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**“Controlling emissions in
a combustion engine”**

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Ship Power - Product Groups

2-stroke



4-stroke



Propulsion



Solution



Exhaust compounds and their environmental impact

NO_x:

- acid rain, acidification
- ozone/smog formation in the lower atmosphere
- damage on vegetation and human health

CO:

- detrimental to health

Total Hydrocarbons/VOC:

- ozone/smog formation in the lower atmosphere
- some considered
- contribute to the greenhouse effect

Particulates/PM:

- detrimental to health in lungs

CO₂:

- contribute to the greenhouse effect

Sulphur:

- acid rain, acidification
- affects components erosion and corrosion

Fuel effects emissions by :

- Chemical additives
- Catalytic residuals
- Sulphur content
- Liquid or gaseous



Methods for reduced emissions

NO_x:

- Engine modifications
- Water treatment (WetPac)
- After treatment (SCR)

CO:

- Oxidation catalysts

Total Hydrocarbons/VOC:

- Improved combustion
- Oxidation catalysts

Particulates/PM:

- Fuel composition
- Related to sulphur content

CO₂:

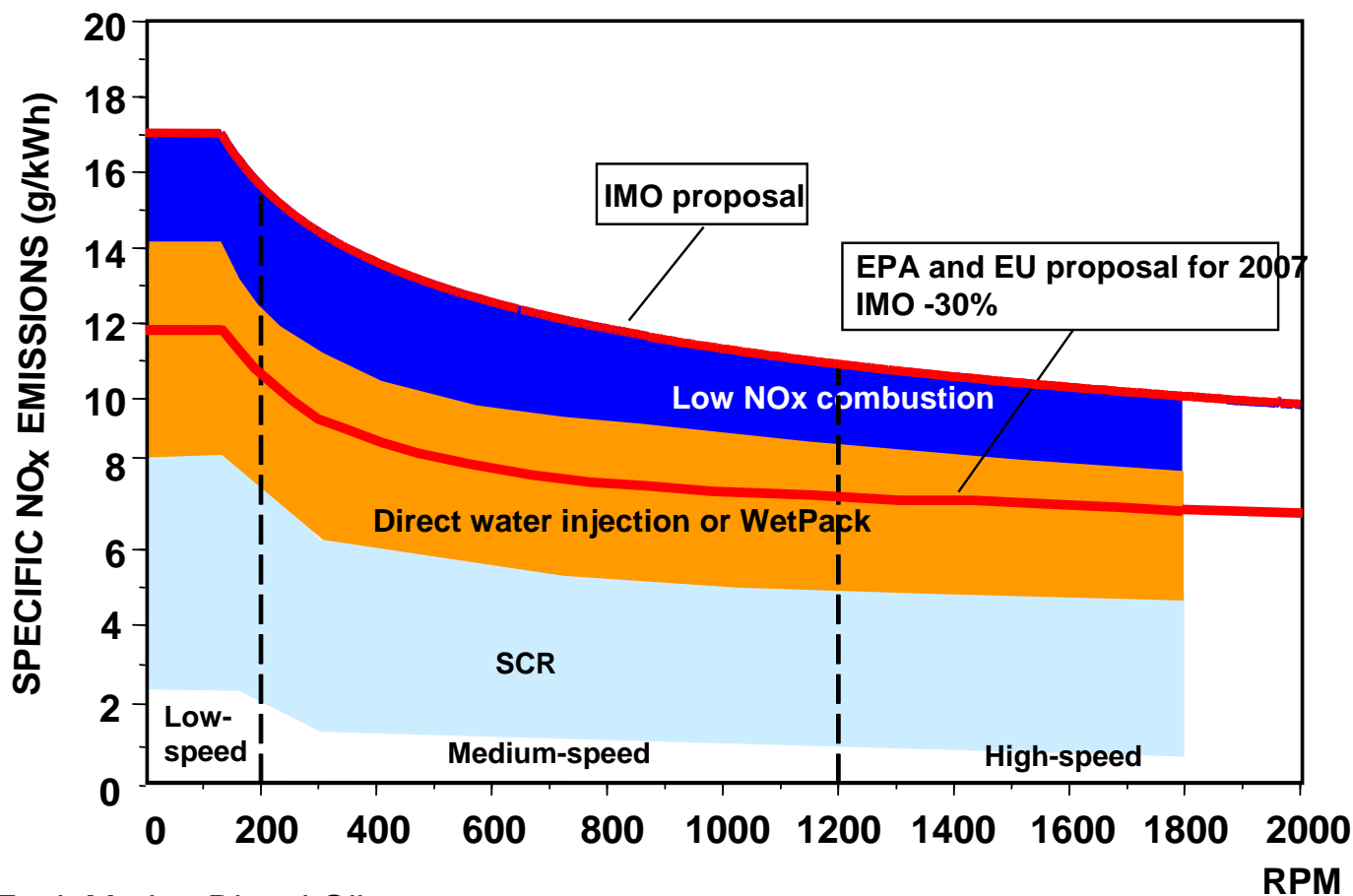
- Reduced specific fuel consumption
- Choice of fuel; gaseous or liquid

Sulphur:

- Fuel related



IMO Global Marine NOx Regulation



Reference Fuel: Marine Diesel Oil
 Implementation: New Ships and major conversions

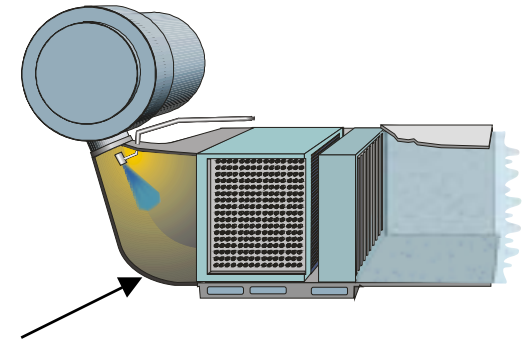
Controlling NOx emissions

Dry technologies

- Miller timing – Variable Inlet valve Closure (VIC)
- Retarded Start of Injection (SOI)
- Common Rail
- Exhaust Gas Recirculation (EGR)

Wet technologies

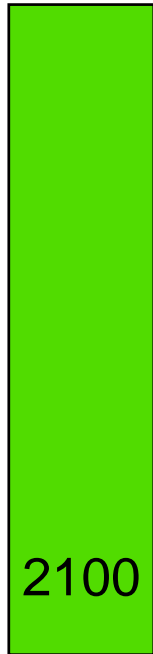
- Fuel/water emulsions
- Humidification of combustion air (WetPac)
- Direct Water Injection (DWI)



NOx emissions of a RoPax with an engine power of 20 MW and operating 5000 h/year

Before 1995

21 g/kWh



1995-2000

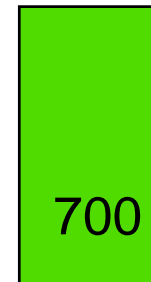
16 g/kWh



Engine control
11 g/kWh



Water injection
7 g/kWh

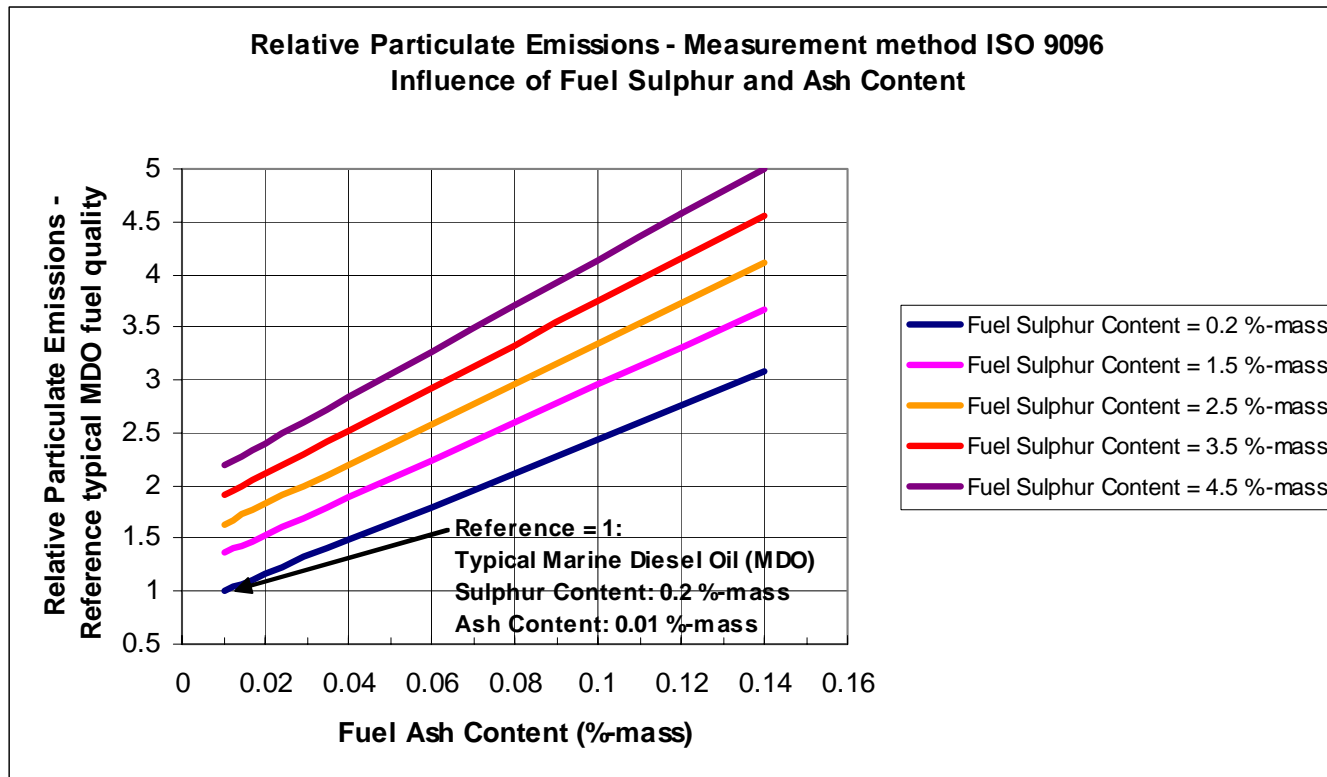


DF Engine gas
3 g/kWh



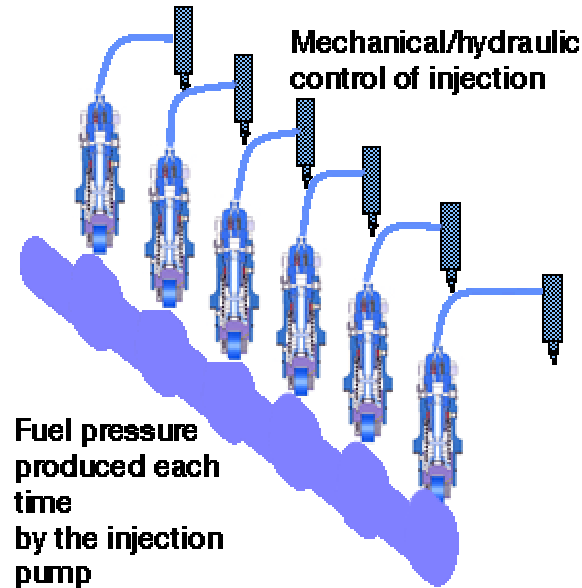
Controlling PM emissions with low sulphur fuel

Influence of Fuel Sulphur and Ash Content on Particulate Emissions

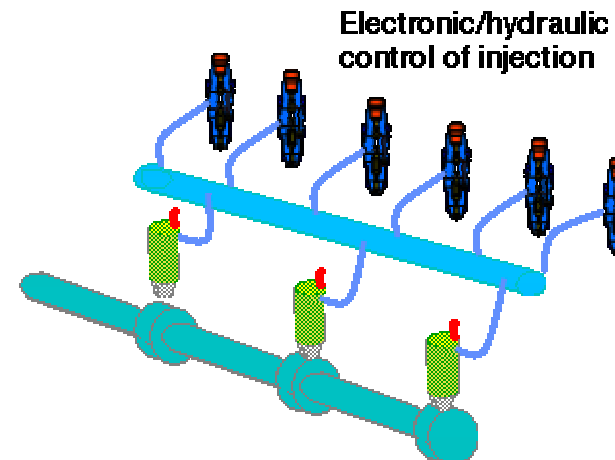


Controlling PM emissions with common rail

Conventional injection system

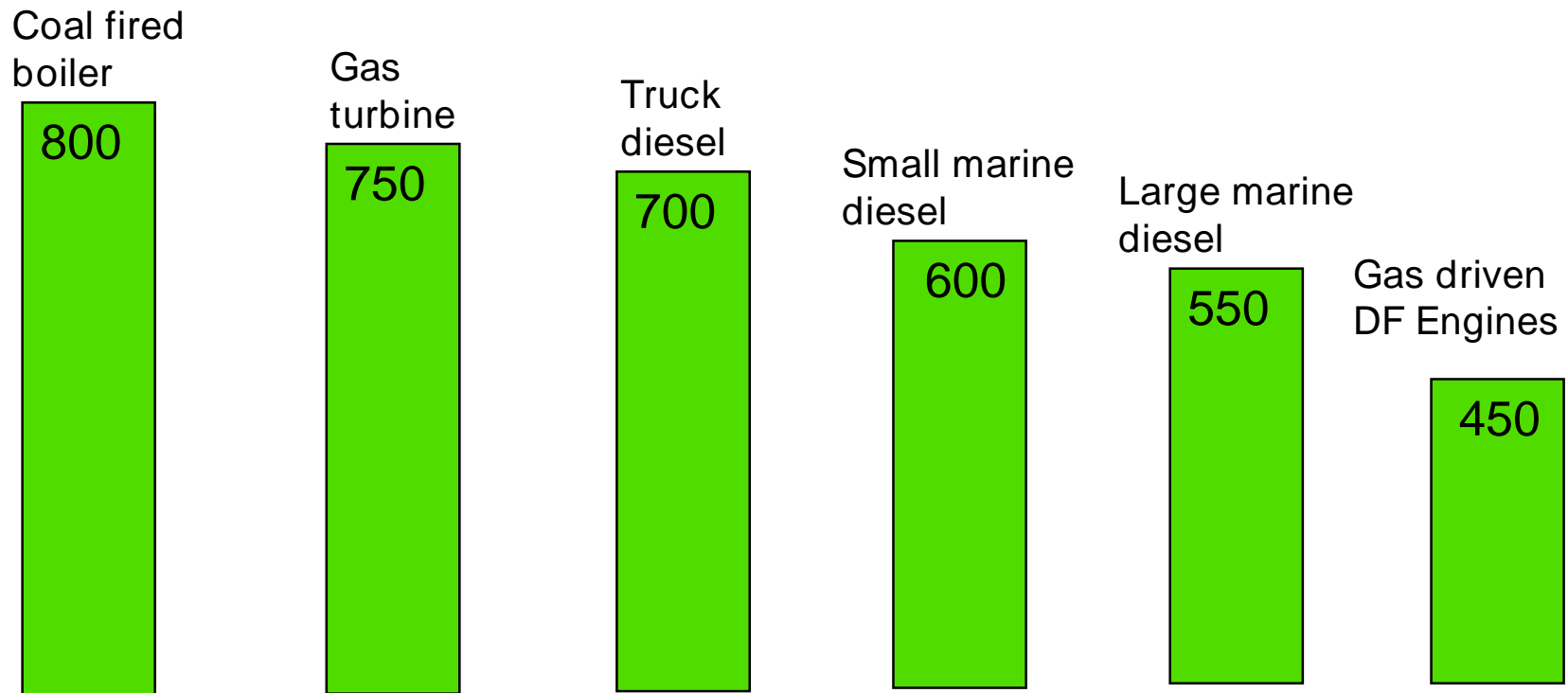


Common rail injection



Controlling CO2 emissions

Specific CO2 emissions in g/kWh (shaft)

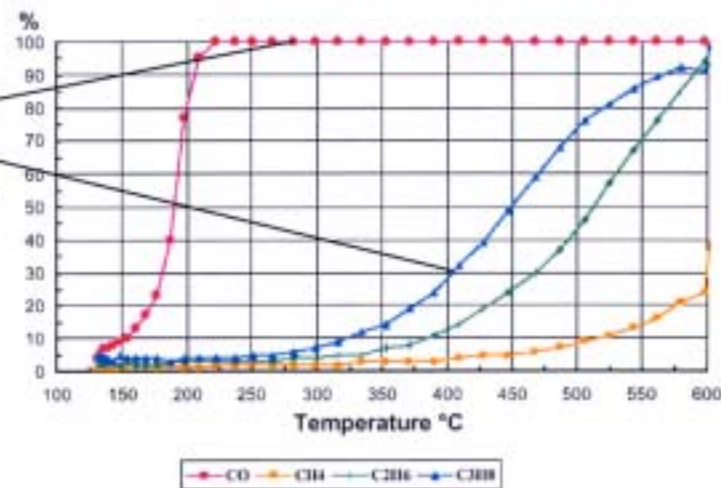
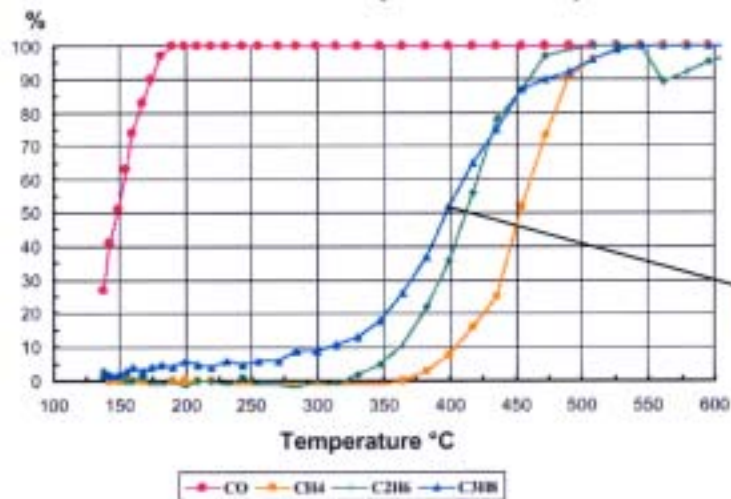


Controlling CO, VOC emissions

Note: Given reductions with fresh catalyst material.

CO catalyst

- Platinum based catalyst
- Low price catalyst (≈ 5 EUR/kW)



VOC catalyst

- Platinum/Palladium based catalyst
- SO₂ sensitive
- Expensive due to high load of noble metals (= 15-20 EUR/kW)



The Future looks bright

Thank you