



Energy research Centre of the Netherlands

# **A new particulate matter abatement technique for shipping**

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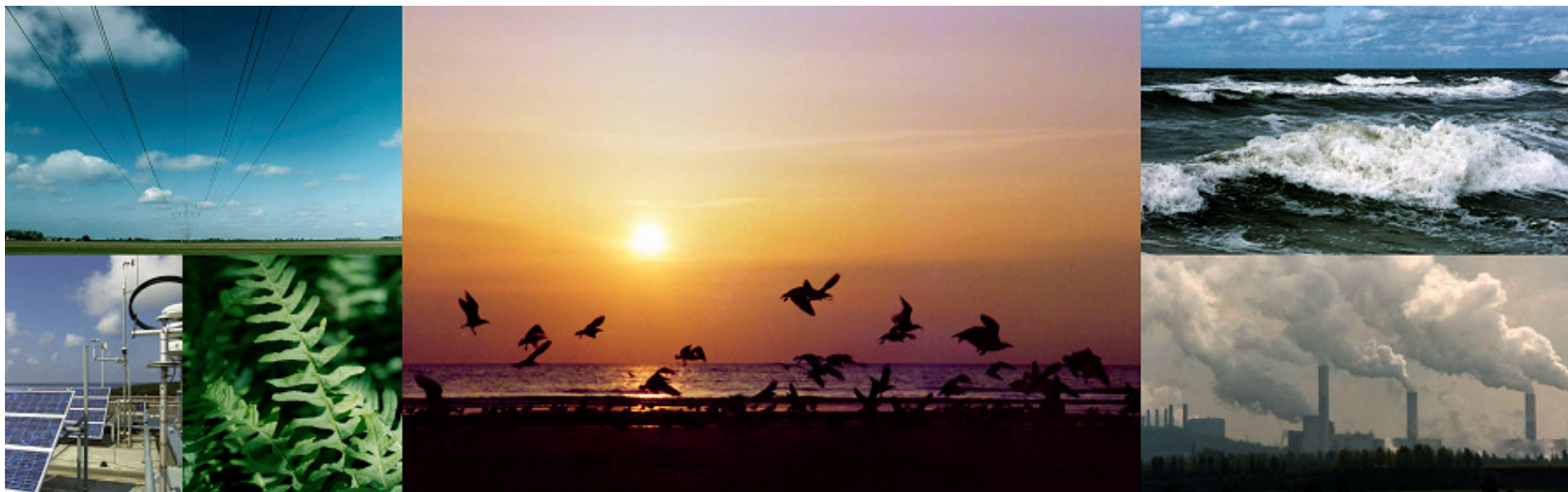
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# A new particulate matter abatement technique for shipping

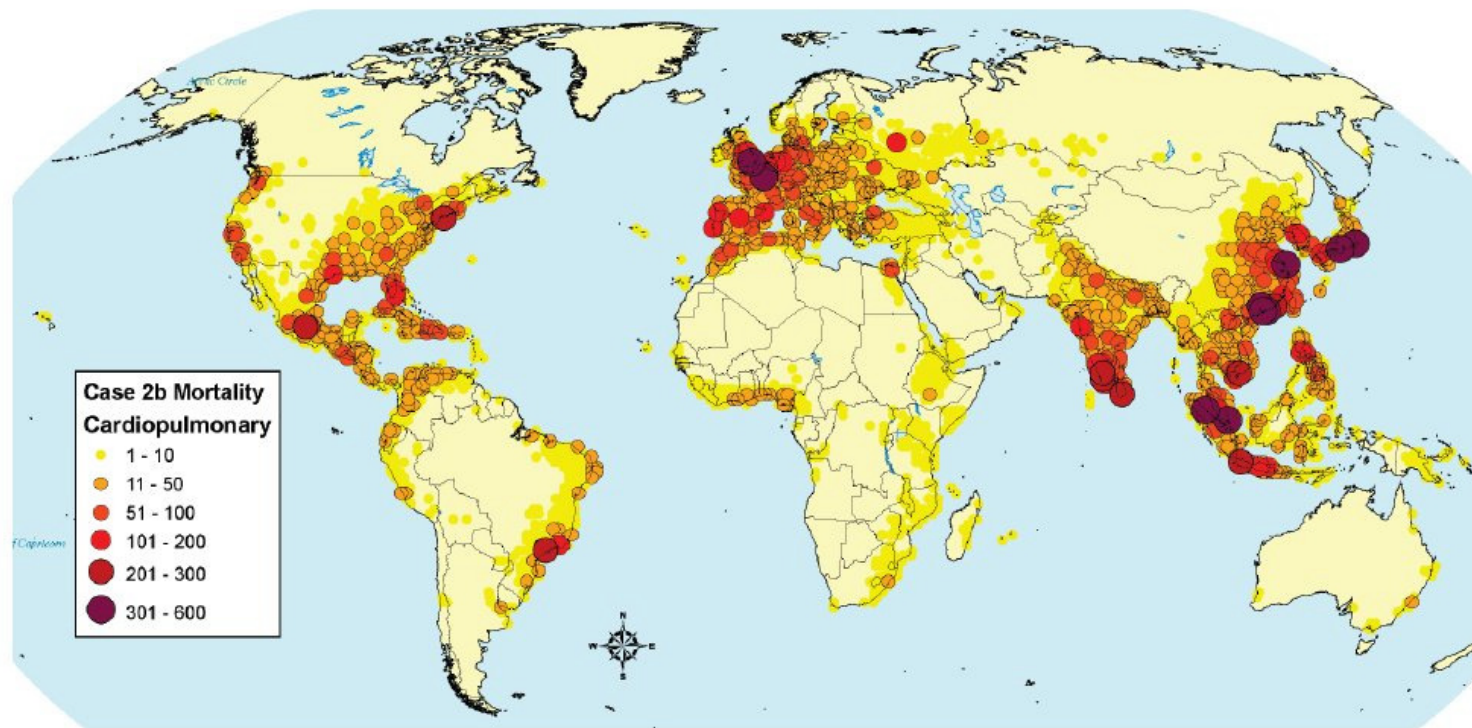
Geert van Rens, L. Rabou, C. Dijkstra, D. Stapersma and G.J. Witkamp  
HAQCC, 29-05-2008



# Content

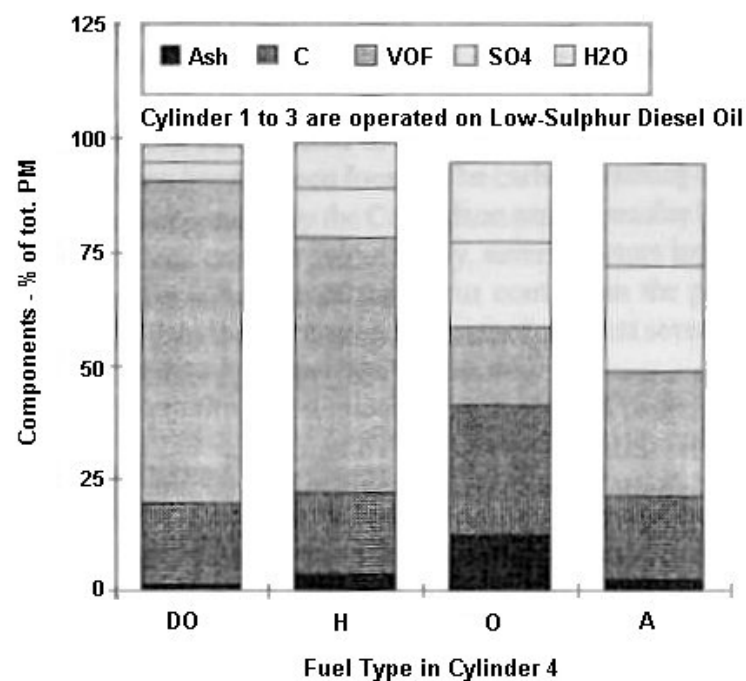
- Introduction
- Results new solution
- Economic comparison with alternatives
- Conclusion and further research issues

# Introduction

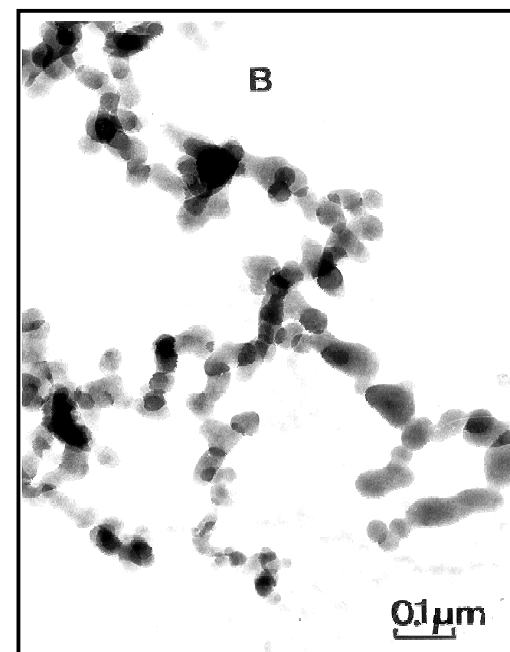


[Corbett et al., 2007]

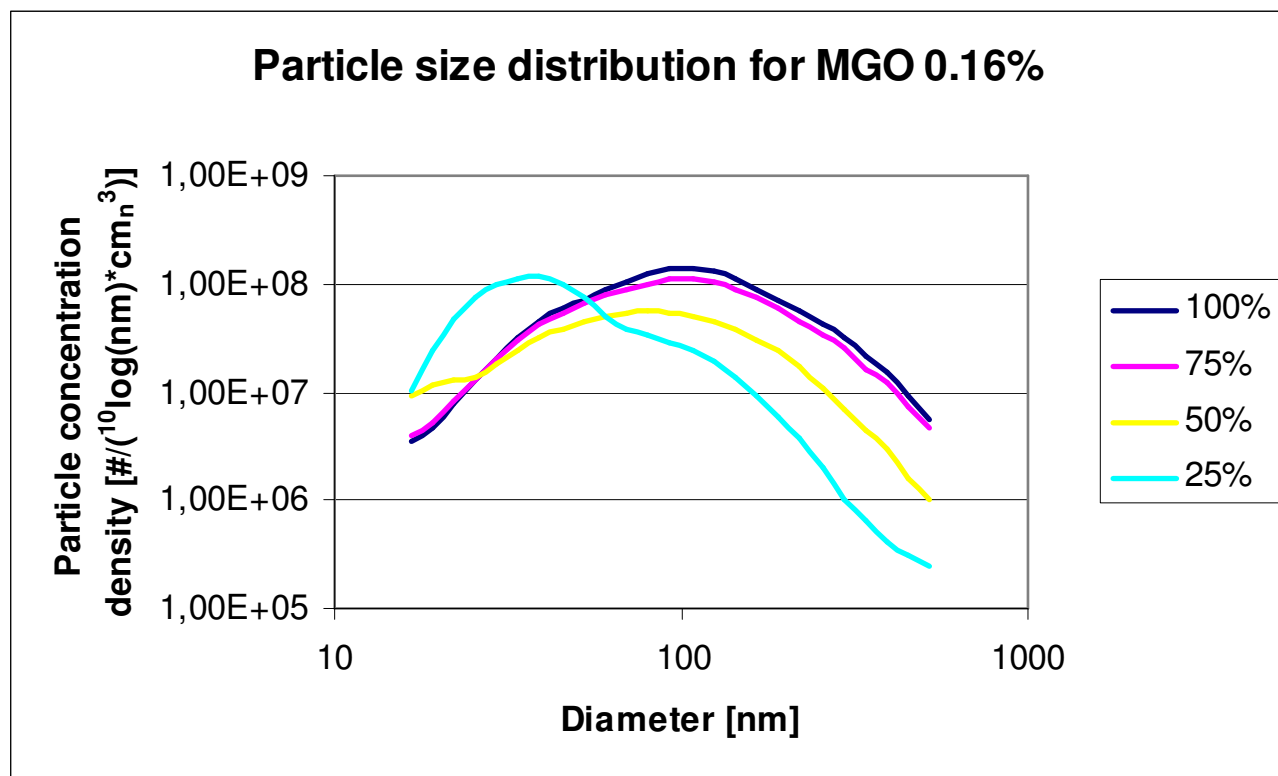
# The problem



[Sher, 1998]



# Introduction



## Introduction

Existing solutions for diesel PM reduction:

- “Soot filter”
- Catalytic options
- Scrubber
- ESP

# Introduction

Aim:

**Reducing PM emissions of shipping with  
presently used fuels**



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## New solution

- Patent pending!
- Physical removal of particulate matter
- Open system
- Continuous removal of captured particulate matter from the system
- Contains known and proven technology

## Results new solution

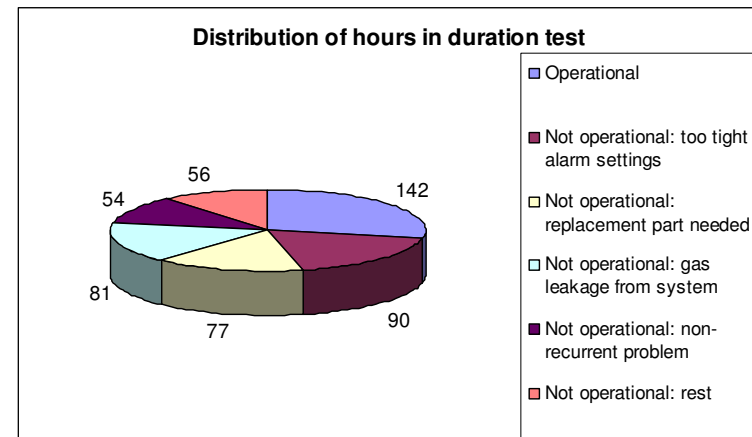
15 kW generator, 100 kg/h exhaust gas

- Initially 70% removal efficiency (mass/mass), unstable operation
- Unstable operation solved
- Removal efficiency increased to 82% (mass/mass)

## Results new solution

Duration test (unmanned):

- 8 runs over 10 hours, longest run 23 hours.
- 142 hours operational (lead time 500 hours)
- Fouling issues with known technology
- Critical components identified
- Start-up behaviour improved



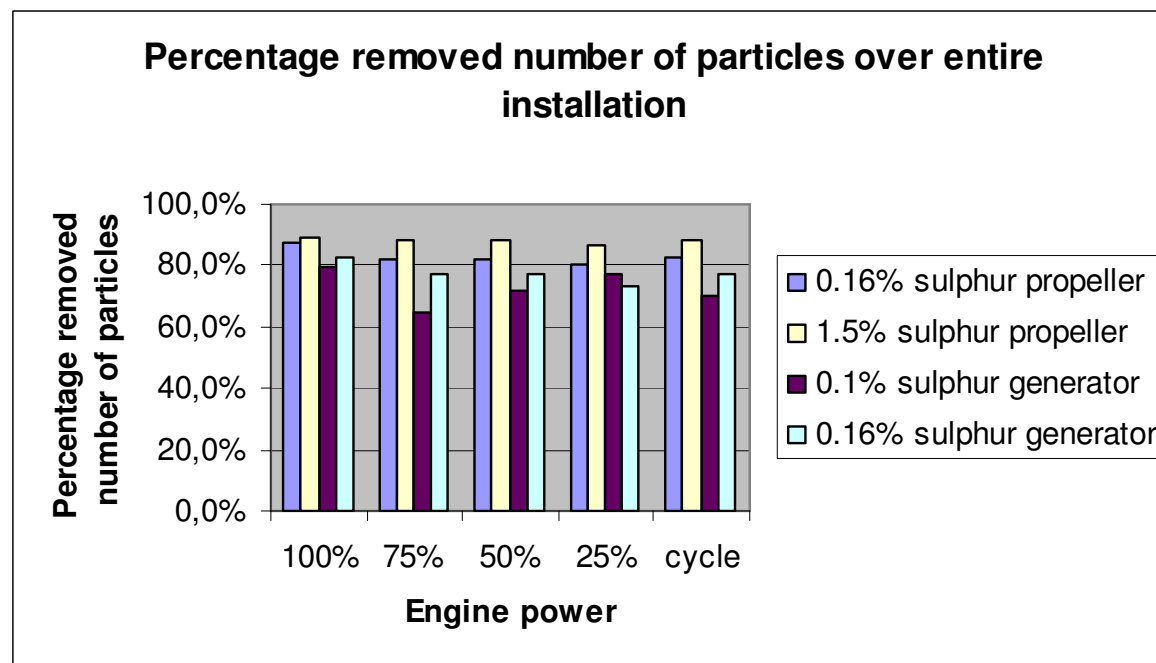
## Results new solution



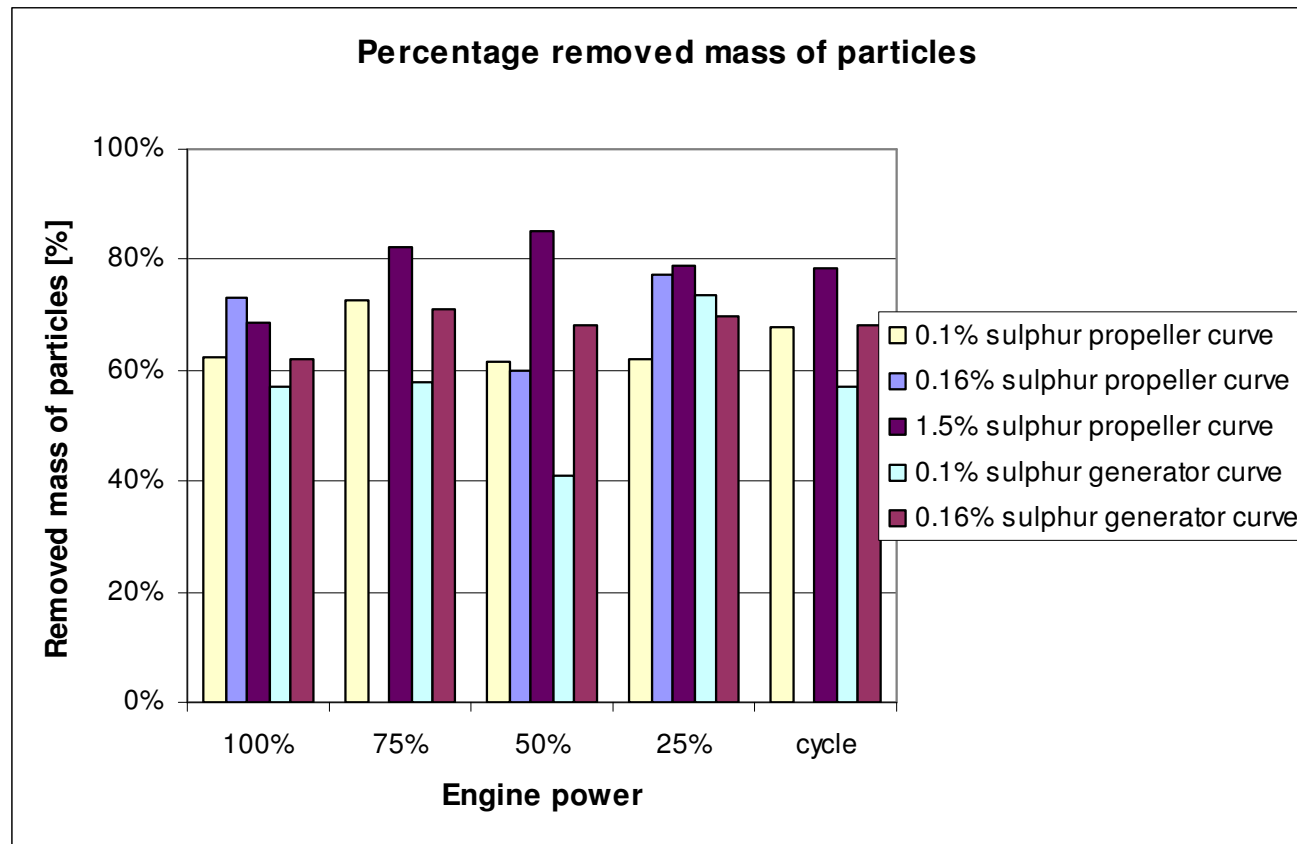
## Results new solution

Slipstream 350 kW engine:

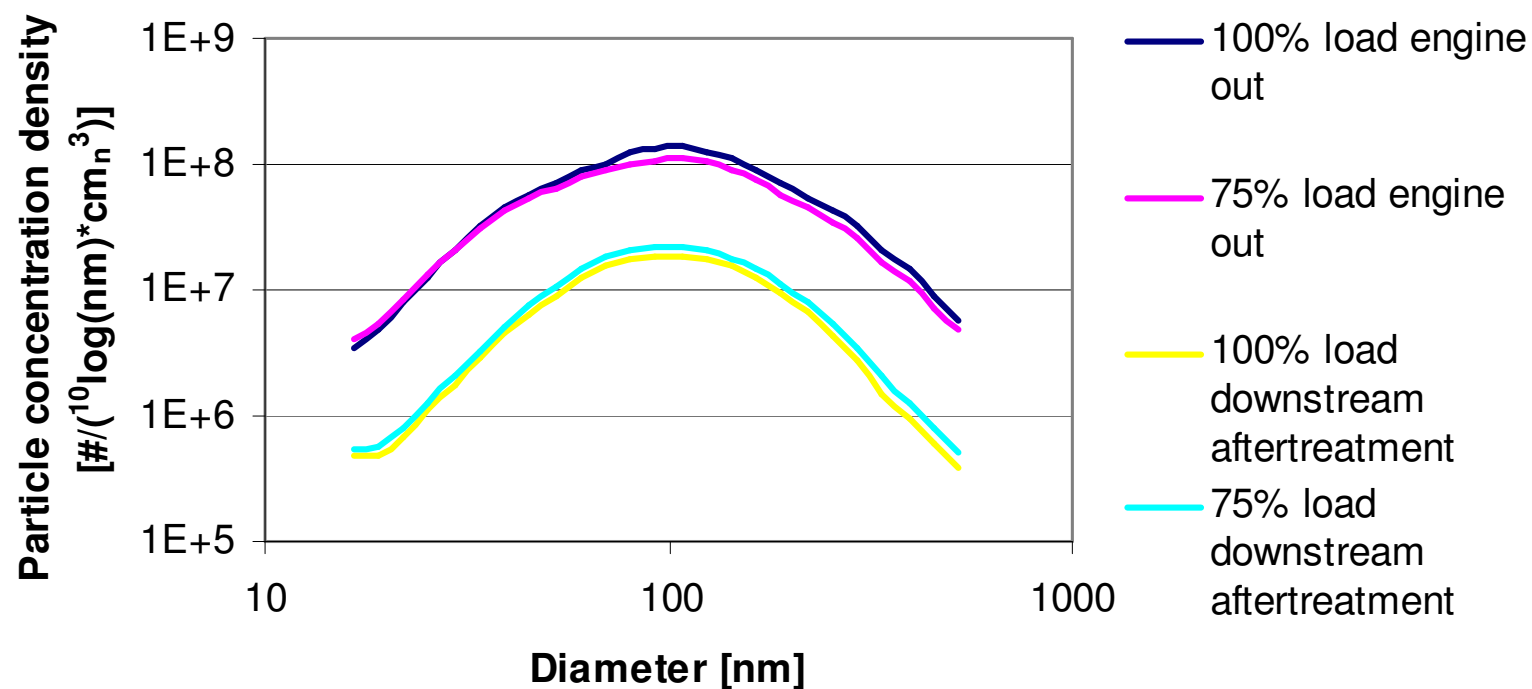
no start-stop problems



## Results new solution



# Results





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# Economic comparison with alternatives

Two cases:

- Inland shipping
- Sea going ferries

## Economic comparison with alternatives

Inland shipping:

- Fuel with max 0.1% sulphur (1000 ppm), from 2012 on fuel with 50 ppm ( $\approx$ road quality)
- Road quality fuel costs only €25 per 1000 kg more than fuel with 0.1% sulphur

## Economic comparison with alternatives

Inland shipping:

PM-filter with low-sulphur  
fuel best option

|                                     | Cost to<br>remove a kg<br>PM |
|-------------------------------------|------------------------------|
| New technology                      | € 462                        |
| PM-filter with low-<br>sulphur fuel | € 163                        |

## Economic comparison with alternatives

Sea shipping:

- Fuel with max 4.5% sulphur
- Fuel in special areas max 1.5% sulphur
- Fuel in harbour max 0.1% sulphur

Fuel with 4.5% sulphur costs €296 per 1000 kg

Fuel with 1.5% sulphur costs €317 per 1000 kg

Low-sulphur fuel (>50 ppm) costs €635 per 1000 kg

## Economic comparison with alternatives

|                                 | €/kg PM |
|---------------------------------|---------|
| New technology                  | 97      |
| Sea water scrubber              | 27-54   |
| PM-filter with low-sulphur fuel | 156     |

Conclusion: Sea water scrubber cheapest, followed by new technology, however a sea water scrubber is less efficient for sub-micron particles

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## Conclusions

- Over 175 hours of operation accumulated
- Up till 80% of mass of particulate matter removed
- 70-85% of number of particulate matter removed
- Great potential for sea shipping
- Not preferred for inland shipping



## Further research issues

- Additional lifetime experiments after solving fouling issues known technology
- System integration

## Acknowledgements

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