



Rolls-Royce

Marine propulsion

powered by natural gas

Port and Shipping Tech Conference
Genoa, November 22-23, 2010

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Content:

- Rolls-Royce Marine: an all-inclusive range of products
- Natural Gas and LNG
- Use of natural gas (LNG) as marine fuel
- LNG supply chain for marine bunkering
- Bergen gas engines - power range
- Rolls-Royce gas propulsion systems
- Some references



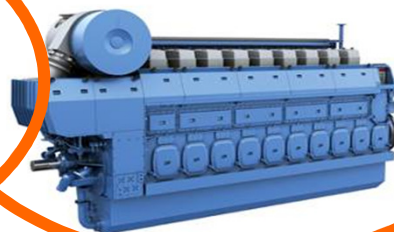
An all-inclusive range of products

Focus on environmental friendly solutions based on the widest range of products in the marine industry

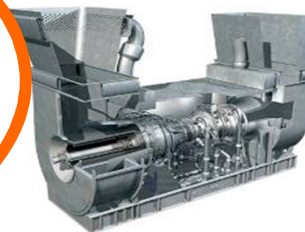
Ship design and integrated ship systems



Diesel and gas engines



Gas turbines



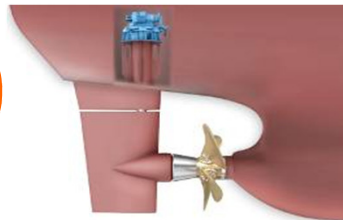
Automation and control - DP



Propulsion systems



Steering systems



Electrical podded propulsors



Azimuth thrusters



Tunnel thrusters



Waterjets



Stabilising systems



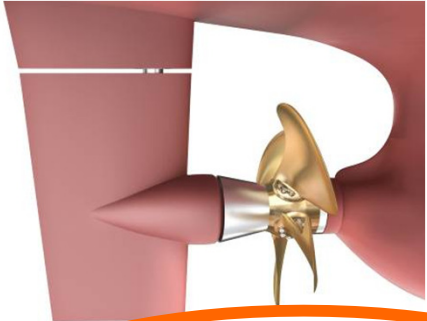
Winch systems



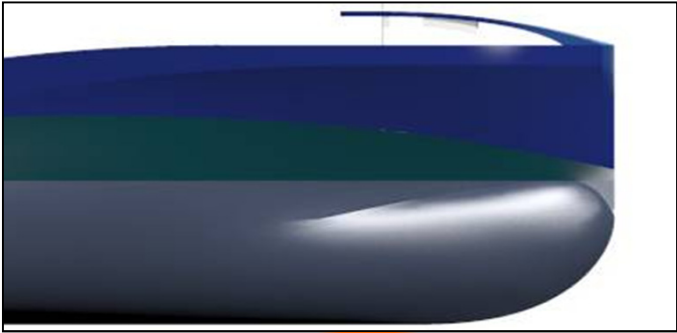
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Increasing oil prices will drive new technologies

High efficiency propulsion and manoeuvring systems

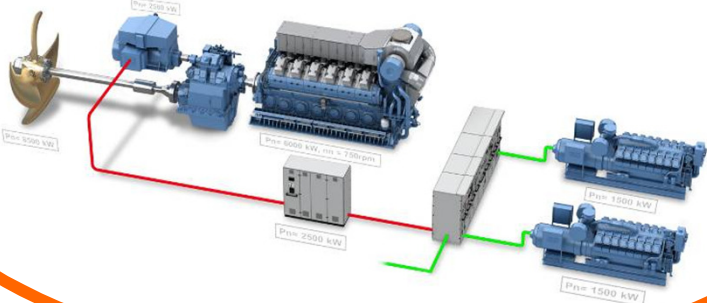


Advanced hull forms



Application for patent protection by Rolls-Royce

Hybrid propulsion



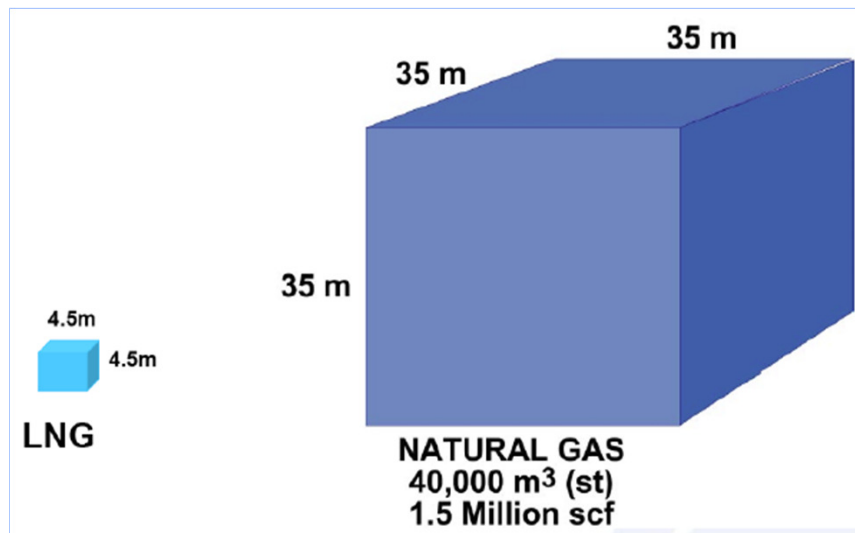
Gas powered propulsion



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Natural gas and LNG

- Natural gas is consisting primarily of methane, a typical composition is:
 - Methane 94%
 - Ethane 4.7%
 - Propane 0.8%
 - Butane 0.2%
 - Nitrogen 0.3%
- Natural gas burns more cleanly than all other fossil fuels:



1: 600



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Natural gas (LNG) as a marine fuel

- **Emissions**

- Reduce harmful emissions of NO_x, SO_x, CO₂, Particles

- **Costs, operability and maintenance**

- Reduced maintenance, higher TBO
- Remove- or Reduce Ship owners taxes and other fees related to emissions
- Reduced LO consumption
- Reduced Fuel consumption, gas engine more efficient than diesel.
- All HFO installations deleted; Heating system with coils, purifiers, treatment units, service- and settling tanks.

- **Installation**

- A simpler propulsion set installation / refurbishment
- A simpler propulsion set operability and maintenance



LNG supply chain for marine bunkering

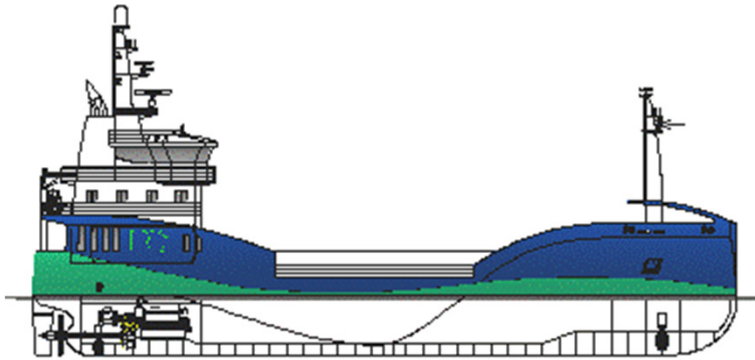
- LNG can be supplied by:
 - Land based stations
 - Tank trucks
 - Coastal tankers
 - Bunker barges
 - Floating bunkering stations



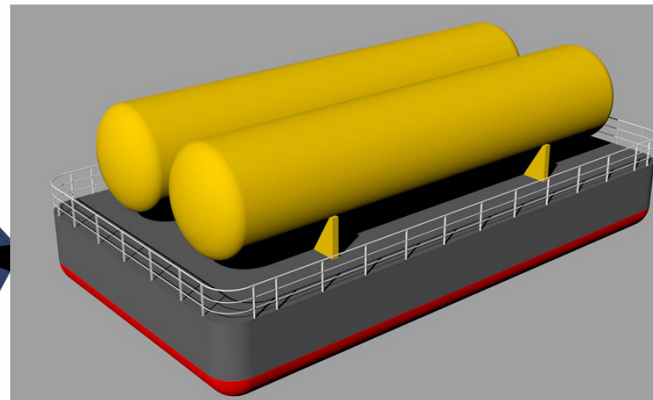
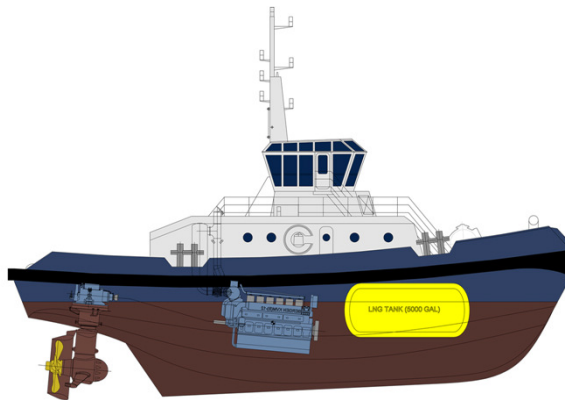
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Forthcoming projects for LNG bunkering operations:

- **Dedicated bunkering vessels**



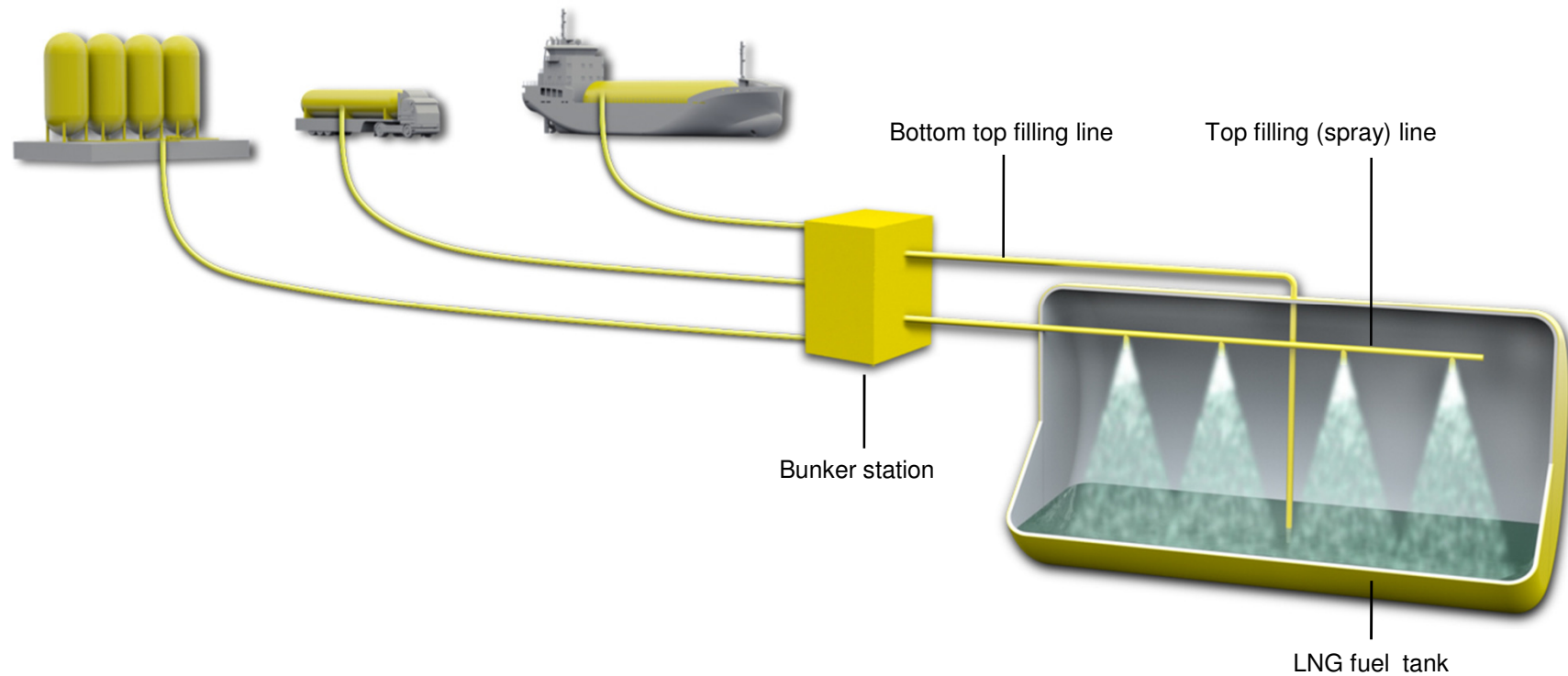
- **Bunker barges w pusher tugs**



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LNG bunkering

Liquefied Natural Gas (LNG) is bunkered by pressure from land based stations, tanker trucks, coastal tankers or bunker barges.



Coastal trading LNG carriers loading at a large import terminal



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The bunkering terminal @ Halhjem 1000 m³ storage capacity



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LNG storage for ferries @ Halhjem



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Delivery - Bunkering



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LNG bunker volumes - 1

FUEL	LHV (MJ/Kg)	Density (Kg/m3)	Energy density (MJ/m3)
MDO	42.7	900	38.430
LNG	54.7	442	24.177
MDO / LNG energy density ratio (same volume): 1.6			

Specific fuel consumption of Bergen gas engines vs. MDO engines (@ MCR):

- Bergen MDO engines: 7770 KJ/KWh
- Bergen gas engines: 7500 KJ/KWh



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LNG bunker volumes - 2

- Considering the existing “C” type (pressure vessels) cylindrical LNG storage tanks
- Considering the additional available space due to absence of conventional fuels installations: heating system with coils, purifiers, treatment units, bunkering, service- and settling tanks
- Considering tanks insulations, additional bulkheads, access trunks, vents, etc.
- Presently LNG could require up to 2.5 / 3 times as much space as MDO for the same amount of energy onboard
- The forthcoming installations of prismatic and membrane type tanks for LNG as bunker will lower the volumetric ratio down to 2 times.



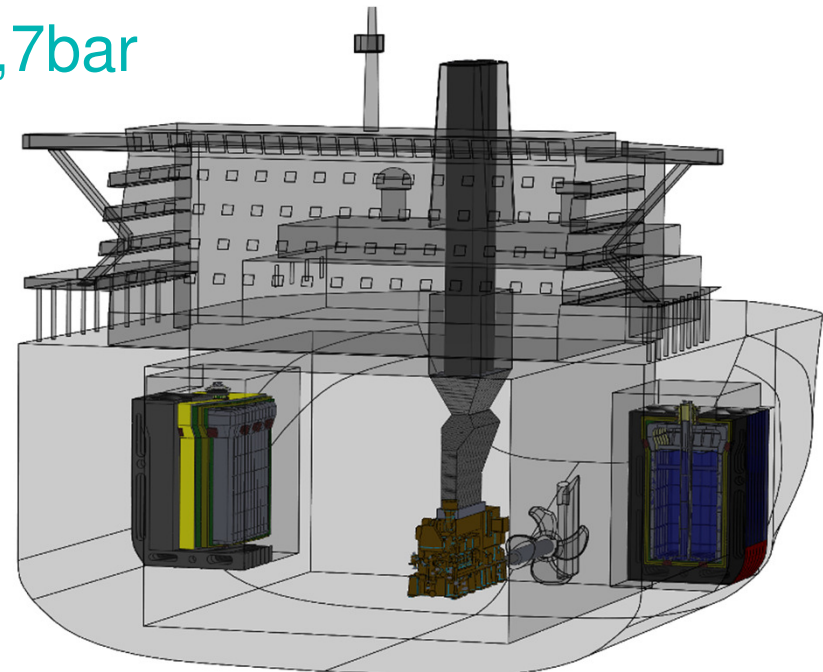
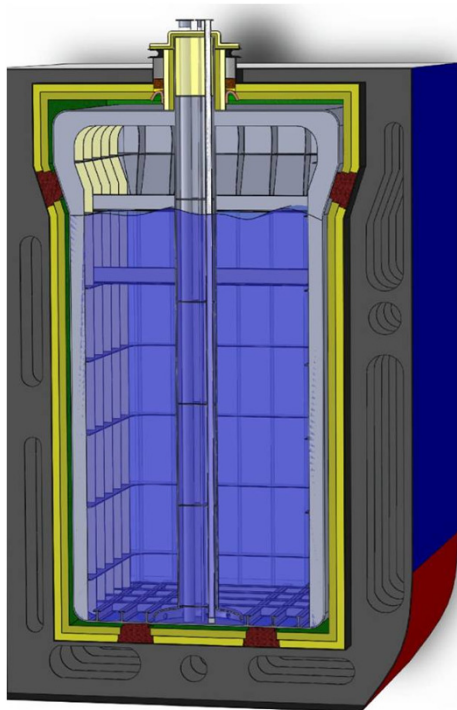
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LNG bunker volumes - 3

A-tank operating mock up in Bergen, NO.

Bunkering on A-tank and on Membrane tanks (prismatic tanks, hull shaped) will also be available

Hull integrated A-tank
Pressure-less – 0,7bar



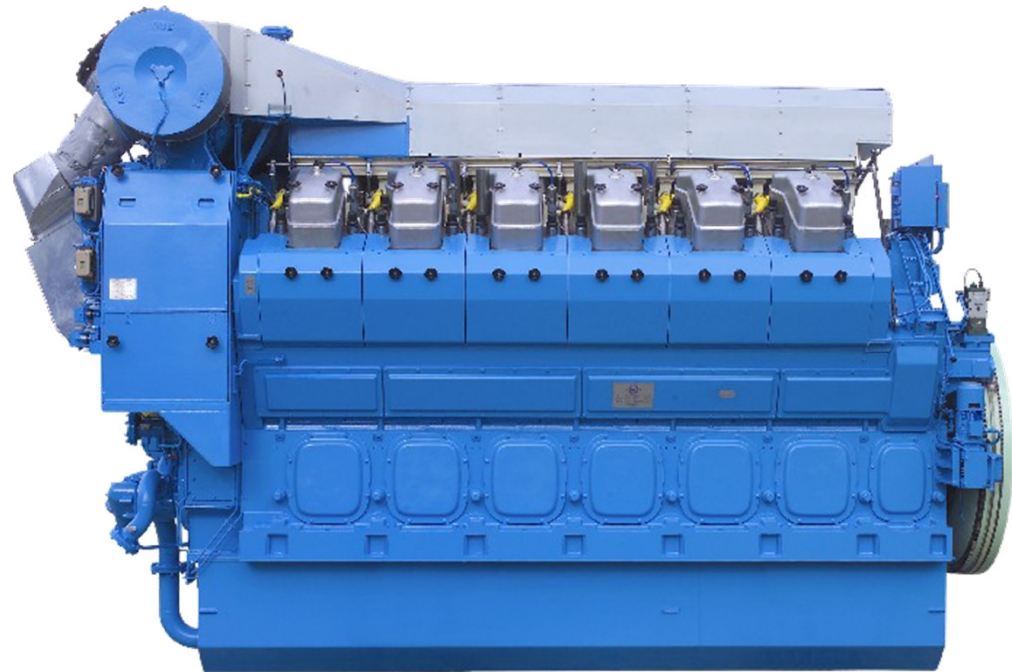
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Gas engine generation

S.I. “Lean Burn” Gas engines

Emissions:

- **CO2 emission reduced net by 30%**
- **NOx reduced by 86 % down from IMO Tier II level (meet IMO Tier III)**
- **PM emission reduced by 98%**
- **SOx emissions resolved**

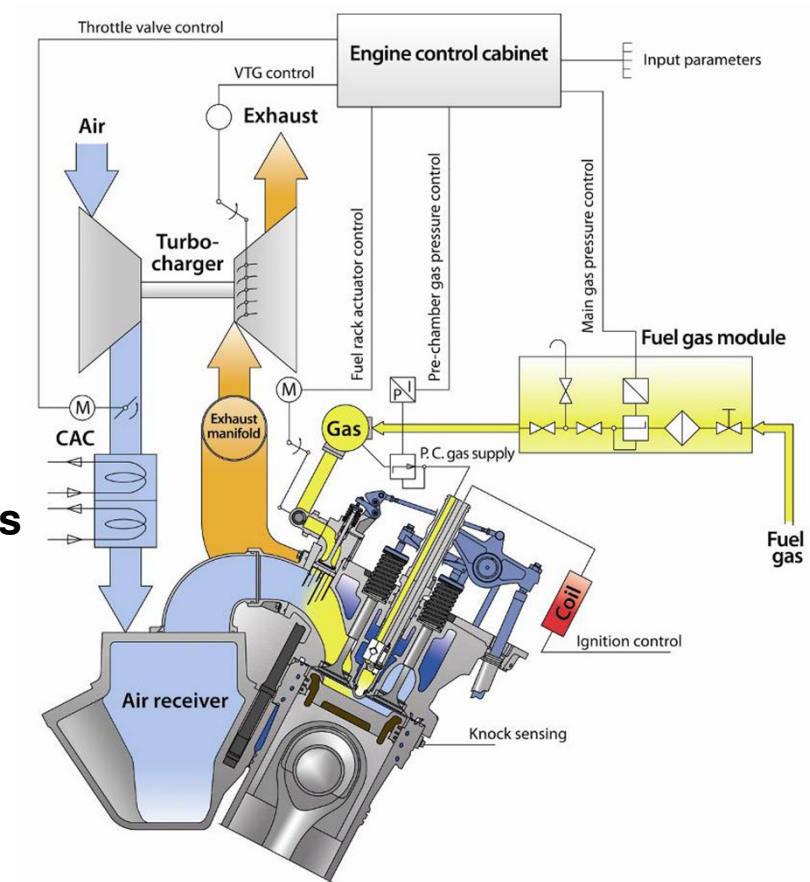


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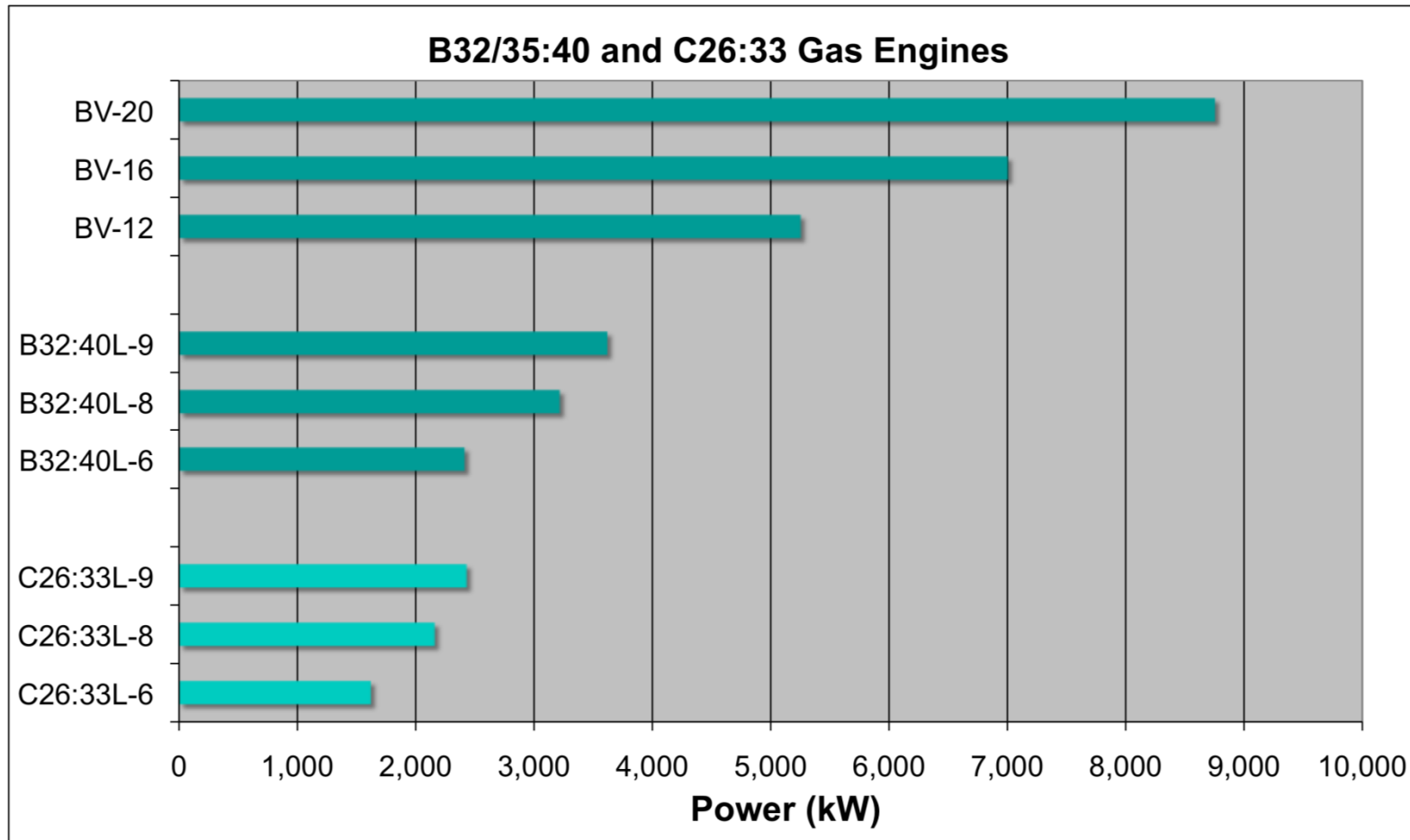
Features and benefits

- The C26:33 & B32/35:40 gas engines

- Compact and powerful
- Exceptionally low emissions of NO_x, CO₂, SO_x and particles
- **Available for both mechanical and electric driven applications**
- **High efficiency, 48%**
- Approved by Class for marine applications
- Service friendly
- **Optimum response at all engine load points (Variable Turbo Geometry)**
- No oil contamination
- Super silent resilient mounting
- Designed for single bearing alternators

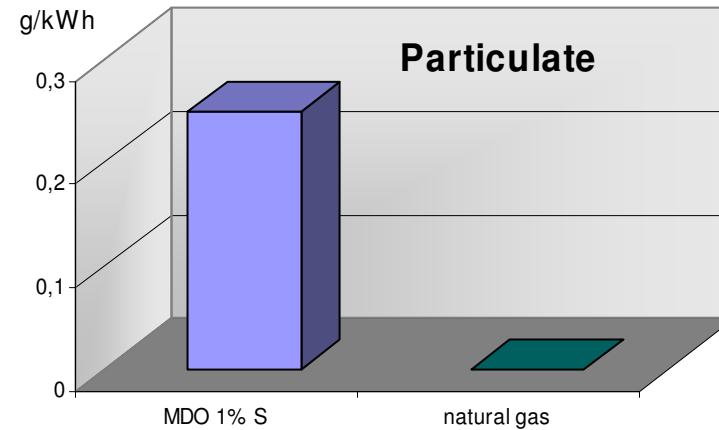
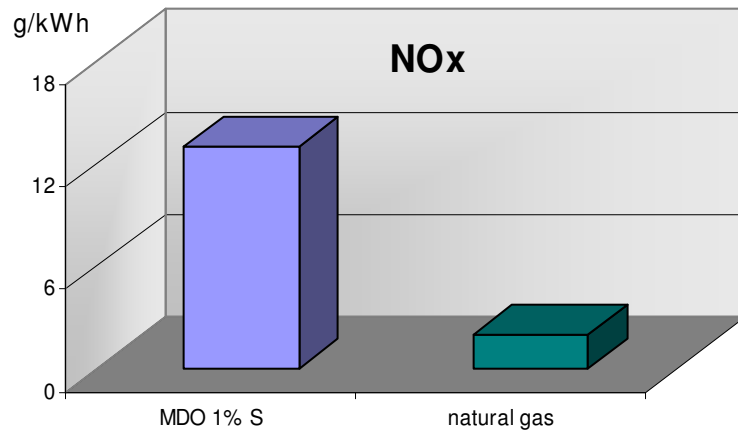
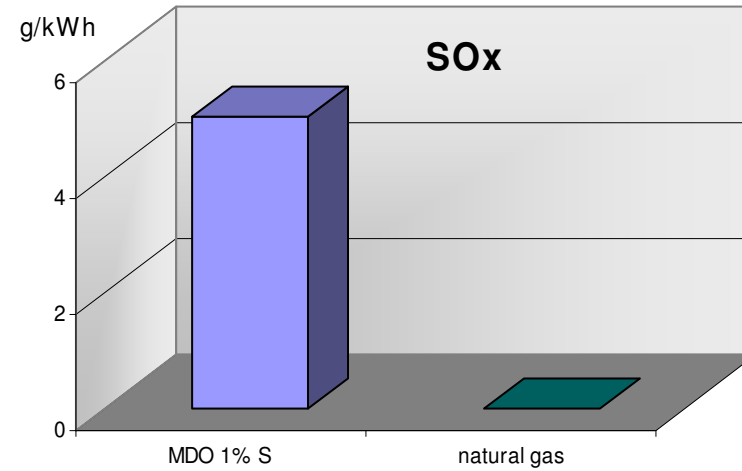
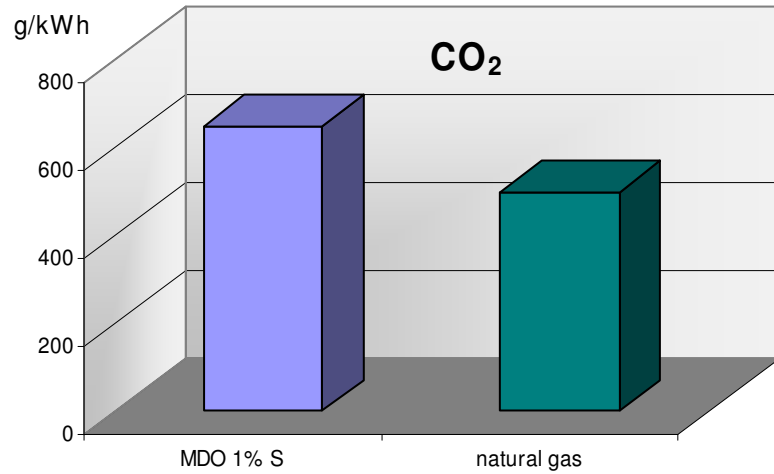


Power range Bergen gas engines



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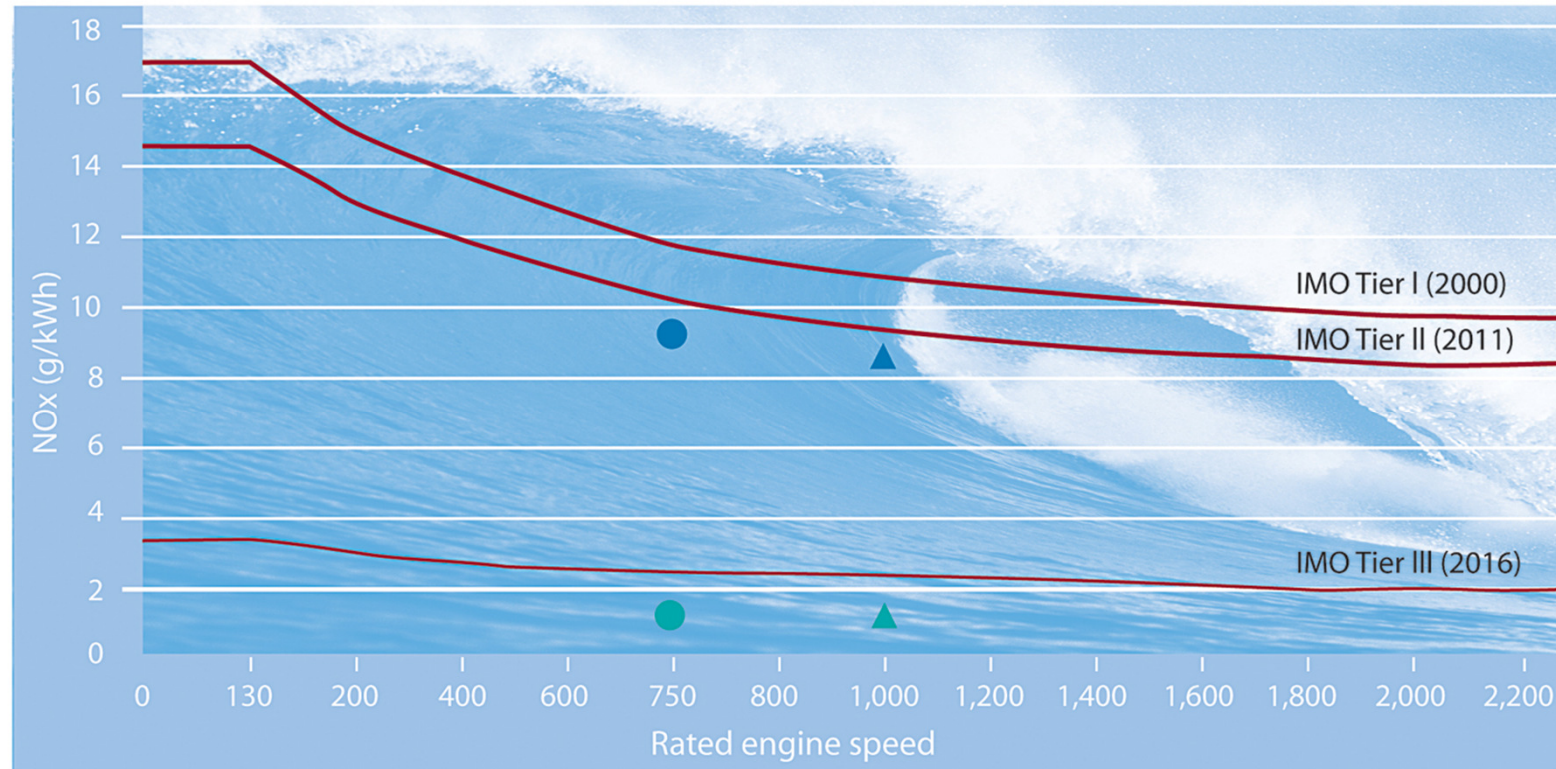
Bergen engines: MDO vs. Natural gas emissions



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NOx IMO emission limits

NOx emission for Bergen engines



● B32:40 diesel with Clean Design notation
 ▲ C25:33 diesel with Clean Design notation

● B35:40 gas
 ▲ C25:33 gas



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HFO / MDO

SCR
reduce
NOx

Scrubber
reduce
SOx

Filter
reduce
PM

Additional costs due to:

- Add Energy = CO2
- Add Urea
- Add maintenance
- Add Complexity



Lube oil
change over

Fuel
change over

Water
Separator

Oil
Separator

Waste
Material



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Dual fuel engine system: LNG+MDO/HFO

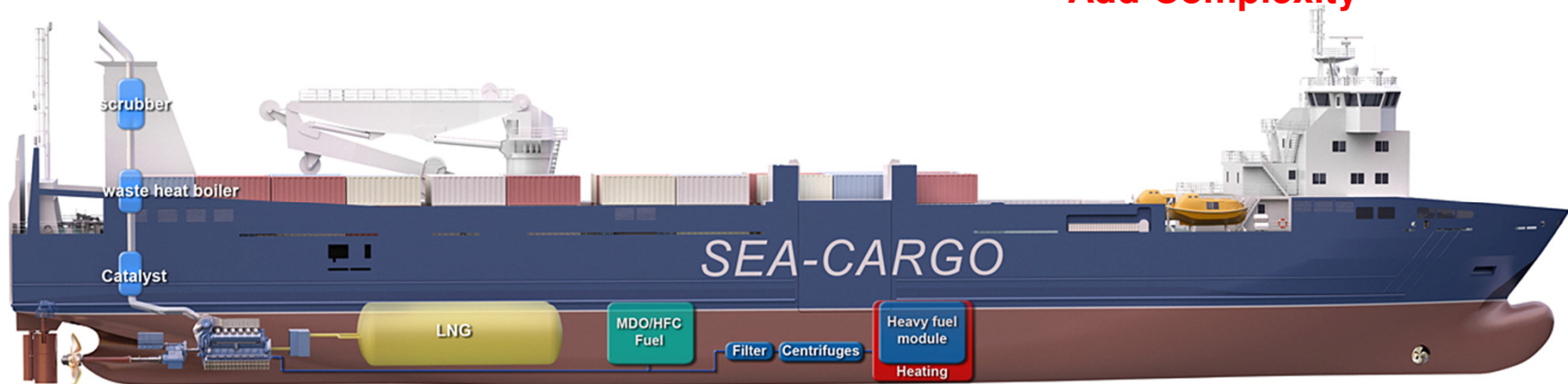
SCR
reduce
NOx

Scrubber
reduce
SOx

Filter
reduce
PM

More cost due to

- Add Energy = CO2
- Add Urea
- Add maintenance
- Add Complexity



Lube oil
change over

Fuel
change over

Water
Separator

Oil
Separator

Waste
Material



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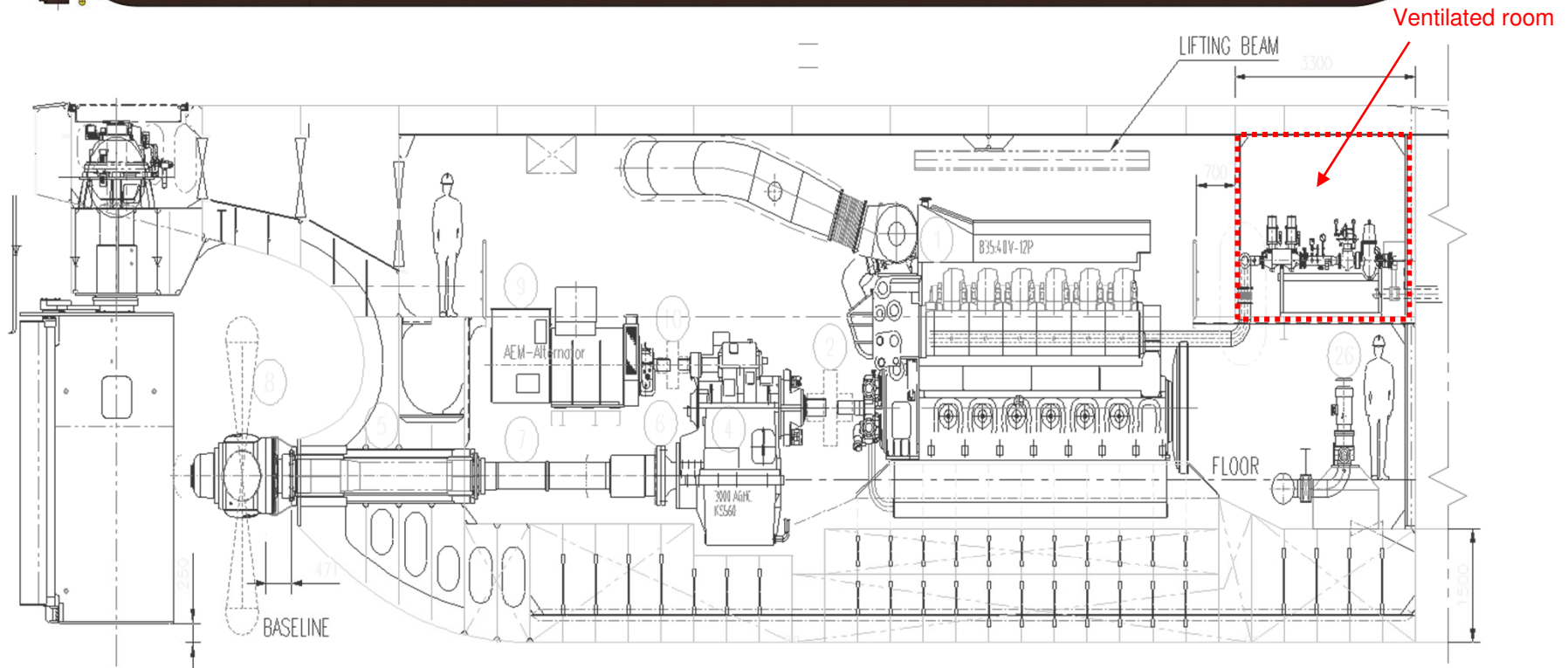
Natural gas

- Less energy = CO2
- No Urea and equipments
- Lower maintenance
- Utmost simplicity: few and "static" ancillary equipments



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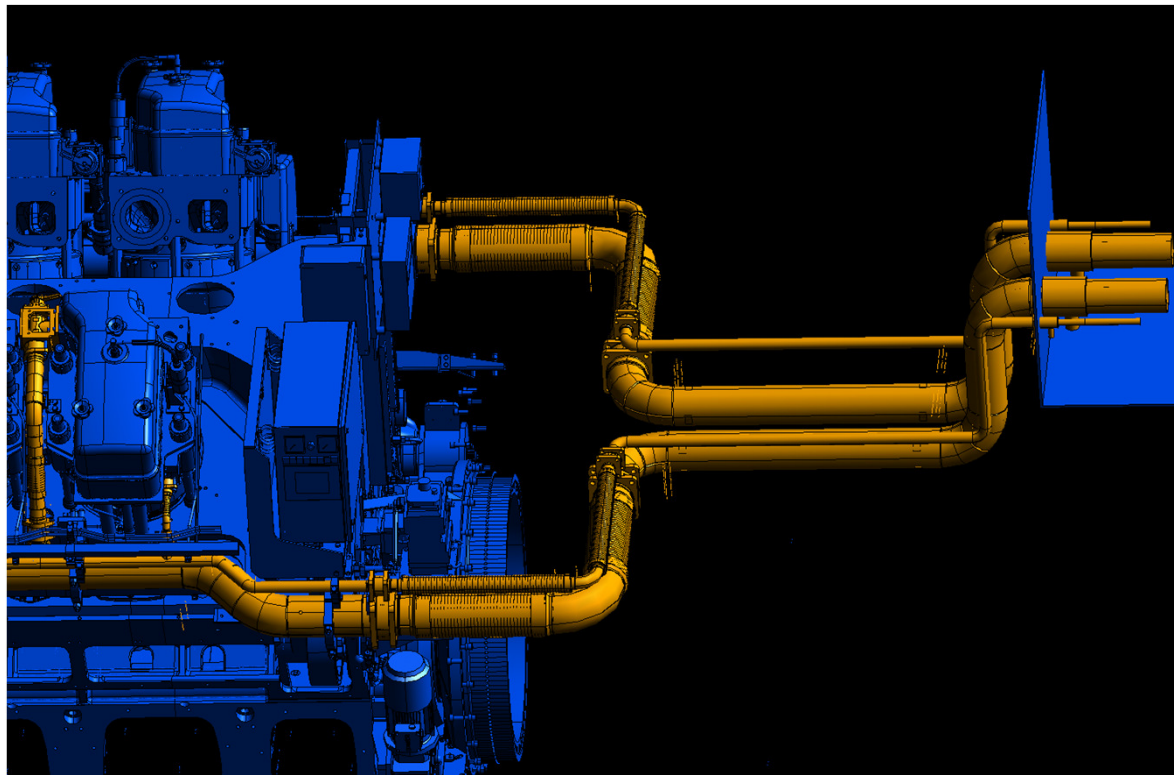
Inherently Safe Installation of engine



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Gas Engines: marine installation

- Double walled piping on main gas supply and pre-chamber gas for Inherently Safe Installation

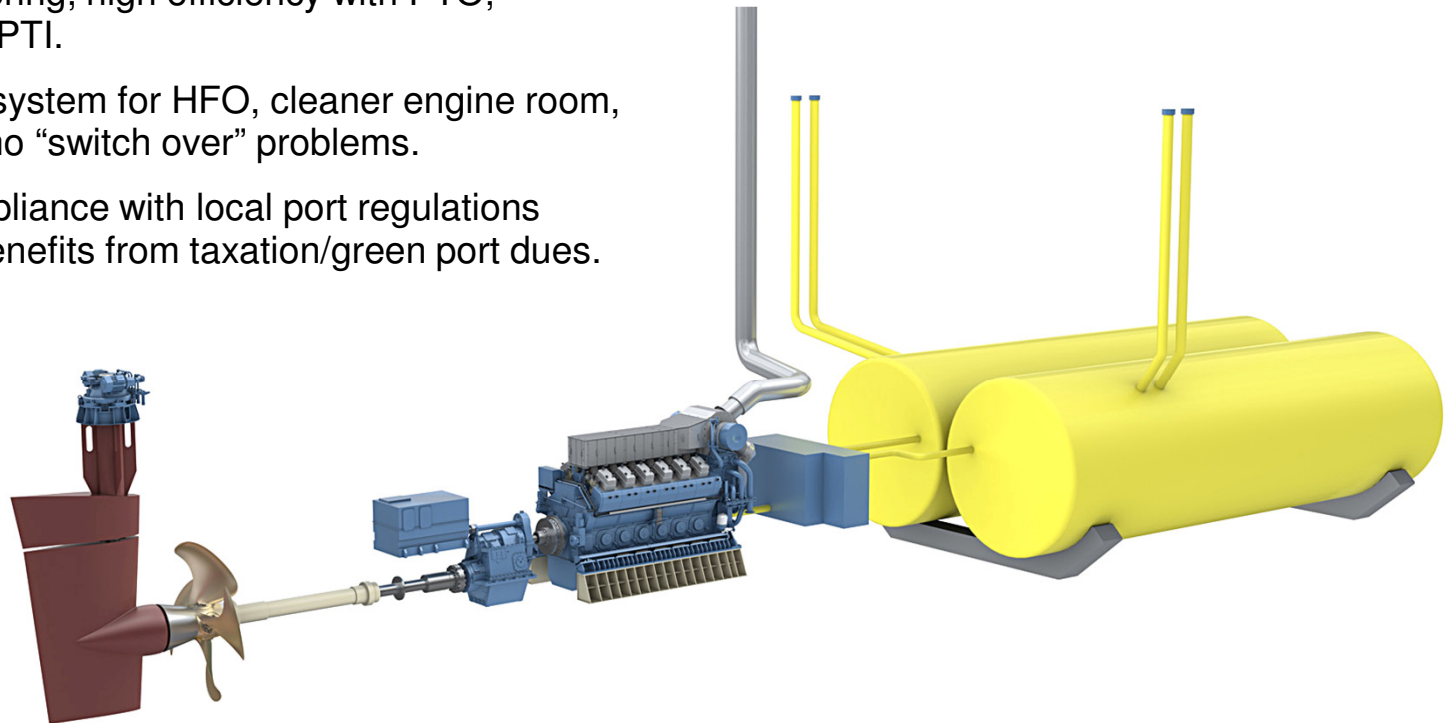


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Dual fuels ships: gas fuelled propulsion system

Operational benefits with LNG, single fuel main engine, MDO back up gensets

- One stop bunkering, high efficiency with PTO, redundancy by PTI.
- No purification system for HFO, cleaner engine room, less waste oil, no “switch over” problems.
- Long-term compliance with local port regulations and potential benefits from taxation/green port dues.

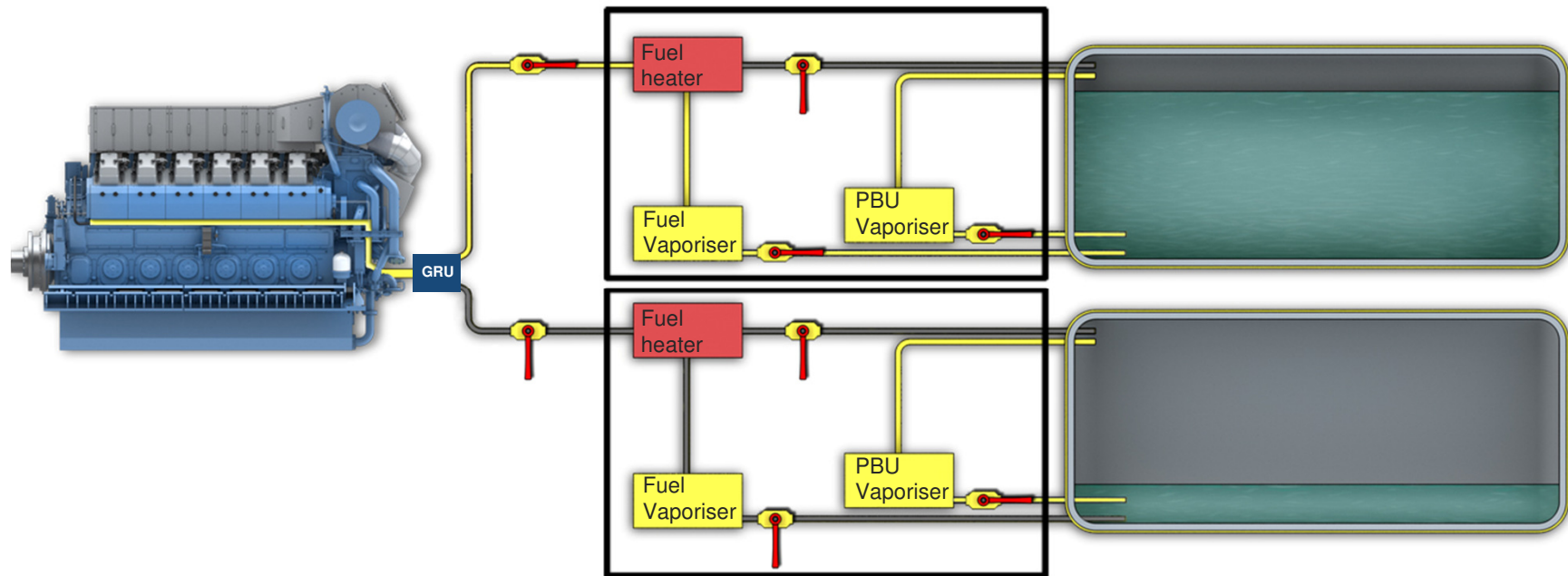


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Gas fuelled propulsion system

No moving equipments in the vaporisation and heating processes

Tank room with PBU vaporiser, fuel vaporiser and fuel heater – normal operation



Tank room arrangement

Bergensfjord, double-ended car ferry

- NO_x reduction = 160,000 cars running for 1 year

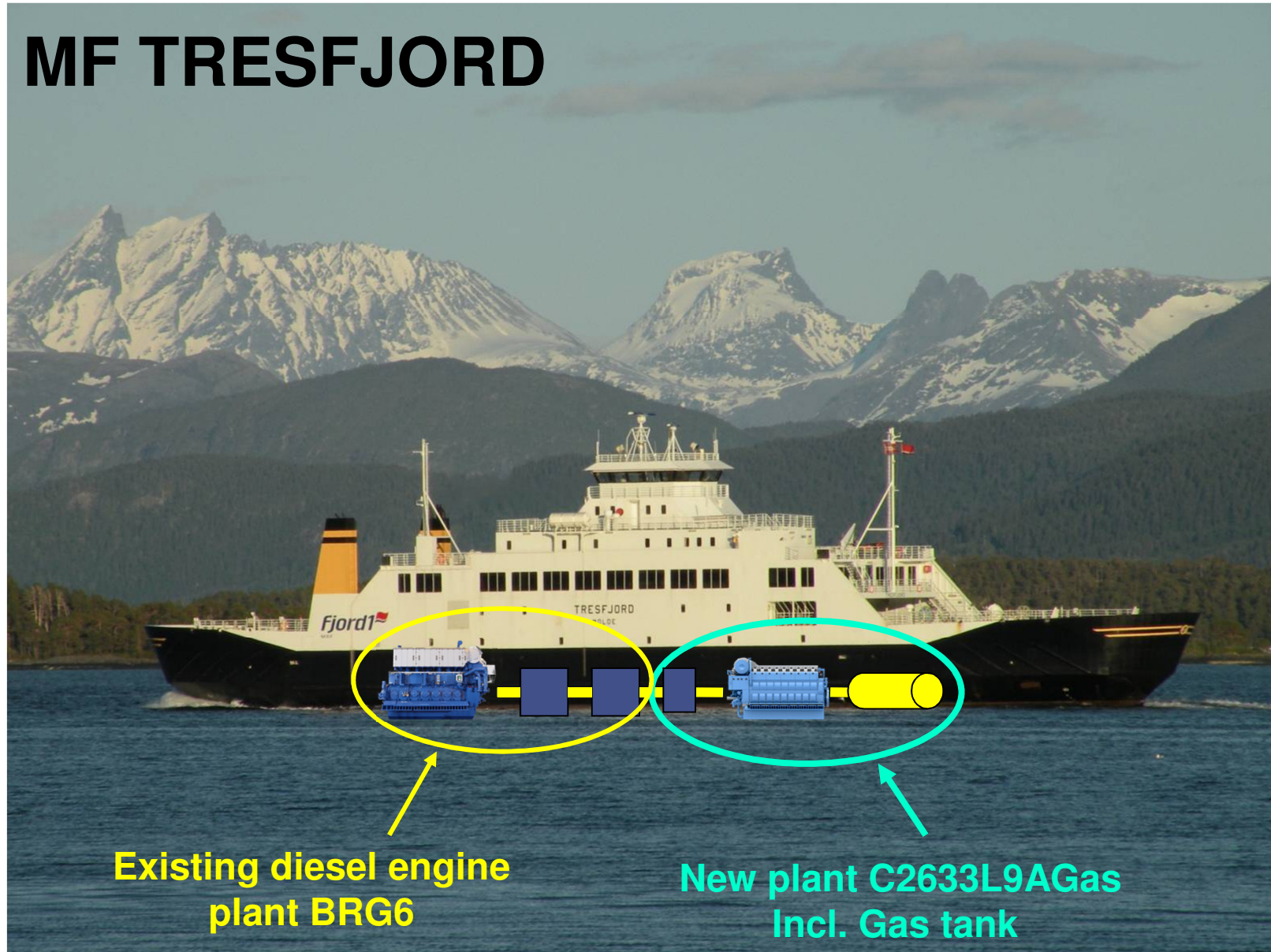


Tresfjord, double-ended car ferry

- Conversion of propulsion system from liquid fuel to natural gas



MF TRESFJORD



Existing diesel engine
plant BRG6

New plant C2633L9AGas
Incl. Gas tank



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On order LNG fuelled sea cargo vessels

The two 132.8 m LNG fuelled Sea-Cargo vessels will be able to carry 5,600 tonnes of cargo, with up to 94teu of containers on deck and 1,240 lane-metres of roro capability.

Rolls-Royce reduction gear, tunnel thrusters, flap rudder and steering gear, automation.

Rolls- Royce LNG fuel storage and handling system complete the package.



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Bergen Lean Burn Gas engines:

- More than 500 sold, over 400 in operation
- More than 20 mill running hours
- Plants with more than 180.000 hrs
- Plants operating 8.500 hrs/year
- Bergen gas engines in operation since more than 20 years



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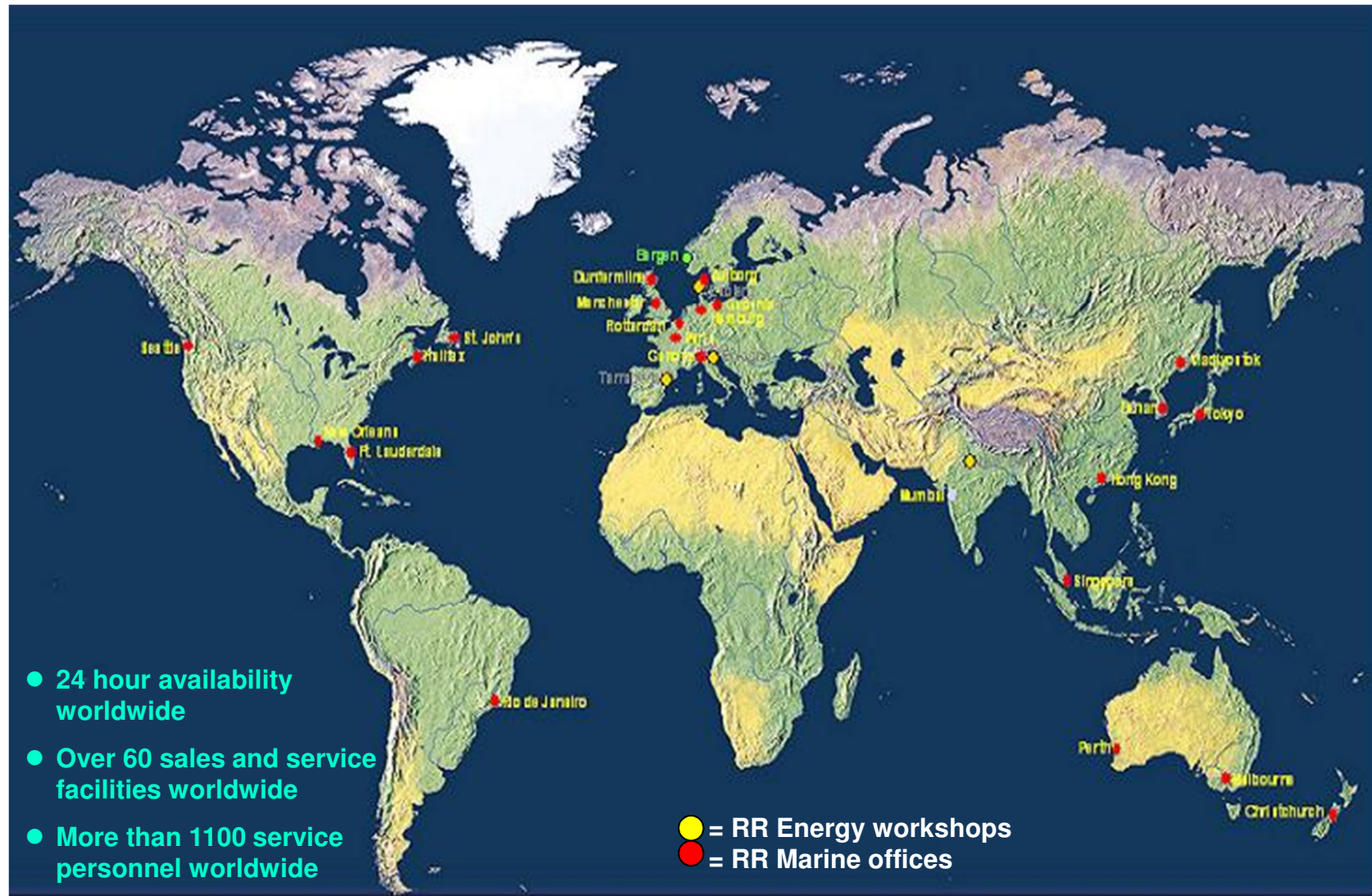
Rolls-Royce LNG marine propulsion:

- 4 LNG-powered RoRo ships for North Sea operation on order
- 2 RoRo / multi purpose vessels under construction in India single engine / single screw
- 1 + 1 fish forage vessel under construction in Turkey
- Two Platform Supply Vessels on order
- 1 Car ferry under conversion for MDO to LNG, ready for operation in February 2011
- 5 Ropax ferries in operation, + 1 under construction and 5 on order
- 4 Ropax ferries single screw gas engines on order
- The 5 ferries are doing 35 port calls/day-51000/year
- Order options and feasibility studies for LNG bunker barges, ropax, container ships, tug boats, OSVs and general cargo vessels



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Rolls-Royce Global Service Network



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Questions? I guess so....at least 3:

- NBs / retrofitting payback period?
- Availability of LNG @ harbours facilities?
- Ex ship LNG cost?



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End

Thank you for your attention

Rolls-Royce Marine

Technological and Business Development

LNG fuelled vessels Campaign

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