MESA

Maritime Europe Strategy Action

TTG 1 – Energy Efficiency

Workshop,

Brussels, 5 March 2014

Programme

		Who	Est. time (min.)
1	Introduction to TTG 1 in MESA	J. Marzi, HSVA	10
2	Ship Resistance	J. Marzi, HSVA	15
3	Hydrodynamic and aerodynamic Propulsion	J. Marzi, HSVA	15
4	Prime Movers	A. Teo, Rolls Royce	20
5	Auxiliary Energy – use and conversion	Ph. Corrignan, BV	20
6	On-board consumers	G. Rousseau, DCNS	15
7	Energy Management	Ph. Corrignan, BV	15
8	Assessment of energy efficiency improvement and Technology uptake in the Shipping industry	T. Smith, UCL	25
9	Summary discussion & recommendations	J. Marzi - moderation	20

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MESA – PRIME MOVERS

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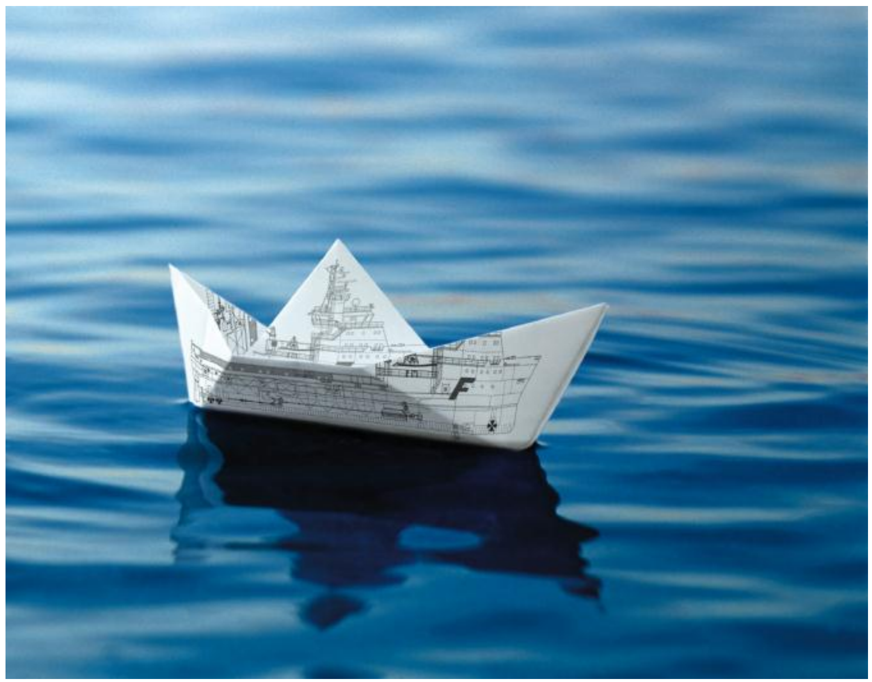
- Introduction
- Technology breakdown structure
- Info-graphics of research projects
- State-of-the-Art assessment
- Summary

Introduction

- Primary propulsion refer to methods of developing power to propel the ship
- 3 biggest marine propulsion challenges faced:
  - Rising fuel costs
  - Introduction of new environmental regulations
  - Potential introduction of carbon taxes

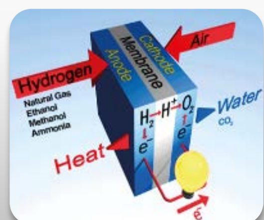
Introduction

- Strong motivation to develop *greener* (Lesser emissions) and *more fuel efficient* prime movers



Technology Breakdown

3.1 Combustion Engines



3.2 Fuel Cells

3.3 Hybrid/Full Electric Systems

Technology Breakdown

3.1 Combustion Engines	3.1.1 Improve Engine Mechanical Efficiency
	3.1.2 Improve Engine Thermal Efficiency
	3.1.3 Improve engine overall efficiency
	3.1.4 Reduce Emissions
3.2 Fuel Cells	3.2.1 Solid-Oxide Fuel Cell
	3.2.2 Proton Exchange Membrane Fuel Cell
	3.2.3 Molten Carbonate Fuel Cell
3.3 Hybrid/Full Electric Systems	3.3.1 Energy Storage
	3.3.2 Integration of hybrid drive system
	3.3.3 Renewable energy

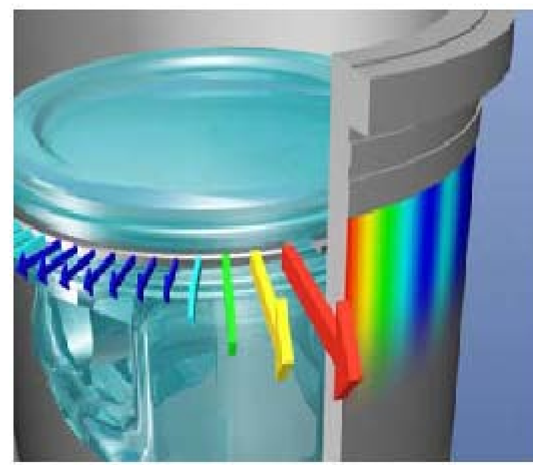
Technology Breakdown

3.1.1 Improve Engine Mechanical Efficiency	Reduce friction losses
	Overall ship powertrain optimisation
3.1.2 Improve Engine Thermal Efficiency	Improve combustion process
	Improve turbocharger efficiency
	Employ advanced engine controls
	Employ Waste Heat Recovery Systems
3.1.3 Improve Overall Efficiency	Employ different engine arrangements
	Optimise overall power & propulsion
3.1.4 Reduce Emissions	Primary methods
	Secondary methods
	Alternate fuel/Dual fuel
	De-rating the engine

3.1.1 Improve engine mechanical efficiency

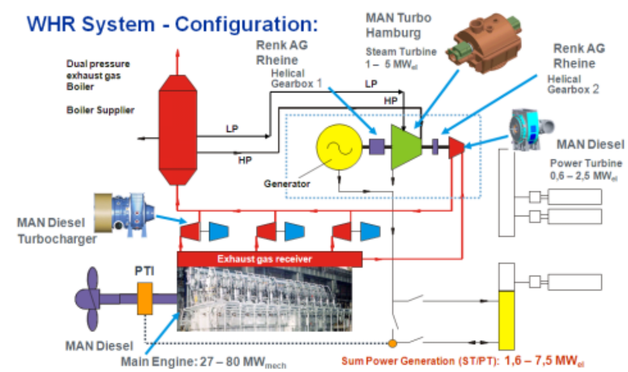
- Dominating causes for frictional losses are the piston ring package and guide shoe bearing
- Reduce these losses to get more from fuel burn and improve lifetime of parts/components
- HERCULES C WP.10 objectives:
  - Lower frictional losses in main bearings of 2-stroke by 10-15%
  - Reduce piston ring wear by 10%, piston ring-cylinder liner by 10% for 2-stroke, 20% for 4-stroke.

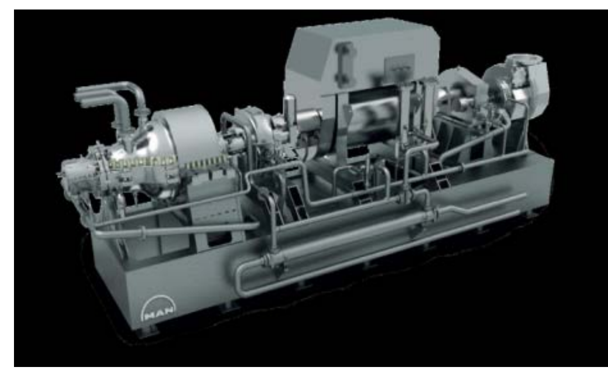
Pressure Distribution in Piston Ring Package (Source: Federal Mogul)



3.1.2 Improve engine thermal efficiency

- Get more power output from thermal energy generated in the fuel combustion process.
- Waste Heat Recovery System
  - Uses heat lost in exhaust gases to produce electricity
  - Reduces fuel consumption of auxiliary engines
  - Recovers up to 12% of lost main engine power. ***(MARC_HRS WHR System for 2-stroke engines of output 25MW)***





MARC_HRS_WHR System by MAN Diesel & Turbo

source: 'Waste Heat Recovery - Marine Systems' MAN Diesel & Turbo

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3.1.2 Improve engine thermal efficiency

- Improve combustion process by increasing charge air pressure and reducing its temperature
- 2-Stage Turbocharging with Extreme Miller Timing
  - Early closure of inlet valves for charge air to expand in cylinders resulting in lower temperature.
  - More optimum division between compression & expansion strokes
  - Achievements: (***Claimed by ABB Turbo Systems***)
    - NOx emissions reduction down to 40%
    - Engine efficiency increase in excess of 2%

Miller Timing (Valve Timing)

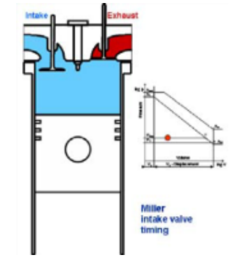
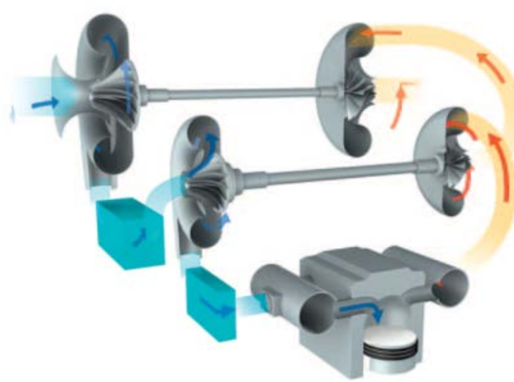


ABB Power2 two stage turbocharging system with intercooler



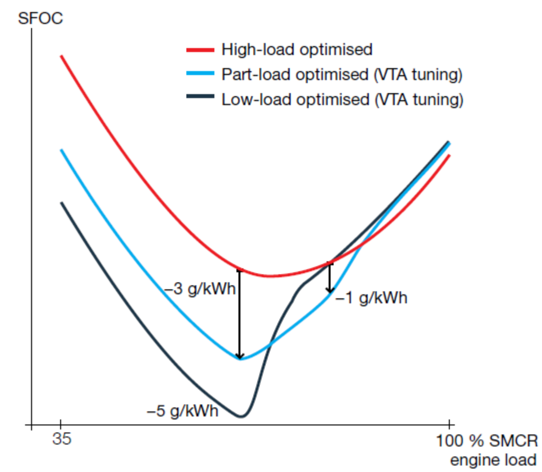
Source: 'Engine performance enhancements by 2-stage turbocharging and variable valve timing', Boris Willneff;

3.1.2 Improve engine thermal efficiency

- Maintaining high efficiency during different operation modes
- Turbochargers with Variable Turbine Area/Geometry
  - Air intake adjusted to changing operating conditions
  - Maintain optimum boost pressure & air-fuel ratio
  - Reduces fuel consumption by up to 2.5% at part-load (MAN B&W)

Variable Turbine Geometry for an ABB TPS Turbocharger

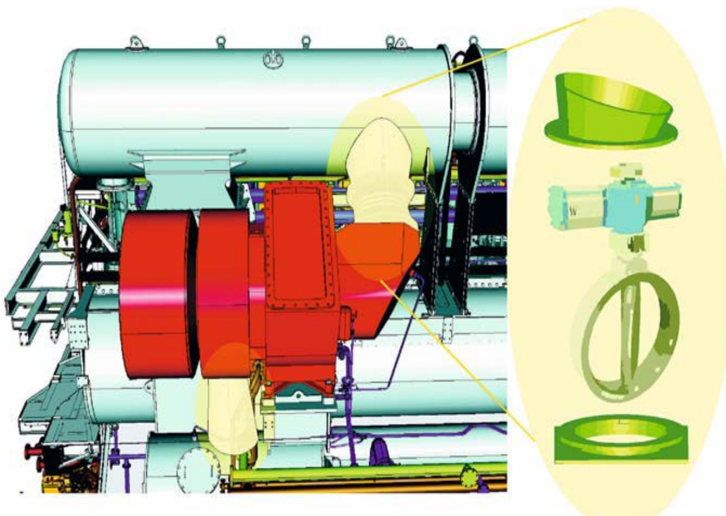
Fuel savings for MAN B&W slow speed engines ME/ME-C engines



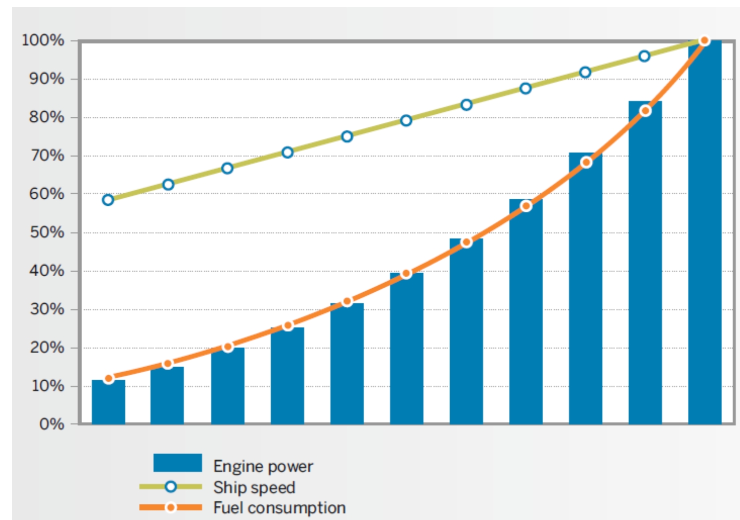
Source: 'Exhaust Gas Turbocharging 2012', MAN B&W; 'Variable Turbine Geometry VTG' Brochure, ABB Turbo

3.1.2 Improve overall efficiency

- Optimise overall prime-mover efficiency by different engine configurations/cylinder numbers per engine
- Running ship at slower speed to reduce fuel consumption and achieve overall savings of 10-25% (Slow steaming operation)



The Wartsila Slow Steaming Upgrade Kit

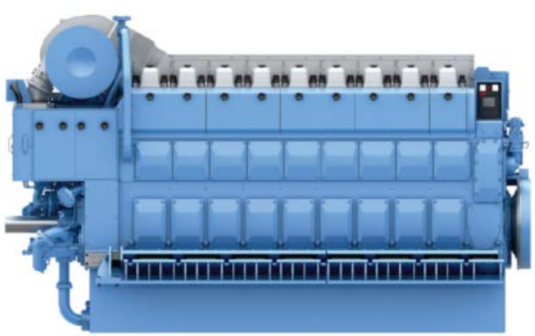


Correlation between ship speed, required engine power and fuel consumption (Slow steaming)

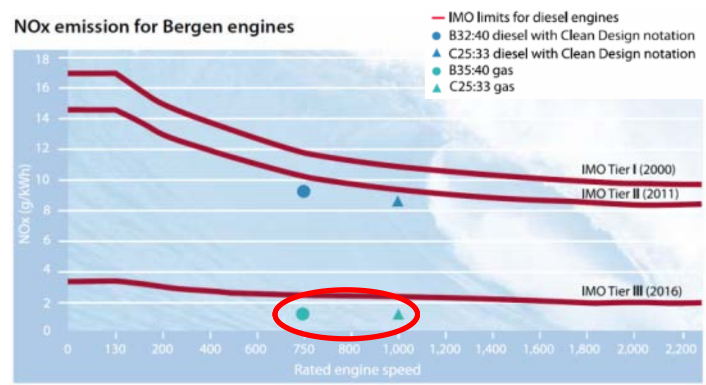
Source: 'Wartsila Technical Journal 02 2010'

3.1.4 Reduce emissions (Pre-treatment)

- Must meet IMO Tier II and soon Tier III enforcement on emissions limit.
- Use alternative fuel (LNG) that has very low content of pollutants – one of the most promising!
- Achieved reduction of: ***(Rolls-Royce Bergen gas engines)***
    - NOx emissions of 92%
    - SOx and particulate emissions virtually eliminated
    - CO2 emissions close to 23%



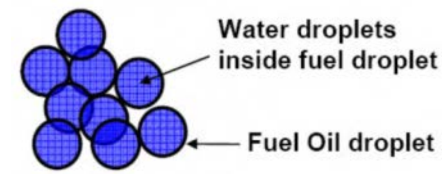
Bergen C26:33L9PG medium speed Gas Engine (2400kW)



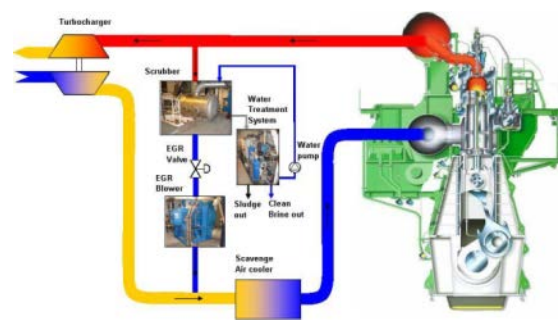
Source: http://www.rolls-royce.com/marine

3.1.4 Reduce emissions (Internal measures)

- Fuel-Water-Emulsion
  - Mixing fresh water with fuel on board to cool combustion in cylinder
  - Reduces NOx emissions by 15 - 20% achieved claims Wärtsilä (Wetpac E-system)
- Exhaust Gas Recirculation
  - Cool and clean some exhaust gas before returning to scavenge air side
  - Reduce oxygen concentration in combustion by introducing water and CO_2
  - NOx reduction of 70% achieved ***(MAN Diesel 4T50ME-X research engine)***



Wärtsilä Wetpac E-system



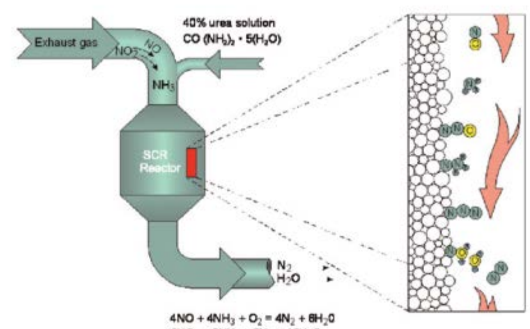
MAN Diesel EGR Schematic for 2-stroke DE

source: http://www.mandieselturbo-greentechnology.com/; Wärtsilä Low NOx Solutions

3.1.4 Reduce emissions (After treatment)

- Exhaust Gas Scrubber (Wet & Dry)
  - Wet scrubber: drenches exhaust gas with sea water
  - Achieved ***(MAN Diesel)***
    - SOx reduction of up to 95%
    - PM trapping of 73%
- Selective Catalytic Reduction (SCR)
  - Treats exhaust gas with ammonia/urea and feed through catalytic converter
  - Achieved NOx emissions reduction by 85-95% (Wärtsilä); up to 80% (MAN Diesel)

EGR scrubber applied on a MAN 4T50ME-X research engine



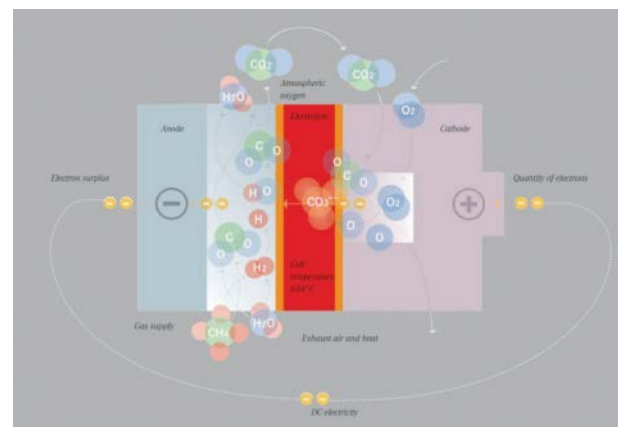
SCR process (source: 'Exhaust Gas Emission Control Today', MAN Diesel)

source: http://www.mandieselturbo-greentechnology.com/; Wärtsilä Low NOx Solutions; 'Exhaust Gas Emission Control Today' by MAN Diesel

3.2 Fuel Cells

- Convert chemical energy of fuel to electric power through electrochemical reactions (Clean power)
- Main technologies: SOFC, PEM & MCFC
- Research in different fuels (Methanol & LNG) or on-board reforming from MDO for hydrogen supply to fuel cells.

The hybrid propulsion ship mv Viking Lady (with 330 kW MCFC – FellowSHIP)

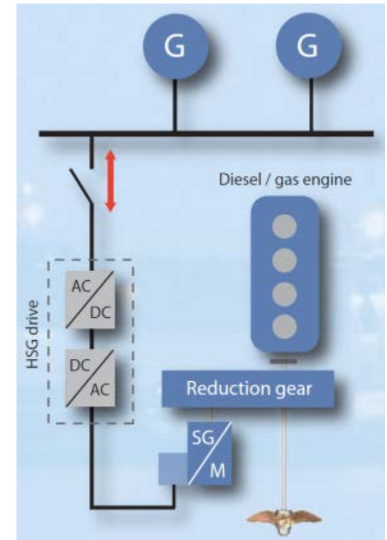


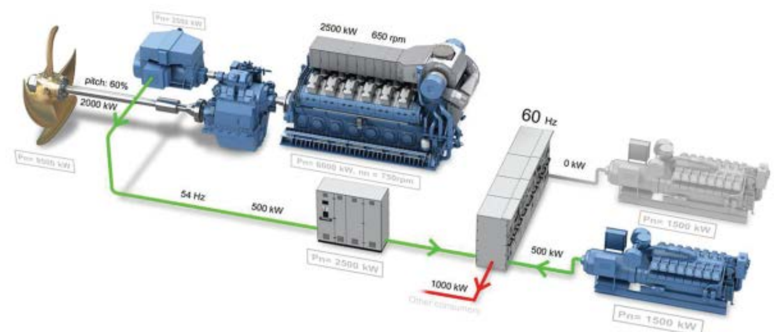
Chemical processes inside a Molten-Carbonate Fuel Cell

source: 'Fuel cells for ships' by DNV; MTU Onsite Energy

3.3 Hybrid/Full Electric

- Hybrid propulsion plant:
  - Main propellers driven by engines through reduction gear
  - Engines configured to drive a powerful shaft generator too
  - Shaft generator can be used as electric motor
  - 5% fuel saving achieved ***(Rolls-Royce)***

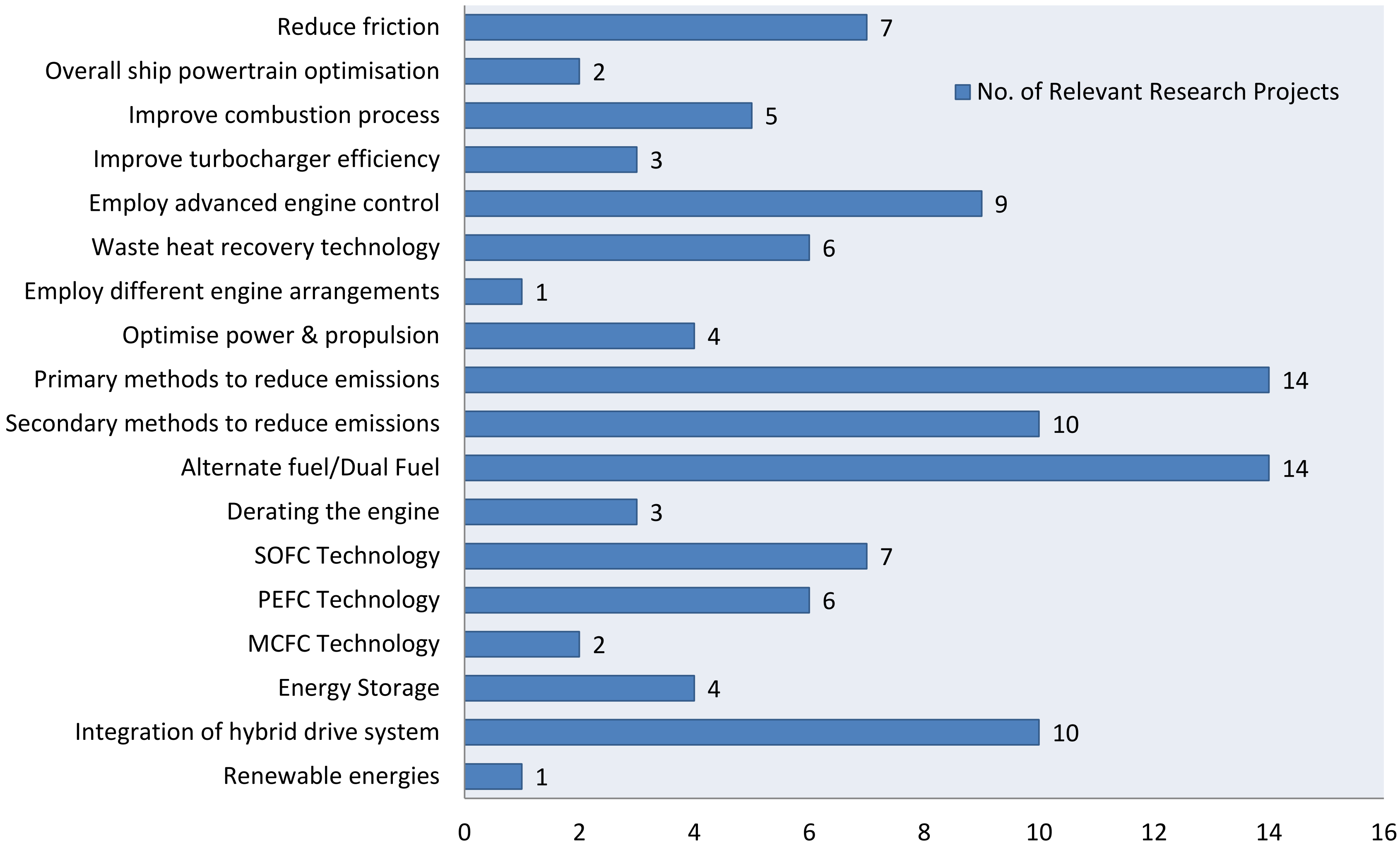




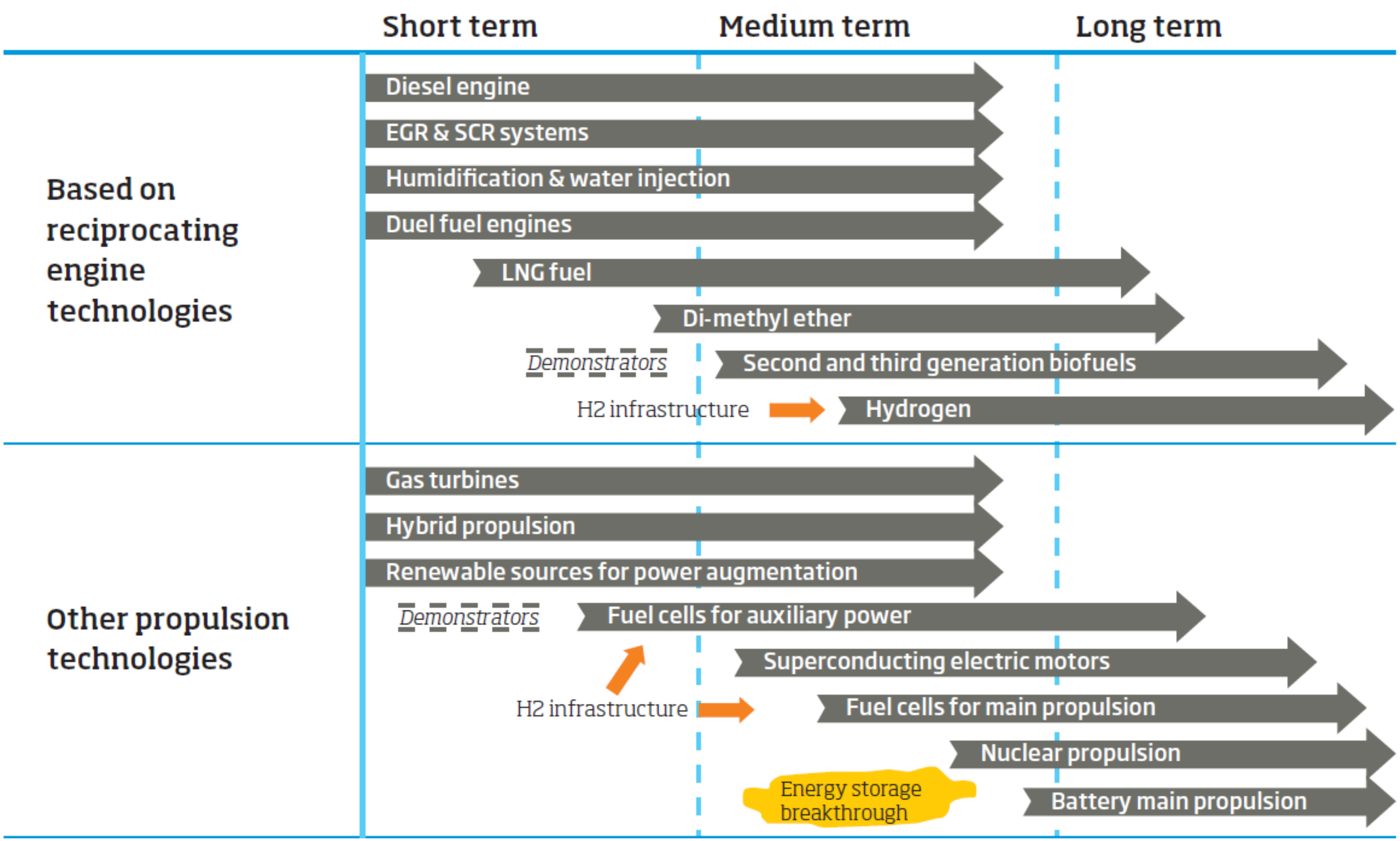
Rolls-Royce Hybrid Shaft Generator System

Source: 'Hybrid shaft generator propulsion system upgrade', Rolls-Royce

Info-graphics of Research Projects



Info-graphics of Research Projects



Source: Future Ship Powering Options – Royal Academy of Engineering

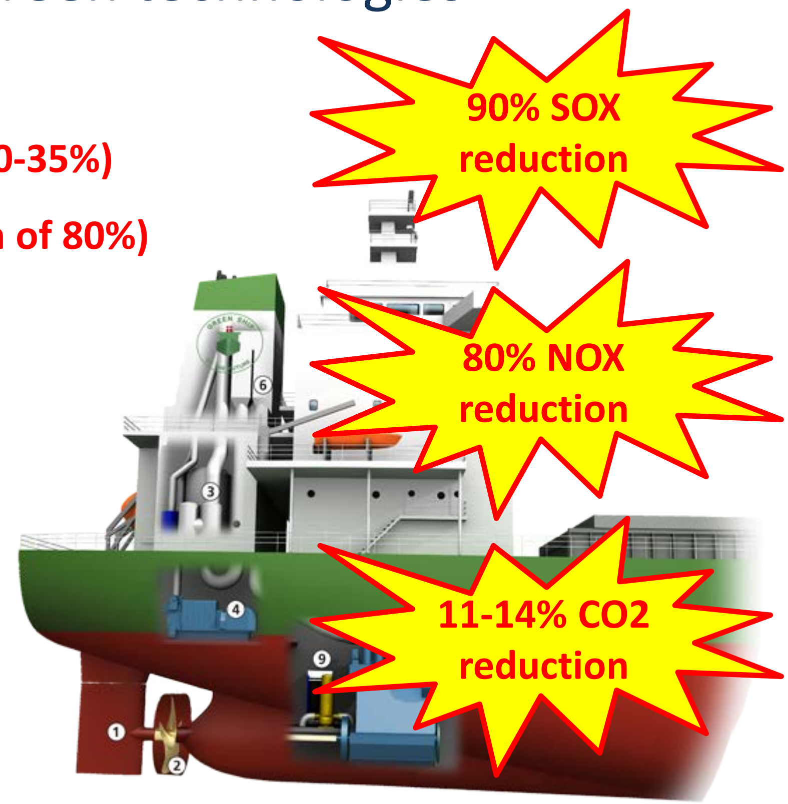
State of the Art Assessment

- Green Ship of the Future, a Joint Industry project for innovation and demonstration of green technologies
- 8,500 TEU container vessel study
  - Water in fuel system **(NOX reduction of 30-35%)**
  - Exhaust gas recirculation **(NOX reduction of 80%)**
  - Waste heat recovery system

    (SFOC reduction of 7-14%)
  - Power and Steam turbine technology

    (Power recovery of 13%)
  - Exhaust gas scrubbers

    (SOX reduction of 98%, PM by 80%)



Source: 8500 TEU Container Ship Green Ship of the Future Concept study.

Summary

- Description of technology structure breakdown
- Overview of current state of the art for prime-mover technology
- Info-graphics for collection of prime-mover technology research projects
- Analysis of technology showcase by ‘Green Ship of the Future’
- More information in supporting slides for more detailed structure breakdown and relevant past & on-going projects

THANK YOU FOR LISTENING