

Rolls-Royce Marine - The “Environship Concept”



System Solutions & Wave Piercing Technology

Odd Magne Horgen



Rolls-Royce

Content

- Rolls-Royce in general
- Engines
- Environmentally friendly system solutions
- LNG as fuel for marine engines



Rolls-Royce plc

World leading supplier addressing four global markets:



Civil Aerospace

- Aero engines
- Helicopter engines



Defence Aerospace

- Aero engines
- Helicopter engines



Marine

- Ship Design
- Equipment systems

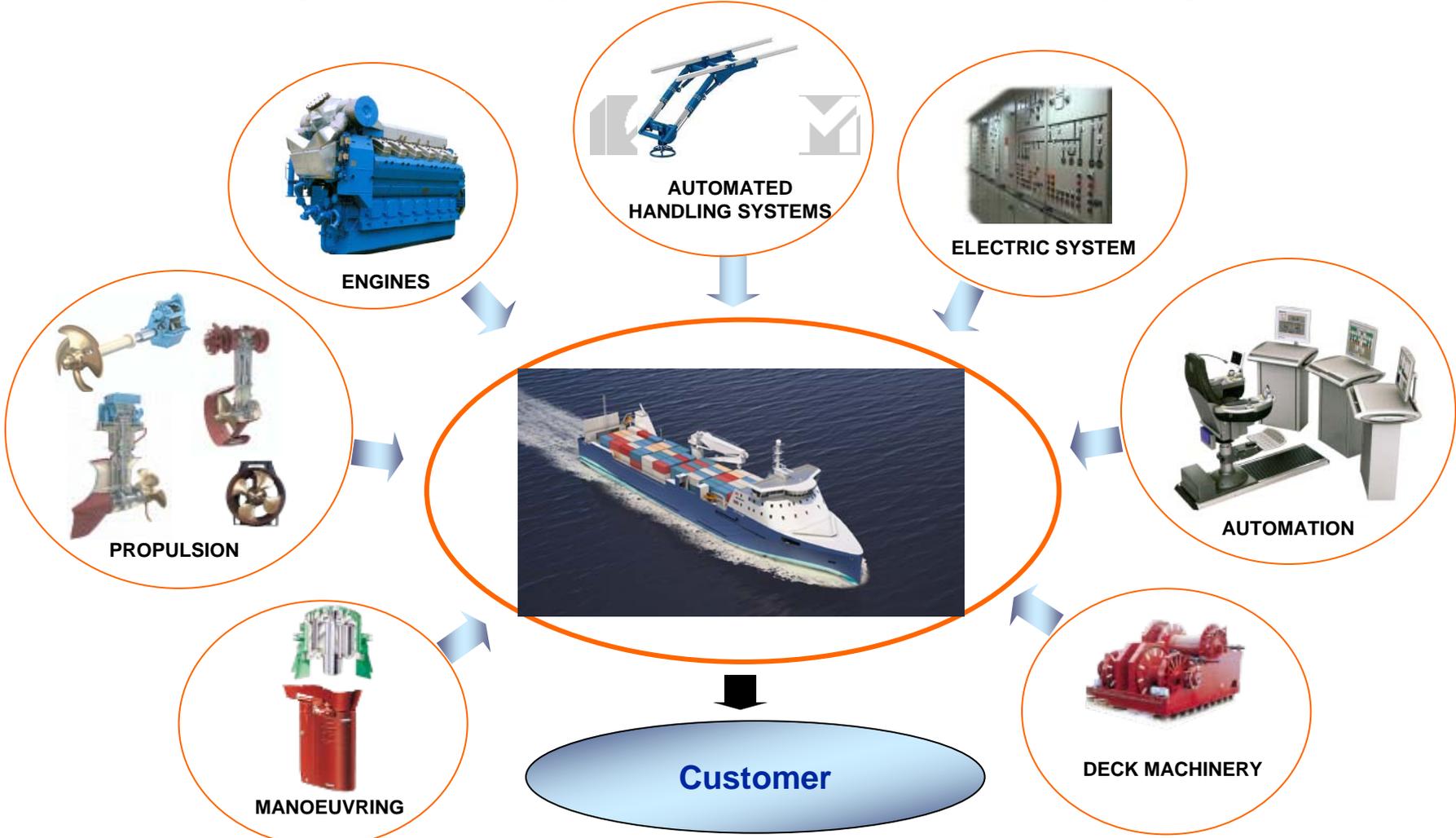


Energy

- Gas turbines

39 000 employees

Rolls-Royce design & integrated ship systems



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

Bergen Engines 2012

Core to a “green strategy” 2012 →



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Bergen Engines

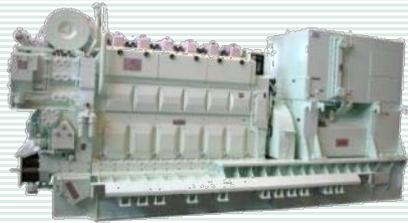
Engines & Foundry

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



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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
V type: 12-16

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
Vee type : 12-16-20

141 B gas engines sold



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Why natural gas? The Drivers !!

- Price
- Emissions



Cruise ship destination, Norway

Geiranger



Bergen - Harbour 2011



Foto: Atle Daae Andersen

**But what if the ship
emissions ruin it...?**

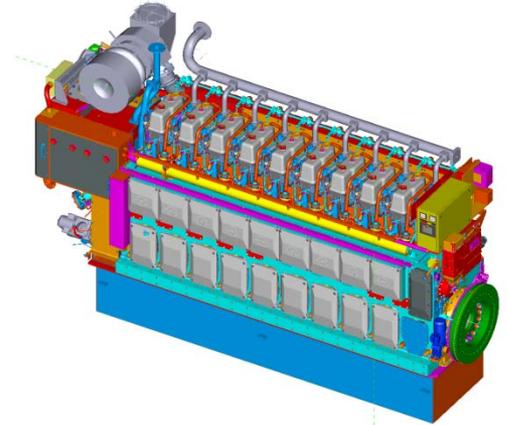


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Emissions, the technology driver:

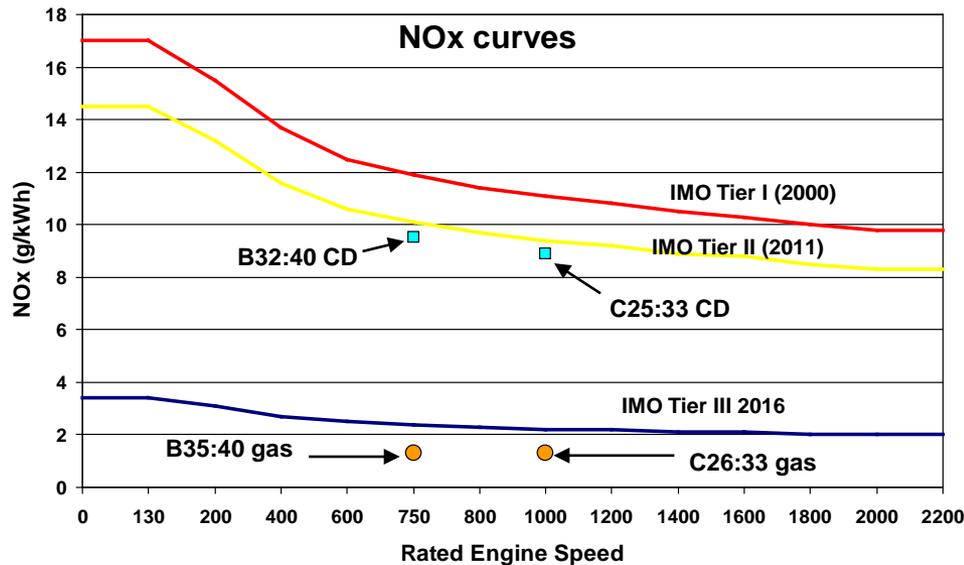
Spark Ignited lean Burn Gas Engines:

- **~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**



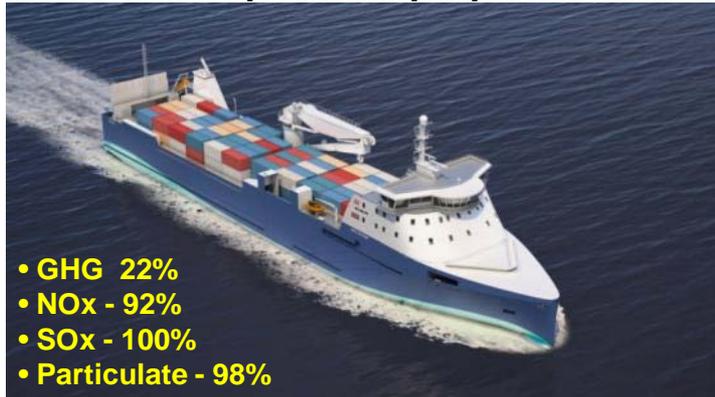
Core Technology Status

- 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.



Ways of reducing emissions

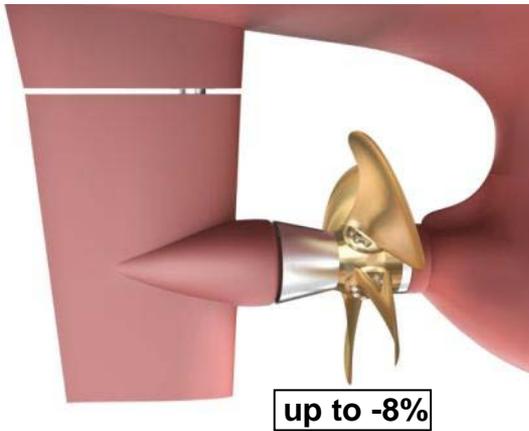
Gas powered propulsion



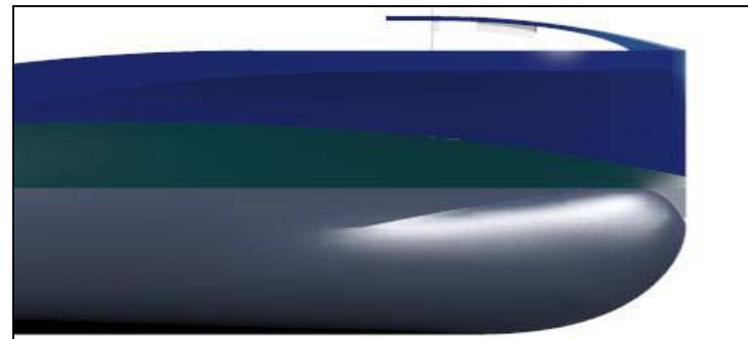
Hybrid propulsion



High efficiency propulsion and manoeuvring systems: PROMAS



Advanced hull forms



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



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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)**



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NorLines - Cargo



**40% Green House Gas reduction!!
22% from engine 18% from design and Promas**

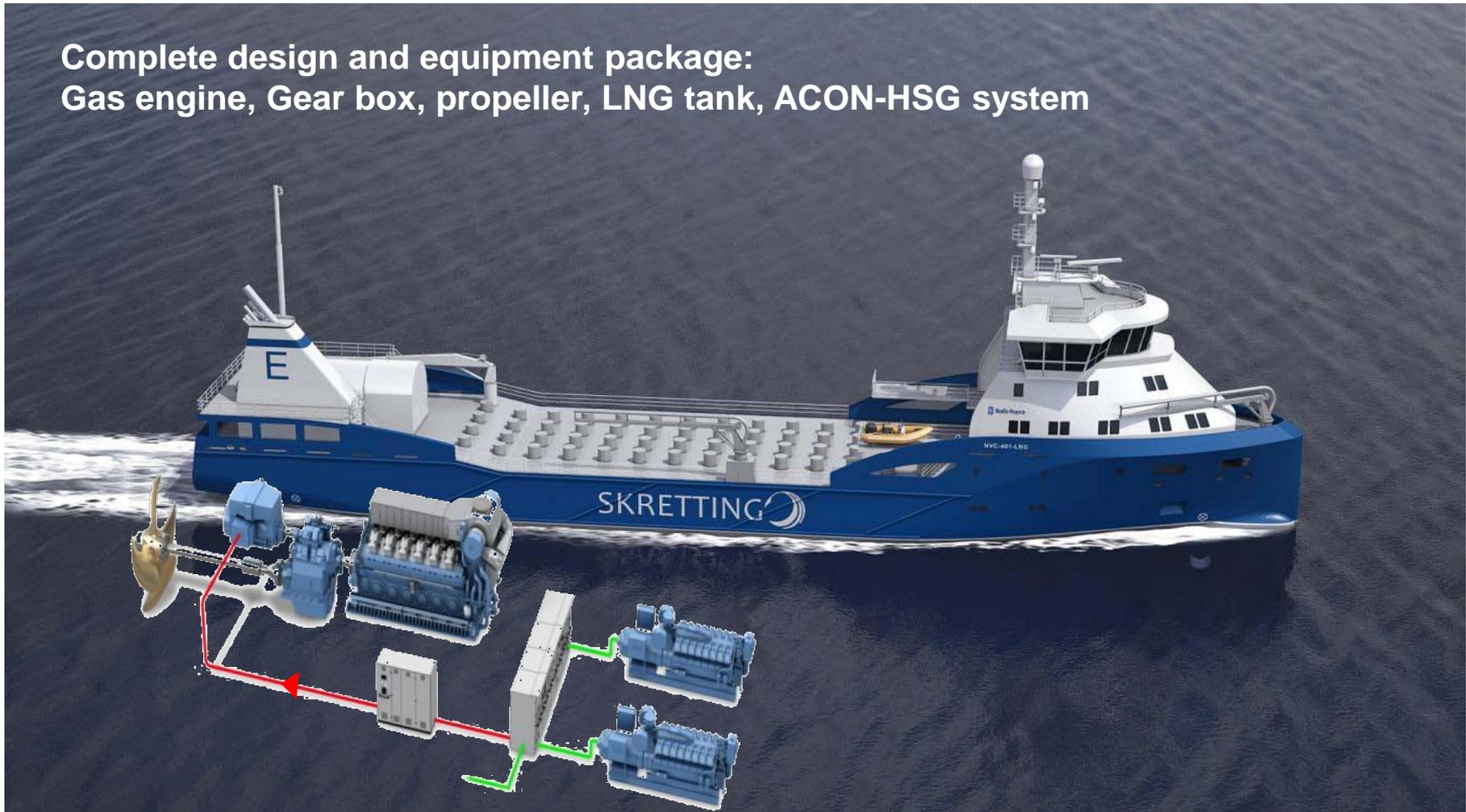
**Complete design and equipment package:
Gas engine, Gear box, propeller, LNG tank, ACON-HSG system**



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Eidsvåg shipping at STX Brattvåg

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



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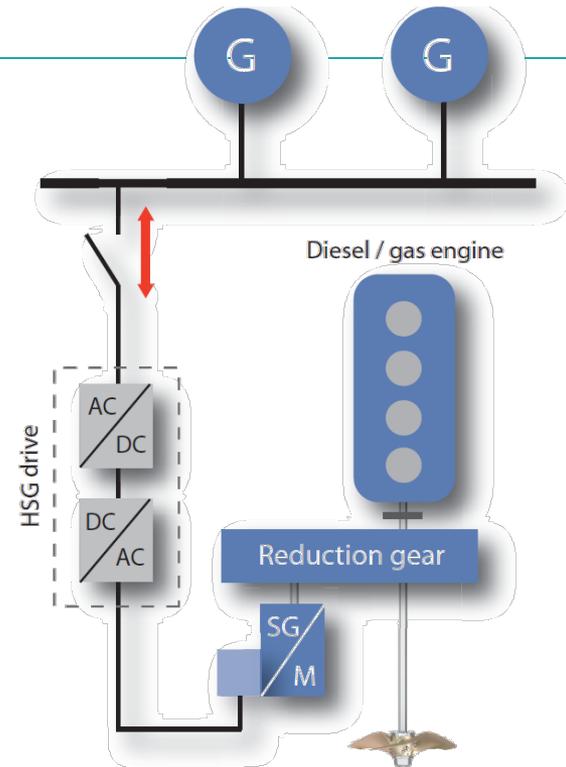
HYBRID SHAFT GENERATOR

Shaft generator to switchboard power flow control.

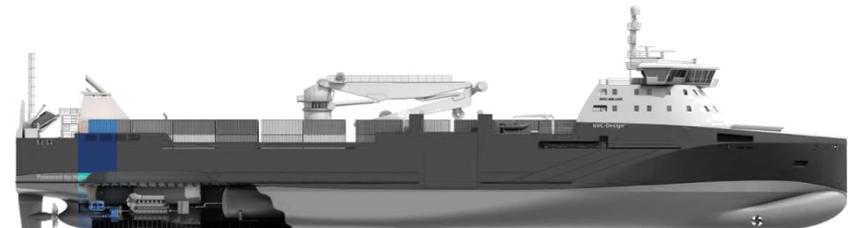
- ✓ Engine and propeller can operate at variable speeds
- ✓ Stable network frequency
- ✓ Fixed voltage

Benefits.

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



ROLLS-ROYCE HSG – HYBRID SHAFT GENERATOR

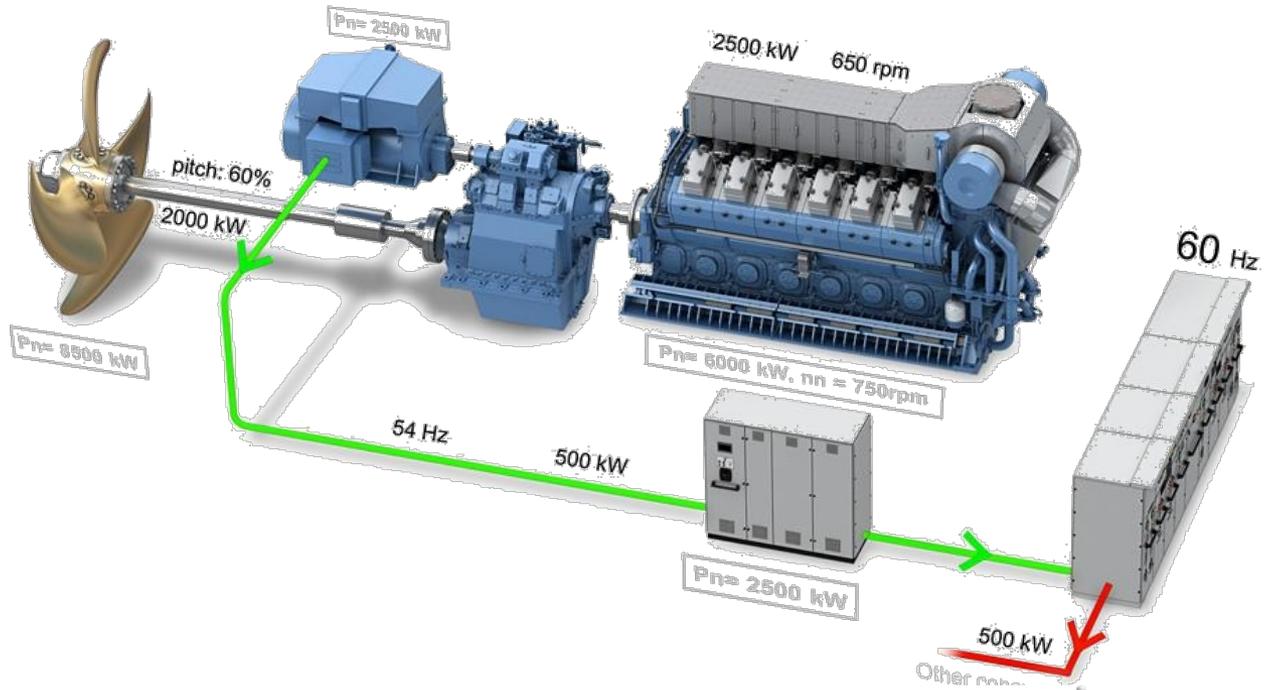


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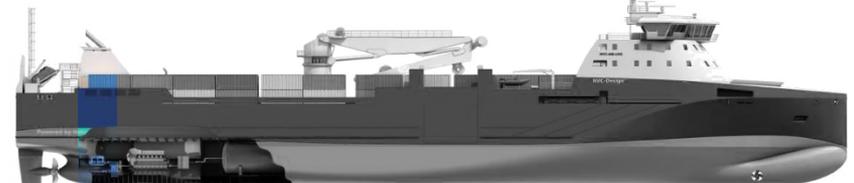
HYBRID SHAFT GENERATOR

A range of operational modes

- ✓ Boost mode
- ✓ Transit mode
- ✓ Parallel mode
- ✓ Diesel/gas electric mode



ROLLS-ROYCE HSG – HYBRID SHAFT GENERATOR

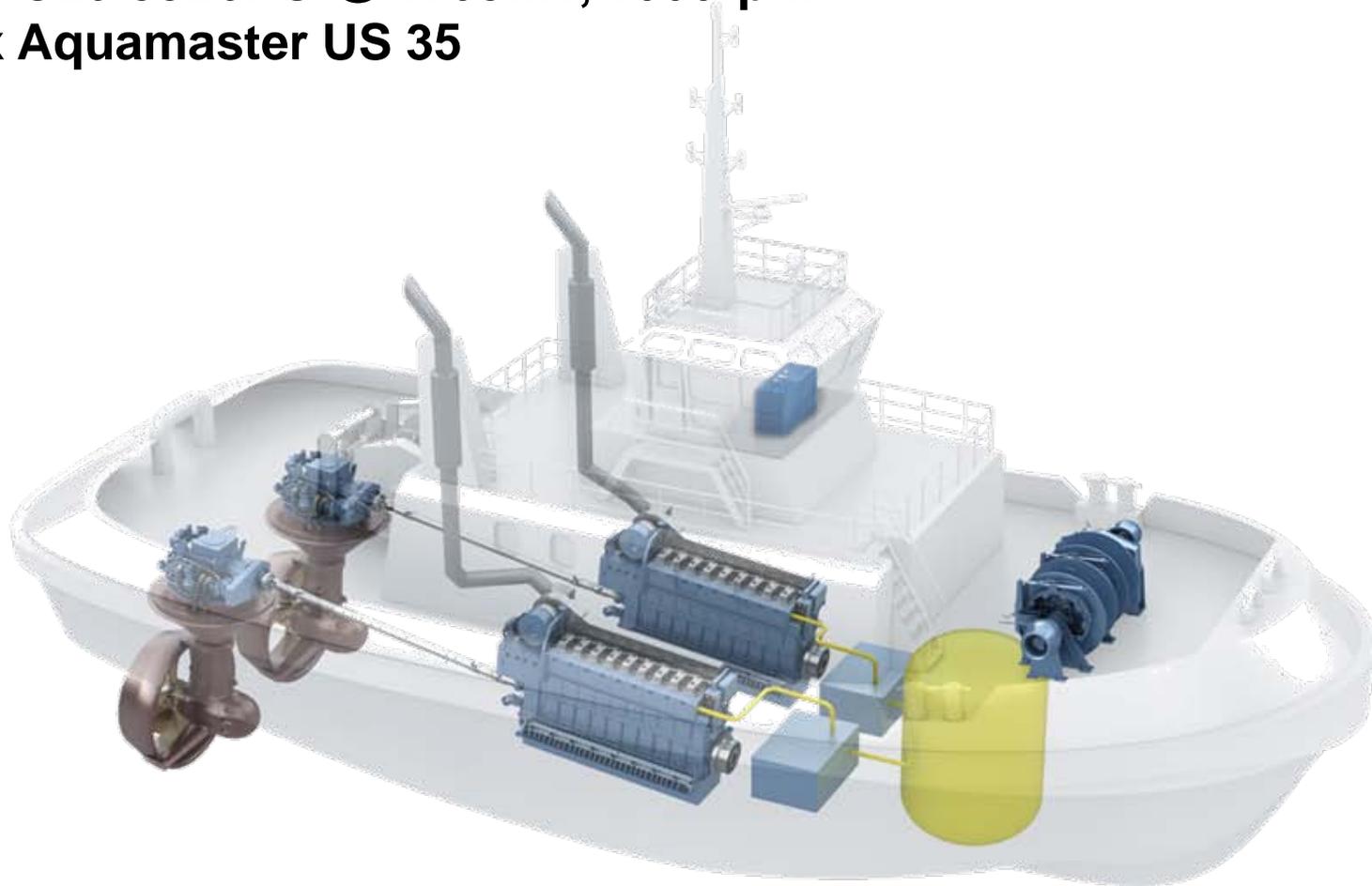


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The new Bukser & Berging tug

2 x C26:33L6PG @ 1705kW, 1000rpm

2 x Aquamaster US 35



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Bunkring Ship to Ship (STS)



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Bunkering Ship to Ship (STS)



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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”



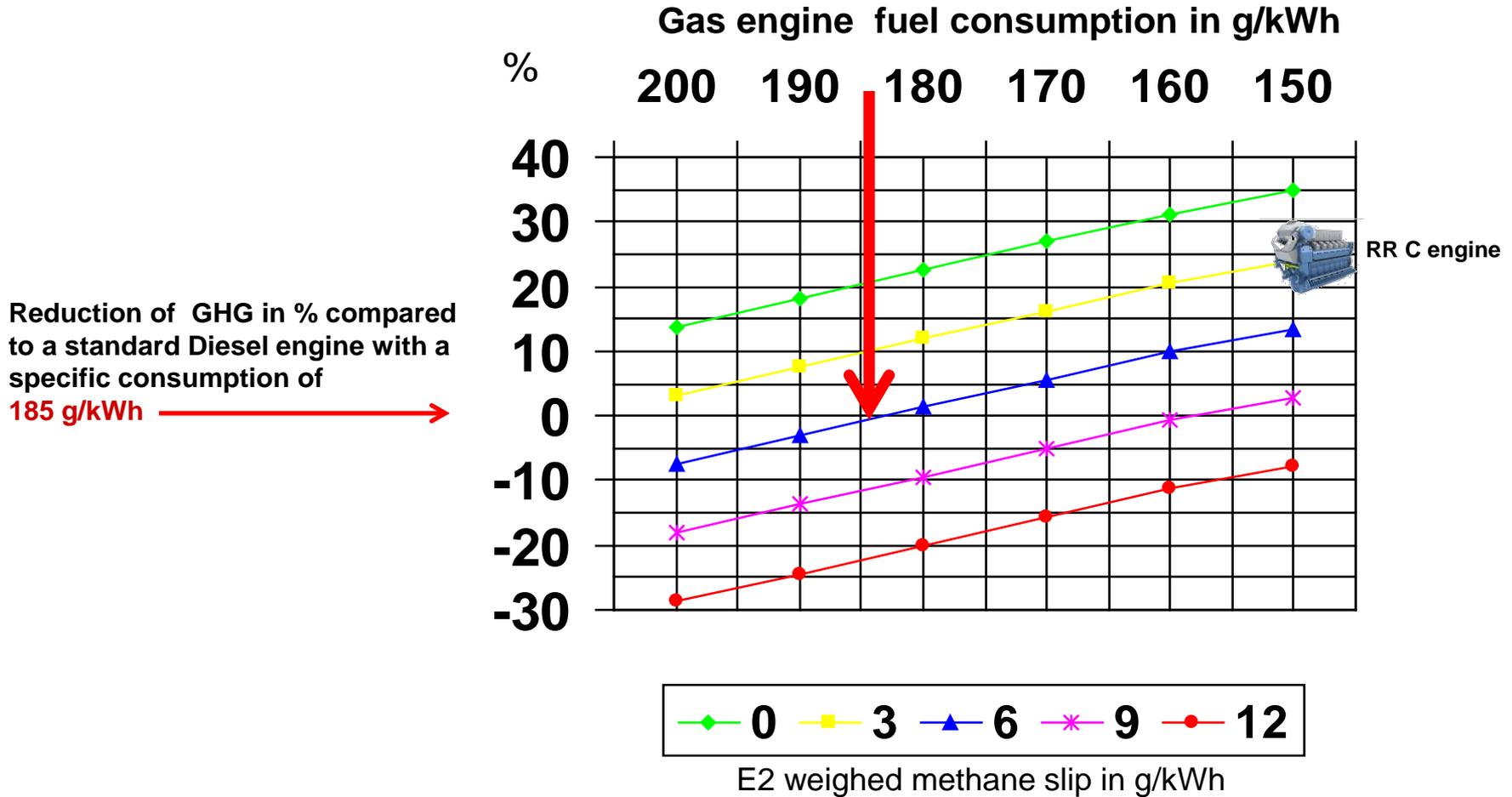
The bunkering station on board

GHG (Green House Gases) **from gas engines**

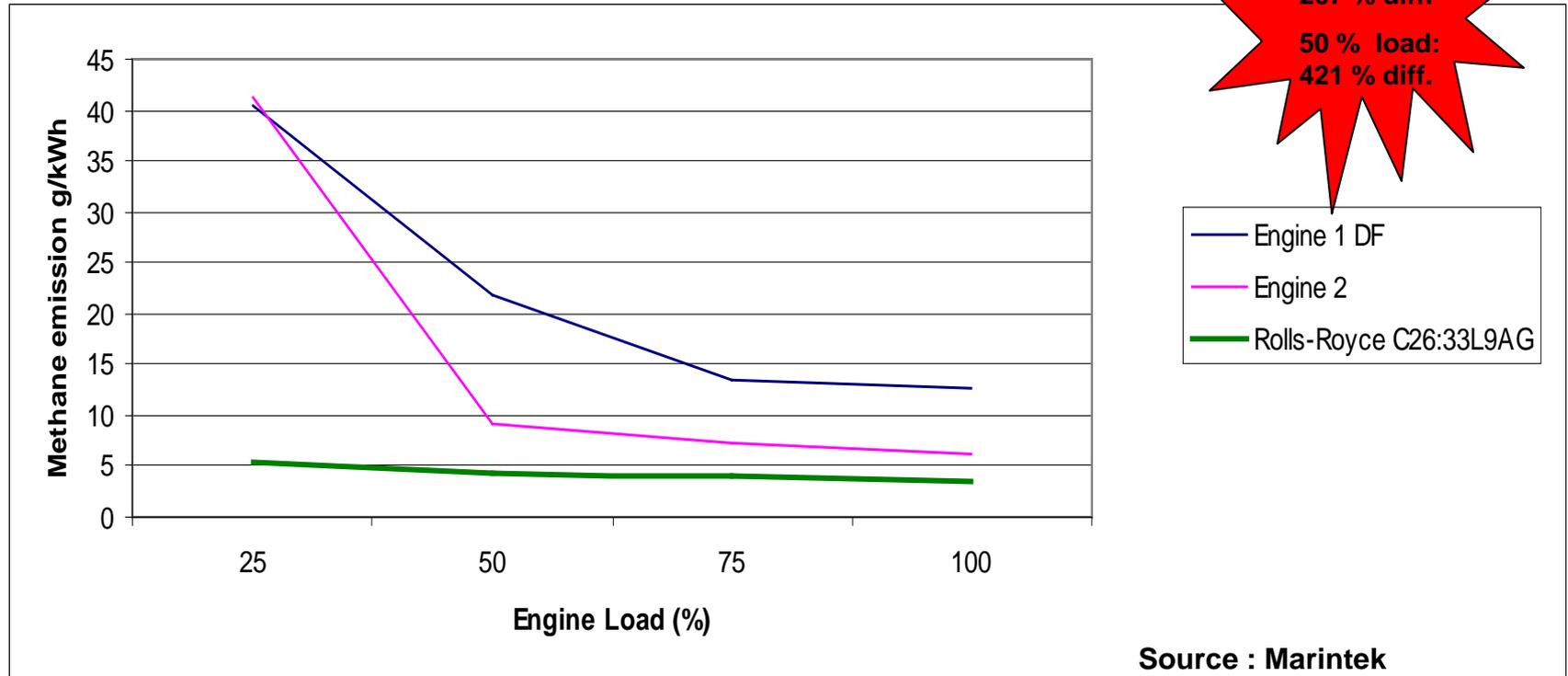
- **1t diesel emits 3,2t CO₂**
- **1t natural gas emits 2,55t CO₂**
- **The difference is 20% reduction**
- **Due to higher energy content in gas the possible Greenhouse Gas reduction is almost 30%**
- **Uncombusted Methane has a GHG effect factor 21-25 times higher than CO₂**
- **If unburned methane is released from the combustion the GHG reduction is quickly eroded**



GHG reduction vs fuelconsumption



Methane emission: Gas vs. Dual Fuel



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



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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



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Natural Gas as Fuel for Future Vessels



- 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



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Summary

- **Marine Gas engines represents 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



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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 - "Boknafjord" (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



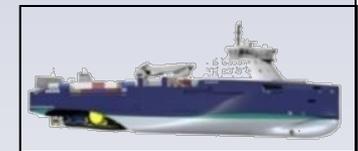
NSK Shipping (1 x C26:33L6PG) & propulsion
 RRM Eidsvåg Shipping 1 x C26:33L9PG & propulsion
 Sea Cargo "vessel 1" (1 x B35:40V12PG) hull 357 & propulsion
 Sea Cargo "vessel 2" (1 x B35:40V12PG) hull 358 & propulsion



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



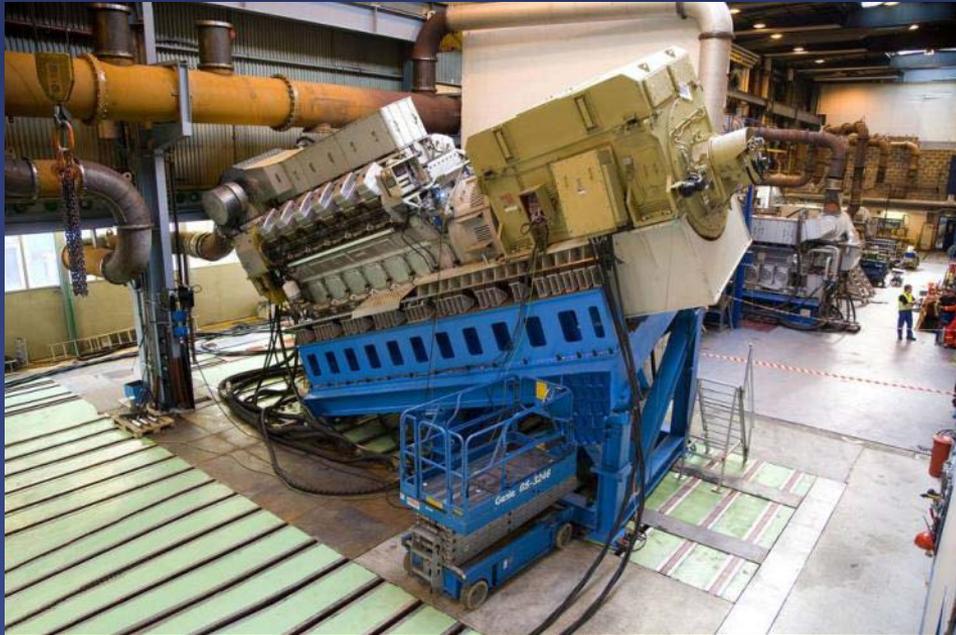
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**Clean engine
crankcase room....
25000 running hrs**



Thanks for your attention!

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



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Questions?



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