Rolls-Royce Marine - The “Environship Concept”

System Solutions & Wave Piercing Technology
Odd Magne Horgen
Content

- Rolls-Royce in general
- Engines
- Environmentally friendly system solutions
- LNG as fuel for marine engines
World leading supplier addressing four global markets:

**Civil Aerospace**
- Aero engines
- Helicopter engines

**Defence Aerospace**
- Aero engines
- Helicopter engines

**Marine**
- Ship Design
- Equipment systems

**Energy**
- Gas turbines

39,000 employees
Rolls-Royce design & integrated ship systems

One contact, one supplier, one deal = a safe & cost-effective solution
Bergen Engines

Engines & Foundry

- 800 employees
- 6500 engines sold
- 3500 in operation
- 556 gas engines
- 40 gas marine
Engine Range

C25:33 engine (2002-)
- Output: 1840 - 3000 kW
- Bore x stroke: 250 x 330 mm
- Speed range: 900 - 1000 rpm
- BMEP: 22.2 - 26.7 bar
- Fuel types: MDO, HFO
- Propulsion and Gen.set applications: Inline: 6-8-9

345 C engines sold

C26:33 engine (2010-)
- Output: 1400 - 2500 kW
- Bore x stroke: 260 x 330 mm
- Speed range: 900 - 1000 rpm
- BMEP: 18.2 bar
- Fuel types: Natural Gas LNG
- Propulsion and Gen.set applications: Inline: 6-8-9

16 C gas engines sold

B32:40 engine (2001-)
- Output: 2765 - 8000 kW
- Bore x stroke: 320 x 400 mm
- Speed range: 720 - 750 rpm
- BMEP: 24.9 bar
- Fuel types: MDO, HFO
- Propulsion and Gen.set applications: Inline: 6-8-9

1100 B engines sold

B35:40 engine (2003-)
- Output: 2625 - 9600 kW
- Bore x stroke: 350 x 400 mm
- Speed range: 720 - 750 rpm
- BMEP: 18.2 & 20 bar
- Fuel types: Natural Gas, LNG
- Propulsion and Gen.set applications: In line type: 6-8-9 & 9
  Vee type: 12-16

141 B gas engines sold
Why natural gas? The Drivers!!

- Price
- Emissions
Cruise ship destination, Norway

But what if the ship emissions ruin it…?
Emissions, the technology driver:

Spark Ignited lean Burn Gas Engines:

- ~92% reduced NO$_x$ emission
- ~22% reduced GHG emission
- 100% reduced SO$_x$ emission
- Zero smoke
- Low unburnt fuel slip
- Low number of particles
- Low maintenance cost
Core Technology Status

- Gas Engines, compliant with the current **IMO II legislation** and **IMO III** from 2016

- **Bergen Engine nett GHG (CO2-CH4 slip) reduction is 22%**

- Diesel Engines, **compliant with the current IMO II legislation**. Requires sub-equipment to meet IMO III from 2016.

![NOx curves diagram](image)
Ways of reducing emissions

Gas powered propulsion

• GHG 22%
• NOx - 92%
• SOx - 100%
• Particulate - 98%

High efficiency propulsion and manoeuvring systems: PROMAS

Hybrid propulsion

Application for patent protection by Rolls-Royce up to -8%

Advanced hull forms
Fjord 1; MF Boknafjord

BERGEN Gas engine technology – 24.6 knots

Electric Propulsion system; 3 x C2633L9AGas + 1 x C25:33L9A mdo
and 4 x 100 AZP

Fuel reduction >30% compared to first 5 ships (7.5% from engine)
NorLines - Cargo

Complete design and equipment package:
Gas engine, Gear box, propeller, LNG tank, ACON-HSG system

40% Green House Gas reduction!!
22% from engine 18% from design and Promas
Eidsvåg shipping at STX Brattvåg

Complete design and equipment package:
Gas engine, Gear box, propeller, LNG tank, ACON-HSG system
HYBRID SHAFT GENERATOR

Shaft generator to switchboard power flow control.

✓ Engine and propeller can operate at variable speeds
✓ Stable network frequency
✓ Fixed voltage

Benefits.

✓ Reduced fuel consumption
✓ Flexible operations
✓ Optimised propulsion mode selection
✓ Longer engine life and reduced maintenance
✓ Increased comfort on board
✓ Improved redundancy
HYBRID SHAFT GENERATOR

A range of operational modes

- Boost mode
- Transit mode
- Parallel mode
- Diesel/gas electric mode
The new Bukser & Berging tug

2 x C26:33L6PG @ 1705kW, 1000rpm
2 x Aquamaster US 35
Complete design and equipment package:
Gas engine, Gear box, propeller, LNG tank, ACON-HSG system

Bunkring Ship to Ship (STS)
Bunkring Ship to Ship (STS)
Gas availability

Today (2012)

- Gas availability steadily increasing worldwide
- LNG carriers (like “Corale Methane”) will bring gas from main- to smaller terminals and ports
- Gas distributors ready to increase gas availability based upon demand
- Gas supply in Europe superceed the LNG demand from ships per today
- Volume of LNG will drive down LNG price
Example: LNG bunkering process
Fjord1 Ferry “MV Raunefjord”

The bunkering station on board
GHG (Green House Gases) from gas engines

- 1t diesel emits 3.2t CO2
- 1t natural gas emits 2.55t CO2
- The difference is 20% reduction
- Due to higher energy content in gas the possible Greenhouse Gas reduction is almost 30%
- Uncombusted Methane has a GHG effect factor 21-25 times higher than CO2
- If unburned methane is released from the combustion the GHG reduction is quickly eroded
GHG reduction vs fuel consumption

Reduction of GHG in % compared to a standard Diesel engine with a specific consumption of 185 g/kWh.

Gas engine fuel consumption in g/kWh

E2 weighed methane slip in g/kWh
Methane emission: Gas vs. Dual Fuel

Methane emission is 21-25 times more aggressive Green House Gas than CO2

Source: Marintek
Natural gas

Spark ignition
High efficiency
Methane number 70
Load response similar to a diesel engine.
Minimum emissions
Simplicity
Lower maintenance cost

No abatement systems needed
Multi-fuel system
Compression ignition
Some compromises to accommodate the two fuels.
After-treatment to meet ECA/EPA regulations?

- 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
Natural Gas as Fuel for Future Vessels

\[
\begin{align*}
\text{NO}_X & \quad - \quad 92 \% \\
\text{GHG(CO}_2\text{-Methane slip)} & \quad - \quad 8 \% \\
\text{SO}_X & \quad - \quad 100 \% \\
\text{Particulate} & \quad - \quad 98 \%
\end{align*}
\]

- Invisible smoke
- No oil spill

- 35 daily port calls 51000/year
- Engines have run more than 35,000 hrs since Jan 2007
- NOX reduction = 160,000 cars running for 1 year
Summary

- Marine Gas engines represent well proven technology.
- LNG is available – increased demand will ensure even better distribution network.
- Dual fuel engines are the choice when enough LNG cannot be carried to complete the voyage.

Where the application allows single fuel marine gas engines:
- More efficient
- Less expensive in terms of operating and life cycle cost.
- Lower emissions, reduced GHG by net 22%
- Less complex engine supporting systems.
- Methane number 70
- Green profile for the ship owner – marketing tool.
Bergen Gas engines for ships:

- 556 gas engines sold, over 400 in operation
- More than 20 mill hrs. experiences
- Plants with more than 140,000 hrs.
- The 5 ferries are doing 35 port calls/day-51000/year.
- The ferry Engines have logged from 18000 - 35000 running hours since Jan 2007

So far 23 gas engines for marine are in operation

"the most economic way to comply with future requirements"

NO OILSPILL DURING BUNKERING

The cleanest marine engine on the market today
BERGEN gas engine January 2012

Fjord1 - “Bergensfjord” (2 x KVGS-12G4 + 2 x KVGS-16G4)
Fjord1 - “Fanafjord” (2 x KVGS-12G4 + 2 x KVGS-16G4)
Fjord1 - “Raunefjord” (2 x KVGS-12G4 + 2 x KVGS-16G4)
Fjord1 - “Mastrafjord” (2 x KVGS-12G4)
Fjord1 - “Stavangerfjord” (2 x KVGS-12G4)
Fjord1 - “Tresfjord” (1 x C26:33L9AG + 1 x BRM-6 (diesel))
Fjord1 - “Bokna fjord” (3 x C26:33L9AG + 1 x C25:33L9LACD (diesel)) w AZP propulsion

Torghatten “ferry 1” (1 x C26:33L9PG) & propulsion
Torghatten “ferry 2” (1 x C26:33L9PG) & propulsion
Torghatten “ferry 3” (1 x B35:40V12PG) & propulsion
Torghatten “ferry 4” (1 x B35:40V12PG) & propulsion

NSK Shipping (1 x C26:33L6PG) & propulsion
RRM Eidsvåg Shipping 1 x C26:33L9PG & propulsion
Sea Cargo “vessel 1” (1 x B35:40V12PG) hull 357 & propulsion
Sea Cargo “vessel 2” (1 x B35:40V12PG) hull 358 & propulsion

Coral Methane 2 x KVGB-12G4 + 2 x B32:40L8A (MFO/HFO) & propulsion

Island Offshore #1(UT776 CDG) @ 2 x C26:33L9AG + 2 x C25:33L6A CD & propulsion
Island Offshore #2(UT776 CDG) @ 2 x C26:33L9AG + 2 x C25:33L6A CD & propulsion

Norlines #1 TBN NVC design, 1xBL35:40L9PG & propulsion
Norlines #1 TBN NVC design, 1xBL35:40L9PG & propulsion

Bukser & Bergning 2 x 2 x C26:33L6PGas + 2 x Aquamaster US35 FPP system
Clean engine crankcase room.... 25000 running hrs
Thanks for your attention!

Designed for robustness, harsh operational environments, and exceptional levels of reliability