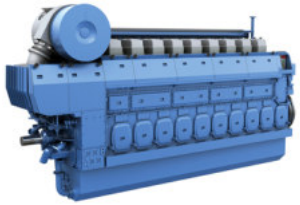
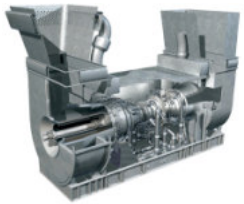
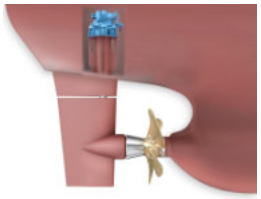
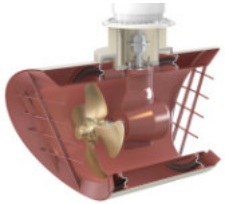
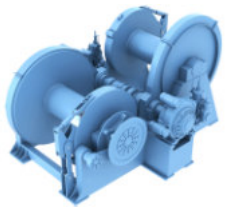
Marine Gas Engines, solutions and possibilities

Leif-Arne Skarbø
Vice President Technology and Development
Rolls Royce Marine, Engines - Bergen

A comprehensive 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 	Azimuth thrusters 
Tunnel thrusters 	Waterjets 	Stabilising systems 	Winch systems 

Focus on Technology Intensive ship types

Commercial Marine

Naval Marine

Market Segments



Merchant

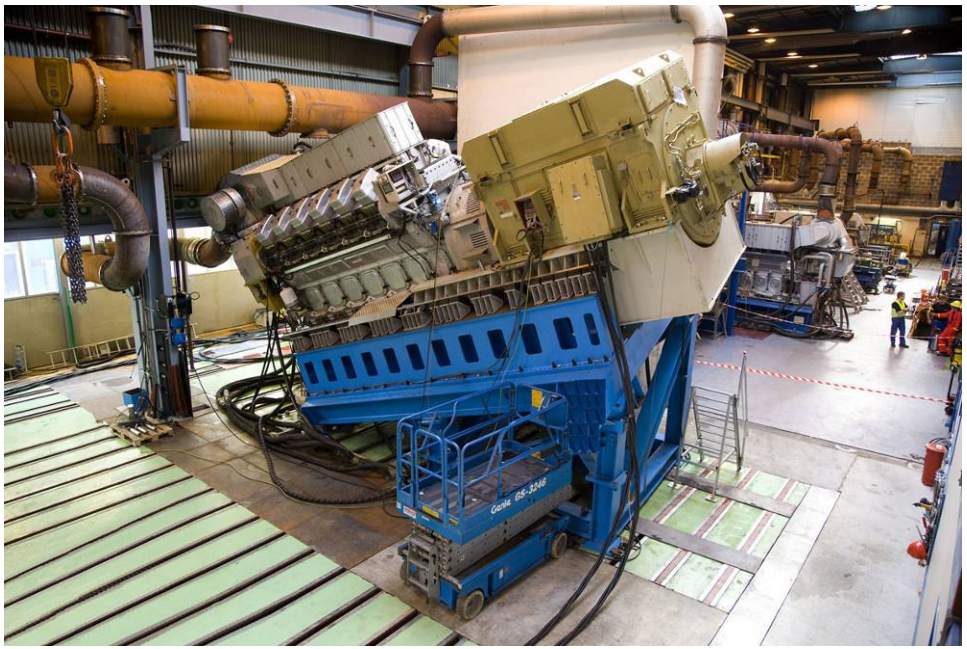
Energy


Offshore

Naval

Rolls-Royce Marine, Engines - Bergen

Designed for robustness, harsh operational environments, and the very best reliability



Rolls-Royce Marine Engines – Bergen

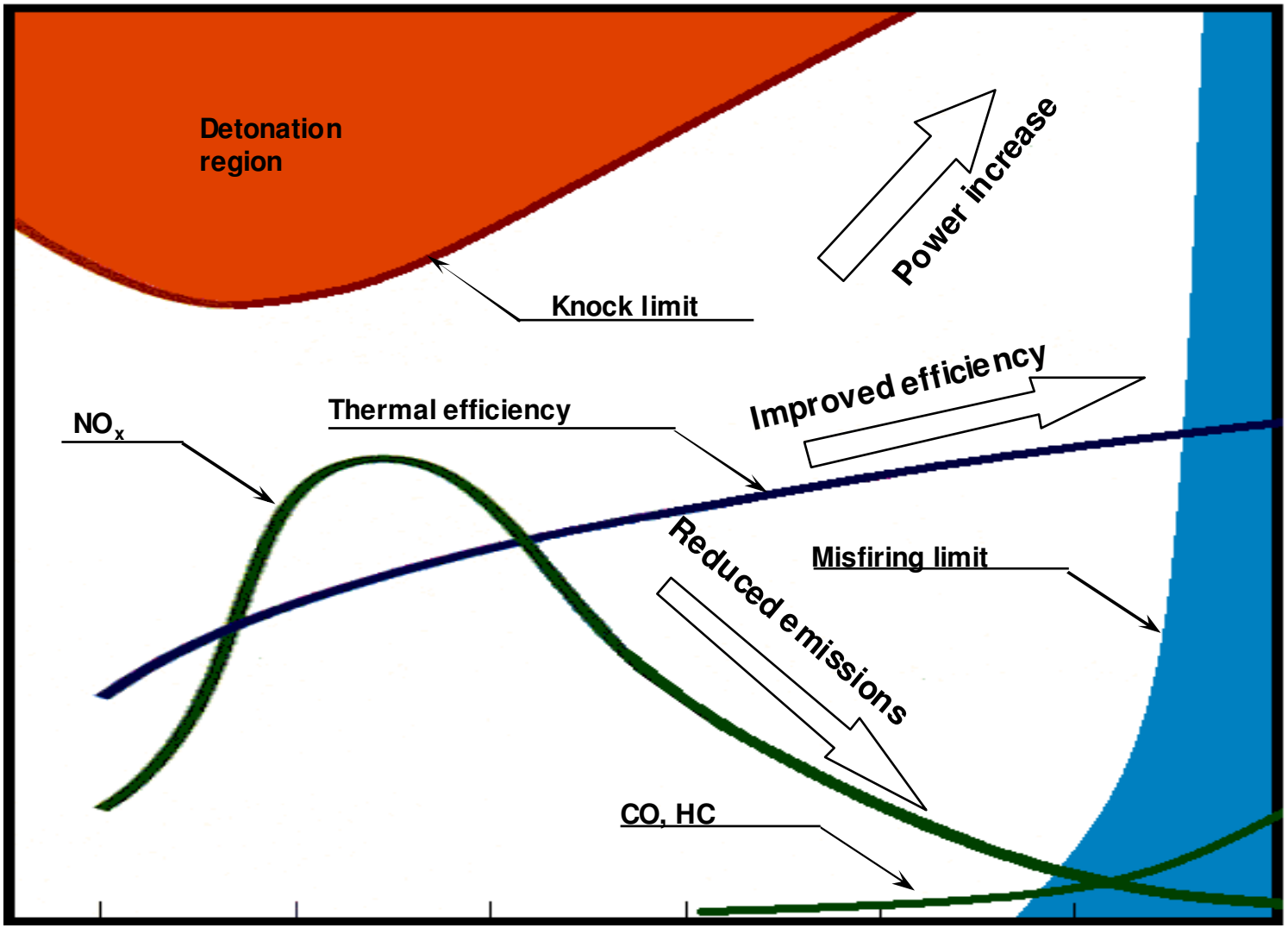
Marine Gas Engines.

Combustion Principles

and

Control

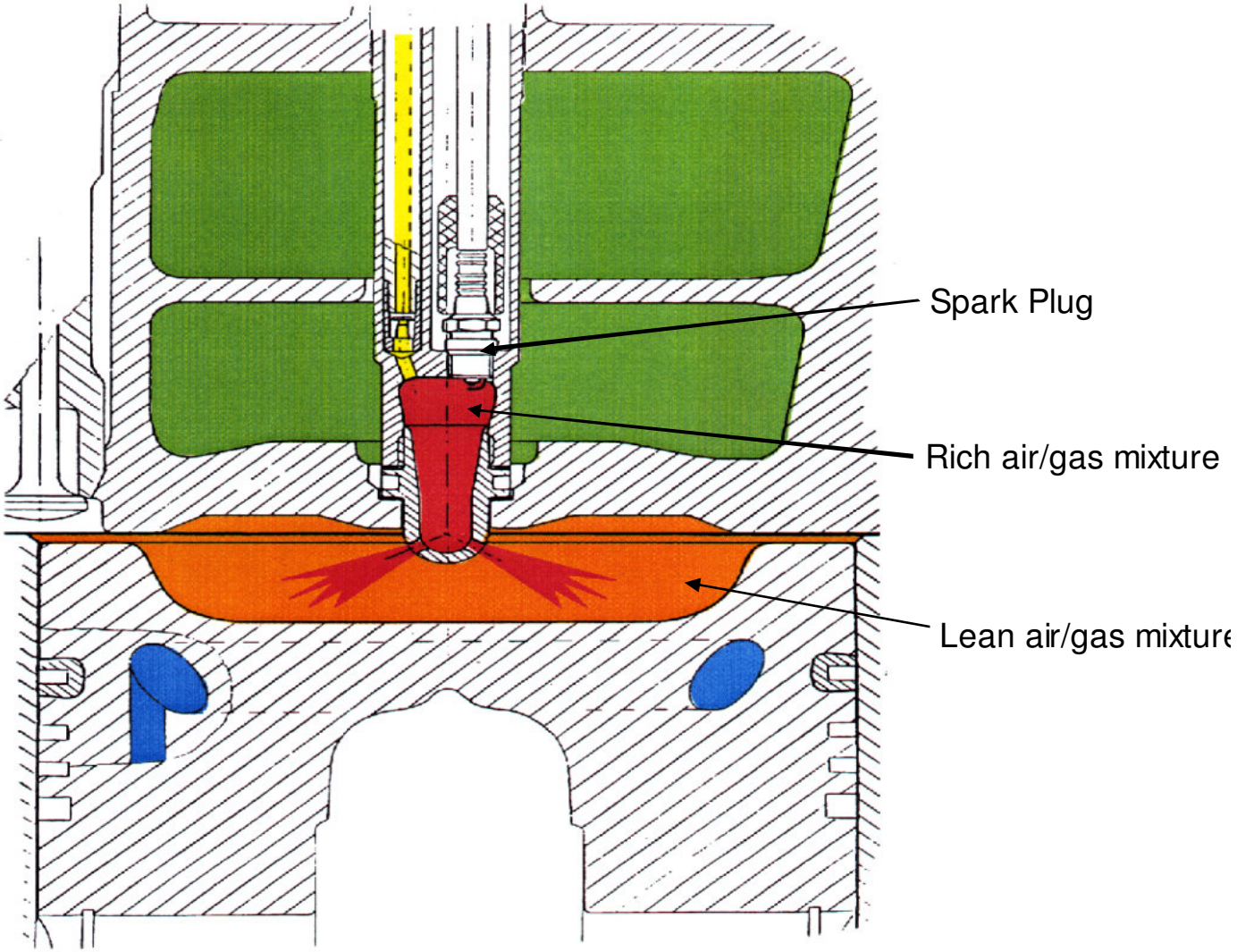
Otto Engine Rich Burn - Lean Burn ?



Engine performance trends as function of air excess ratio

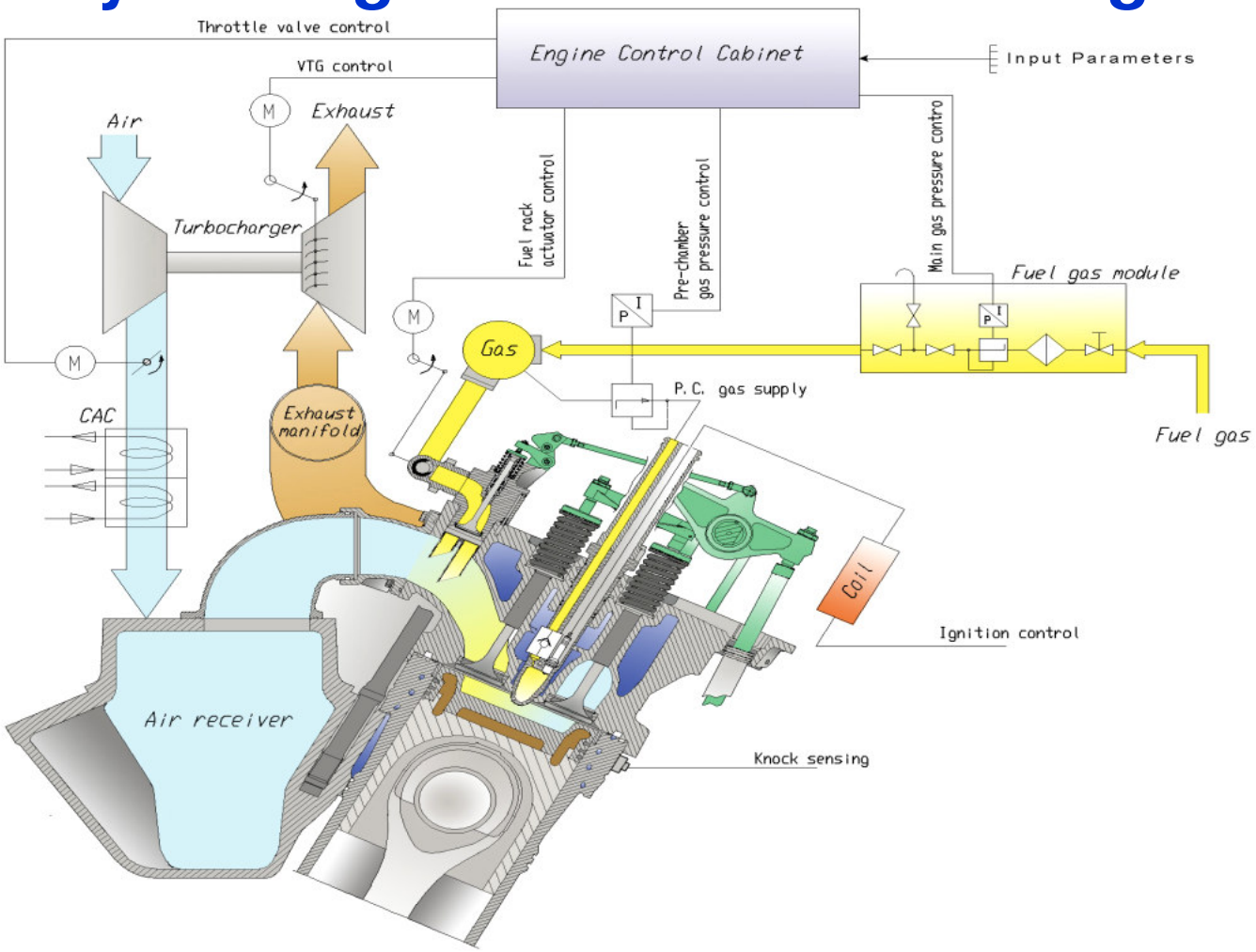
Rolls-Royce

How to Burn Lean!



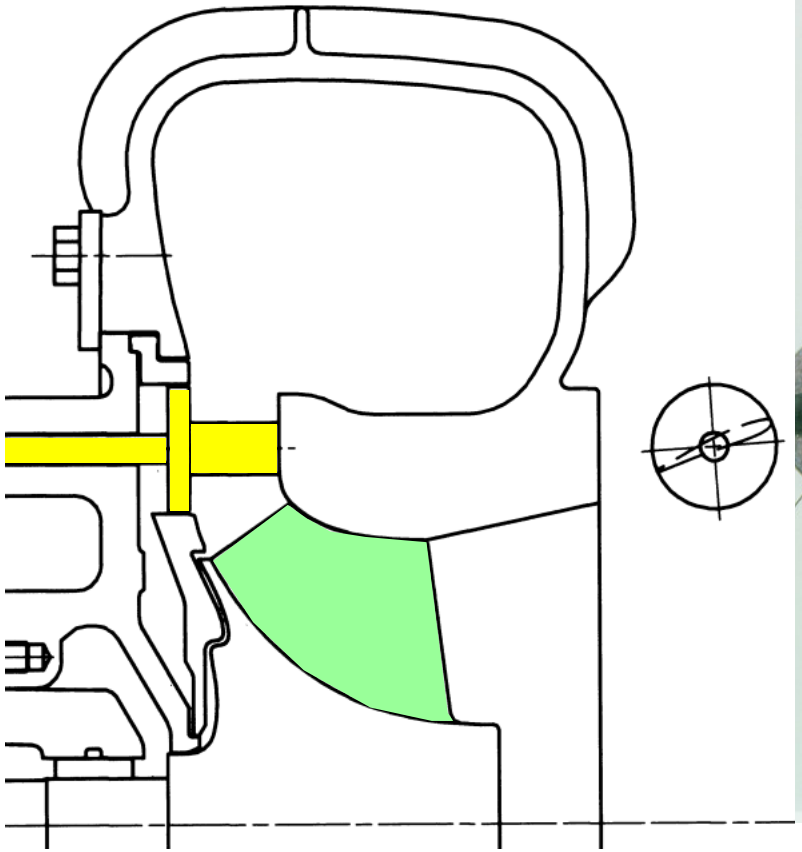
LEAN-BURN COMBUSTION SYSTEM

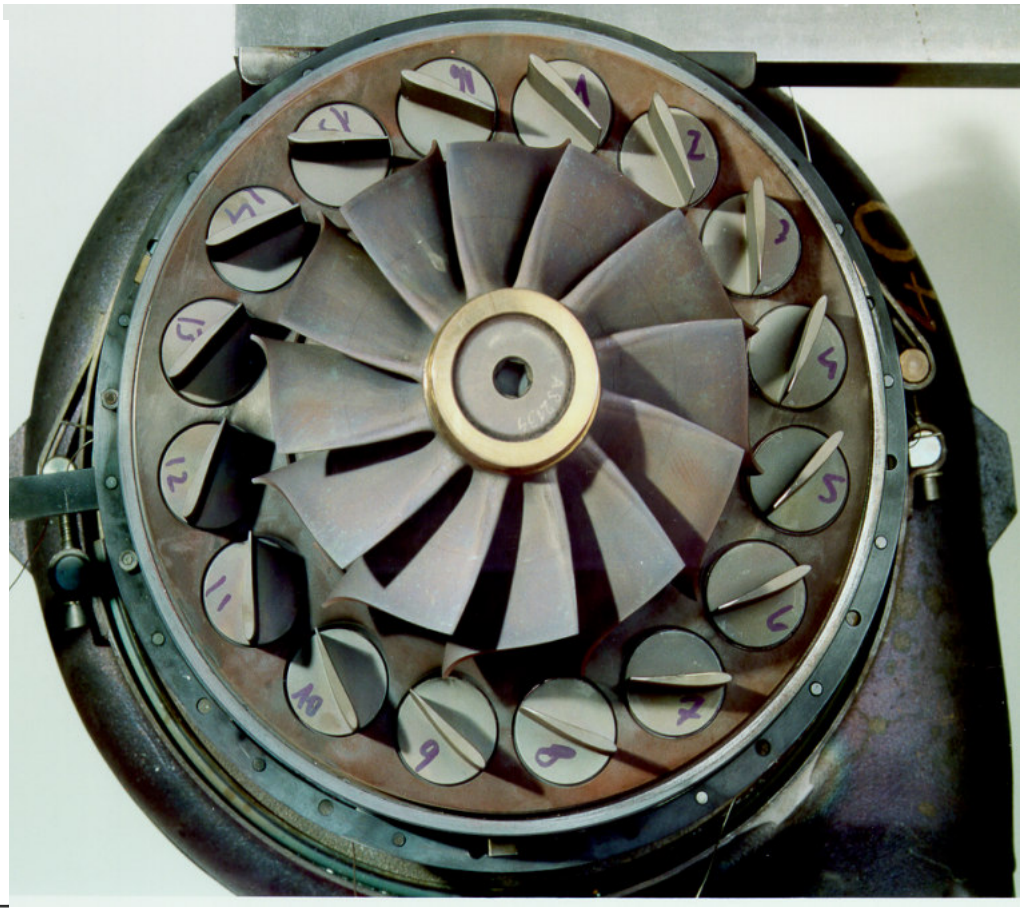
Operating Principle
Rolls-Royce Bergen Lean Burn Gas Engines



Rolls-Royce Bergen Lean Burn Gas Engines

Variable Turbine Geometry:



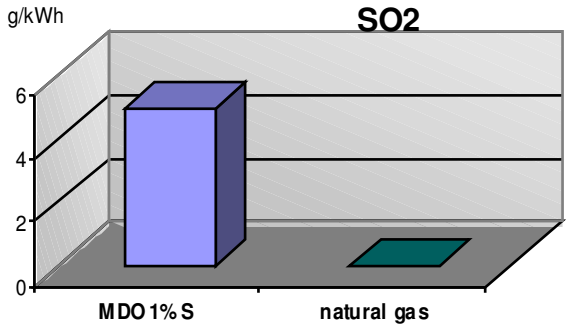


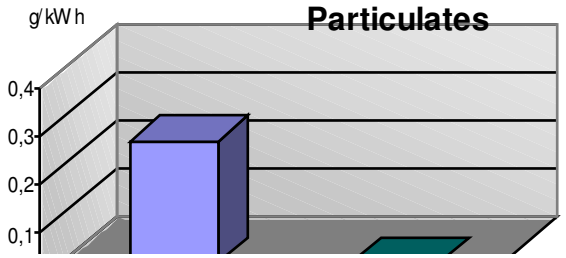
A successful pioneering cooperation between ABB and Rolls-Royce Bergen

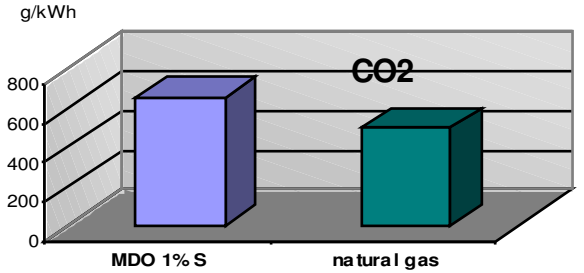
Rolls-Royce

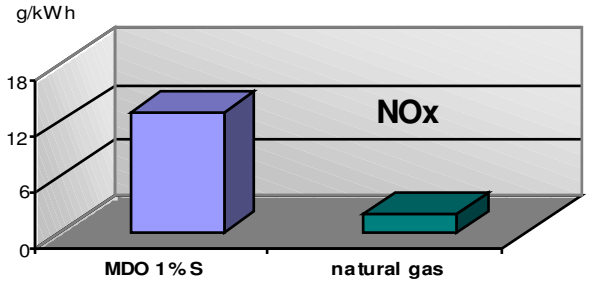
Exhaust emissions - Natural Gas versus Diesel Fuel

- Sulphur emission is eliminated
- Particulate matter is close to zero
- CO_2 is reduced by more than 20% due to unburned methane slip the net reduction of greenhouse gases is somewhat lower.
- NO_x is reduced by 80-90%

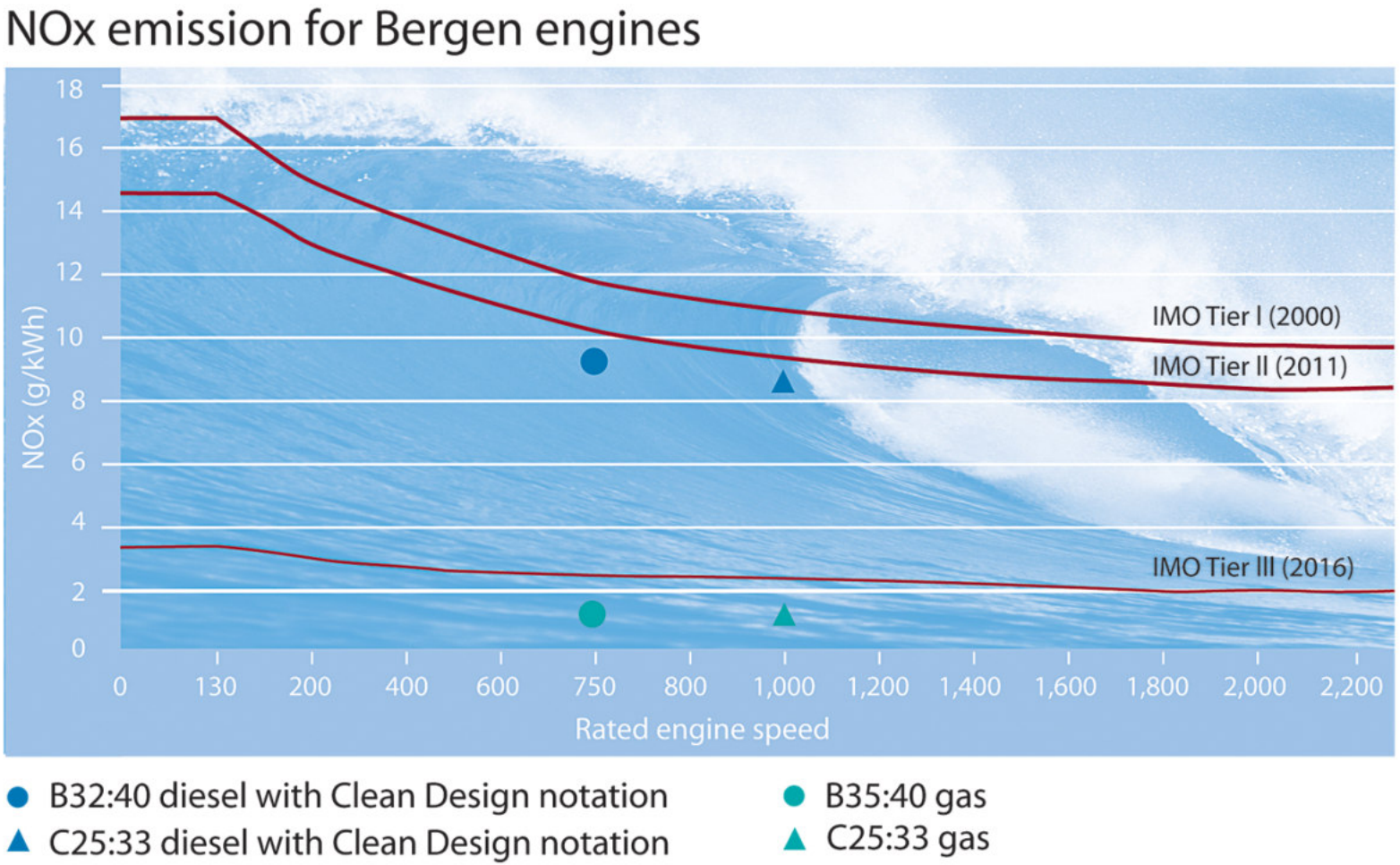








Emissions from Diesel and Gas Engines.

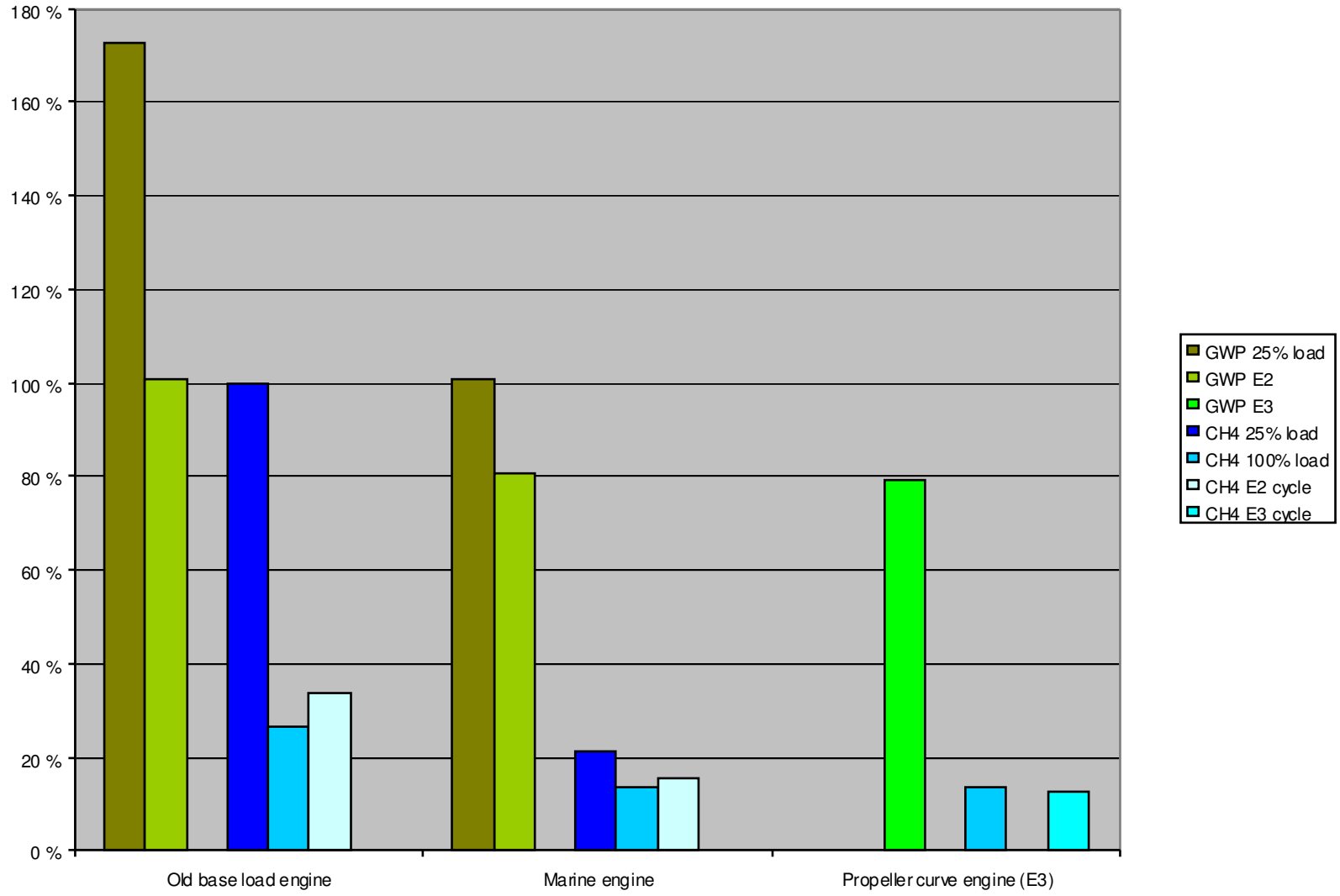


CO_2 Green House Gas Equivalent Emissions

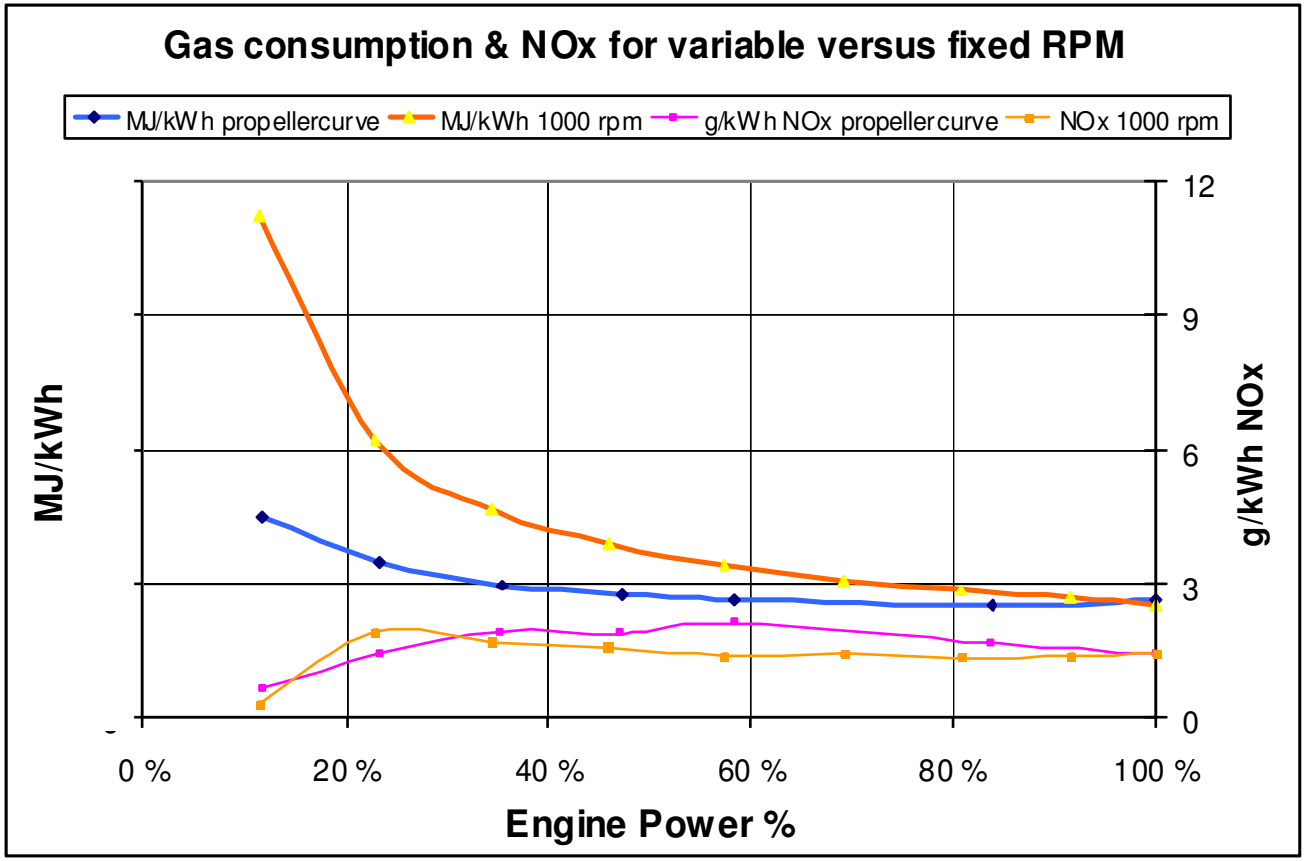
Methane slip and Global Warming Potential (GWP)

GWP in percentage of IMO Tier2 diesel.
CH4 in percentage of worst case engine.

E2 cycle (speed%/power%/weight): 100/100/0.2 100/75/0.5 100/50/0.15 100/25/0.15
E3 cycle (speed%/power%/weight): 100/100/0.2 91/75/0.5 80/50/0.15 63/25/0.15



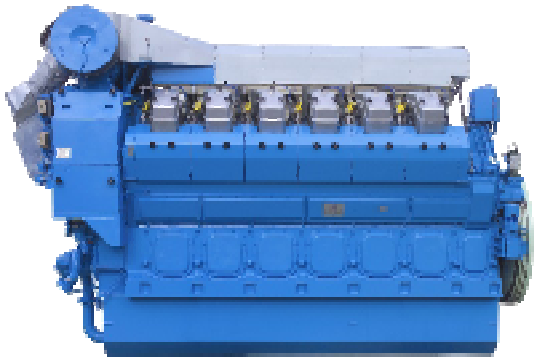
Rolls-Royce Gas Engines



How to control emissions in Diesels ?

- The options

SCR NOx	Scrubber SOx	Filter PM



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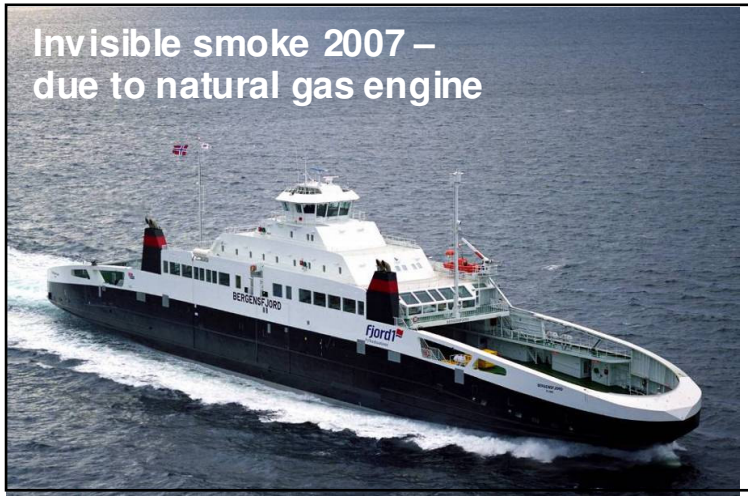
- Higher consumption => CO_2
- Urea => cost
- Complexity
- Maintenance

Urea Equipment	Water/MDO/ HFO/ fuel oil Treatment	Spil Material

Smoke issues…..



Natural Gas

- clean fuel for future vessels

- NO_X ÷ 92 %
- CO_2 ÷ 23 %
- SO_X ÷ 100 %
- Particulate ÷ 98 %

Rolls-Royce

Low emissions:

- How to achieve CO_2 reductions exceeding 40% ?

- With modified/existing product range
  - To achieve this on a vessel to vessel comparable basis
  - Ingredients
    - Efficient hull design reducing loss in waves (2-5% CO_2)
    - Azipull and CPP/Promas (5-9% CO_2)
    - Gas engines (20% CO_2)

”Ny-frakt”
How to renew the aging coastal fleet ?

Rolls-Royce

Lean Burn Gas engines

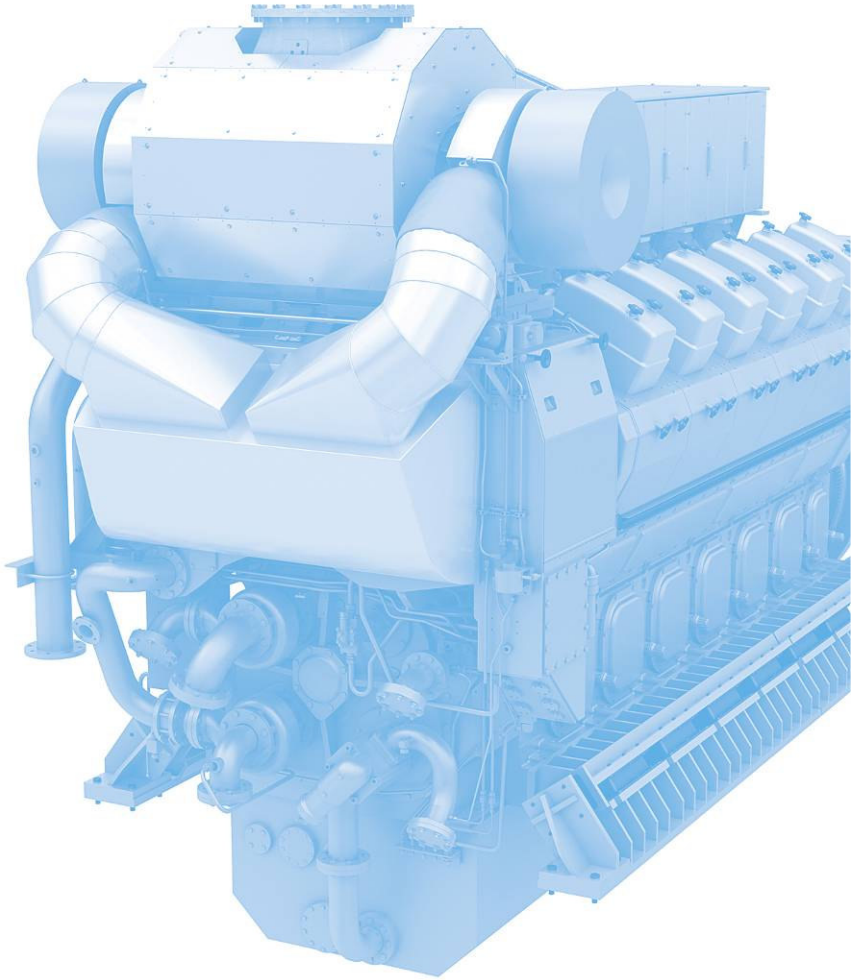
- The logical choice for ships

- More than 500 sold, over 400 gas engines in operation
- More than 20 mill running hrs experiences
- Plants with more than 140.000 running hrs
- Plants operating 8.500 hrs/year
- The five car ferries (16 engines) have logged from 12.500 to 19.000 running hours

Rolls-Royce marine engines

- The Bergen series

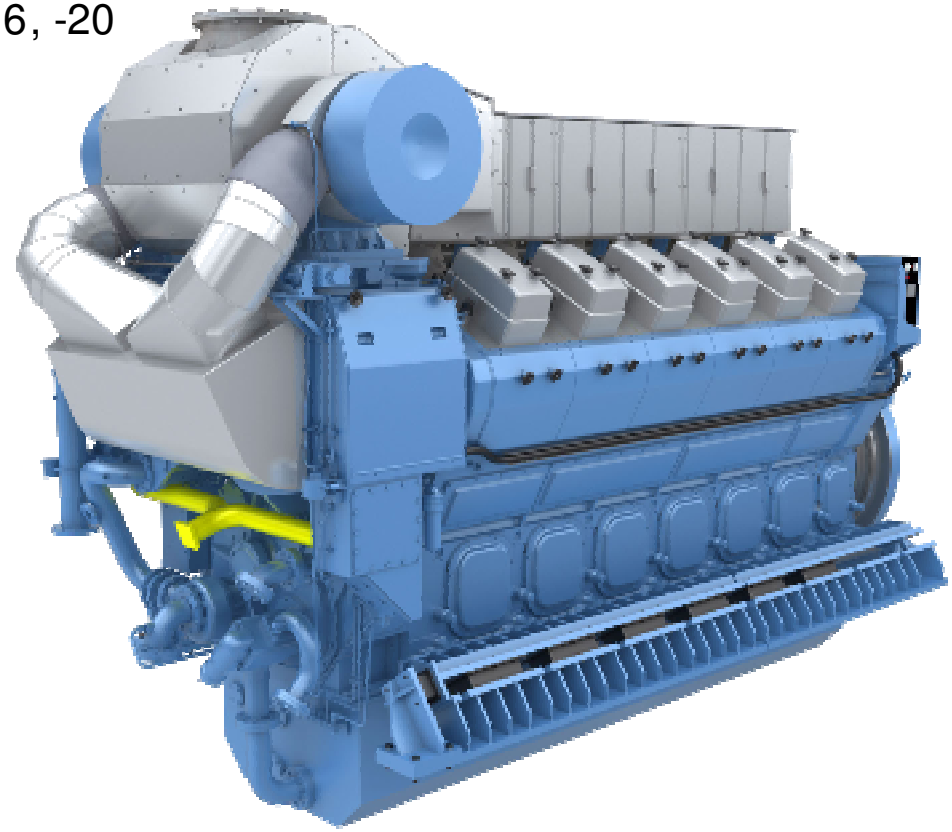
- Established in 1943
- First HFO engine delivered in 1963
- First lean-burn gas engine delivered in 1991
- Part of Rolls-Royce 1999
- First 16 gas engines for marine propulsion delivered 2006
- Over 6000 engines sold world wide, more than 4000 are still in operation
- Engine range 1400 kW to 8500 kW
- Lloyd's Quality Certificates: ISO 9001:2001 and 14001



The Bergen B-series gas engines

- Spark ignited lean-burn gas engine

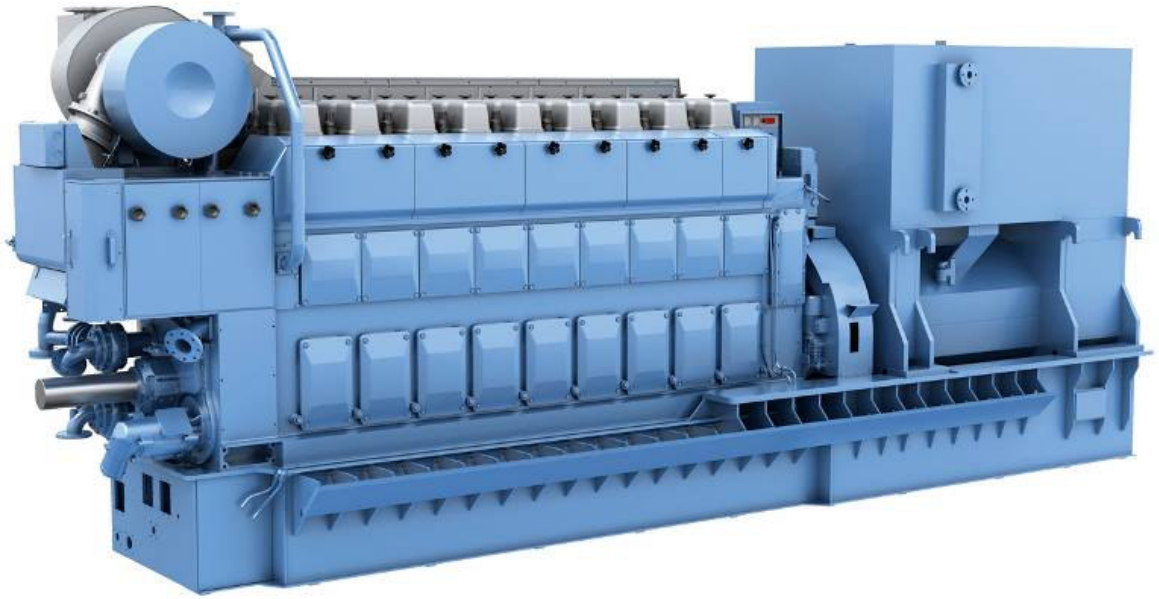
- Types: B32:40L6-8-9 & B35:40V12, -16, -20
- Bore: 320 / 350 mm
- Stroke: 400 mm
- Power: 420 / 440 kW / cyl
- Speed: 500 - 750 rpm
- Power range: 2320 - 8500 kWmech



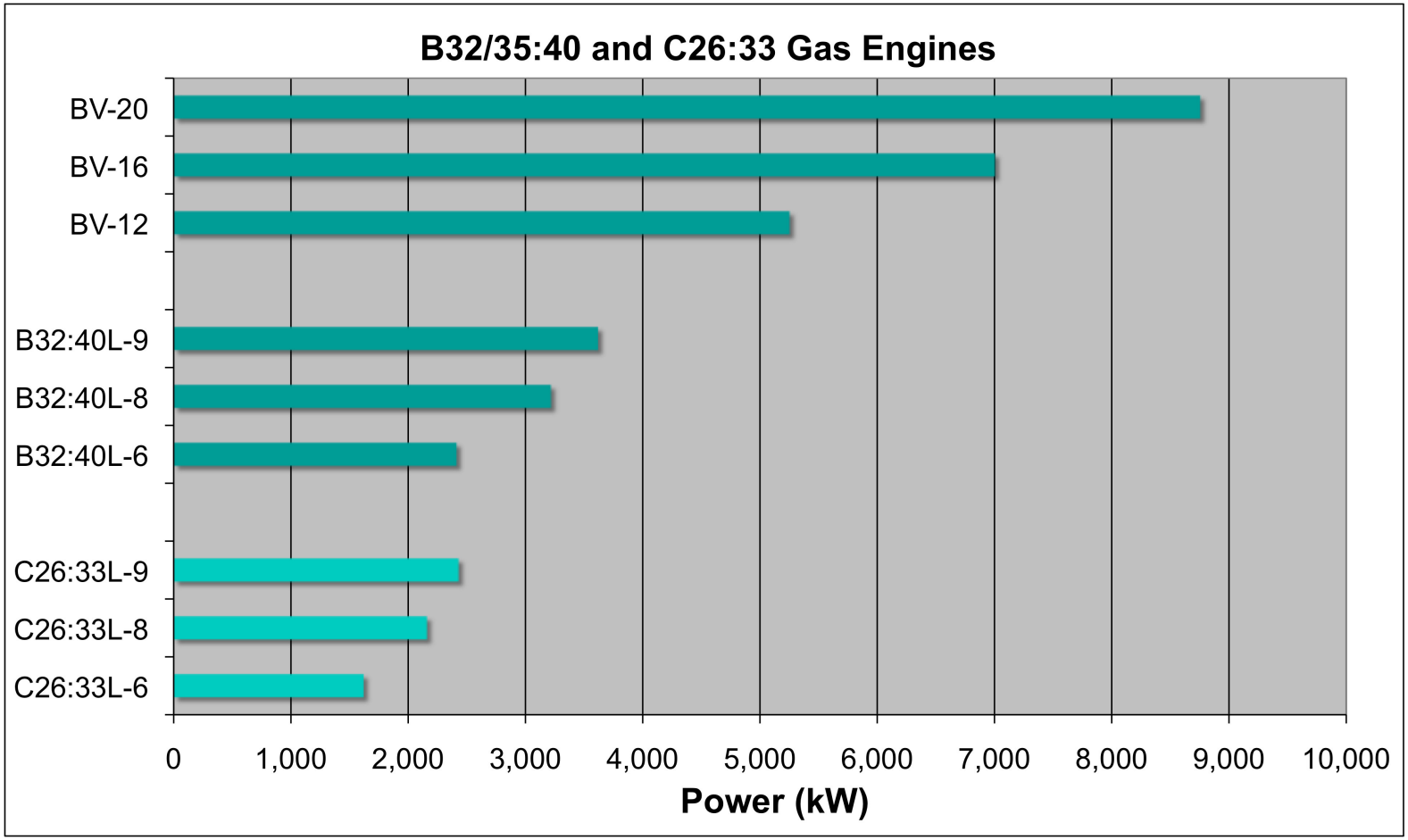
The Bergen C-series gas engines

- Spark ignited lean-burn gas engine

- Types: C26:33L6-8-9
- Bore: 260 mm
- Stroke: 330 mm
- Power: 270 kW / cyl
- Speed: 600 – 1000 rpm
- Power range:
  1460 – 2430 kW mech



Power range gas engines



Powered by natural gas

- probably the cleanest cargo vessel since the age of sails

The 132.8 m LNG fuelled Sea-Cargo vessel will be able to carry 5,600 tonnes of cargo, with up to 94teu of containers on deck an 1,240 lane-metres of ro-ro capacity

- CO_2 emission reduced by 23%
- NOx by 90 %
- SOx eliminated

Typical vessels equipped with Bergen Gas Engines

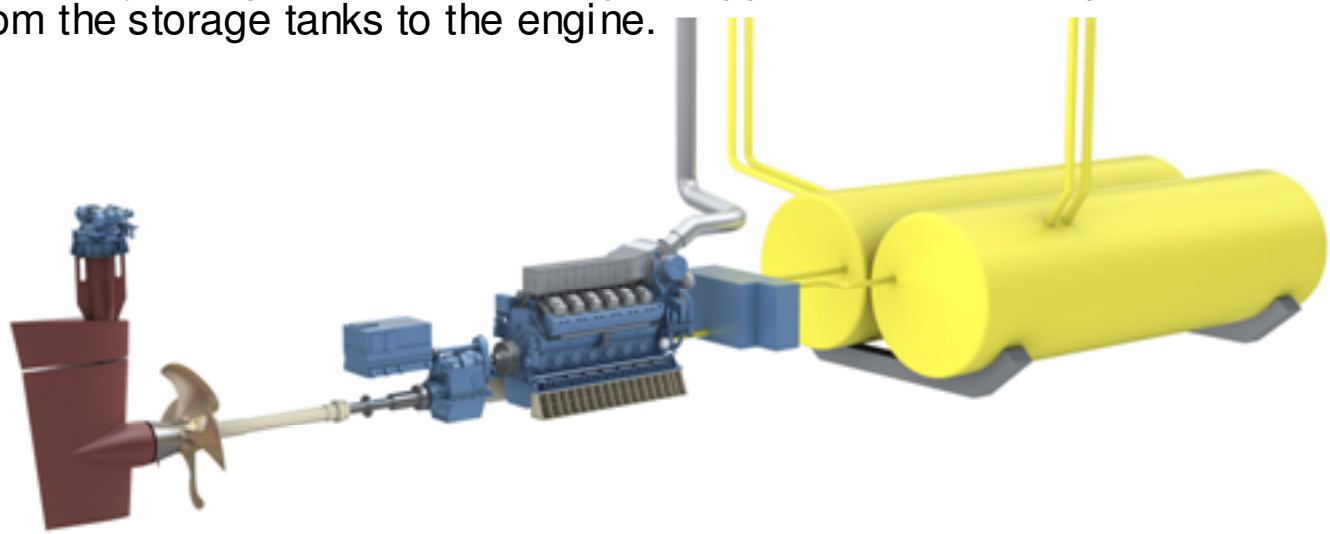
MF "Bergensfjord"
(coastal ferry)

LNG/LPG Carrier Coral Methane

LNG/LPG Tanker

Gas safe machinery space

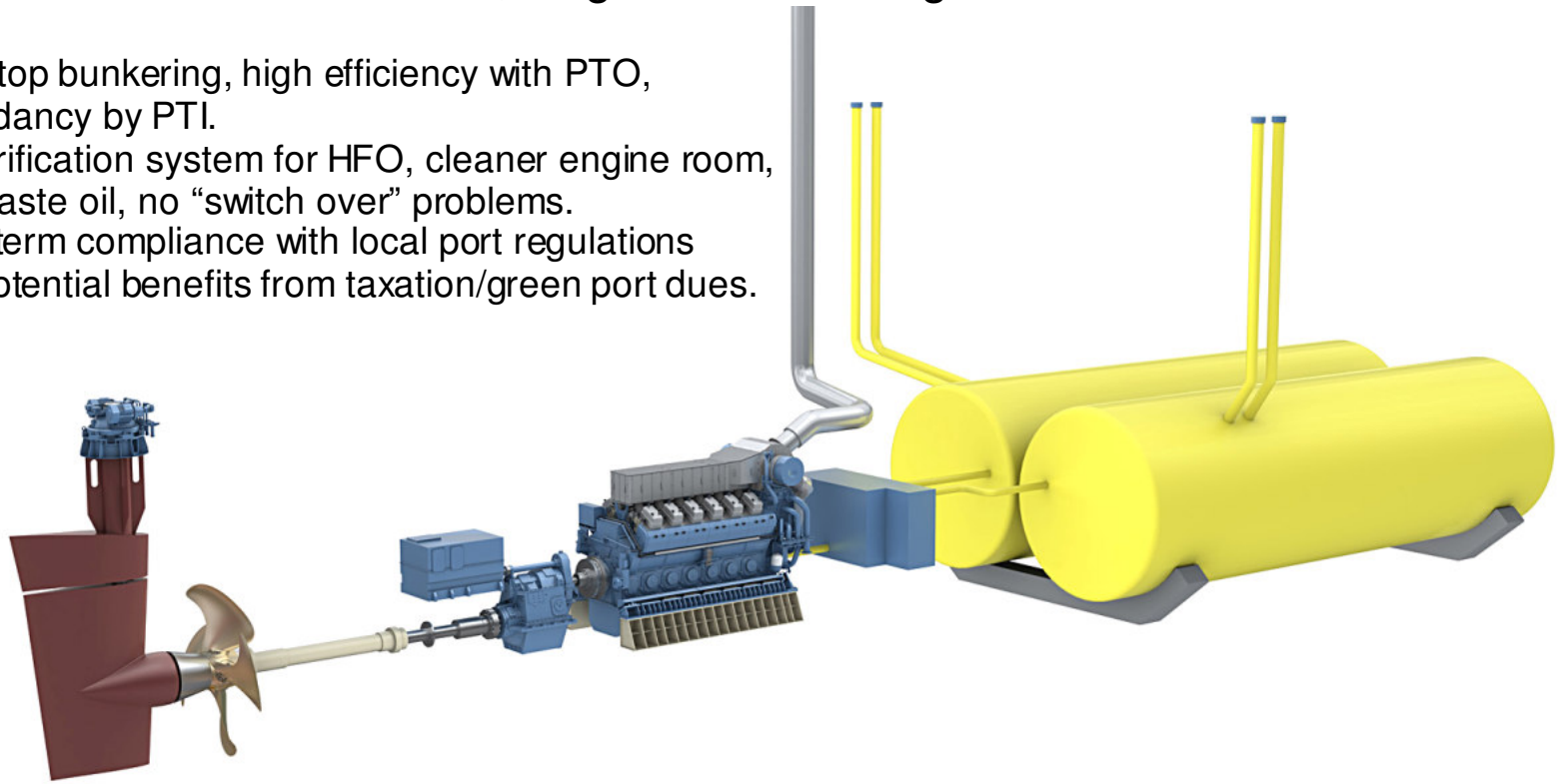
- All gas supply piping within closed spaces must be double wall piping or ducting.
- In case of leakage in a gas supply pipe making shutdown of the gas supply necessary, a secondary independent fuel supply must be available.
- For single fuel installations (gas only) the fuel storage shall be divided between two or more LNG tanks of approximately equal size.
- For “Gas Only “- engines, the two fuel gas supplies shall be independent all the way from the storage tanks to the engine.



“From bunker flange to propeller thrust”

Operational benefits with LNG, single fuel main engine:

- 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.



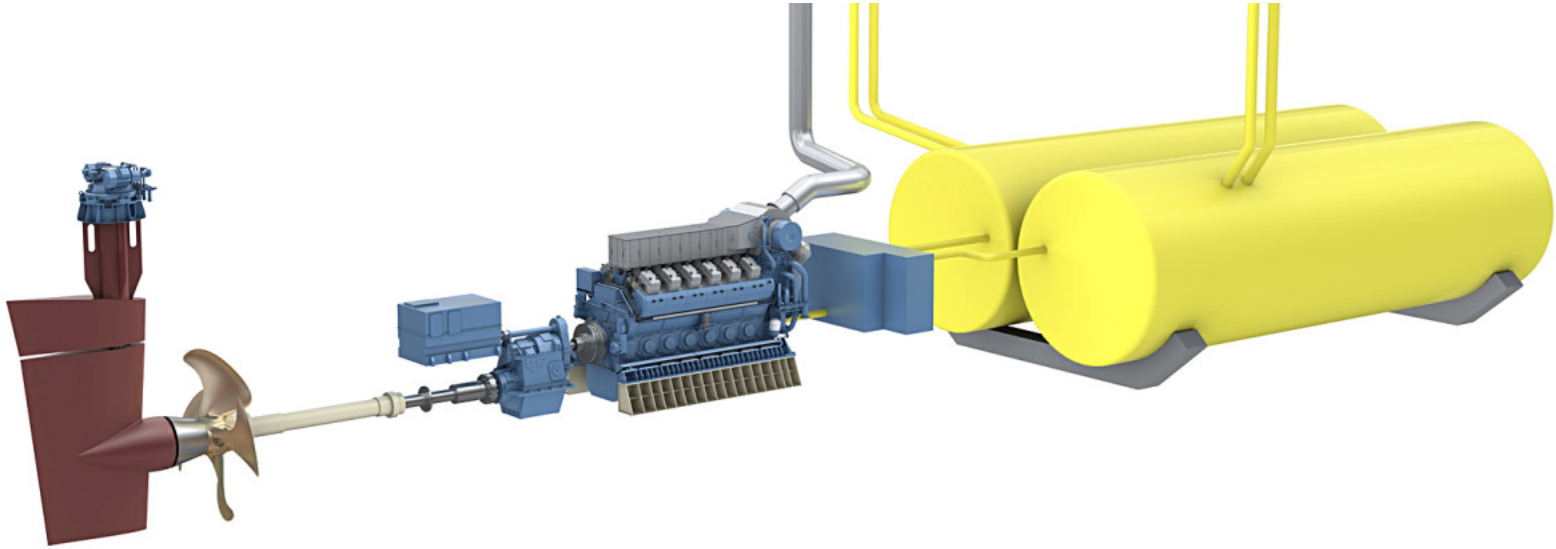
May arrange hybrid LNG-direct (main) / Diesel-electric (Aux)

“From bunker flange to propeller thrust with single gas propulsion engine installation, - - can it be done - - ? ”

Requirements for single gas engine propulsion unit:

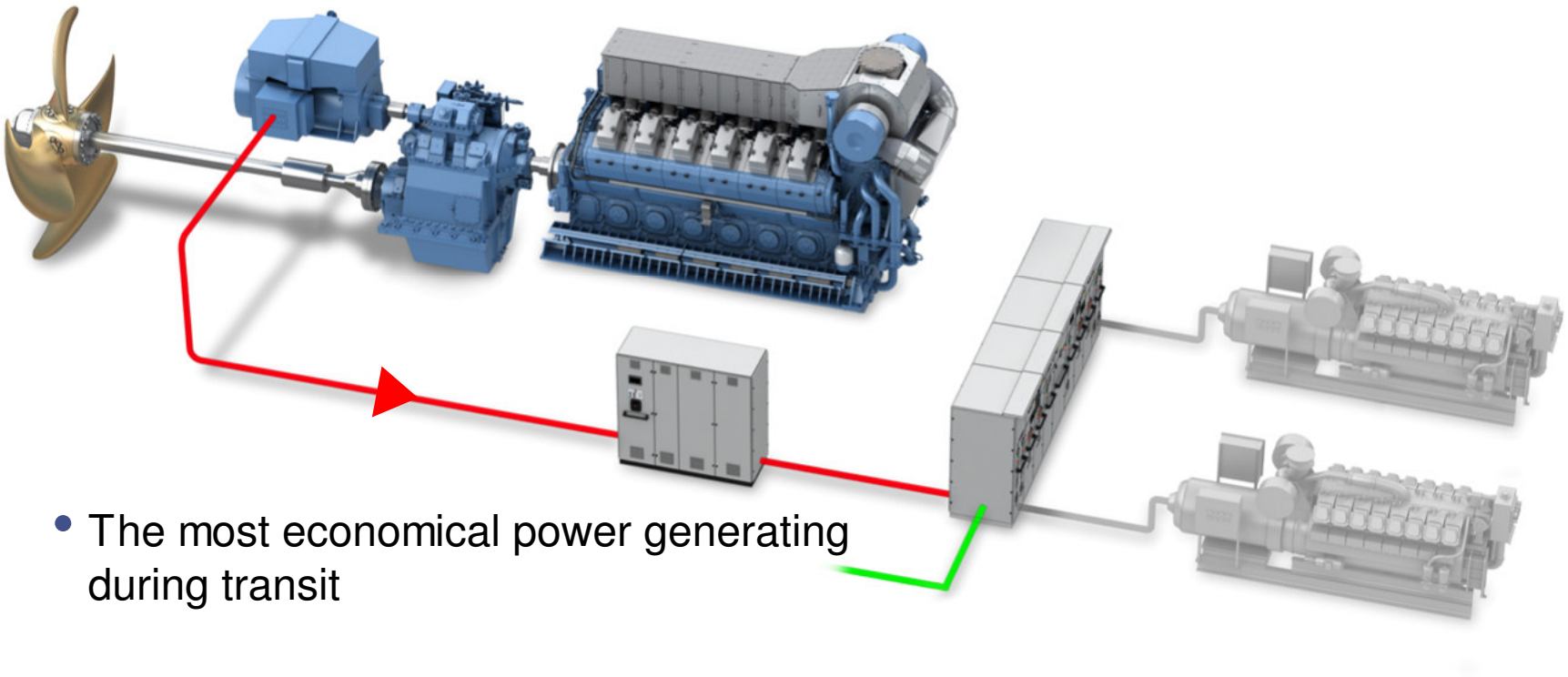
- Two independent fuel tanks.
- Two independent fuel supplies to the engine.
- Possibility to shut off one or a group of cylinders and still maintain steering speed?

- The answer to this is down to the final result of “IMO interim guidelines on safety for natural gas-fuelled engine installations in ships” an the national administration’s interpretation (Sjøfartsdirektoratets tolkning.) In addition comes any additional requirements from Class.



Hybrid Propulsion System

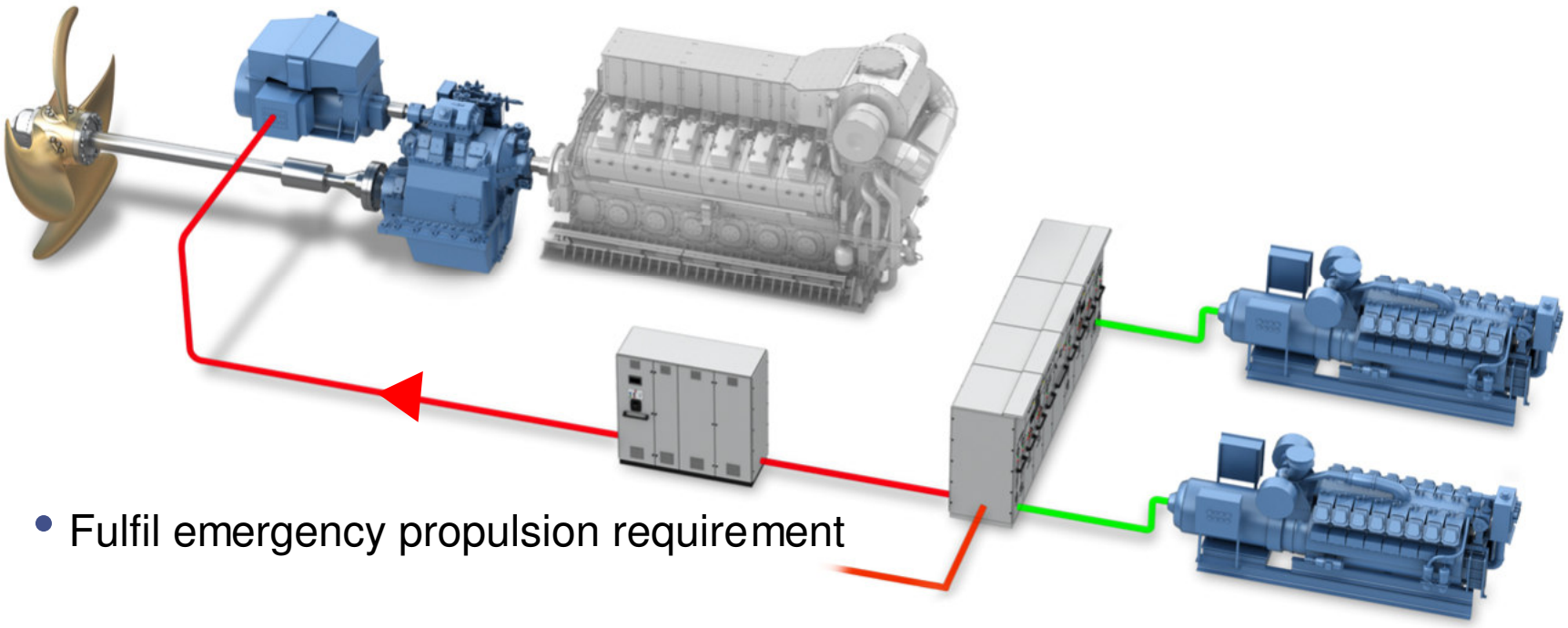
Diesel or Gas Mechanical at Full Speed



- The most economical power generating during transit

Hybrid Propulsion System

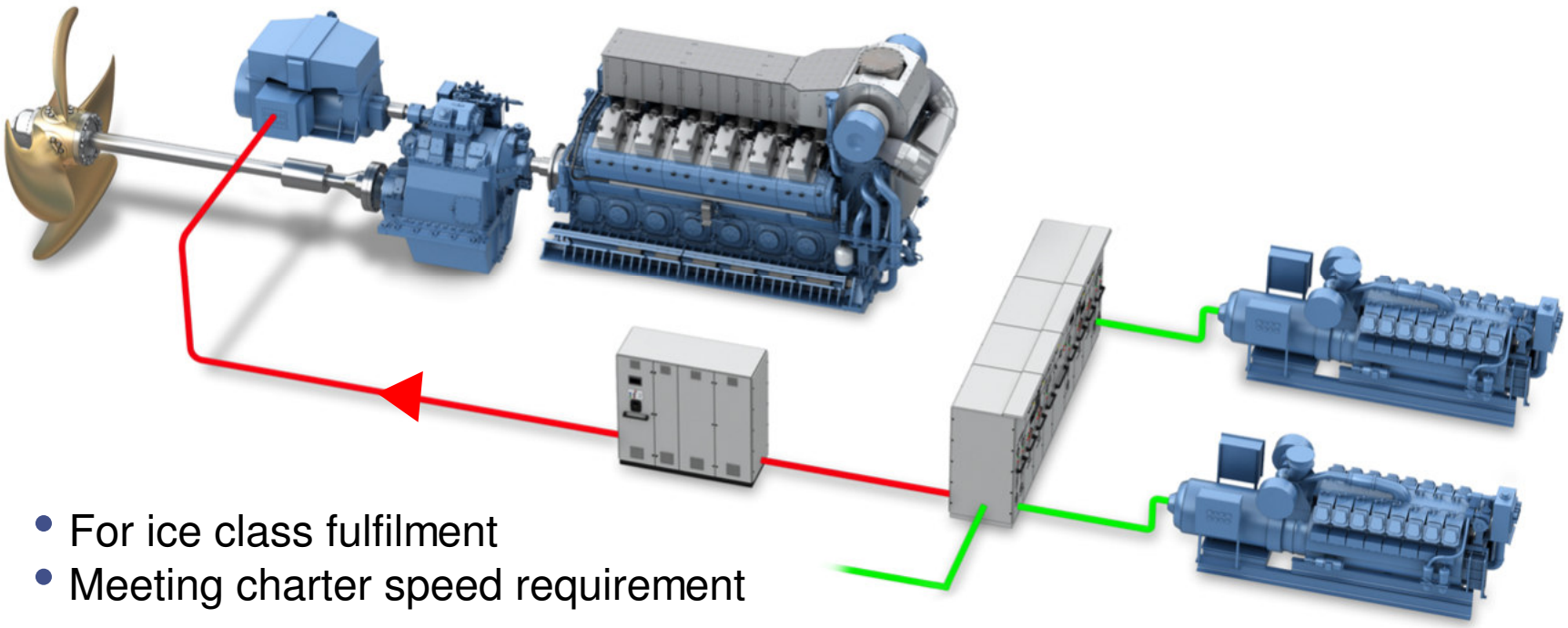
Diesel or Gas Electric at Slow Speed



- Fulfil emergency propulsion requirement

Hybrid Propulsion System

Diesel or Gas Mechanical Boost Mode



- For ice class fulfilment
- Meeting charter speed requirement

Heavy fuel oil

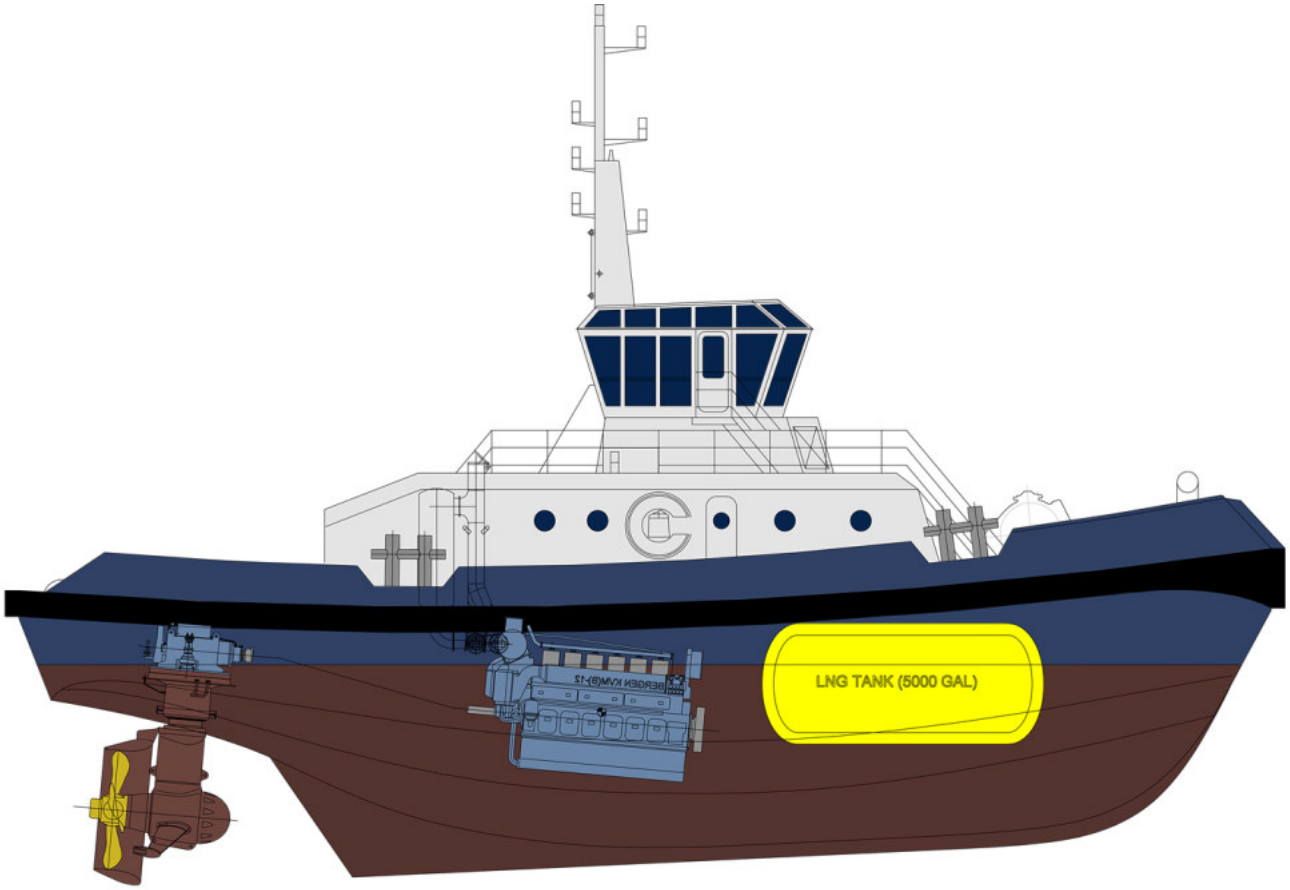
Natural gas

GasNor & Anthony Veder

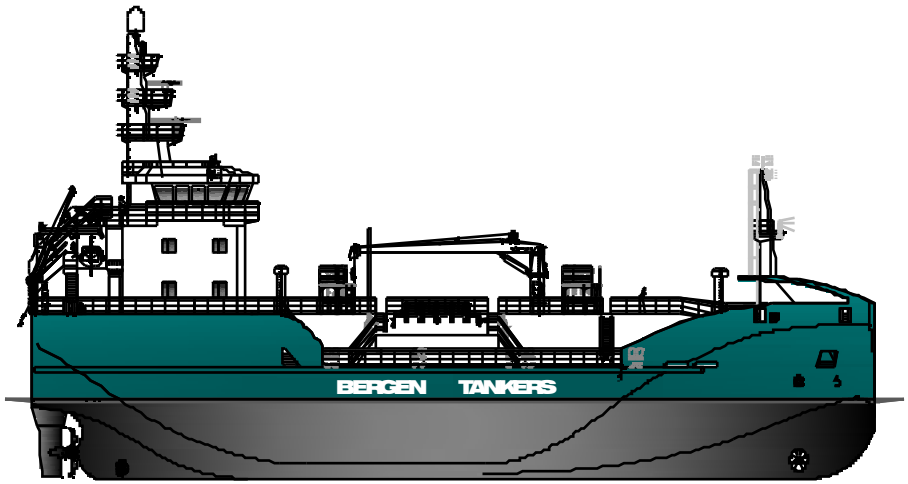
Marine systems from Rolls-Royce

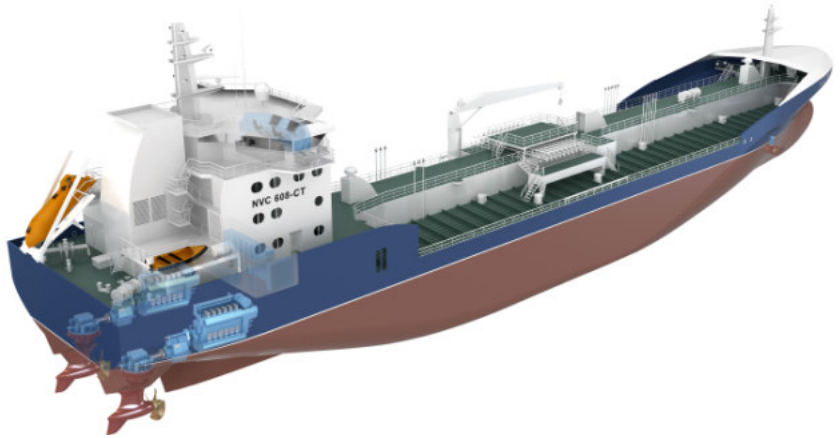
Crowley, Glosten & Rolls-Royce - Tug

Rolls-Royce selected due to Engine Load Response and Emissions

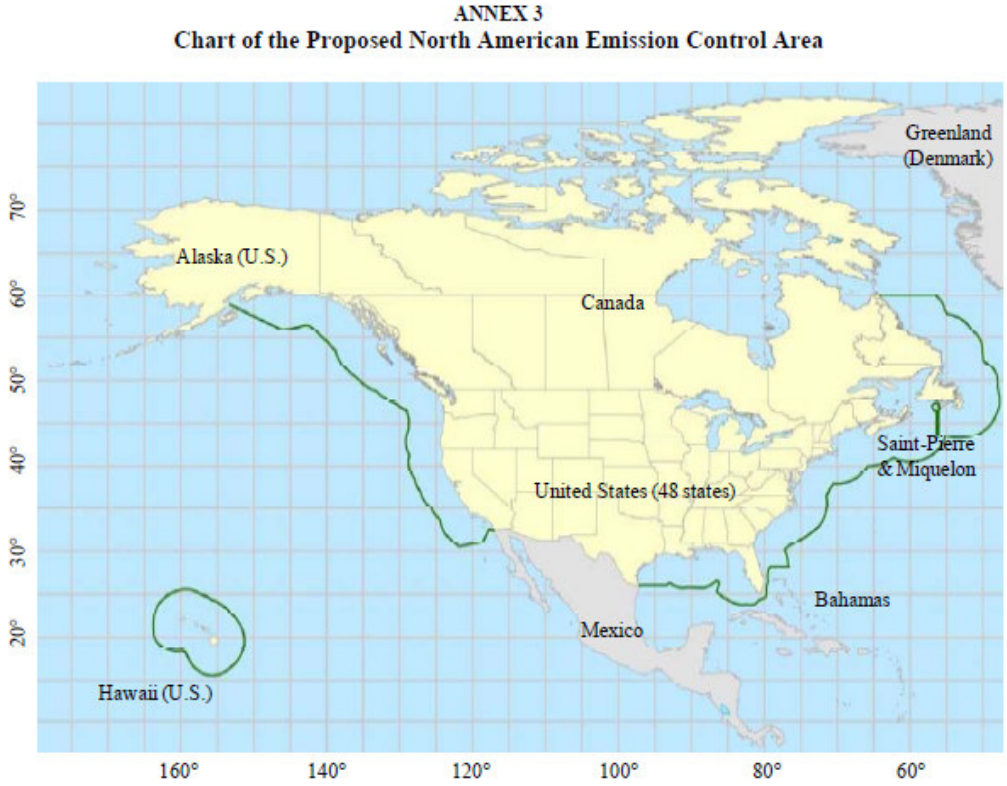


Example:
Product Tankers– on LNG

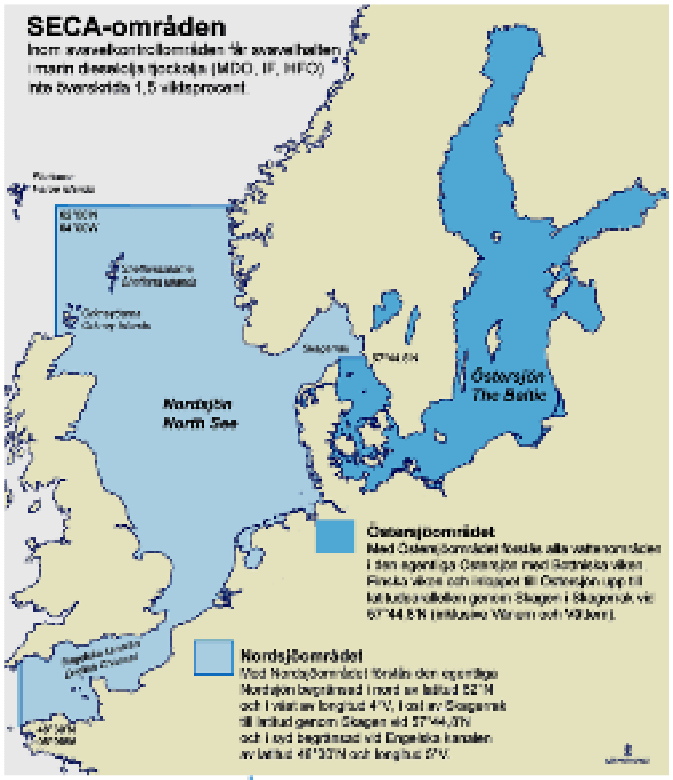




Legislation will drive future demand



Clean Energy
North America's leader in clean transportation



GASNOR

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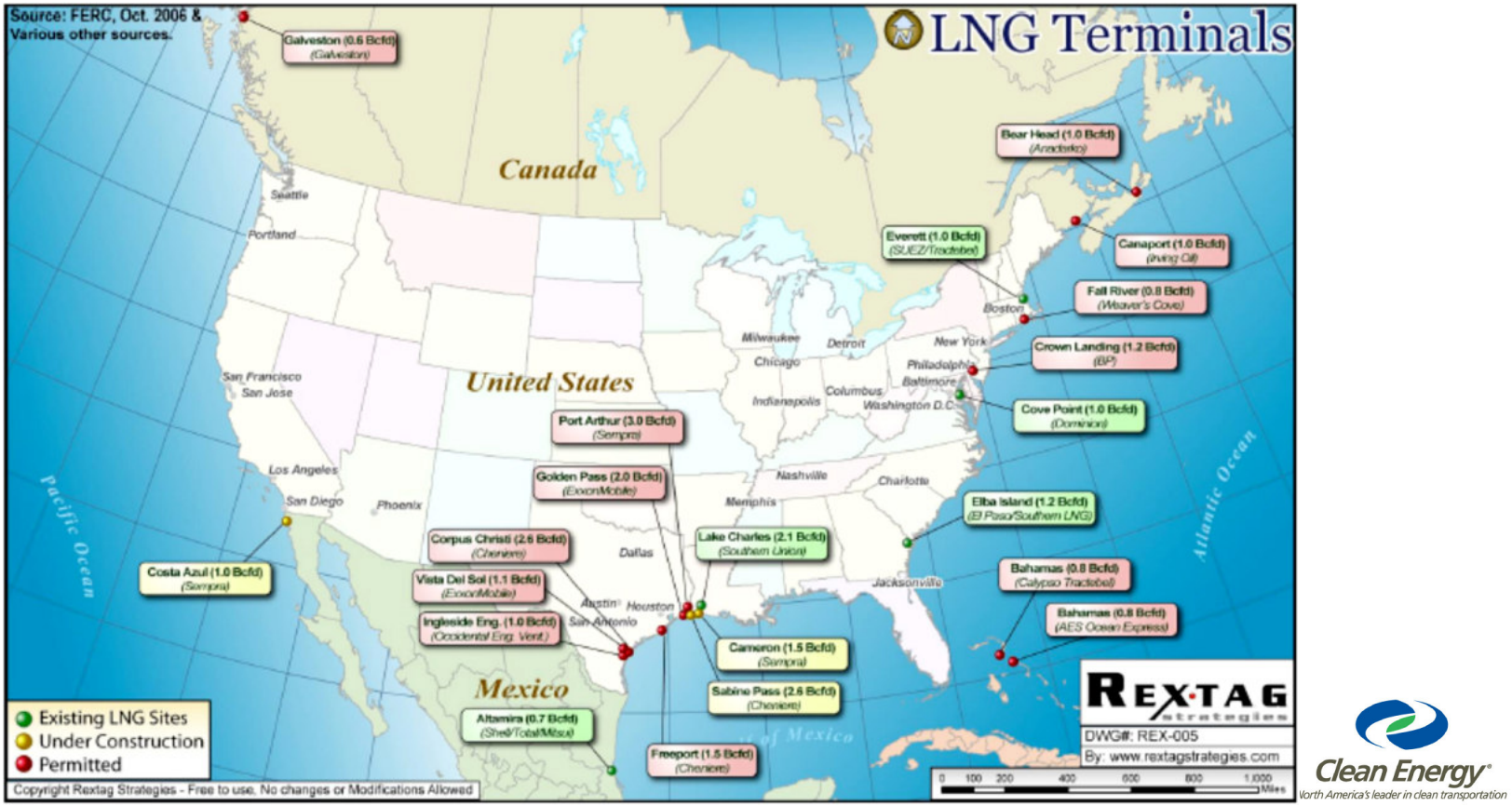
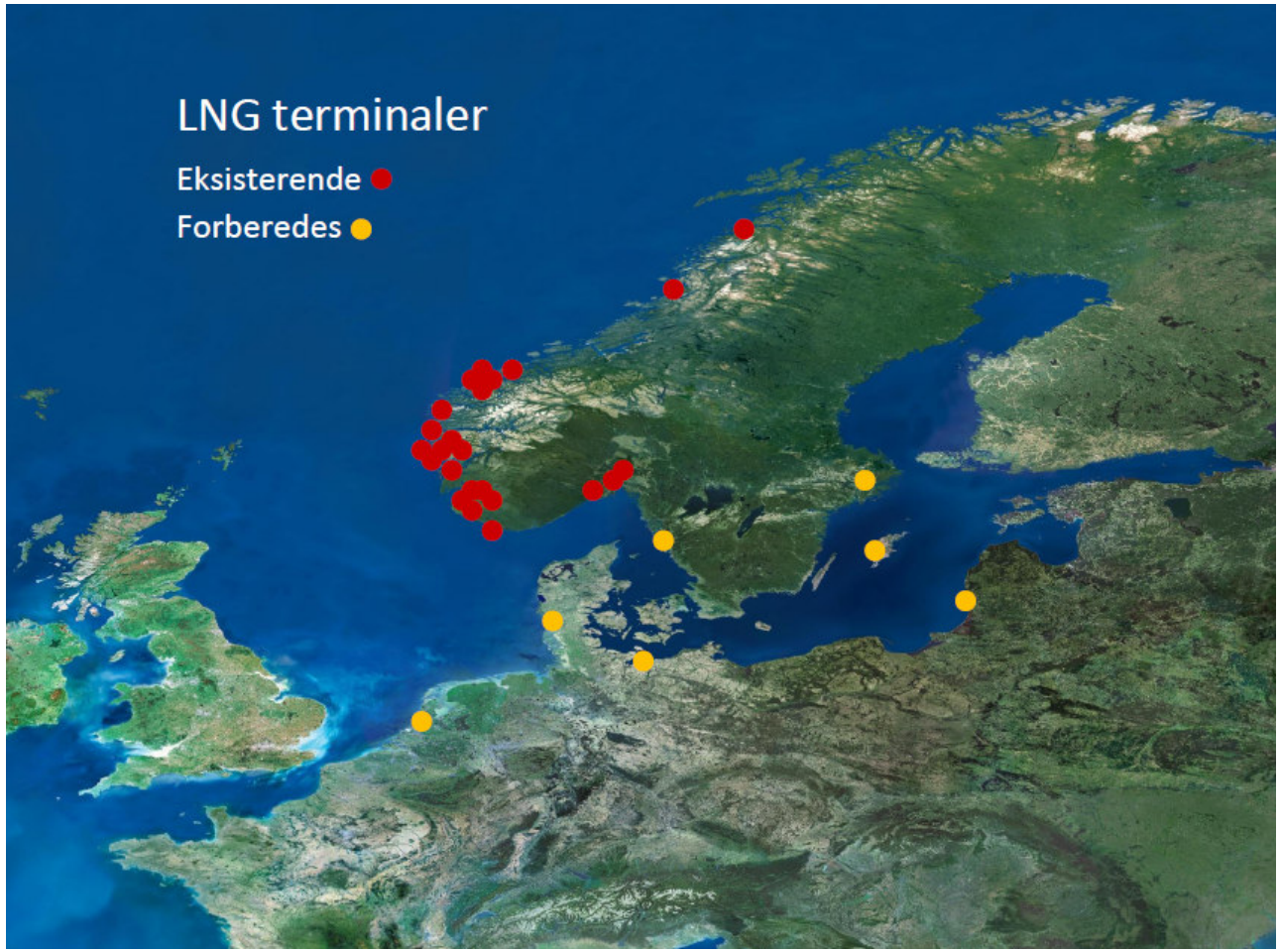
Rolls-Royce

LNG import and export terminals



"We can deliver LNG to any port in North America" Ref: groche@cleanenergyfuels.com

LNG terminals Nordic - Baltic



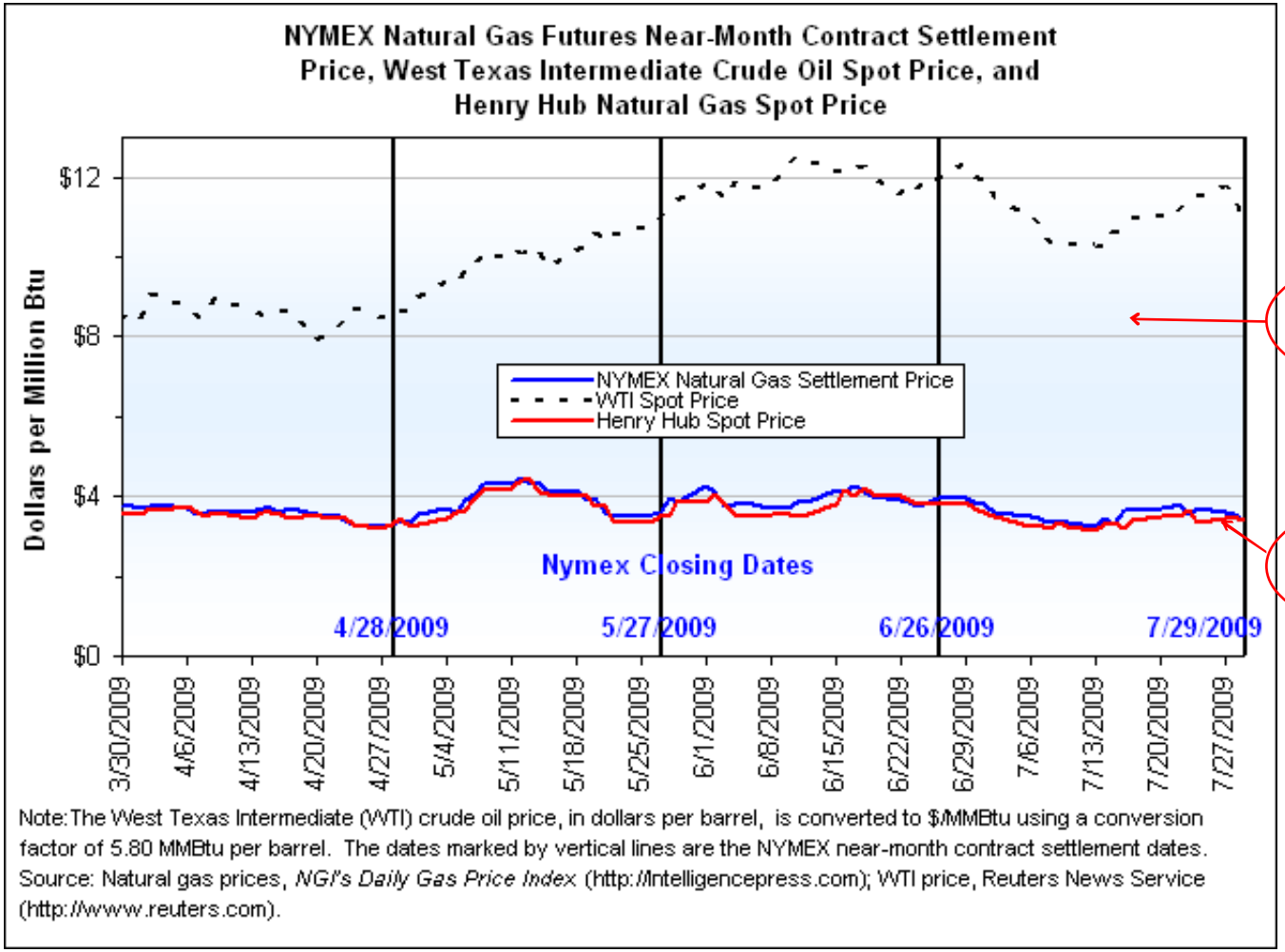
Ref.
GASNOR

Limitations on LNG availability?

- Large scale LNG terminals does not allow any ship to enter terminal
- Large terminals does not have small ship piers and piping/flanges etc.
- Logistics and handling is a challenge

However: Nordic and Baltic will be earlier than a vessel can be built.

Huge price gap on Oil to Gas



Price for Marine LNG in Norway?

World market LNG

Conclusion, gas engines for ships.

- Positive climate effect by green house gas emission reduction.
- NOx-emission challenge solved.
- LNG distribution infrastructure may need further stimulus.
- Await also possible benefits for EU ship operators e.g emission related Port Fees?

- **The technology is ready for use -**

Rolls-Royce Marine, Engines - Bergen

Engine no. 6000 B35:40V20-gas-engine