# The Road to Net Zero:
# Internal combustion engines for a sustainable future.


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Director, Marine APAC

Rolls-Royce Solutions Asia




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# Rolls-Royce group

A world-class technology company, built on three strong and complimentary business units.

Power Systems is the group's 2nd largest business and frontrunner in electrification.

## Civil Aerospace

35
types of commercial aircraft powered by us

16,400
engines in service around the world

17,900
total employees

## Defence

160
customers in over 100 countries

16,000
engines in service around the world

11,100
total employees

## Power Systems

>40,000
customers in 13 different industries

20,000
reciprocating engines sold per year

≈ 9,000
total employees

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# Power Systems
## At a glance

Rolls-Royce Power Systems provides world-class power solutions and complete life-cycle support under the product and solution brand *mtu* and serves 13 different customer industries around the world.

**1** Governmental

**3** Marine & PowerGen

**4** Industrial

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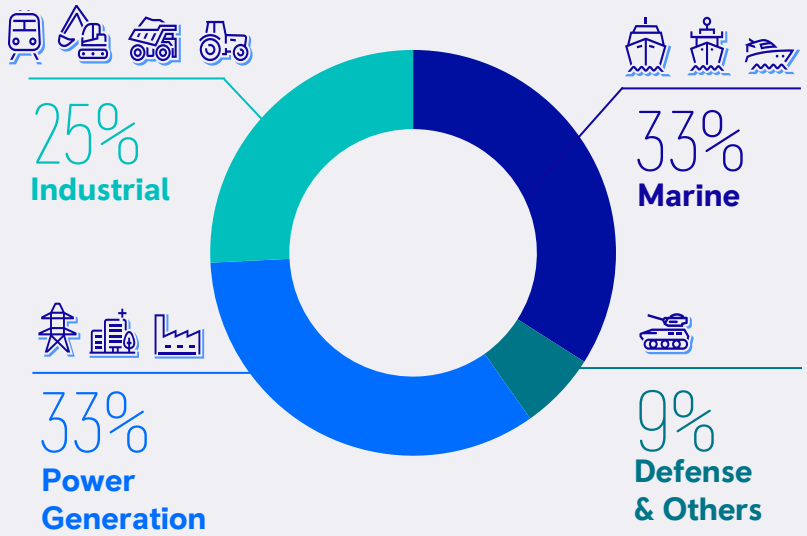
**Revenue 2021**

€ 3,199m

**Employees**

9,452













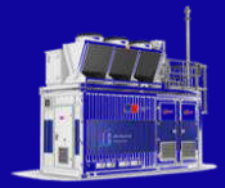


# OUR DECARBONIZATION PLAN

## 2023
The most important engine series are ready for sustainable fuels

## 2030
Complete product portfolio lowers greenhous gas emissions by 35% to 2019

## 2021
**Net Zero program:**
Rolls-Royce sets targets for itself on climate neutrality



## 2025
Power supply with carbon neutral fuel cell systems

## 2050
Rolls-Royce Group will be completely climate neutral.

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# Strategy Power Systems 2030
## Transformation from engine manufacturer to sustainable solutions provider

1

### Strengthening the core business

Strengthening our traditional systems & engines portfolio

2

### Solutions provider

Expansion of the existing portfolio with new components, digital products and services

3

### Lifecycle services

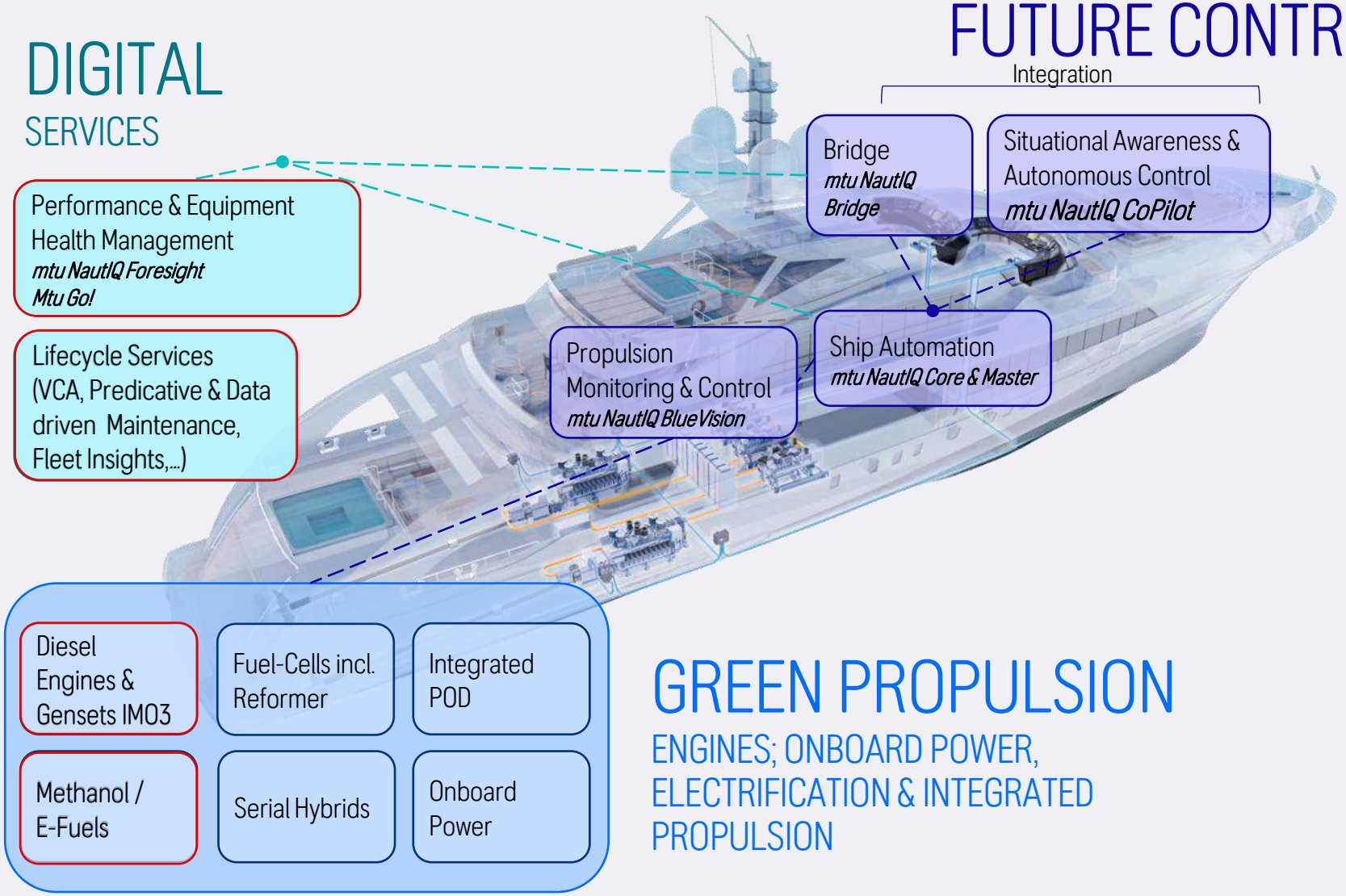
Transformation of our business model to utilize the entire product life cycle

# Providing intelligent lifecycle services & setting the benchmark in fuel flexible green power solutions.

## Bridge to propeller strategy:

## Commercial Marine & Yacht

**Our "Bridge to Propeller" offering enables clear customer benefits by connecting propulsion, automation and services.**

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# *mtu* Series 4000 M03 (unrestricted continuous)

Series 4000 M63

Series 4000 M65

**Next Generation**

| | Series 4000 M03 | Series 4000 M05 | |
|---|---|---|---|
| **Emission compliance** | IMO Tier II | IMO Tier II | |
| **PM mass flow, calc (g/kWh), at FSP** | 0.08 | 0.031 | ↓ - 60 % |
| **Max power per cylinder** | 140 kW | 160 kW | ↑ + 14 % |
| **Cylinder versions** | 8V / 12V / 16V | 12V / 16V / 20V | |
| **Power range (kW)** | 746 – 2240 | 1380 – 3200 | ↑ + 40 % |
| **Bore / stroke (mm)** | 170 / 210 | 170 / 210 | |
| **Displacement per cylinder (l)** | 4.77 | 4.77 | |
| **Max power per volume (kW/l)** | 29.4 | 33.8 | ↑ + 15 % |
| **Fuel consumption** | 209 g/kWh | 201 g/kWh | ↓ - 4 % |

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# Alternative fuel options to Diesel

| Fuel Options | Syn. Diesel | e-CH4 | el. Power | Ammonia | Hydrogen | | Methanol |
|---|---|---|---|---|---|---|---|
| **Energy Conv.** | Diesel Engine | Gas-Engine | Pure-E Battery | Ammonia Engine | $H_2$-Engine or Fuel Cell | | MeOH-Engine or Fuel Cell |
| Energy Price Factor compared to Diesel | 2x – 3x *Liquid* | 1.8x - 2.5x *Liquified @-162 °C* | 0.4x - 3.5x | 1,8x – 2,25x *Liquid @-33°C* | 1,7x – 2x *Liquified @-253 °C* | 1,3x – 1,5x *Compressed @350 bar* | 1,8x – 2,6x *Liquid* |
| **Volume / Weight** Factor incl. Tank | 1x / 1x | 4x / 2x | 17x / 45x | 3x / 3x | 3x / 2x | 13x / 7x | 2,2x / 2,2x |
| **Impact on Application** | Volume & space challenges for exhaust gas aftertreatment. Fuel production on large scale difficult. | Ideal for non space critical designs, & known routes with access to infrastructure. Fuel with much experience | Ideal for very short distances with/or low energy demand, near to shore, predictable schedule, non weight or space critical design | High toxicity of fuel, unlikely to be approved for typical RRS applications | Short & medium routes, non space critical design, close to H2 specific infrastructure | | Excellent compatibility with ICEs. Liquid and clean fuel, good for ship design. FC for Hotel Load as option |
| **Pro´s** | Highest Energy Density. No modi-fication of engine | Medium costs & energy density | Highest energy efficiency<br>No local emissions | Zero carbon solution<br>Medium costs & energy density | Zero carbon solution<br>Low possible production costs | | Medium costs & energy density, grey MeOH available (commodity) |
| **Con´s** | High production cost and only foreseen for Mobile applications | can be substituted by H2 or methanol (marine) | Highest system volume & weight | still in discussion due to safety | High system volume & weight<br>Logistics & Infrastr. | | Infrastructure of green & blue Methanol needs to be developed |

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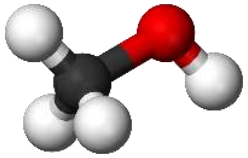
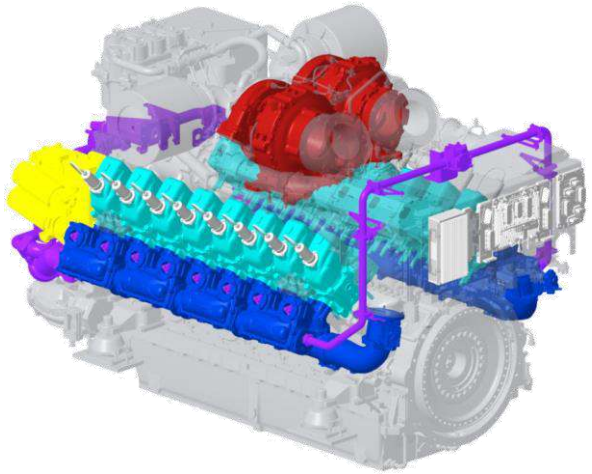
# Methanol Conclusion



Arguments for methanol as the best alternative to fossil diesel in shipping.



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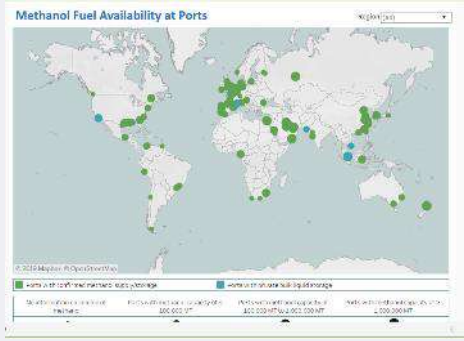
**Liquid**
(-98°C...65°C)
biodegradable and safe to handle

**Production**
conventionally produced and traded worldwide on large scale (>100mio t p.a.), green methanol production increases already

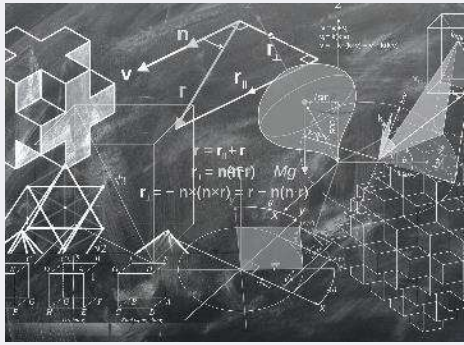



**Available**
methanol is one of the most traded commodities and a key product for the chemical industry


**Proven**
already in use at medium speed engines and known by classification societies

**Net Zero Ready**
green methanol can be produced based on green Hydrogen

**Balanced**
best alternative in volume and energy density compared to other GHG friendly fuels



**Flexible**
methanol can be combined with fuel cells (reformer) for power supply on board

**Attractive**
OPEX of green methanol will be comparable with other GHG-friendly fuels and less than e-diesel

# LCC optimization S4000M03 & M05

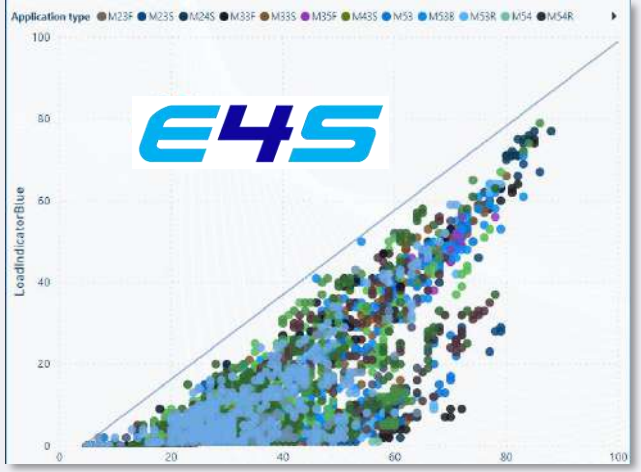
Significant reduction of lifecycle costs achieved due to increased TBOs and completely new developed maintenance schedules with optimized maintenance tasks.

New TBO calculation model resulted in a doubling of TBOs in some cases - up to

**96k hrs** for M55R

**72k hrs** for M65

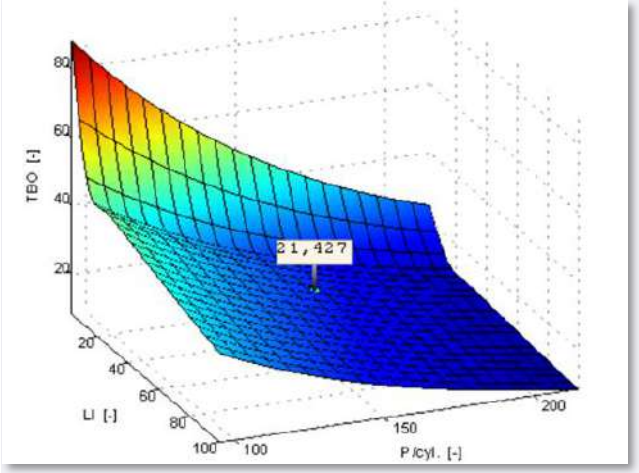
**54k hrs** for M65L




Extensive analysis of field data led to

**6 new load bands**

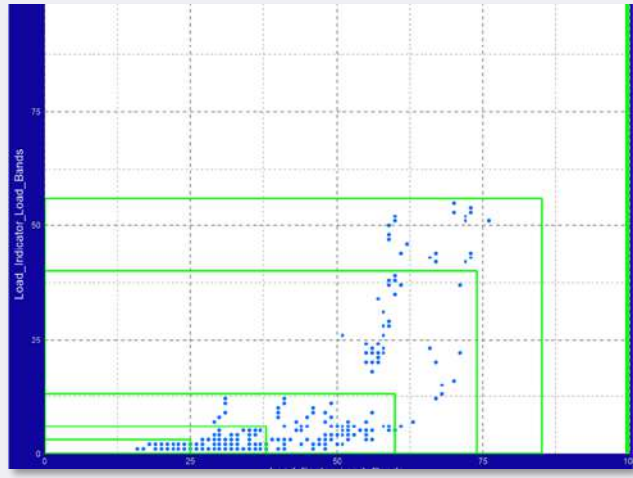
that perfectly match reality




**LCC reduction** achieved by more then

**- 40%**

depending on engine type, load profile and boundary conditions




Engine lifetime extended by 40% to

**25 years**

**Reduced lifecycle maintenance cost** (per operating hour)

**Reduce vessel downtime**

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## Scheduled maintenance

Scheduled maintenance strategy contains the manufacturer's maintenance specifications according to the agreed load profile.

## Predictive maintenance

Predictive maintenance strategy performs analysis with real-time and long-term data as well as data of an ideal system condition and reports anomalies to the crew.

## Corrective maintenance

In the event of an alarm, corrective maintenance strategy supports the crew with fault tree analysis, videos and related documentation.

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# Thank You For Your Attention.


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