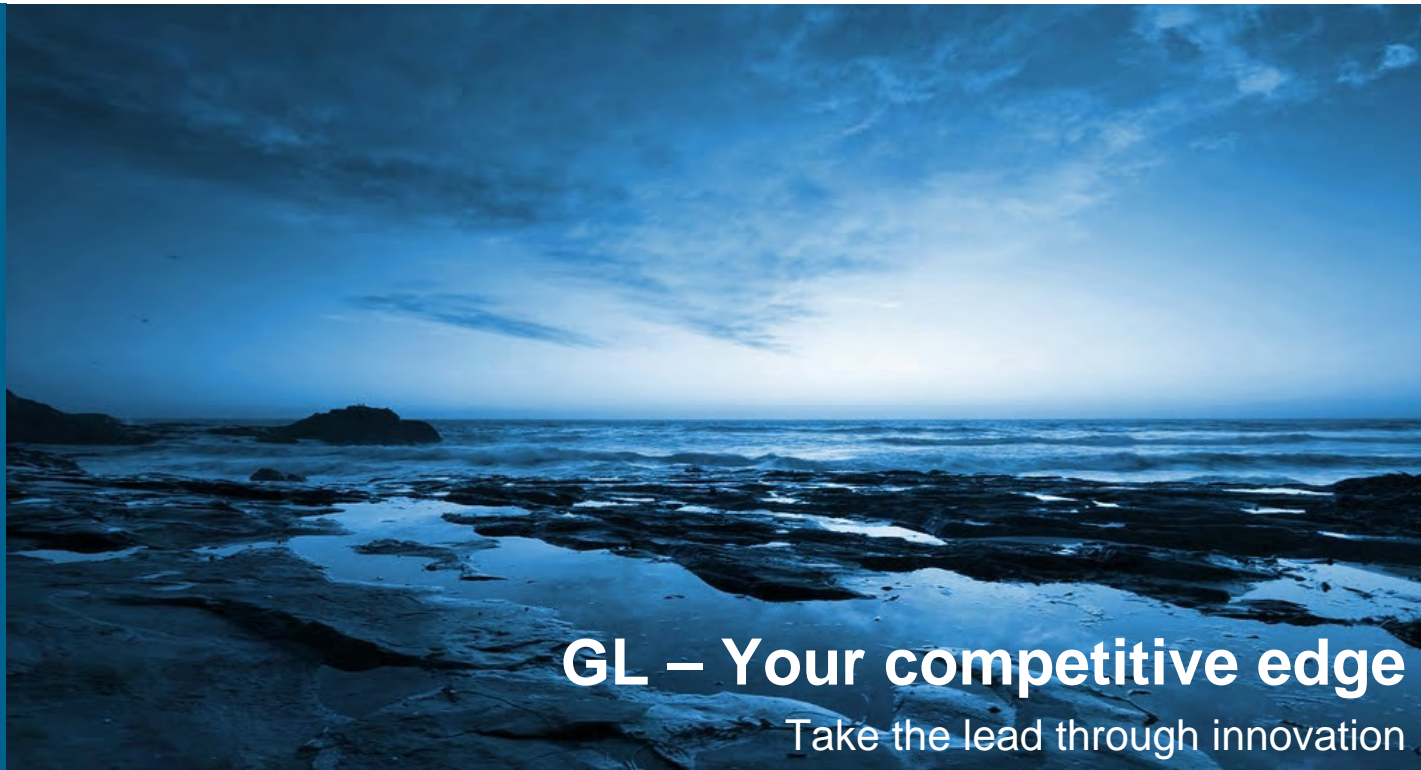


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## Technical opportunities to reduce emissions from shipping

Torsten Mundt, Head of Group Environmental Services, Strategic Research and Development



# Content

- some background on Emissions from ships
- Emission substances
- methods to combat against emission substances
- conclusions



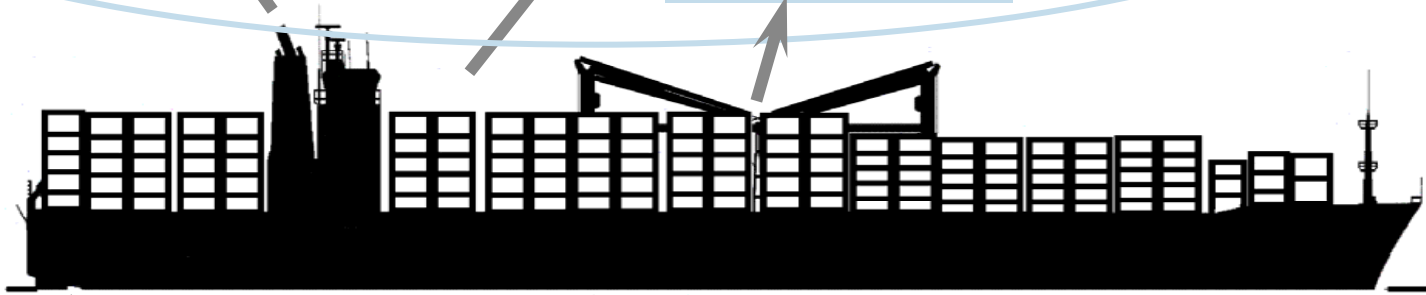
# principal emissions from ships

## Emissions into Air

CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub>, PM

Ozone-depleting substances

VOCs (Tanker)



Bilge water / oil

Waste water

Garbage

Antifouling

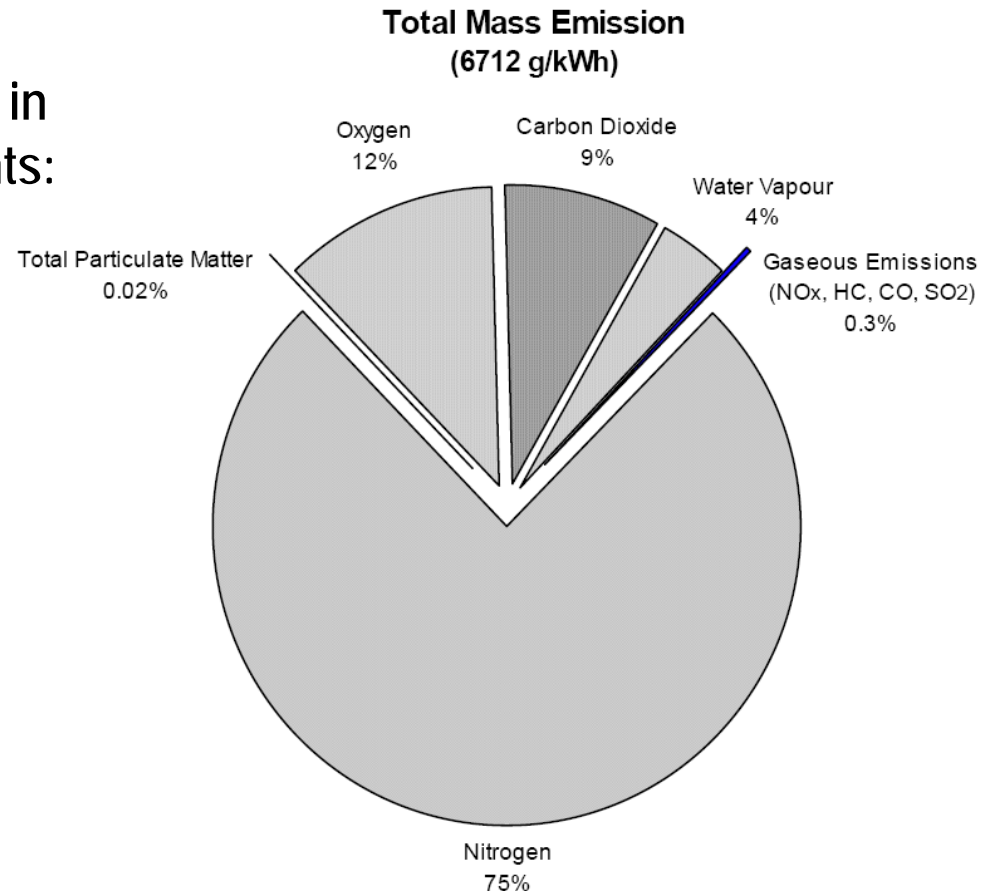
Ballast water

## Emissions into Sea

# Emissions to Air from Internal Combustion Engines

Combustion of Diesel Oil in an Internal Combustion Engine results in production of the following pollutants:

- Nitrogen Oxide (NO<sub>x</sub>)
- Carbon Monoxide (CO)
- Hydrocarbons (HC)
- Sulphur Oxides (SO<sub>x</sub>)
- Particulate Matter (PM)



# Technical principles to reduce Emissions

Methods for the reduction of pollutant emissions from Marine Diesel engines:

- pre – combustion
    - ⇒ fuel-/charge air treatment
  - Primary
    - ⇒ engine internal measures
  - Secondary
    - ⇒ exhaust gas after treatment
- ⇒ alternative fuels (switch of combustion process)



# Emission substances and reduction opportunities

## NO<sub>x</sub>

- engine internal (injection timing, Miller – timing, two stage turbo charging, ...)
- wet technologies (emulsion, direct water, HAM)
- after treatment via SCR (restricted sulphur content)

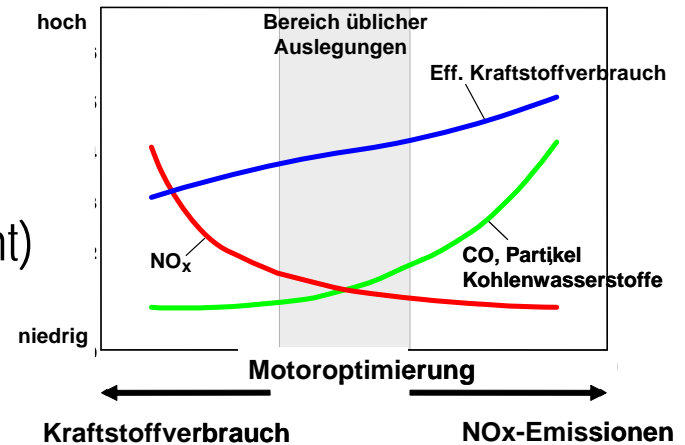
## SO<sub>x</sub>

- solely depending on sulphur fuel content  
⇒ use of sulphur reduced fuel necessary
- after treatment via scrubbing (dry / wet -closed and open loop technology -)

## PM

- amount depending on several circumstances (Sulphur, operating condition, load...)
- no after treatment possible / available for international shipping (HFO)

HC's, CO (because auf Diesel process few emissions and fulfills requirements)



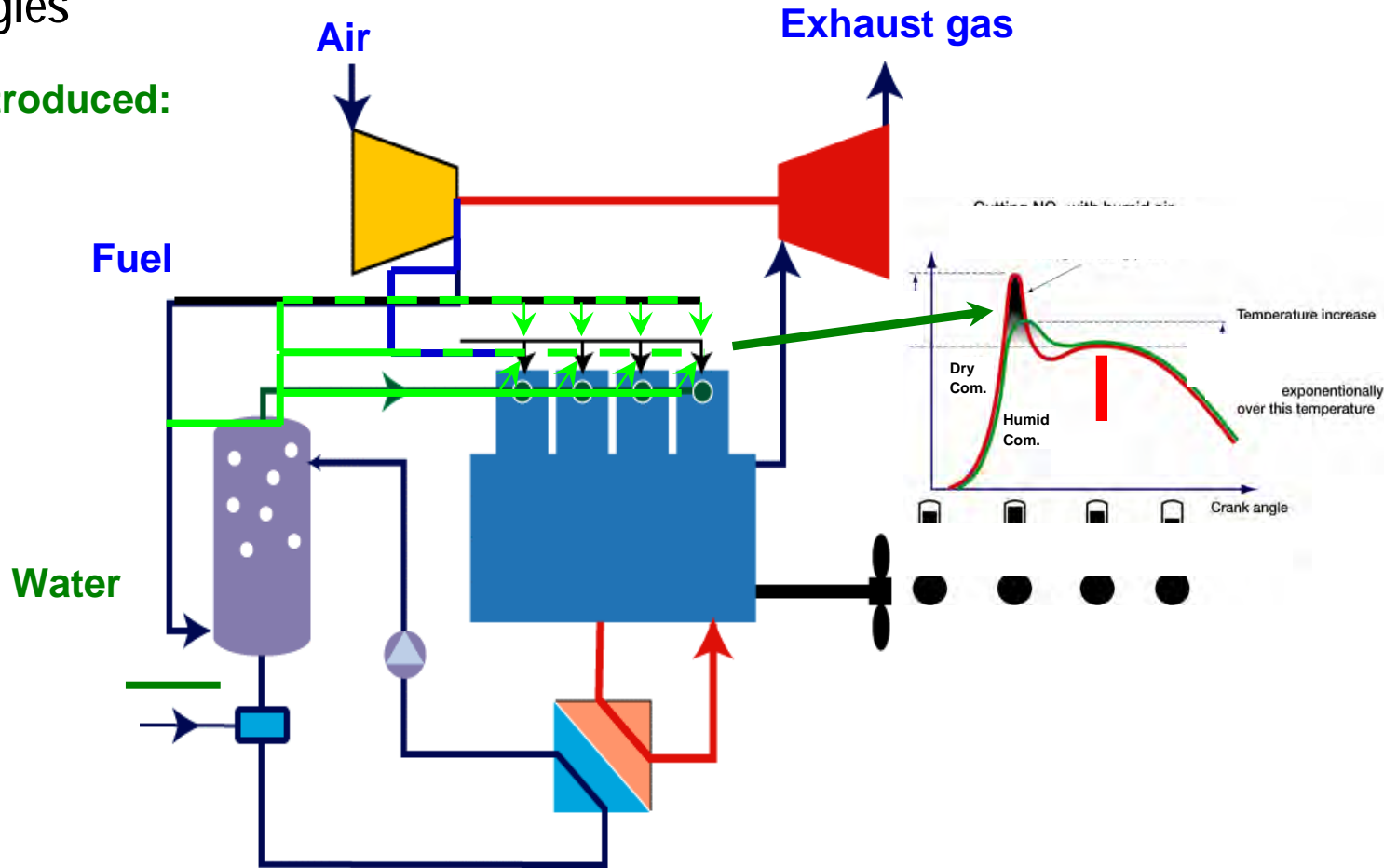
# NO<sub>x</sub> reduction opportunities

(1/2)

## Wet technologies

### Water to be introduced:

- direct
- via charge air
- via fuel

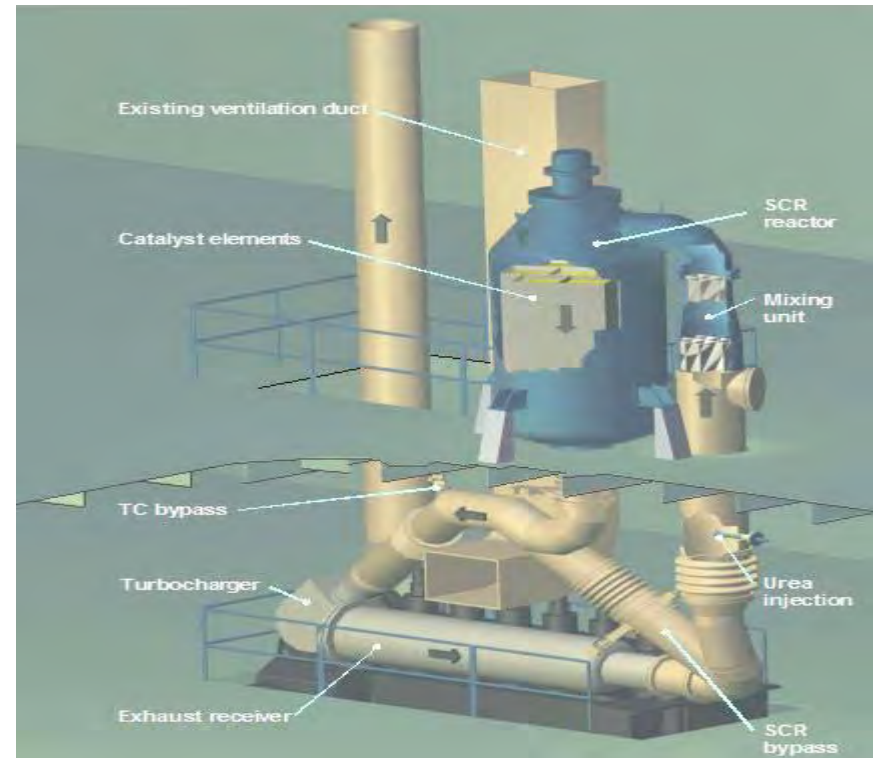
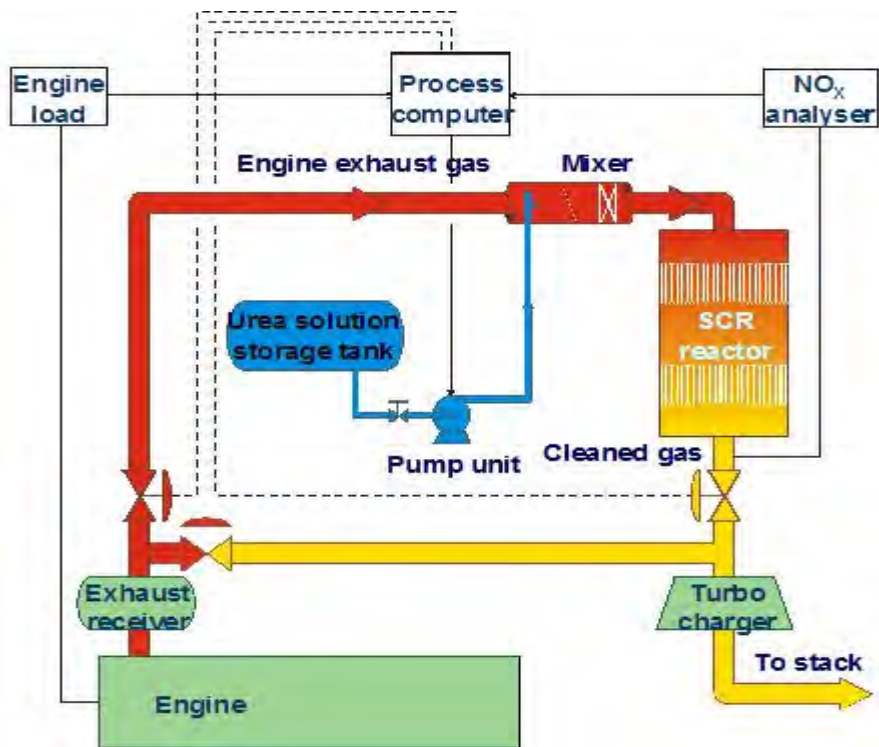




# NO<sub>x</sub> reduction opportunities

(2/2)

## Selective Catalytic Reduction (SCR):

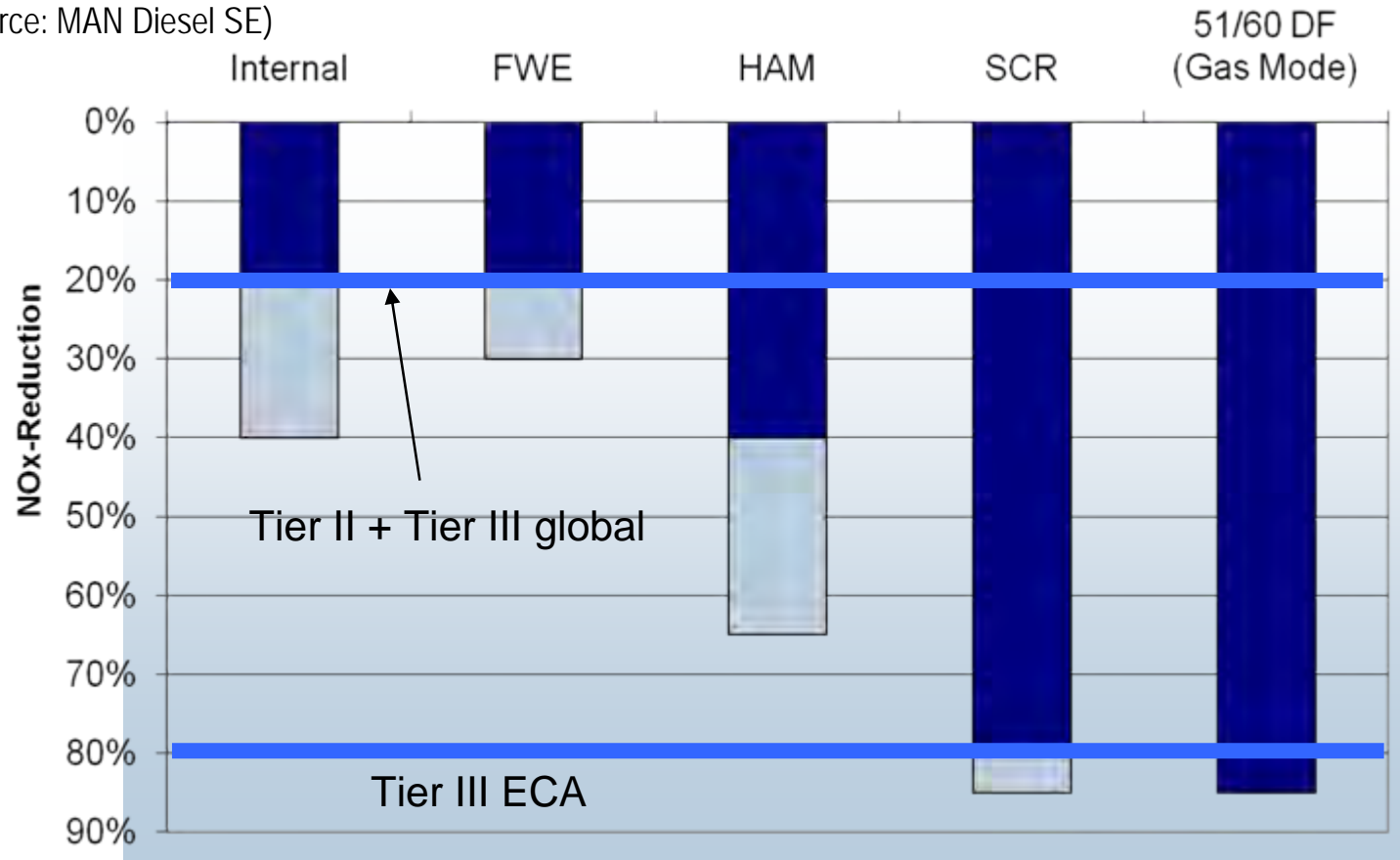




# Effectiveness of NO<sub>x</sub> reduction opportunities

## Potential of NO<sub>x</sub> reduction technologies

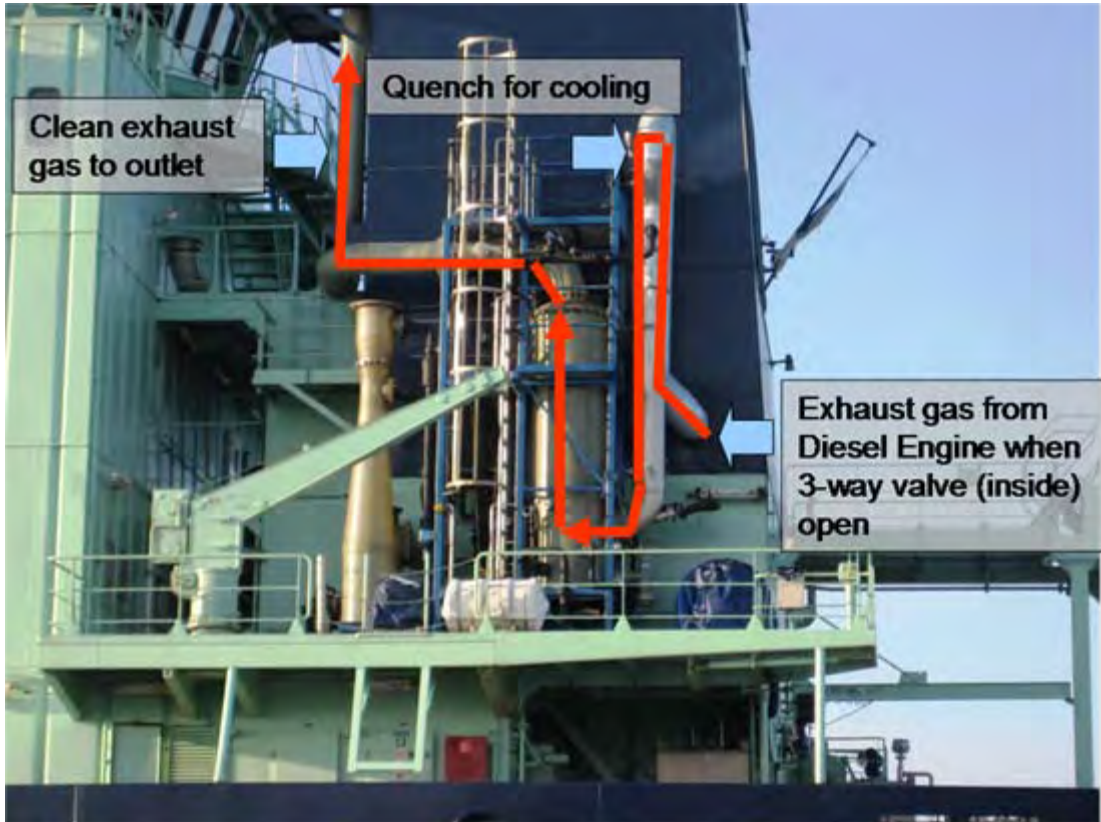
(Source: MAN Diesel SE)



# SO<sub>x</sub> and reduction opportunities

(1/2)

## Wet scrubber system (closed loop) on MV Suula



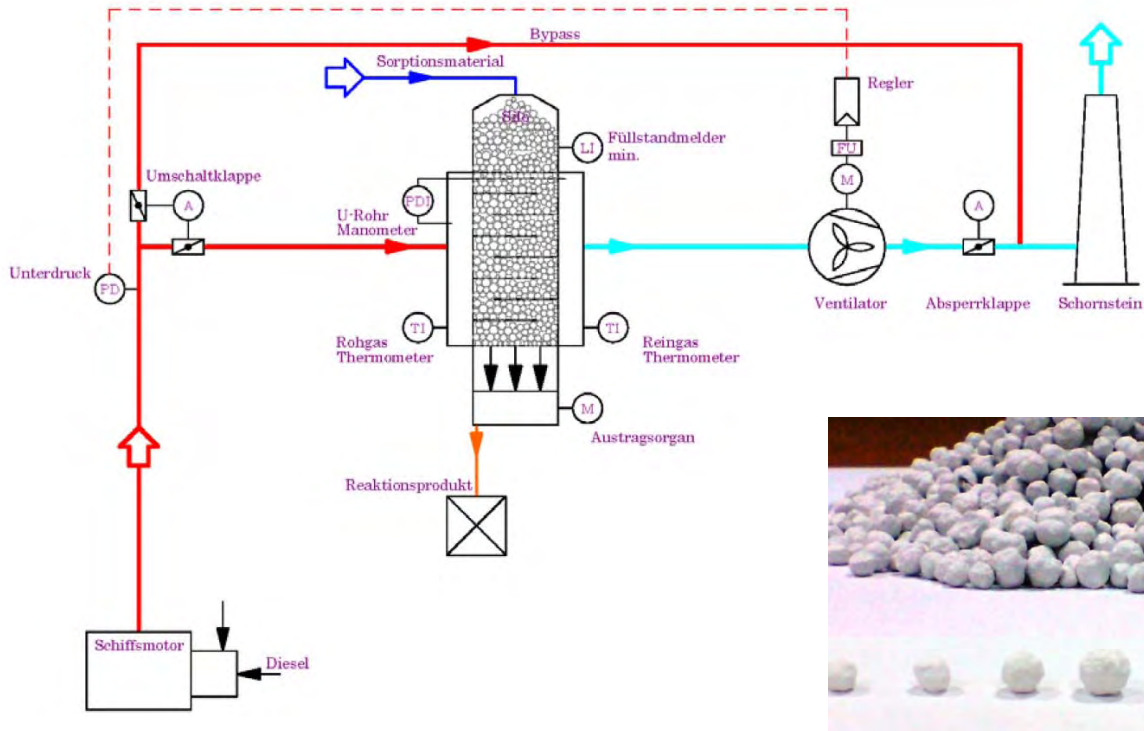
Source: Wärtsilä



# SO<sub>x</sub> and reduction opportunities

(2/2)

## Dry scrubber system on MV Timbus



Source: Couple Systems



# basics on PM emissions

PM is a mixture of solid and liquid material

- carbon particles
  - hydrocarbons
  - inorganic matter
- ⇒ causing considerable health damage

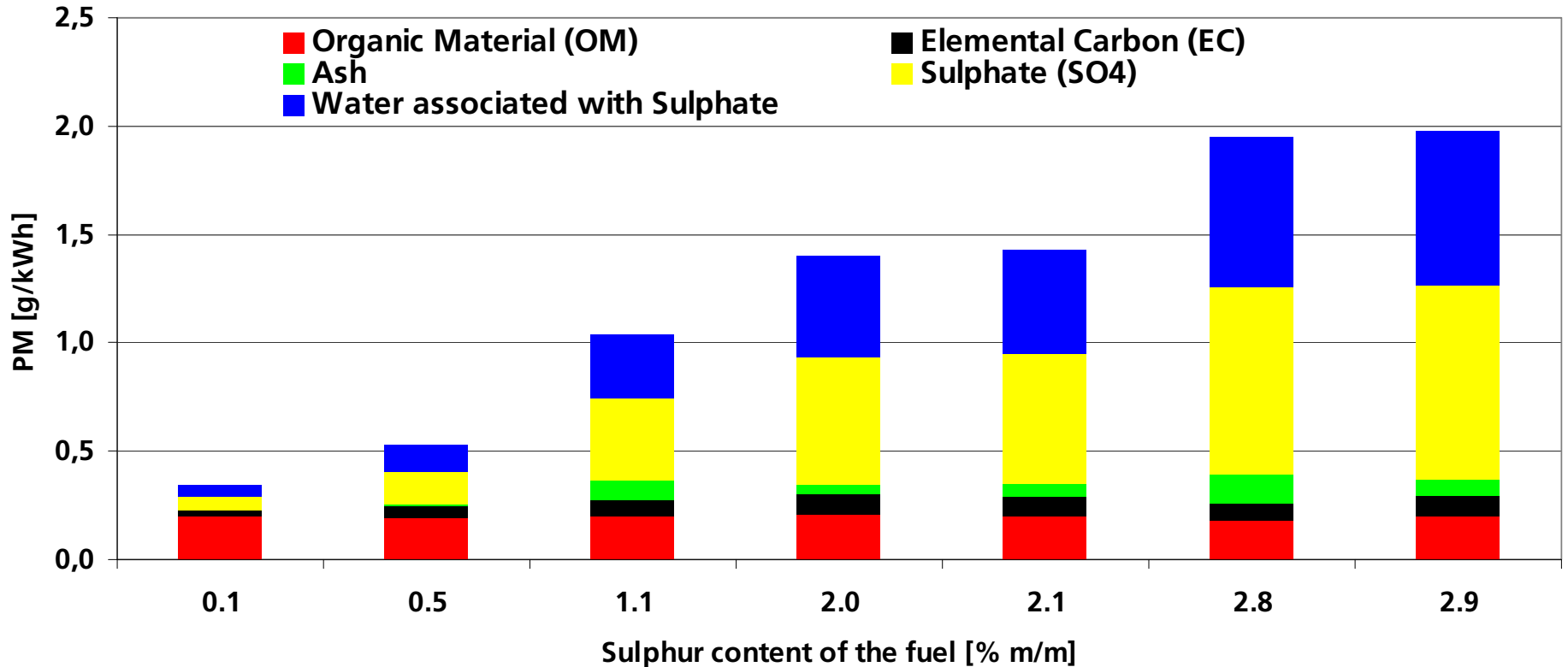
Influencing factors (among others) are:

- Sulphur content of the fuel
- Air to Fuel ratio
- Turbulence
- Injection Pressure in Diesel Engines
- Maintenance condition of the injection and air supply equipment



# Effects of Sulphur Content on Particulate Matter (PM)

## Particulate Matter of a 2-stroke Diesel Engine on a test bed at 100% Load



# Remarks concerning Technical Safety

Mandatory requirements:

- SOLAS Convention  
and
- Class Rules

⇒ safety is of utmost priority!

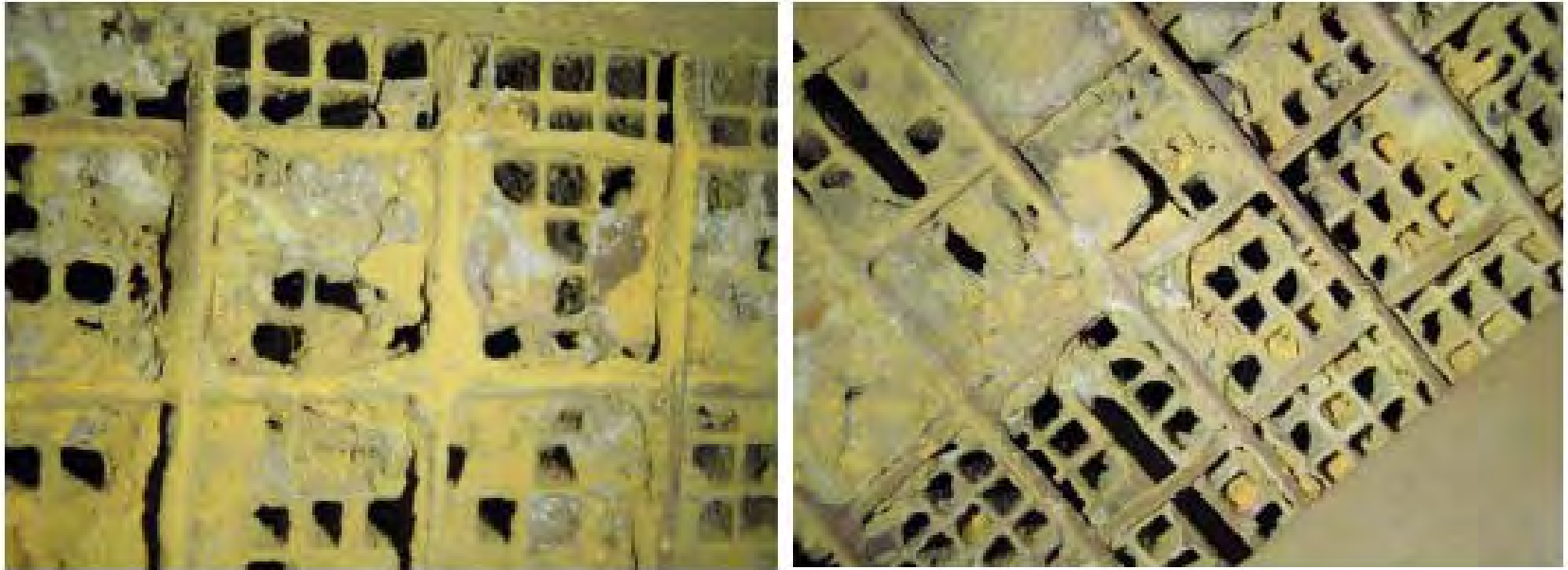
Safe ship operation means:

⇒ Protection of the environment



New GL Rules 2010, 2.N  
„Exhaust Gas Cleaning Systems“

## Example concerning Technical Safety



Clogging of Catalyst block due to bad urea quality



# Comparison of Emission Reduction Capabilities

	Internal Measures	FWE	HAM	SCR	Gas Fuelled Engines
NO <sub>x</sub>	20-40%	20-30%	40(-65)%	80-85%	85% in Gas Mode
CO <sub>2</sub>	↑	-	-	↑	↓
PM	-	↓	-	-	↓
Smoke	-	-	↑	-	↓
SO <sub>x</sub>	-	-	-	-	↓
Others	-	-	-	Ammonia slip!	CH <sub>4</sub> - slip

# Conclusion

Emission reduction means doing efforts

- needs investment
- should be tested and proven (before mandatory required)
- is not CO<sub>2</sub> - neutral
- ...



Emission reduction must be solved under an holistic approach.  
Maintaining a holistic view on the ship's energy conversion system  
will lead to efficient and environmentally friendly ship operation.

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**Thank you for your kind attention.**

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