

LNG fuelled ships

Norwegian experience

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ECSA – EMSA meeting Brussels 24th of November 2009

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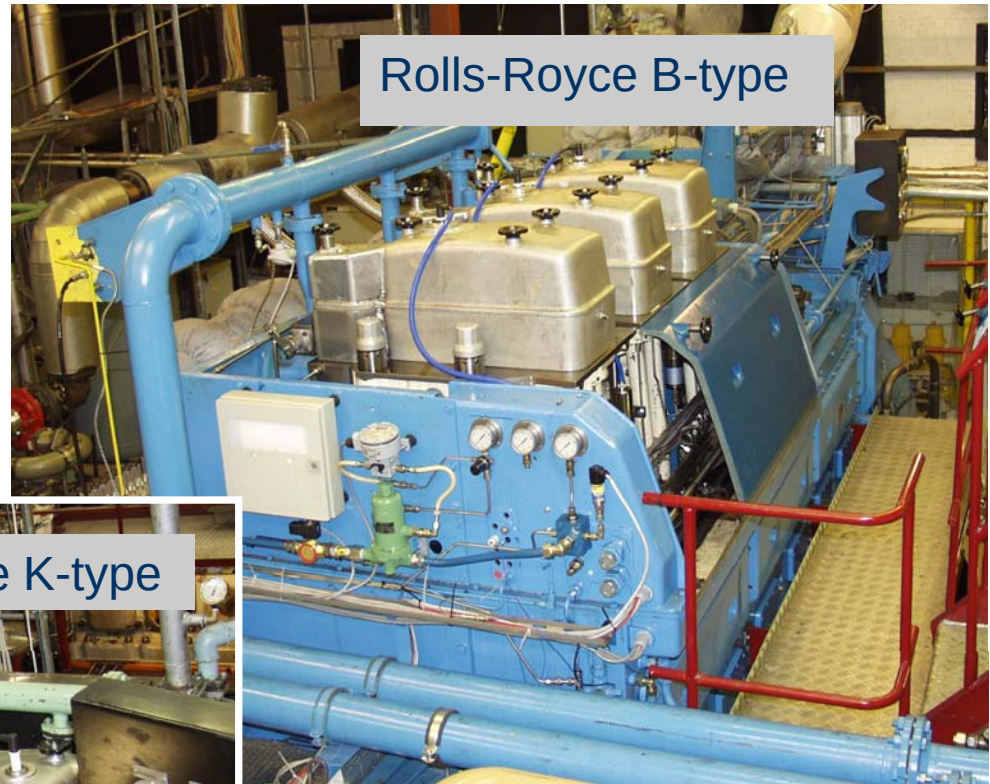
Independent research and development institute



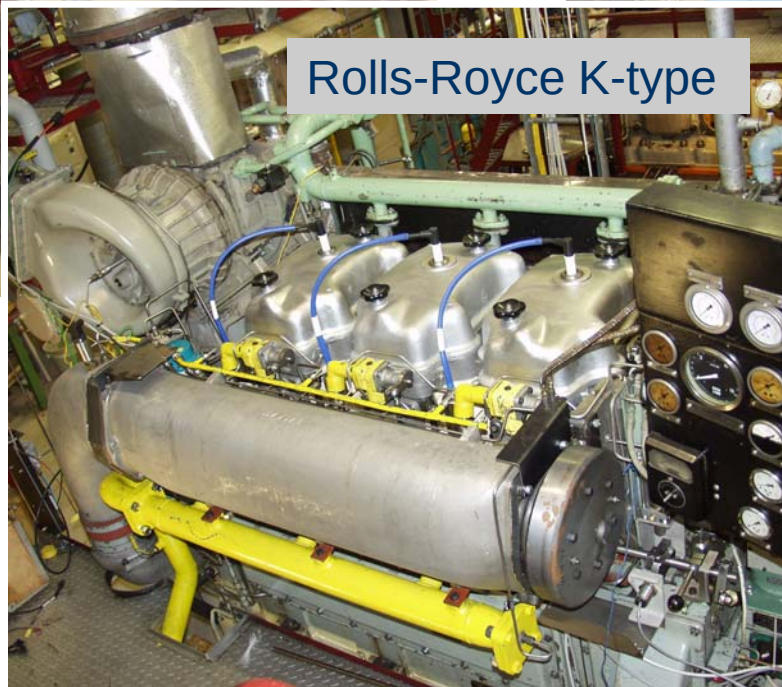
Gas engine development since 1984



Wärtsilä Vasa 32



Rolls-Royce B-type



Rolls-Royce K-type

Dual Fuel gas engines
Lean Burn gas engines

- Constant speed (generator load)
- Variable speed (propeller load)

Kystgass

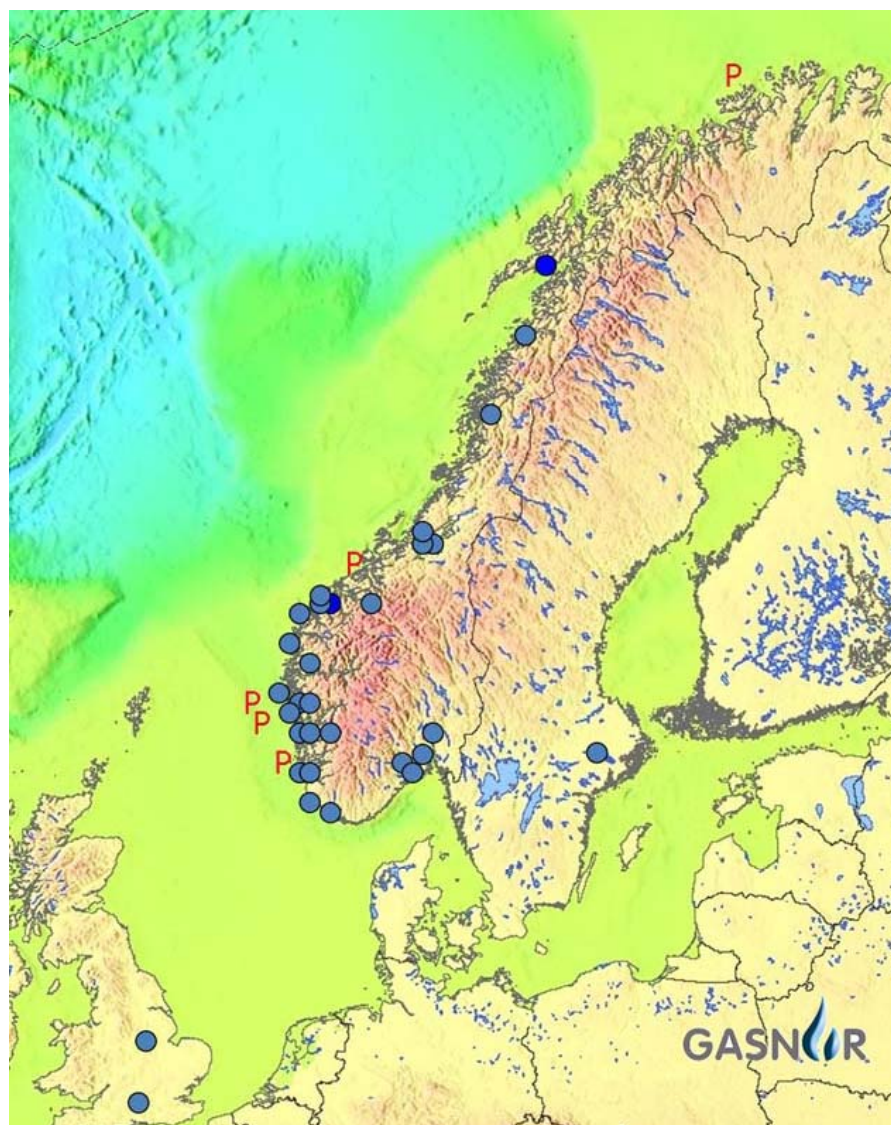


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LNG distribution and production capacity

Small scale receiving terminals in Norway (2009)



Receiving LNG terminals

- LNG receiving terminals in operation (green) and under construction (blue)
- Total number of 30 terminals
- Wide span in size
100m³ - 3500m³ LNG

Source of LNG

Local production (marked **P**)

■ Karmøy	20000 ton/year
■ Kollsnes1	40000 ton/year
■ Kollsnes2	80000 ton/year
■ Tjelbergodden	<u>10000 ton/year</u>
Total	150000 ton/year

Small receiving terminal at an aluminum plant

LNG ship 1000m³ LNG



New LNG carrier capacity of 7500m³ (Operated by Antony Veder)



Lyse gas LNG i Risavika Stavanger



Capacity 300 000 tons/year Starting 4. quarter 2010
Possible second train 300 000 tons/year

Nordic LNG (Lyse Gas and Skaugen)

Logistic solutions with ships



Six multi gas (LNG, Ethylene, LPG) carriers of 10 000 cbm and two of 12 000 cbm

Large LNG terminals in Europe

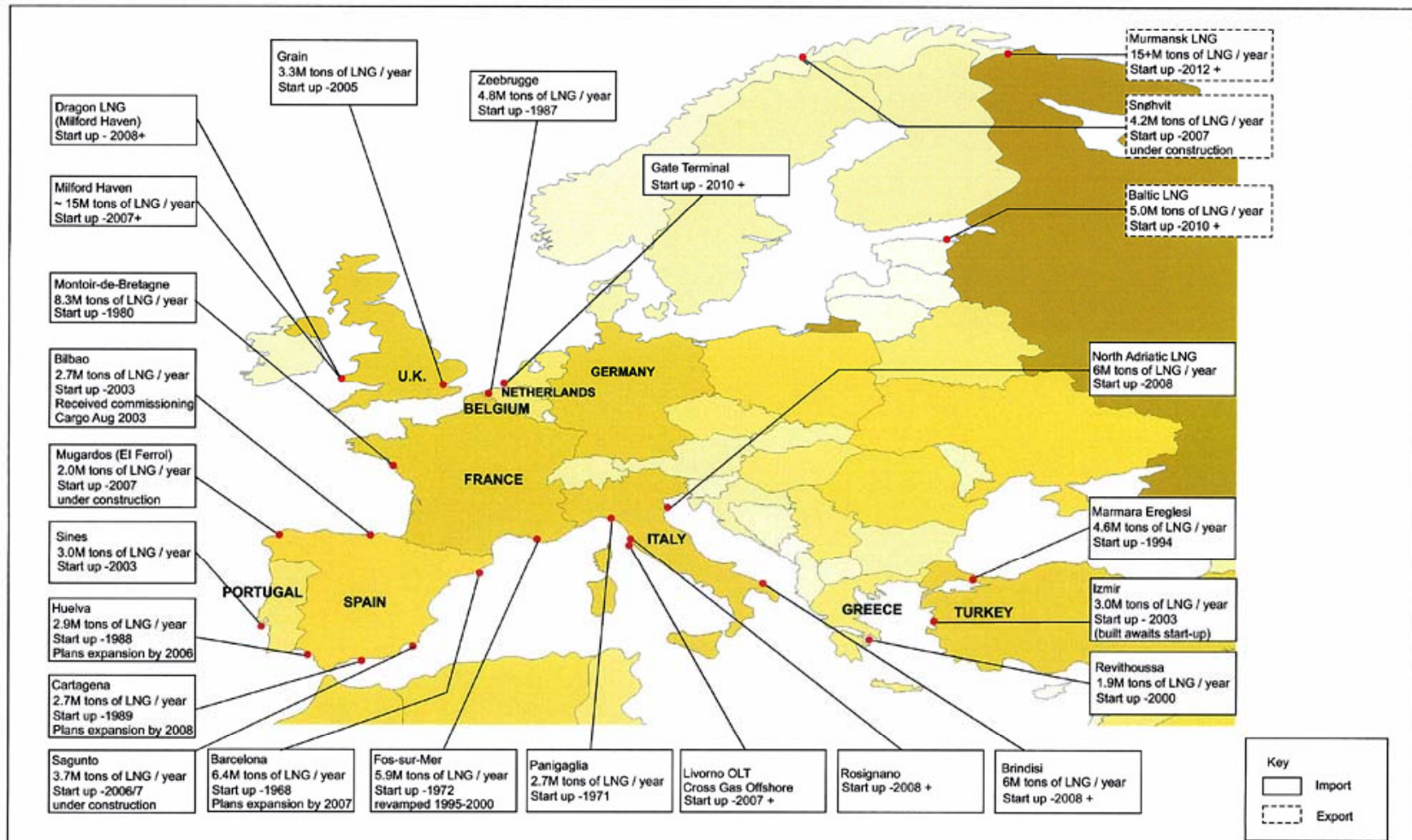


Figure 3.7

LNG TERMINALS (EUROPE)
 (SOURCES: WORLD LNG MAP FEBRUARY 2006 EDITION. PETROLEUM ECONOMIST &
 THE GLOBAL LIQUEFIED NATURAL GAS MARKET: STATUS AND OUTLOOK.
 ENERGY INFORMATION ADMINISTRATION, US DEPARTMENT OF ENERGY. DECEMBER 2003)

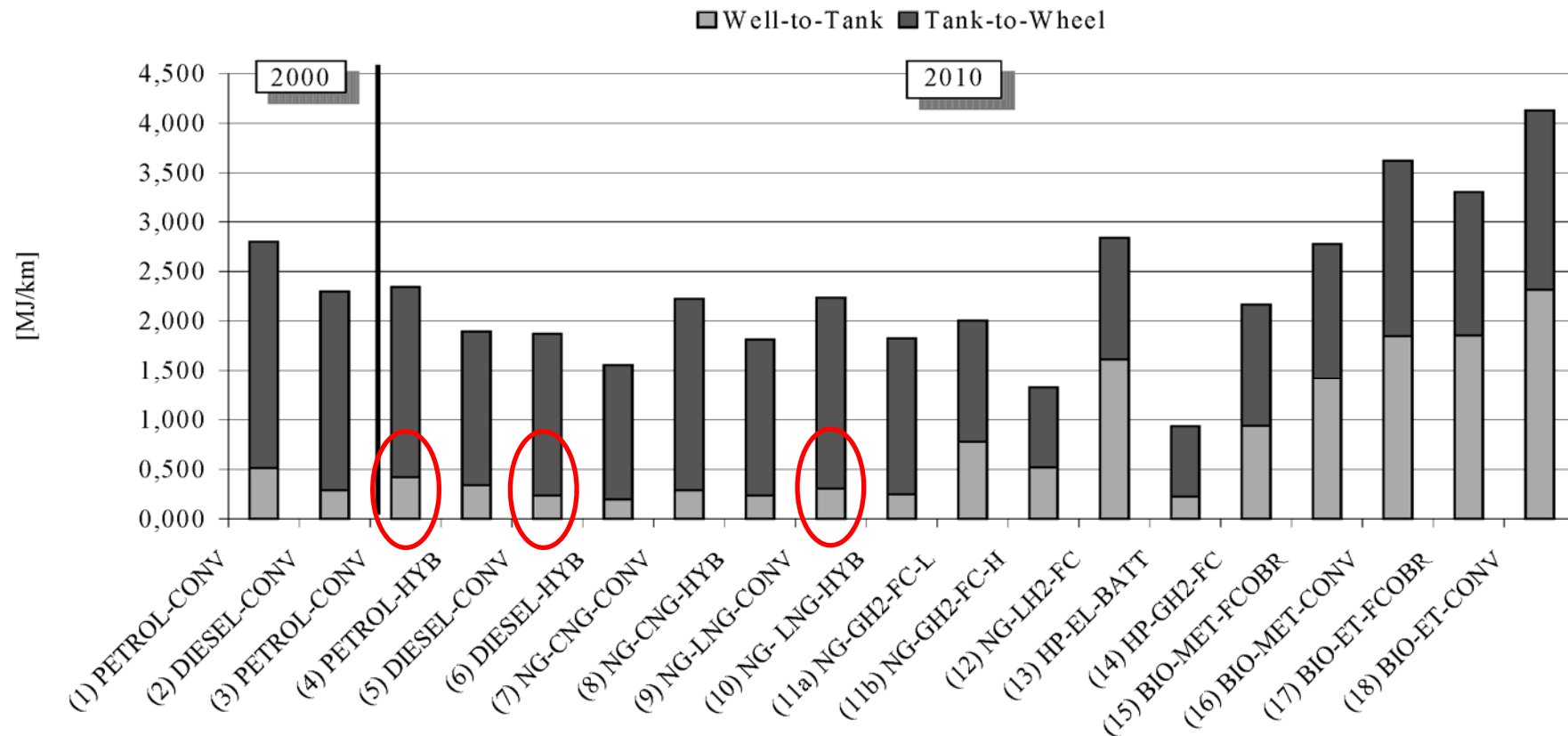
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 DATE: 13/07/05

Environmental
 Resources
 Management



LNG chain – energy consumption

Well – to – wheel analyses, road transport



Well – to – Tank (energy consumption processes)

1. Feedstock production
2. Feedstock transport
3. Fuel production
4. Distribution and reforming of the fuel
5. Refueling

Source:

Int. J. Alternative Propulsion Vol. 1, No 4, 2007

Alternative fuels and sustainable mobility

K.G. Høyer, E. Holden, Western Norway Research Institute

LNG fuelled ships - experience

Natural gas as fuel for ships - experience



The first LNG ferry Glutra 2000



Two Supply Vessels 2003

Two supply vessels 2009



Series of five LNG car ferries 2007

Three LNG car ferries 2009

Seven new LNG ferries on order



One military vessel in operation 2009

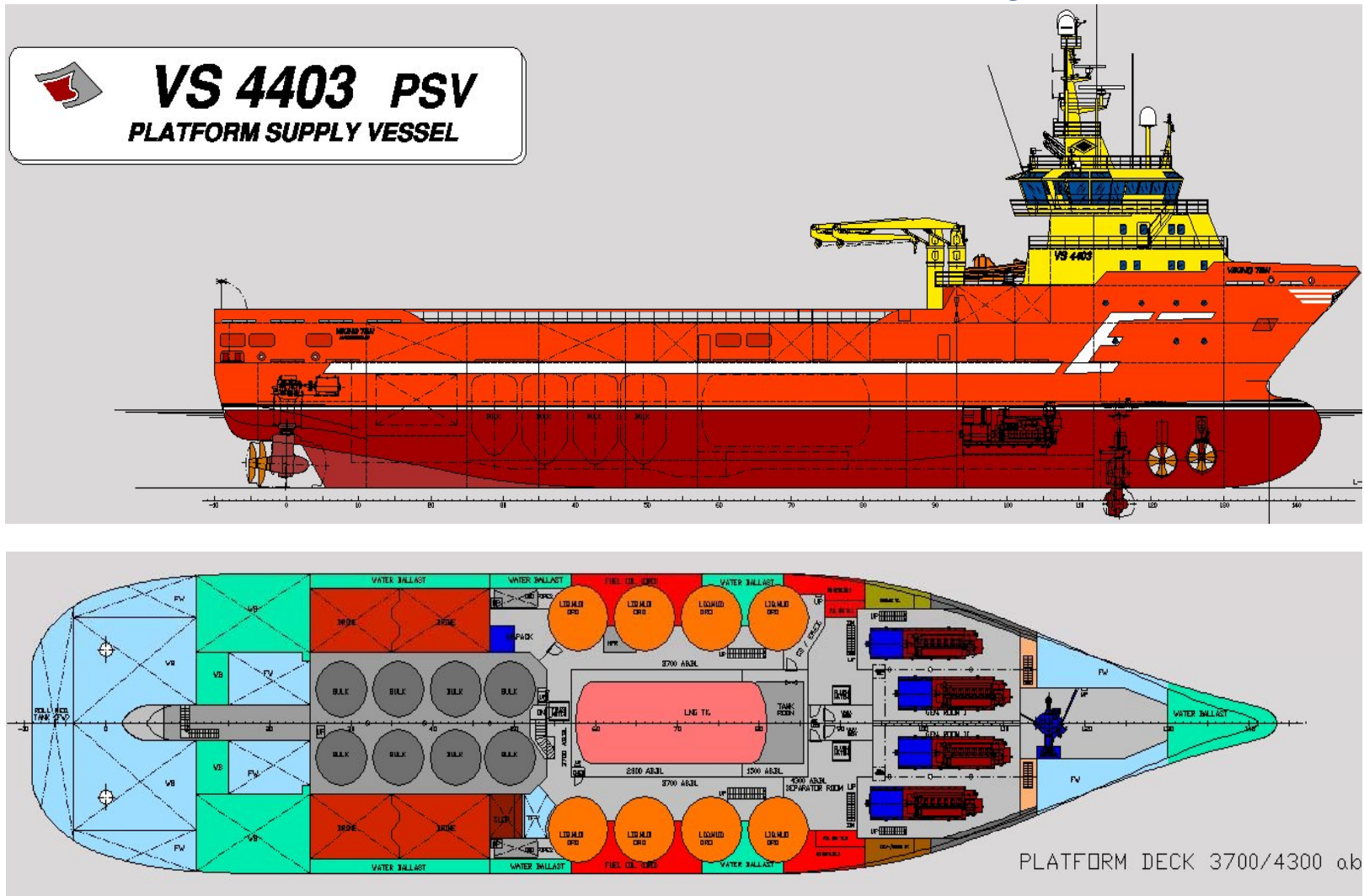
Two military vessels on order

Supply skip



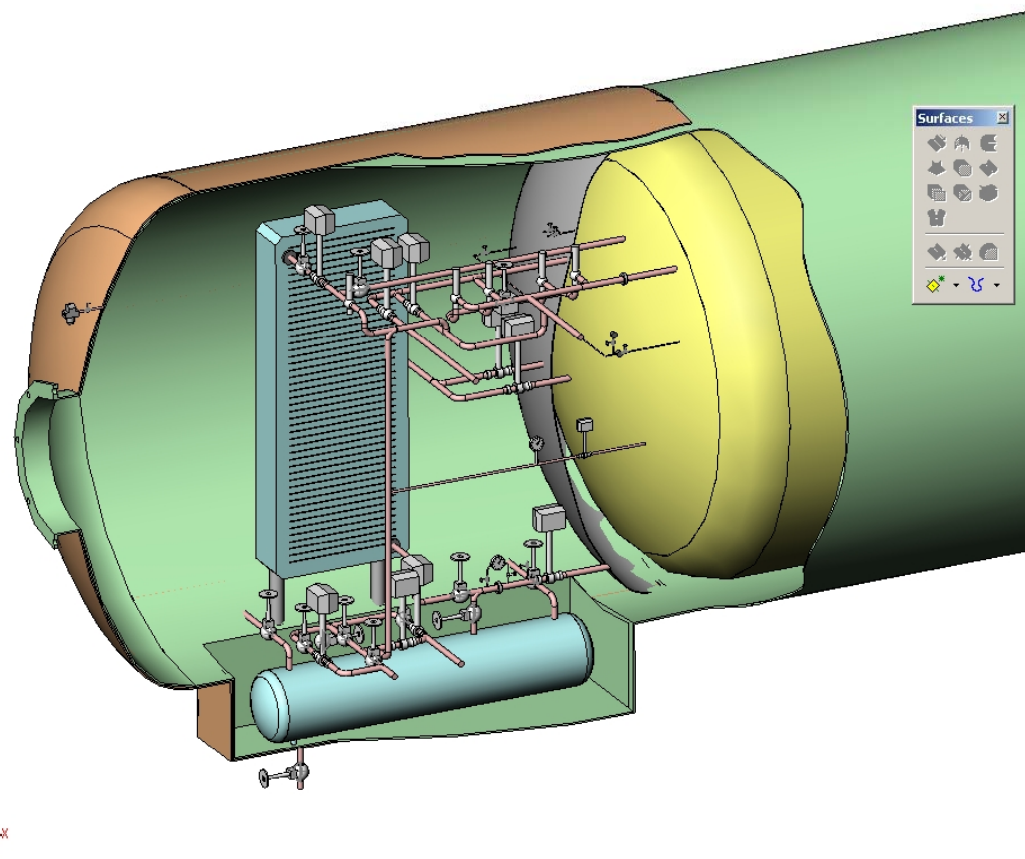
Engines and LNG tank arrangement

4 Generator sets: Wärtsilä 6x32 DF, LNG storage 240 m³



LNG storage vacuum isolated pressure tank

Outer tank as secondary barrier (low temperature material)
Integrated cold box extension of the outer tank



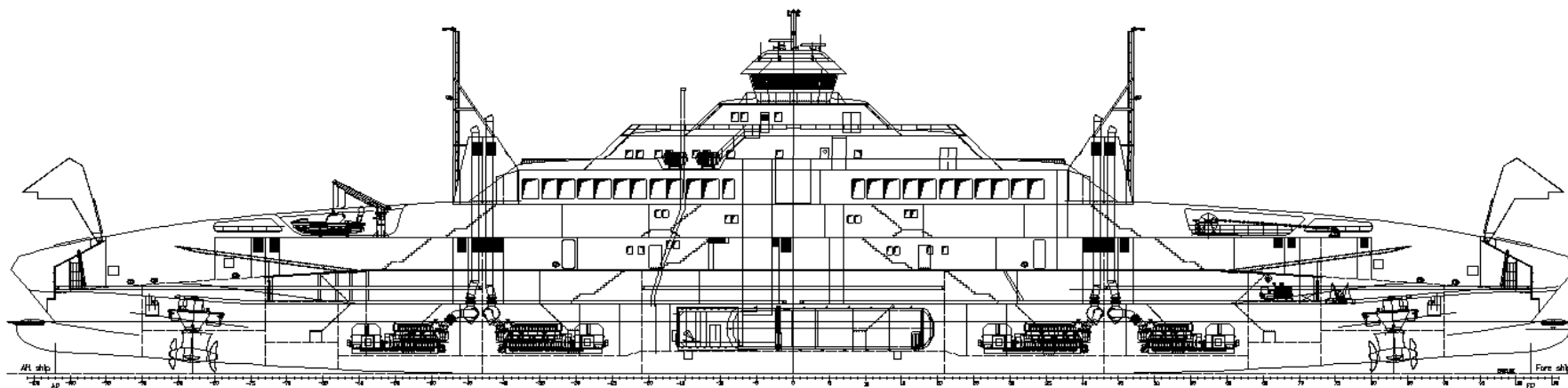
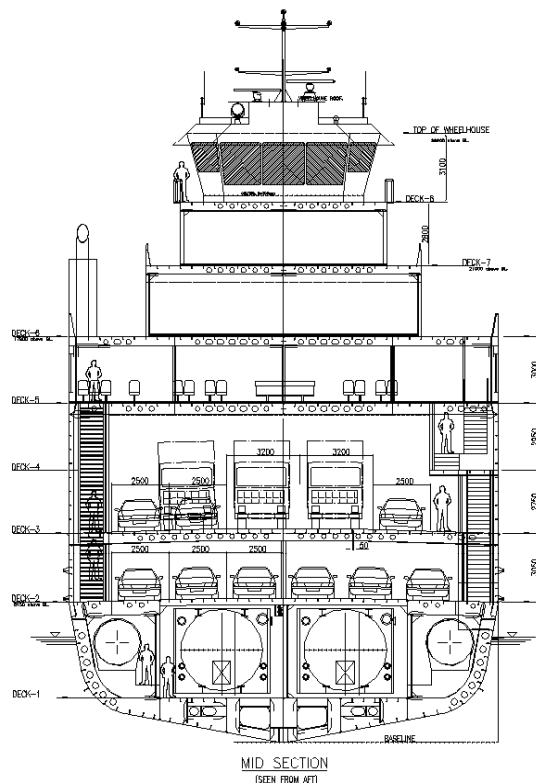
“Bergensfjord” In service January 2007



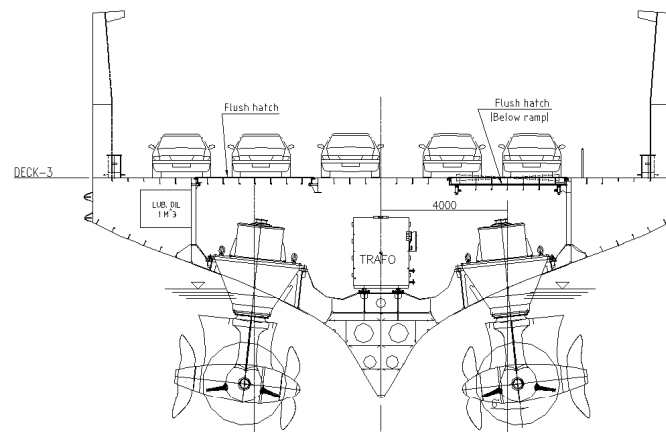
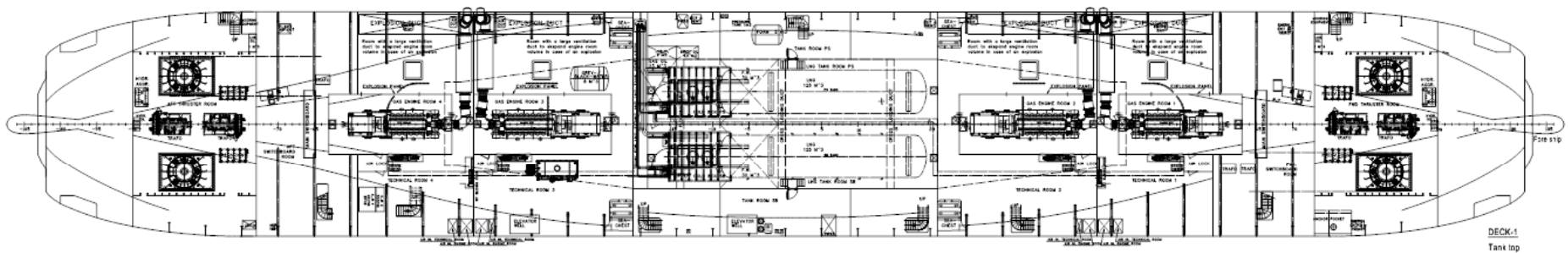
LNG ferry Bergensfjord

Main dimensions and capacities:

- Overall length 130 m
- Breadth 19 m
- Draught max 4, 6 m
- Cars (pcu) 212
- Passengers 590
- Service speed 21 knots
- LNG storage: 2 x 125 m³ LNG



Bergensfjord – General arrangements



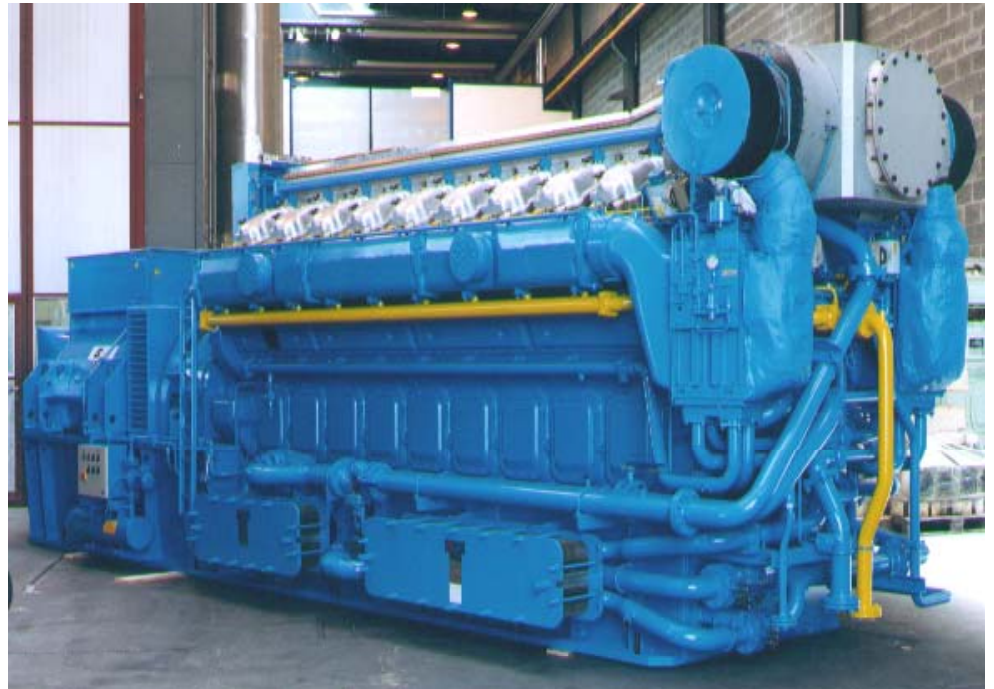
Bergensfjord - Gas engines installed

Rolls-Royce K-type
Lean Burn gas engines

2 KVGS 16G4 – 3535 kW each

2 KVGS 12G4 – 2650 kW each

Total power installed: 12370 kW



LNG bunkering station at ferry berth



Capacity bunkering station:
2x 500m³ LNG

LNG transferred by pump

Filling time for the large
LNG ferries about two
hours

Refuelled every third night

Bunkering LNG ferry

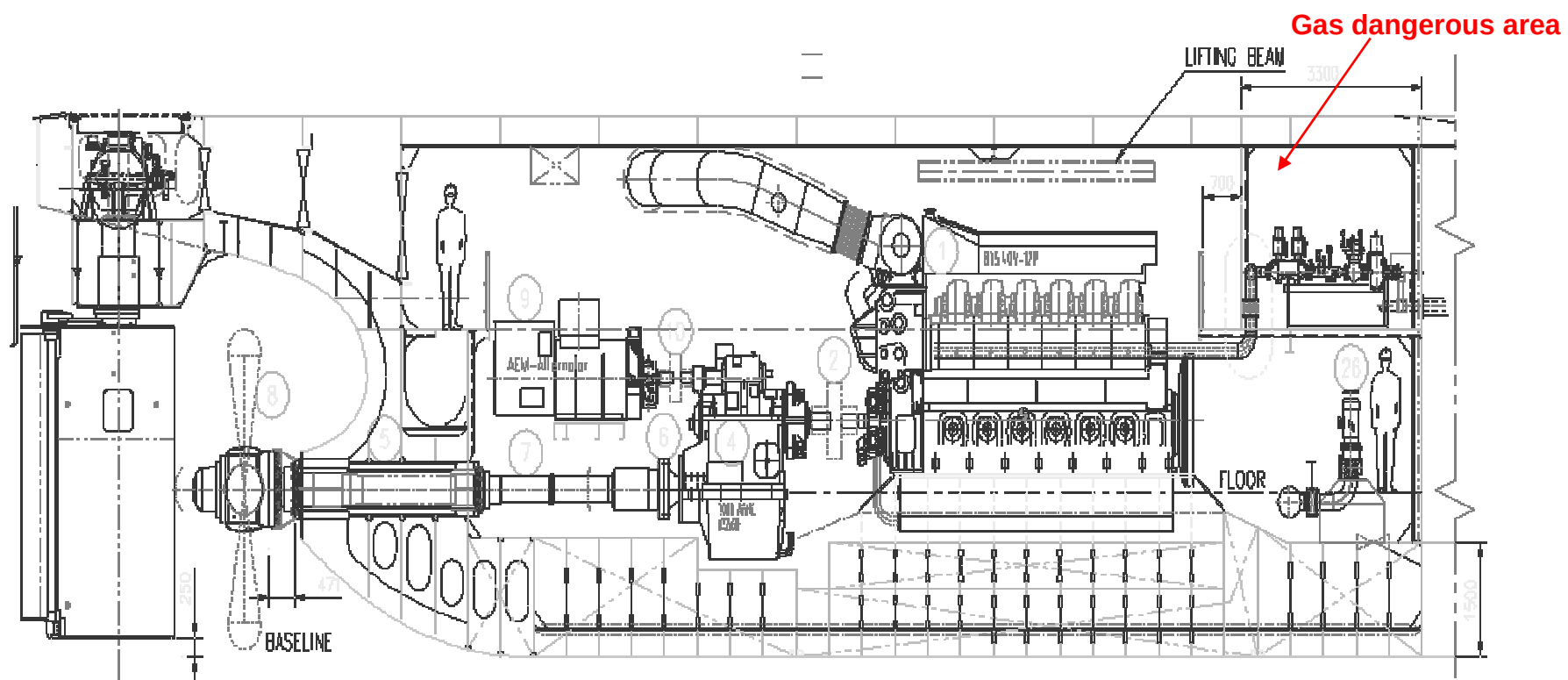


New LNG ship concepts and design

LNG powered RoRo freight ship (gas only)

Two ships under construction for delivery in 2010-11

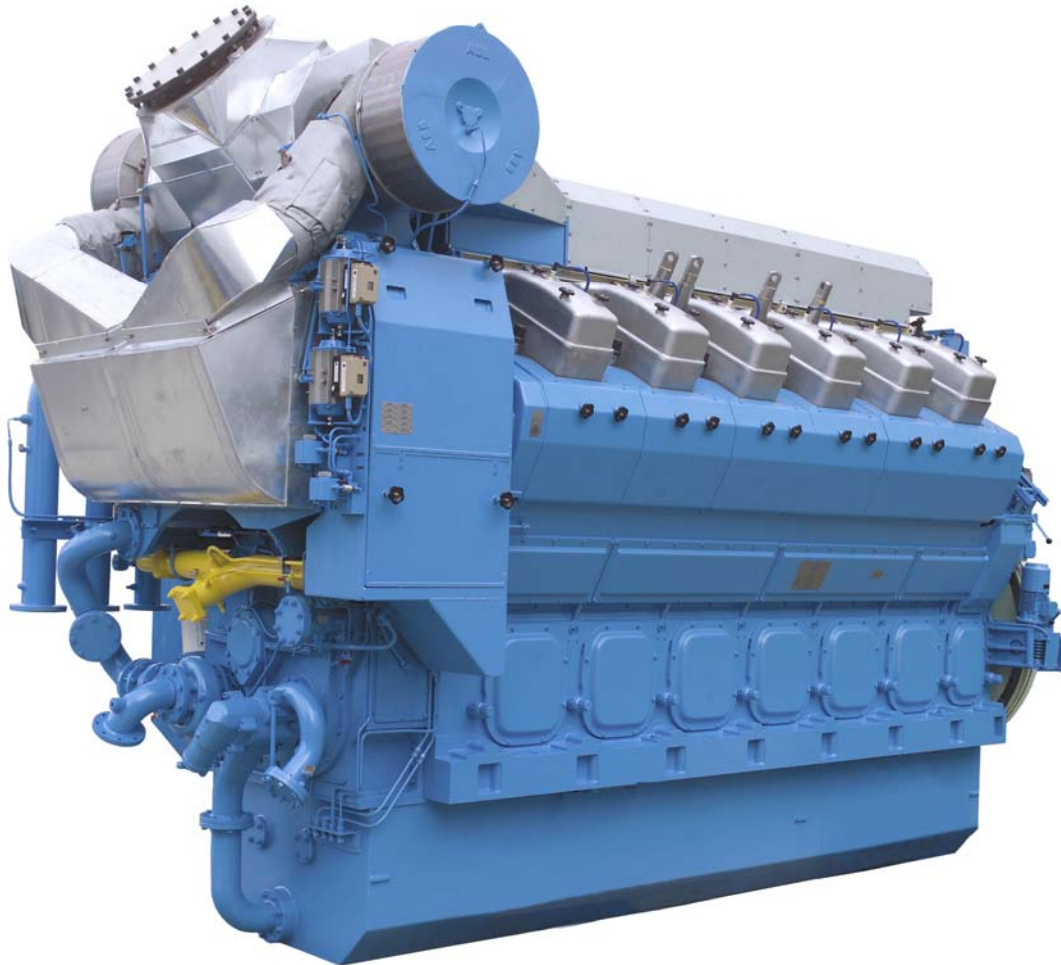




Main gas engine

Rolls-Royce Bergen B35:40 V 12

Spark ignited lean-burn gas engine



Rolls-Royce Bergen

Gas engine B35:40-V12

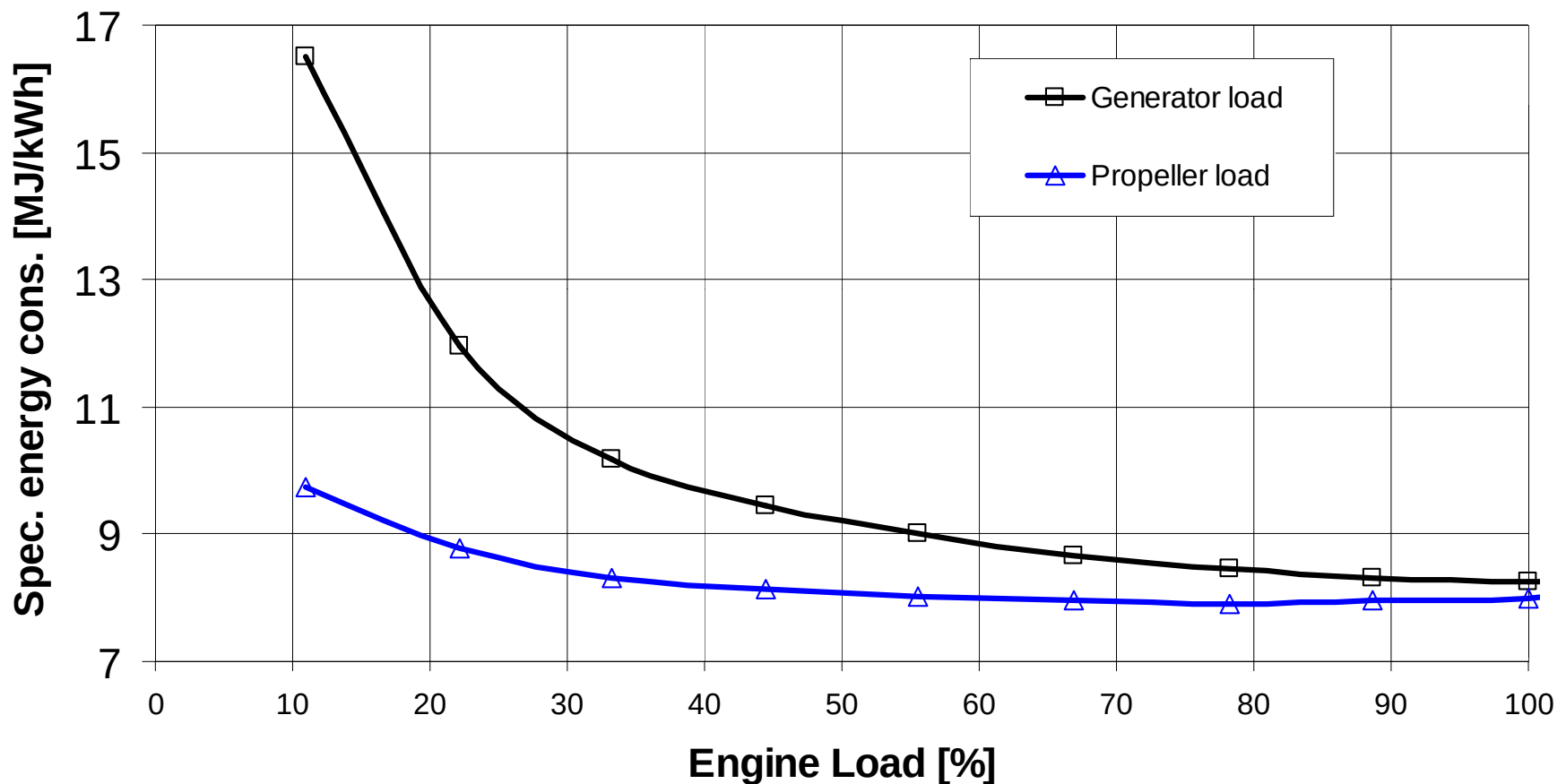
Power: 5250 kW

Efficiency: 48%

NOx: 1,2 g/kWh

Mechanical vs electric drive

Lean Burn gas engine

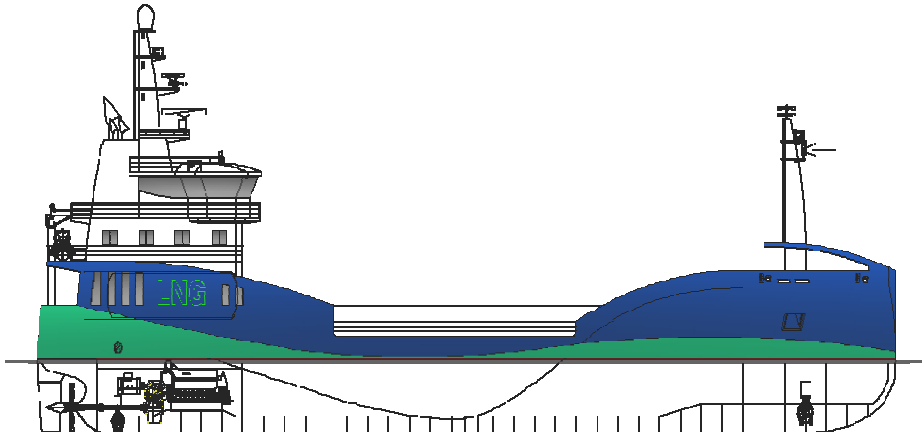


Thermal efficiency:

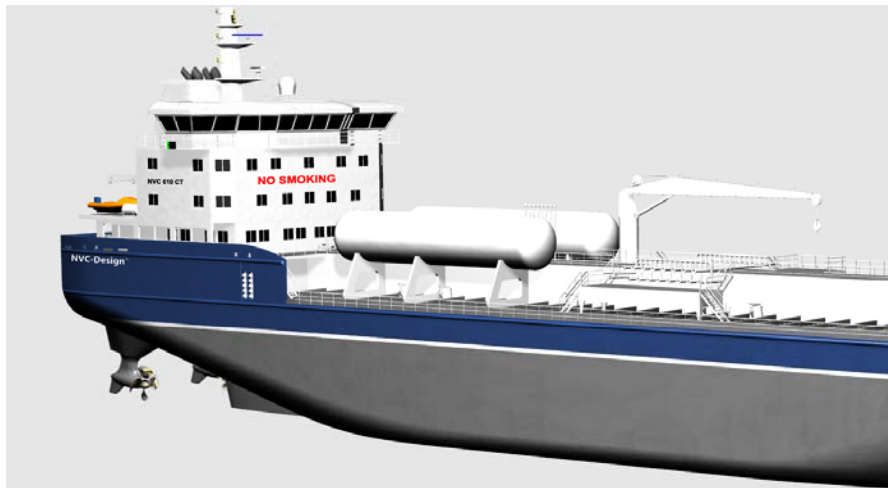
Power output/fuel input $\Rightarrow$ kWh/9 MJ $\Rightarrow 10^3$ W3600s/9*10⁶Ws $\Rightarrow$
3600/9000*100% $\Rightarrow$ 40%

Based on measured data from Rolls-Royce Bergen

New concepts and design

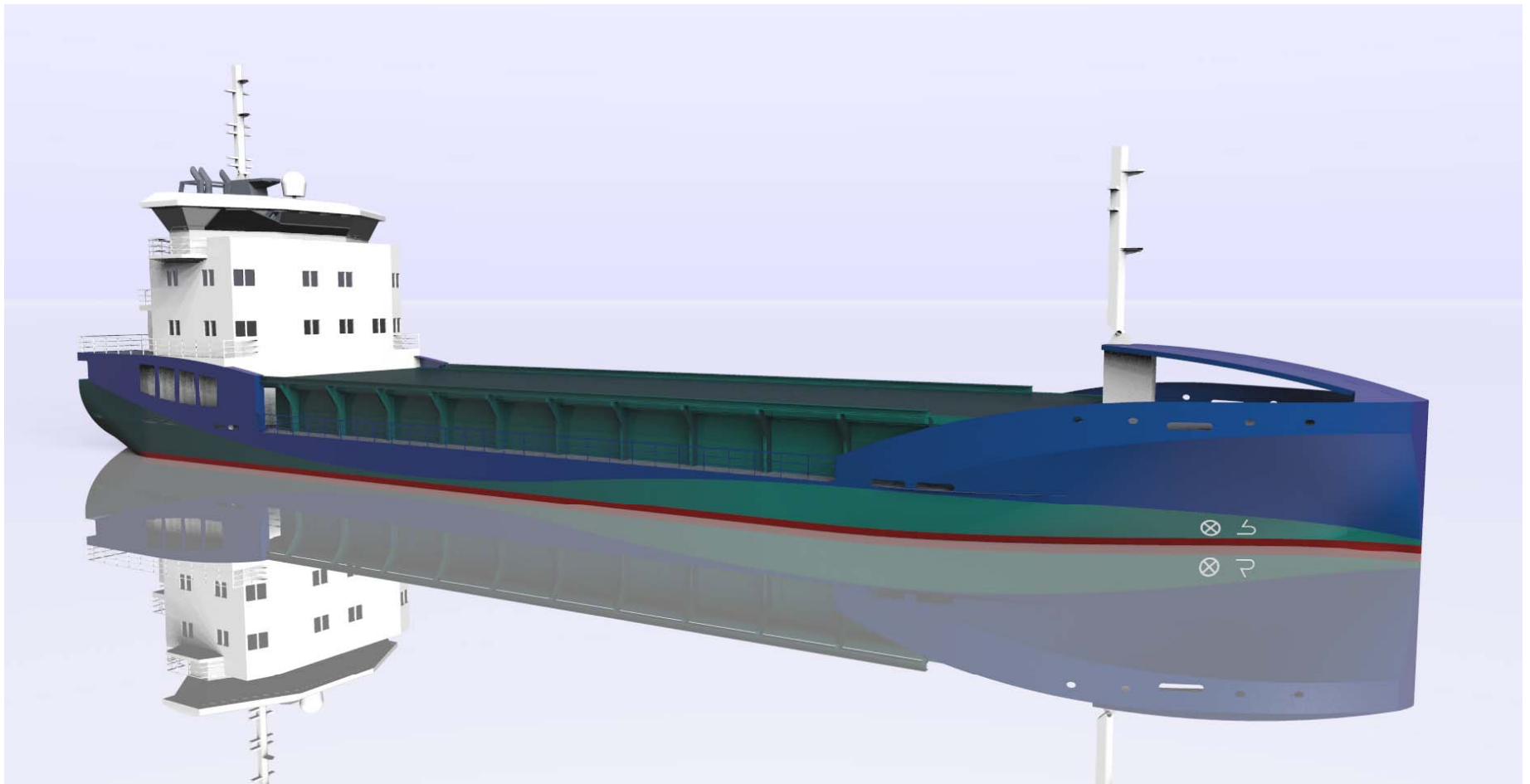


Four small costal bulk carries
designed or considered



Two oil product tankers designed
or considered

Coastal bulk carrier, gas only



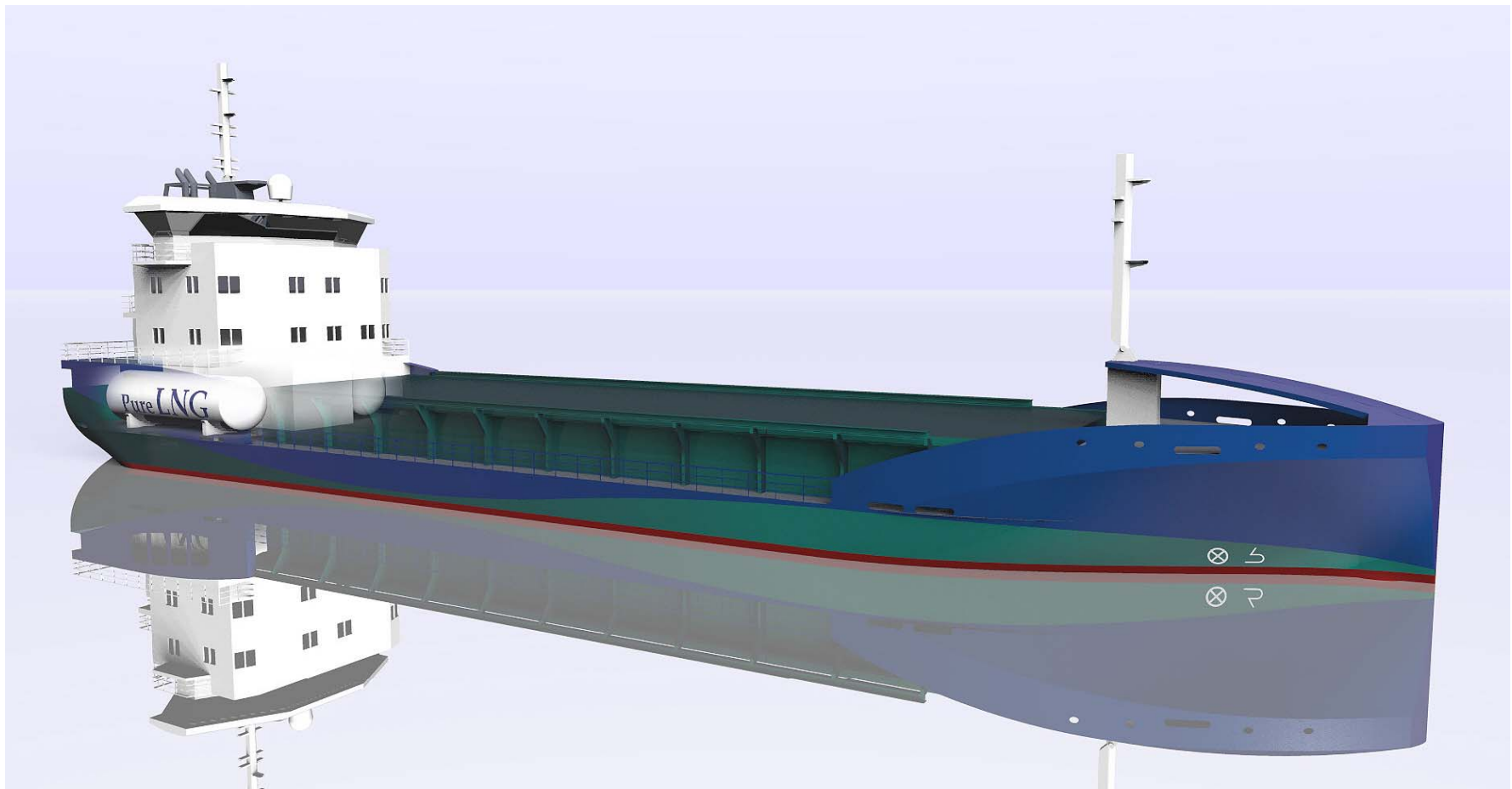
Coastal bulk carrier, gas only

Single gas engine and mechanical drive

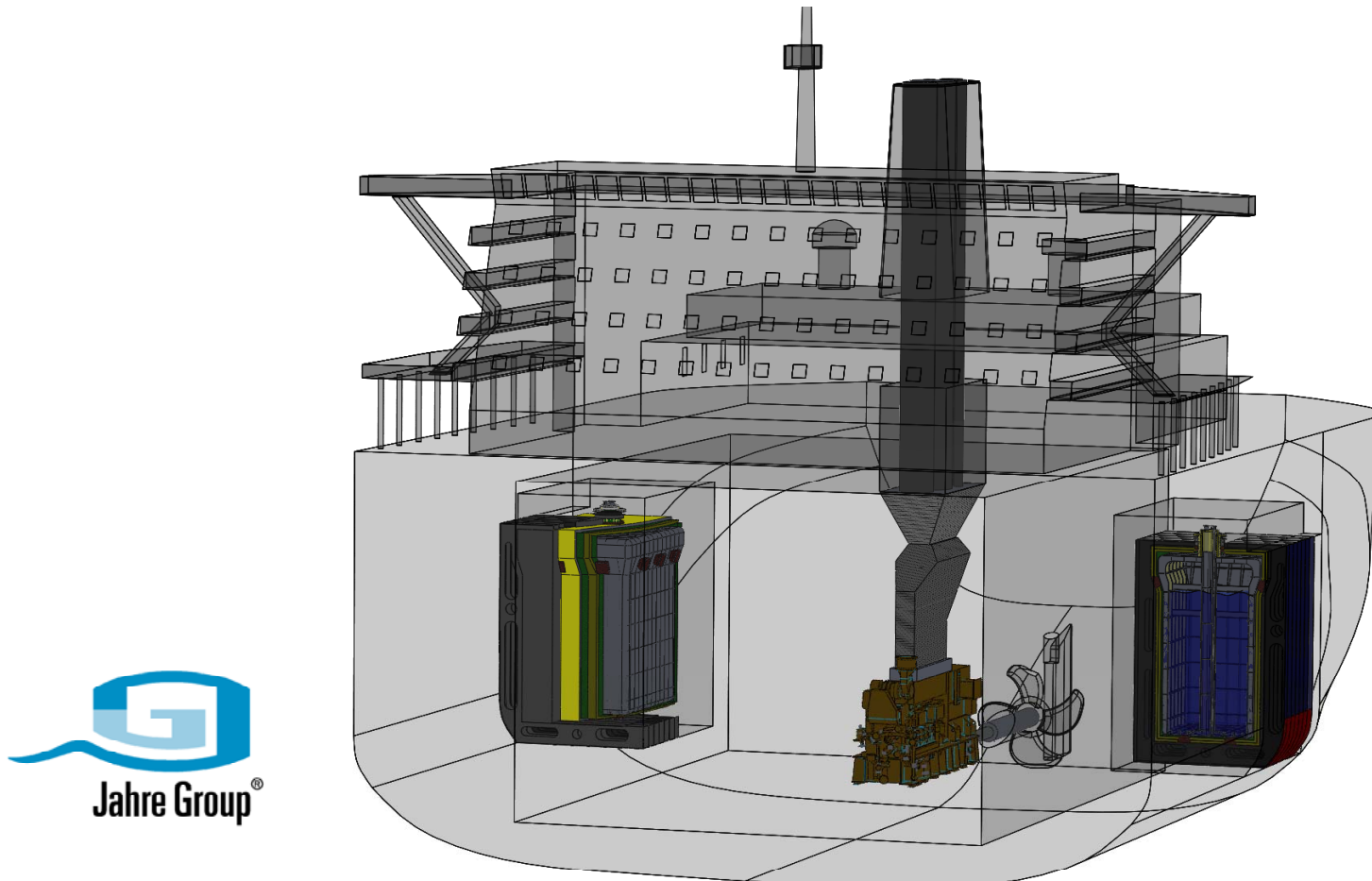
Two 50 m³ LNG storage tanks

About one week operation between refueling

Extra building cost for LNG operation – about 1.5 mill Euro (2008)



Development of a new LNG storage system (IMO A tank)



Tank you for your attention

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