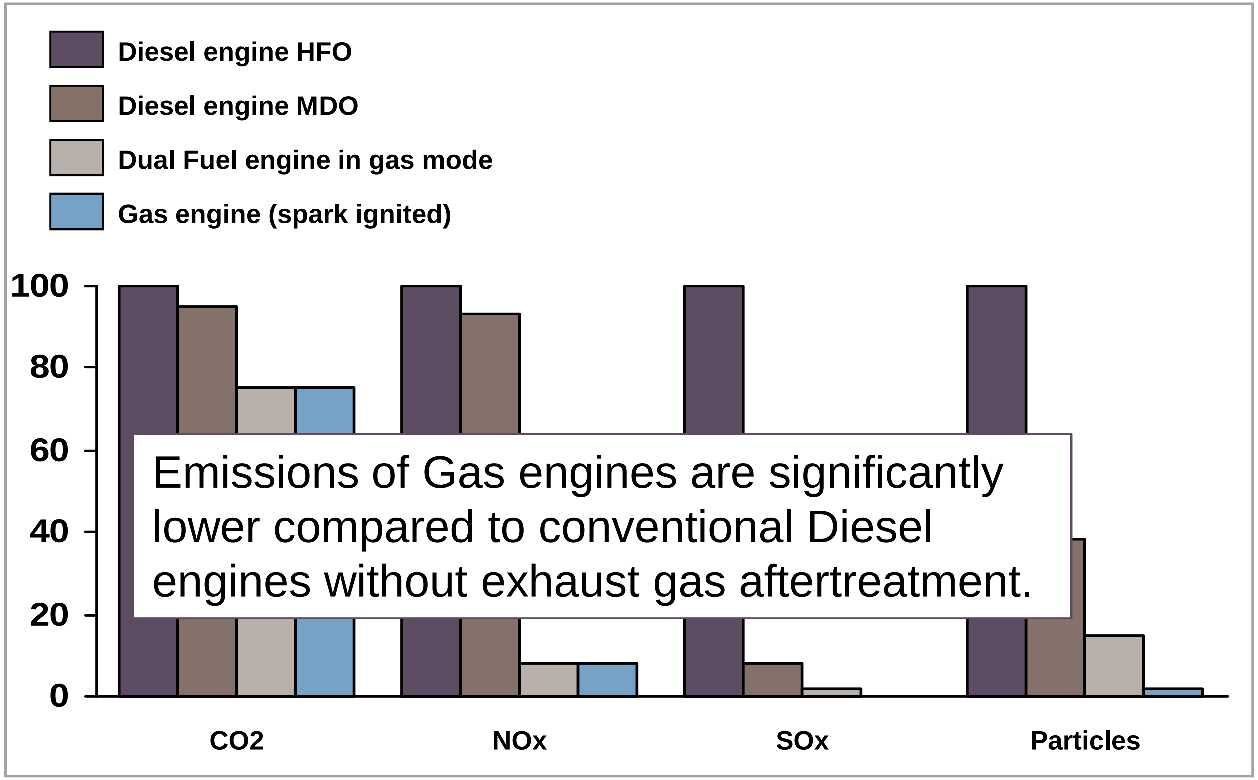
Sources: LSE Research; EIA; IEA, World Bank, Bloomberg

3 Motivation for Gas Engines in mobile Applications Emission legislation for marine Diesel engines



3 Motivation for Gas Engines in mobile Applications Emissions of Diesel and Gas engines

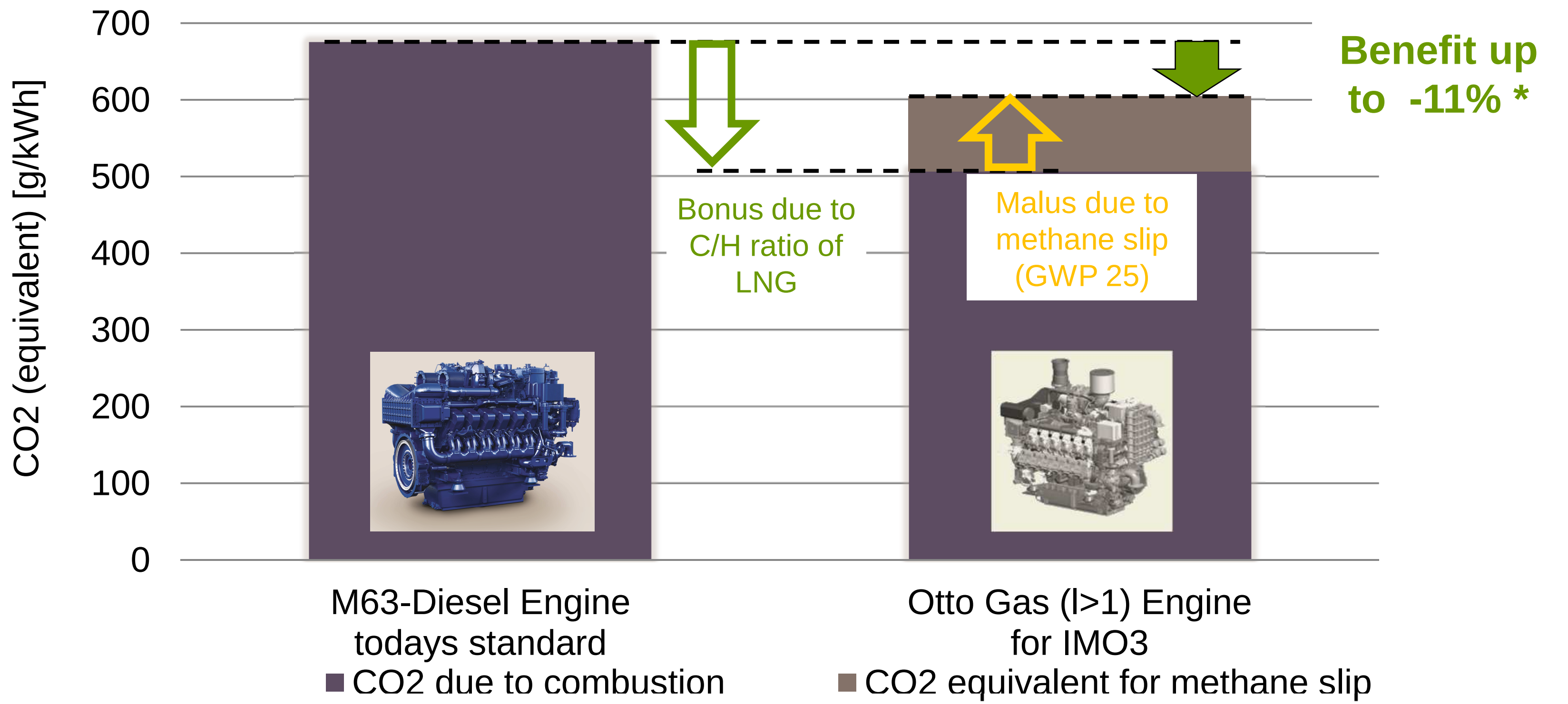
Emissions of Diesel compared to Gas engines



Emissions of Gas engines are significantly lower compared to conventional Diesel engines without exhaust gas aftertreatment.

3 Motivation for Gas Engines in mobile Applications
Emissions of Diesel and Gas engines

Equivalent CO2 emissions in TUG operating cycle



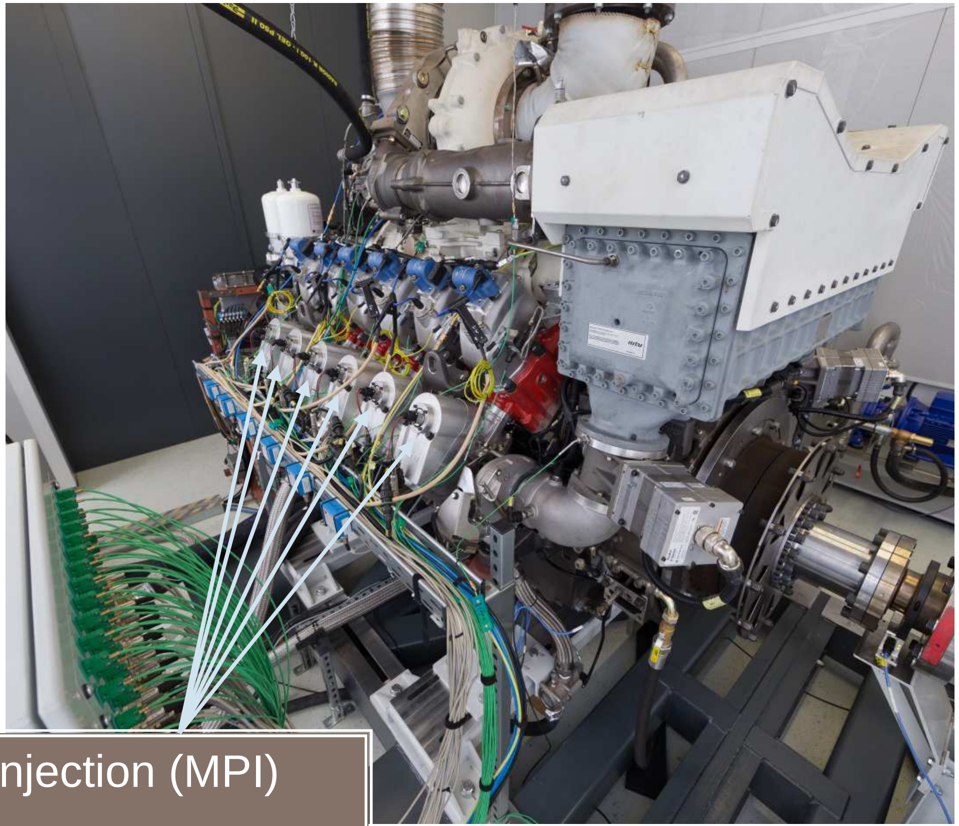
➢ **Gas engines have the potential to reduce GHG-emissions.**

GWP - Global Warming Potential

assumption: 1A load profile & same efficiency (Diesel and Otto Gas in operating cycle)

4 MTU lean burn Gas Engine Design
S4000 Gas Engine for Marine Applications

Engineering Targets:	
Application	Marine Commercial
Emissions	IMO3 / EPA T4 & low Methane Slip
Base-Engine	S4000 M63 Bore: 170 mm Stroke: 210 mm
Combustion	Otto-Gas (λ>1)
Engine Mapping	like M63
Engine Dynamics	like M63
Safety concept	IGF-Code: Gas-safe



Multi Point Injection (MPI)

➔ Double walled gas supply

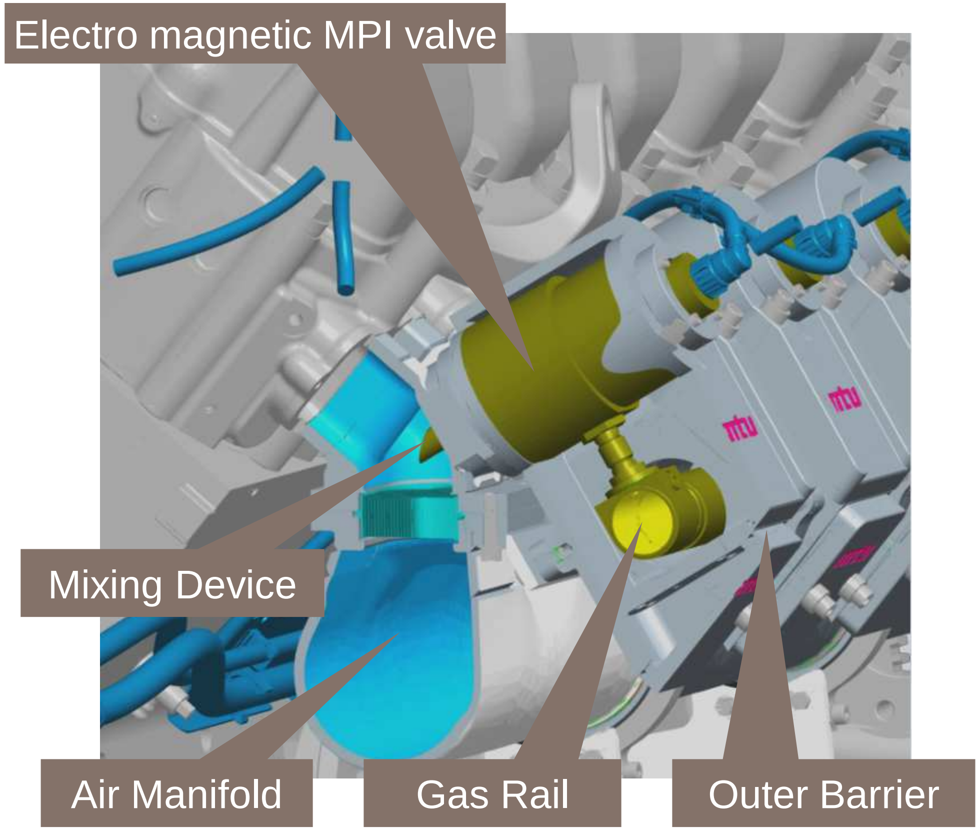
4 MTU lean burn Gas Engine Design
Multi Point Injection with Electric Valves

High flexibility to influence
the air / gas mixture with MPI-valves:

- Begin of injection
- Gas rail pressure

Flexible injection strategy:

- ➢ **Opportunity to optimize mixture quality for combustion stability at each engine operating point.**

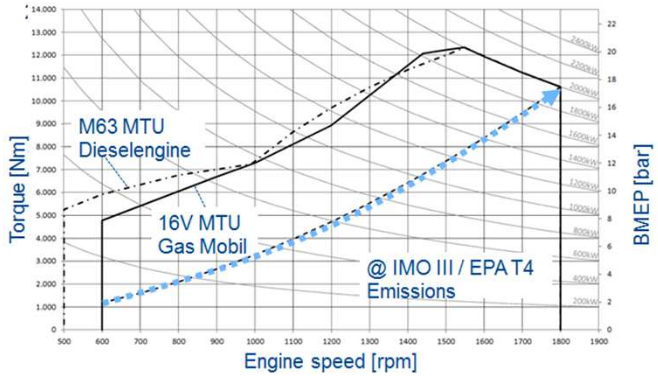


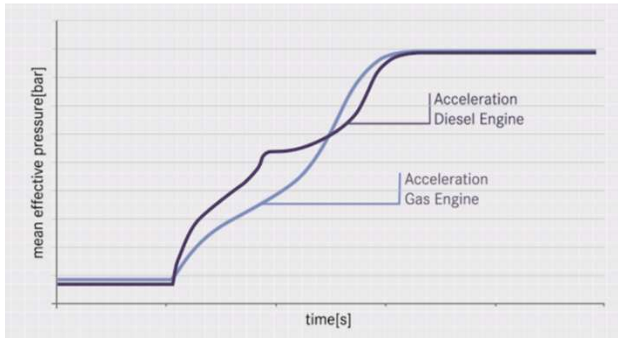
4 MTU lean burn Gas Engine Design transient performance

Key requirements and achievements:

- ➢ Performance map/range like Diesel

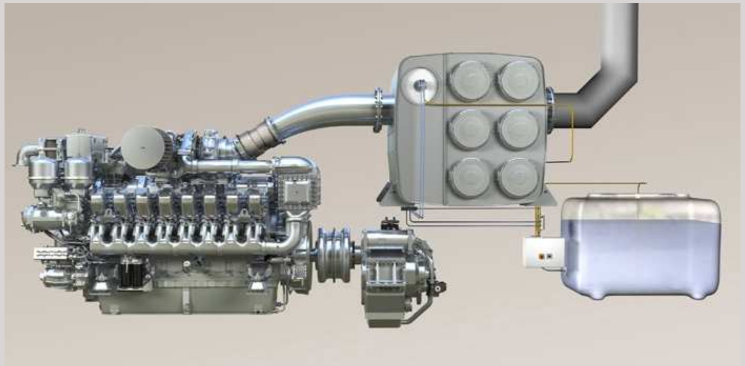
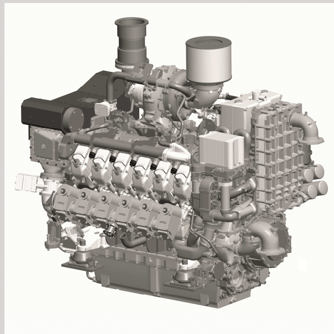
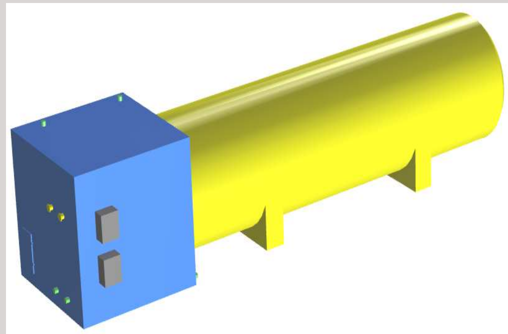
- ➢ Dynamic acceleration behaviour





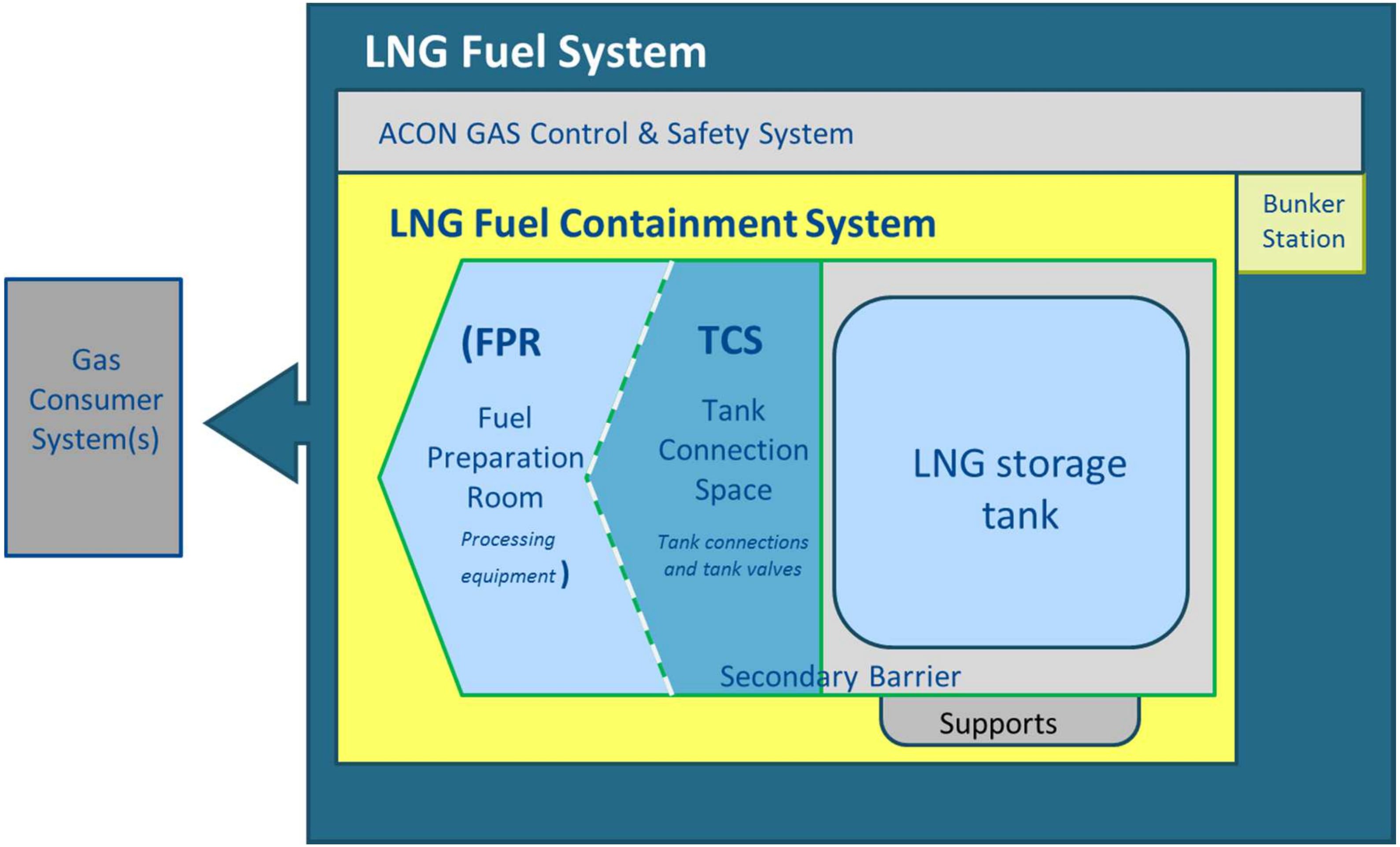
➢ First pure Gas high-speed engine with Diesel like performance.
Perfect match to application profile 1A in commercial marine (e.g. Ferries and Tug boats).

5 MTU´s options for future Marine Applications
Diesel and Gas Engines for IMO3

Diesel + SCR	Natural Gas
	 
+ proven, established + fuel logistics and handling - complexity: SCR - operational cost - limited oil reserves	+ operational costs + engine complexity: lean burn no EAT + global gas reserves - gas infrastructure - gas storage system

➢ **Diesel and Gas Engines are future fuel options for Marine applications.**

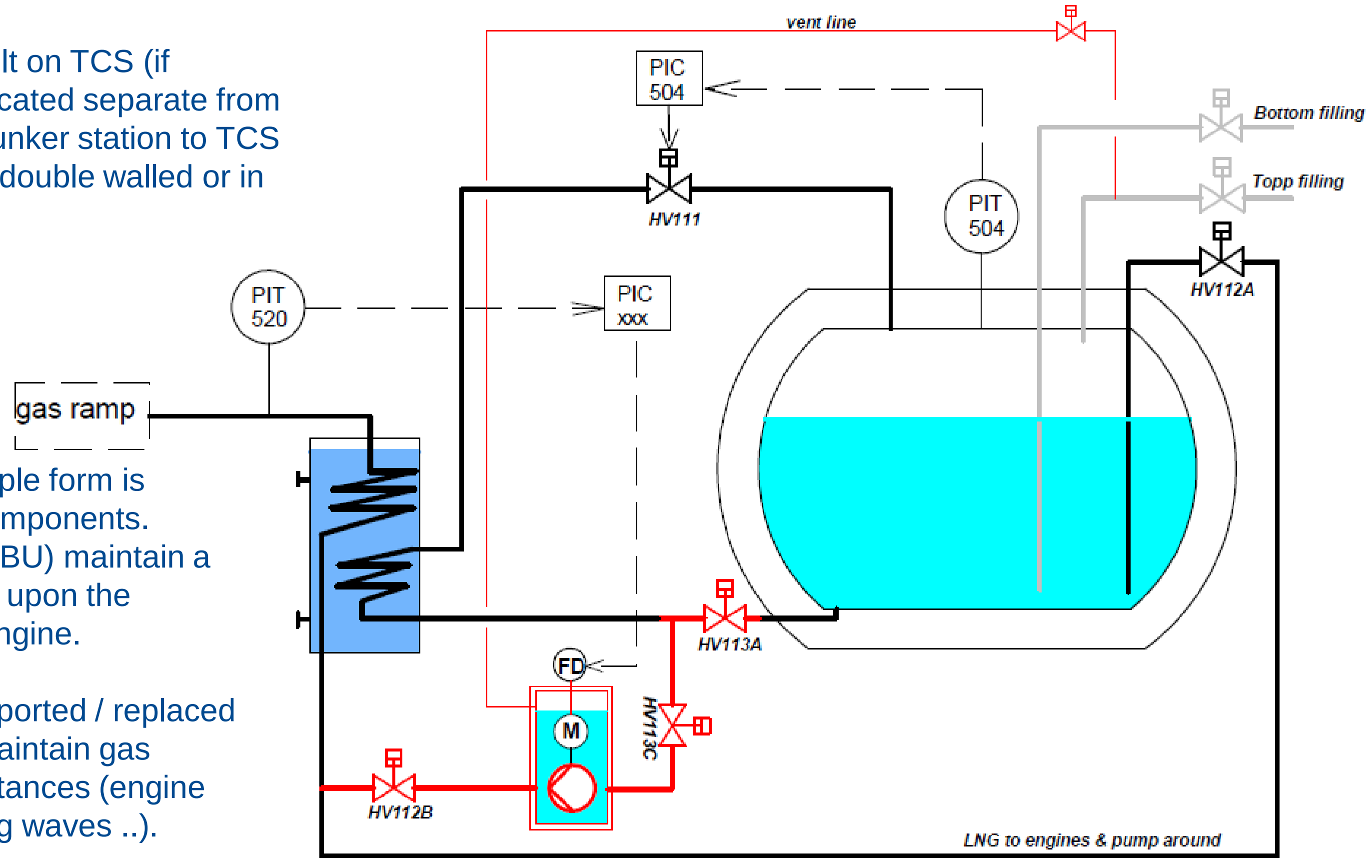
6 LNG Fuel systems Definitions



Rolls-Royce

6 LNG Fuel systems with PBU

Bunker station can be built on TCS (if TCS/Tank is on deck) or located separate from TCS. Bunker pipes from bunker station to TCS going below deck must be double walled or in duct with ventilation.



Source: Cryo AB

Process system in its simple form is gravity based, no active components. A Pressure Buildup Unit (PBU) maintain a pressure in the tank based upon the pressure required by the engine.

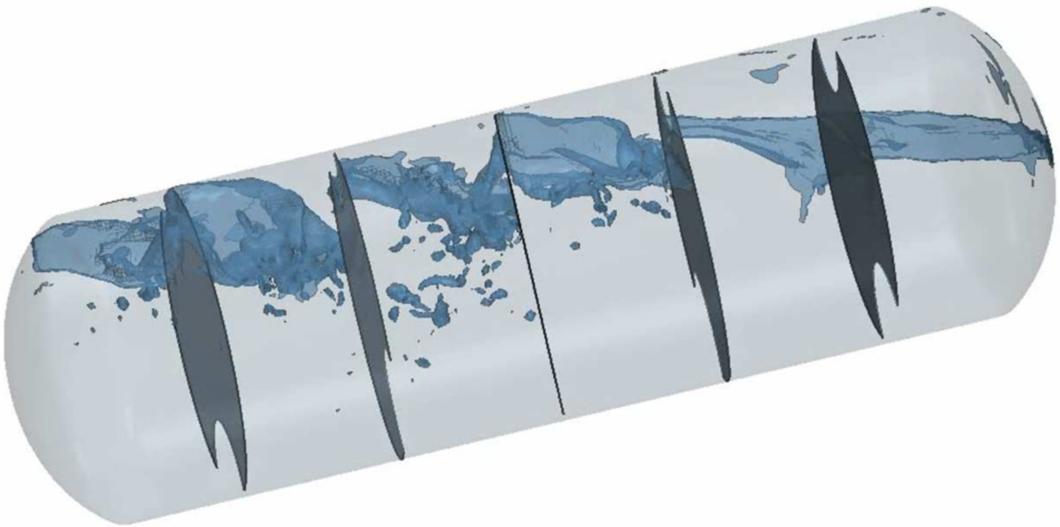
PBU can optionally be supported / replaced by a cryogenic pump, to maintain gas pressure under all circumstances (engine acceleration, sloshing in big waves ..).

A separate vaporizer and heater (combined) feed the engine.

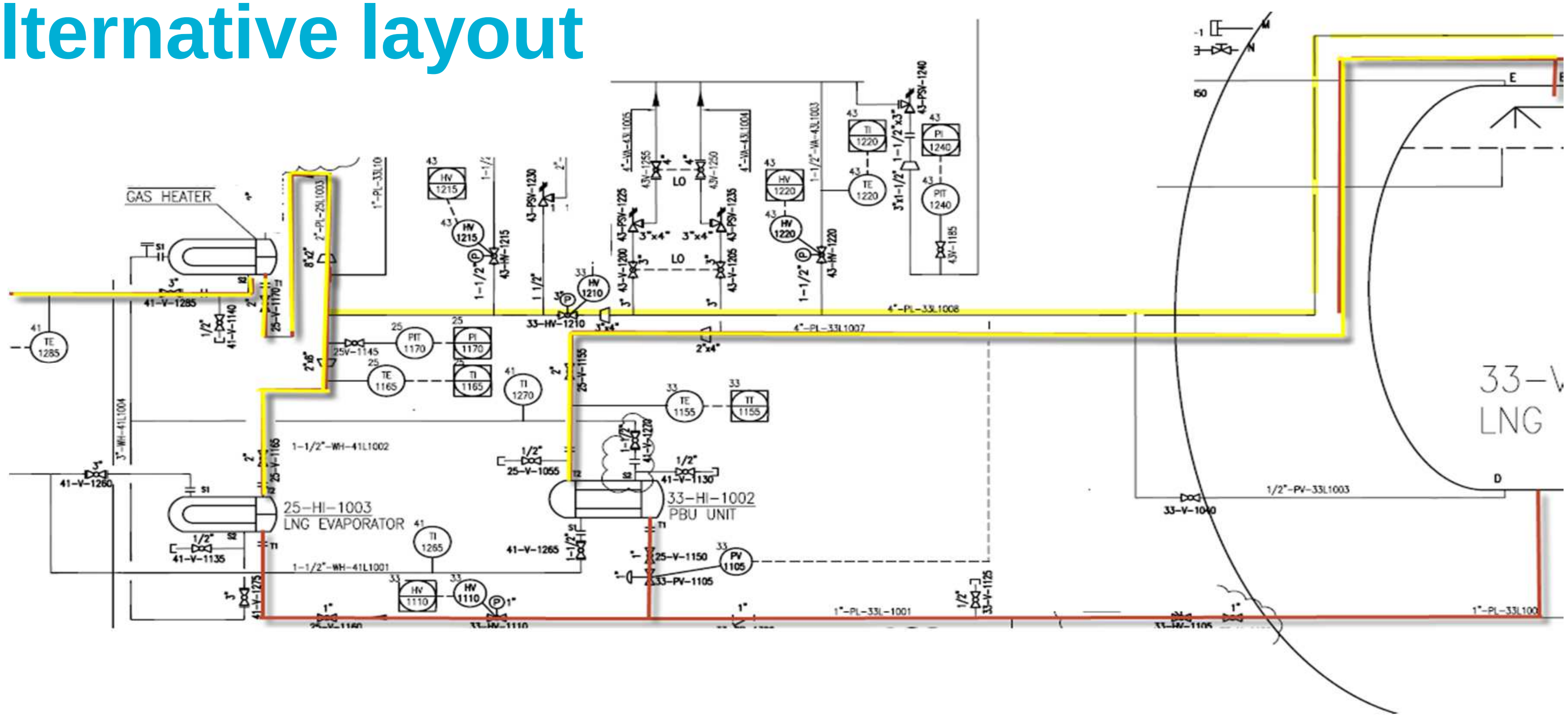
LNG Fuel Tank(s) can be located above or below deck and be horizontal or vertical. Requirements for fire insulation, cofferdam, ventilation etc. to be considered by ship designer.

Rolls-Royce

6 LNG Fuel systems
Excursion: Sloshing



6 LNG Fuel system with PBU alternative layout

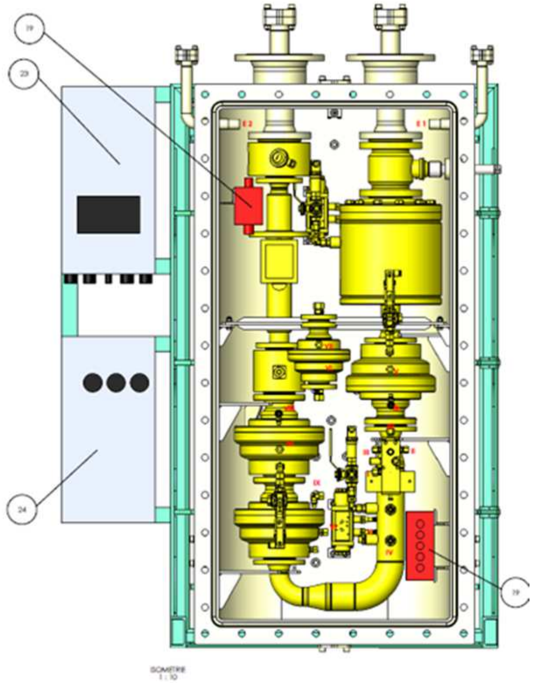


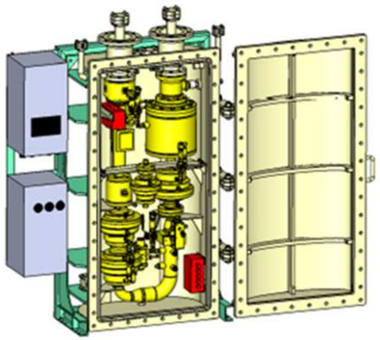
The sketch on last slide shows a combined water glycol bucket where the PBU is one circuit and Vaporizer and Heater is combined in a second circuit.

Alternatively PBU, Vaporizer and Heater can be separate units
→ Increased complexity but easier to replace if units fail. It also allows to take gas directly from gas pillow at full load.

6 LNG Fuel system
Gas Regulation Unit

- Gas Regulation Unit (GRU)
  - part of engine scope
  - located in TCS or in a separate housing





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7 IMO – IGF-code and Class regulations

- Inherently gas safe engine → ordinary engine room
  - Double walled pipes to cylinder (outer space ventilated w/gas detection or overpressure inert gas filling w/pressure detection)
- Non inherently gas safe engine → engine in ”container” with ventilation
  - **E**mergency **S**hut-**D**own of engine in case of gas leakage
- Single engine installation
  - Redundant propulsion min. 40% of installed ME power
- Multiple engine installation
  - Redundancy requirements fulfilled, but needs 2 TCS’ (process plants)

IMO INTERNATIONAL MARITIME ORGANIZATION **E**

MARITIME SAFETY COMMITTEE
95th session
Agenda item 22

MSC 95/22/Add.1
19 June 2015
Original: ENGLISH

REPORT OF THE MARITIME SAFETY COMMITTEE ON ITS NINETY-FIFTH SESSION

Attached is annex 1 (Resolution MSC.391(95) – Adoption of the International Code of Safety for Ships Using Gases or other Low-Flashpoint Fuels (IGF Code)) to the report of the Maritime Safety Committee on its ninety-fifth session (MSC 95/22).

8 Gas Engines in Marine Application
Challenges to overcome

Especially small scale shipping is facing severe barriers on its way to LNG:

- High equipment costs due to
  - high safety requirements
  - currently small target market
  - limited development activities
  - high component prices
- Limited range of available engines
- Lack of small scale bunkering facilities
- Missing harmonization of LNG-coupling and transfer equipment (Link between delivering facility and receiving vessel)
- Rules and regulations (e.g. IGF code) for vessels and legal framework for LNG bunkering infrastructure not finalized yet → long and expensive permitting processes
- Education and Training of LNG handling crew

8 Gas Engines in Marine Application
Potential Measures to make it a success

- Facilitate standardization and innovation projects for guidelines and components aiming to cost reduction of LNG equipment without reducing the safety
- Initiate cooperation and harmonization with other small scale shipping markets like USA and China in order to reduce the problem of small market and missing incentive for manufacturers and suppliers to invest in development of new technology

The common efforts of all involved parties will be necessary.

Communication platforms:
- LNG-Initiative Nordwest
- LNG Masterplan
- Maritime LNG Plattform
- etc.

Thank you for your attention