Further development of technology for operation on LNG

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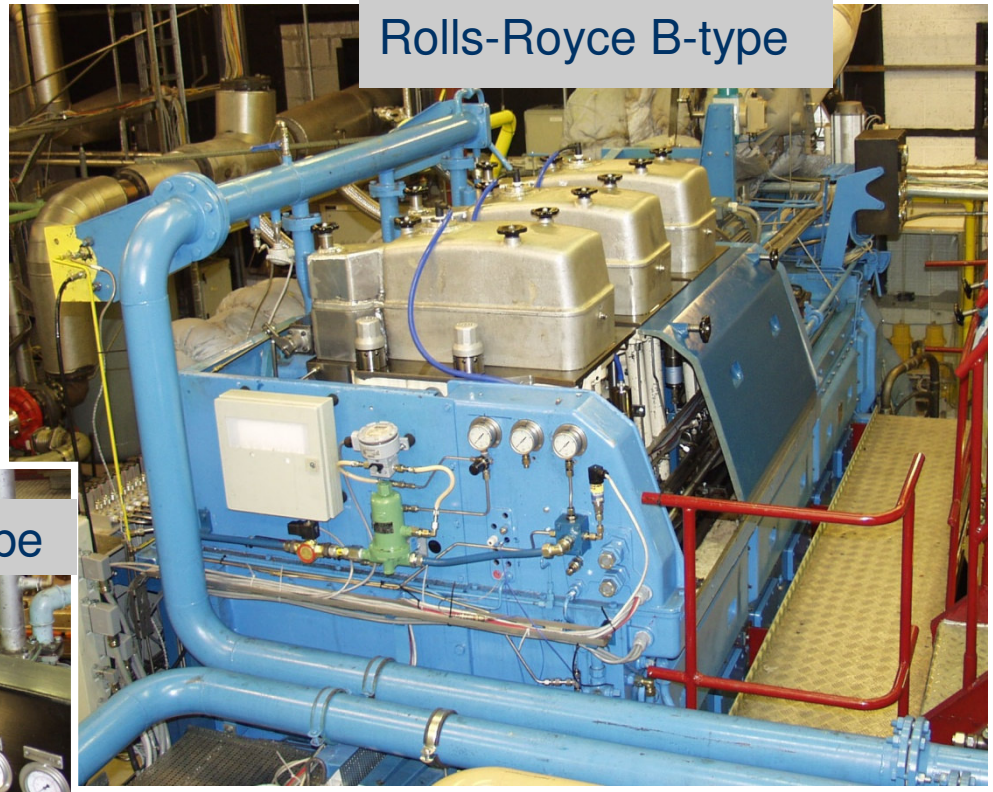
MARINTEK
Independent research and development institute

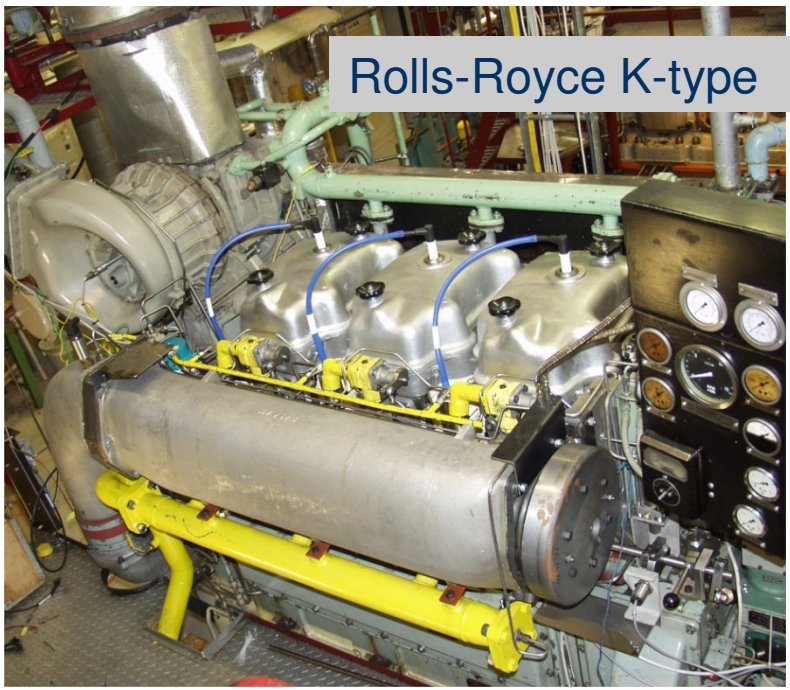
Machinery Laboratory
Gas engine development since 1980

Wärtsilä Vasa 32

Rolls-Royce B-type



Rolls-Royce K-type



Dual Fuel (high pressure) gas engines
Dual Fuel (low pressure) gas engines
Lean Burn gas engines

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

Gas fuelled ships and greenhouse gas emission

Head line in the Norwegian Technical magazine

"LNG engines worst for the climate"

Greenhouse gas emissions from gas fuelled ships

CO_2 emissions from combustion of natural gas

- Natural gas vs Marin Gas Oil (MGO) $\Rightarrow$ ca 26% reduction
- Natural gas vs Heavy Fuel Oil (HFO) $\Rightarrow$ ca 30% reduction

Assuming combustion at the same thermal efficiency

Global Warming Potential (GWP) factor

- CO_2 = 1
- Metan = 21-25

Meaning 1kg methane coresspond to 21-25 kg CO_2

Greenhouse gas from gas fuelled ships:

- CO2 + Methane x GWP-factor

Greenhouse gas emission for gas fuelled ships is dependant of the thermal efficiency of the combustion process and the amount of methane slip

Greenhouse gas emission from existing gas fuelled ships in Norway


M/F "GLUTRA"

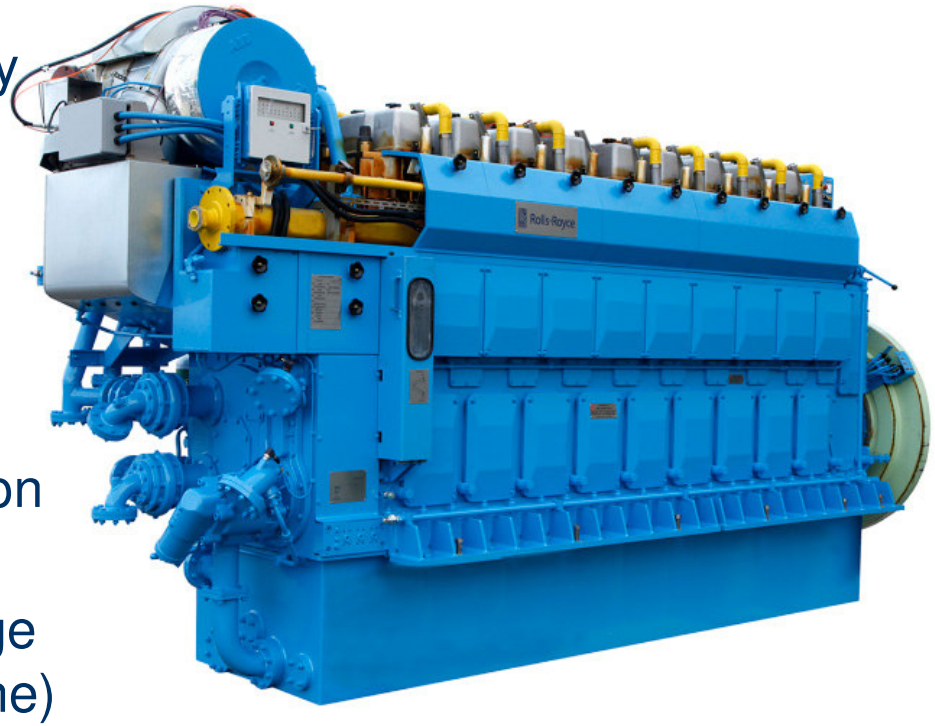
All the gas engine solutions for the ships in operation emit a significant amount of un burnt methane (methane slip), especially at low load. Greenhouse emission is therefore den pendant of the operation profile

MARINTEK has performed a study on the methane slip form the gas fuelled ships and find that the greenhouse gas emissions are unchanged or negative compare to similar operation on MGO

Three different gas engine concepts for ships

Spark Ignited Lean Burn gas engine characteristics

- Single fuel, low pressure gas supply (4-5 bar)
- High energy efficiency, at high load higher than the diesel counterpart
- Low emissions, meets IMO tire III
- Challenge on methane slip, minimized by design and combustion process control
- GHG reduction potential in the range of 20-30% ref. to HFO (incl. methane)
- Sensitive to gas quality (Methane Number)
- Not suitable for conversion of existing engines



Rolls-Royce C26:33L9

Dual-fuel (low pressure) engine characteristics

Wärtsilä 6L50DF

- Dual Fuel low gas pressure supply (4-5 bar)
- High energy efficiency at high load
- Low emissions, meets IMO tire III
- Challenge on methane slip, limited possibility to combustion process control
- Reduction of GHG is dependant on level of methane slip
- Sensitive to gas quality (Methane Number)
- Flexibility in fuel mix
- Possible for conversion of existing engines (extensive rebuilding)

Dual-Fuel (high pressure) engine characteristics

- High pressure gas injection (300 -350 bar) 4-stoke and 2- stroke Maintain diesel engine performance.
- No methane slip, GHG reduction in the range of 30% ref. to HFO
- Need NOx reduction techniques to meet IMO tier III
- Not sensitive to gas quality
- Pumping LNG to 350 bar and evaporate is simple and with low energy requirement
- Flexibility in fuel mix
- Suitable for conversion of existing engines (simple rebuilding)