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Retrofit of three Danish ships with DPF and NO_x-reducing technology – a new Danish venture

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Emission regulations for ships

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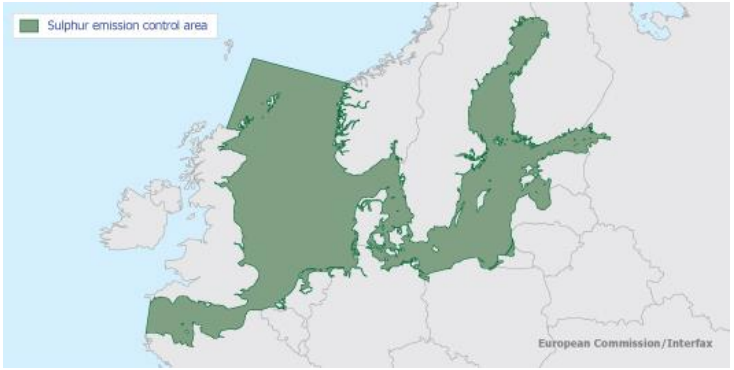
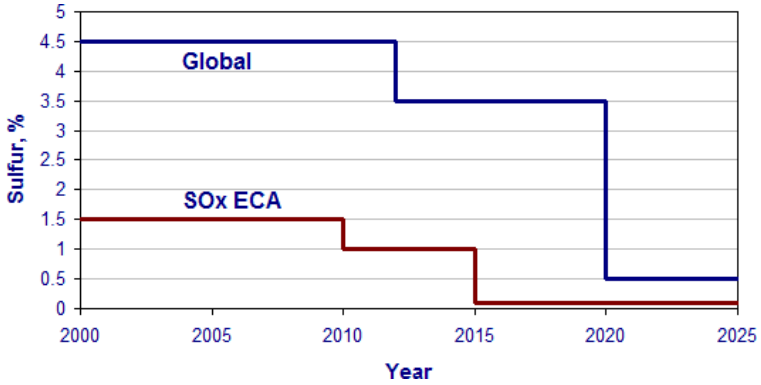
- Sulphur:
  2015: 0.1% (1000 ppm) S, SECA
  2020: 0.5% (5000 ppm) S, global
- NO_x:
  2011: Tier II, new ships, global
  2021: Tier III, new ships, NECA (~80% reduction)



- Mitigation options:
  - Sulphur: Low sulphur fuel or SOx scrubbers
  - NOx: EGR, SCR
  - Alternative fuels (e.g. LNG)
  - Battery operation
  - DPF



Why reduce ship emissions?

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- Pollution from ships in Danish waters costs the society ~500 million EUR (15-20 % of the total air pollution costs[1])
- 10.001 islands
  - 70 of which are inhabited
- 67 ferry routes
  - Several have more than one ferry

[1] "Air pollution impact on health in Denmark", DCE 2014

Local inconveniences

- Harbor fronts – urban movement
- Passenger inconvenience
- Workplace environment

New Danish venture (2017-2020)

- 3 DPF and 2 SCR technologies from 3 different manufacturers to be matured, demonstrated and validated

  1. DPF
  2. DPF+SCR (urea)
  3. DPF+SCR (pure ammonia)

- Measurements in-stack + ambient

- PM / PN / black carbon regulation from ships not yet introduced though…

1. Hirtshals-Kristiansand
Color Line og Fjordline
99 56 19 00 el. www.colorline.dk
97 96 30 00 el. www.fjordline.dk

2. Hirtshals-Larvik
Color Line
99 56 19 00 el. www.colorline.dk

17. Hals-Egense
Hals-Egense Færgefart
98 25 12 77 el. www.hals-egense.dk

Research: Allan Graubæk og Nanna Claridge Foldschack

Småfærgerne i Danmark har en fælles hjemmeside med henvisninger til hver enkelt færges hjemmeside og sejlplan

www.smaa-faergerne.dk

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Ships of interest

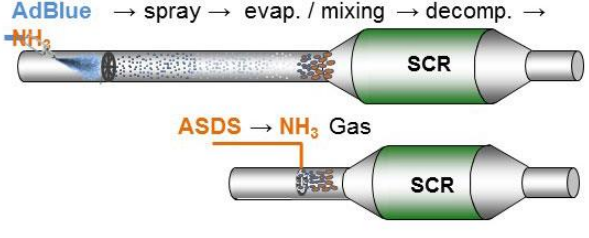
	Case 1 M/F Isefjord	Case 2 WMO	Case 3 M/S Pernille
Main engines	2 x Cummins QSK19-M 373 kW (MCR rating)	4x Scania D13 405 kW (MCR rating)	2x Volvo Penta TAMD 120 BCC 250 kW (MCR rating)
	2011 IMO Tier II	2013 IMO Tier II	1981 No Tier rating
Auxiliary engines	2 x Cummins 6CT8.3-D(M) 122 kW (Prime rating)	2x Perkina 29 kW (Prime rating)	2x Volvo Penta 80 kW (Prime rating)
	2012 IMO Tier II	2013 IMO Tier II	1981 No Tier rating

Technologies / installations

- Case 1: M/F Isefjord, Hundested Rørvig
  - MGO 50 ppm S fuel
  - DPF solution from Exilator

- Case 2: World Marine Offshore
  - MGO/MDO up to 1,000 ppm S fuel – challenge (no standard catalyst solution)
  - DPF+SCR (urea) from Purefi

- Case 3: Sundbusserne M/S Pernille
  - MGO 50 ppm S fuel
  - DPF+SCR (pure ammonia) from Amminex



Experimental setup

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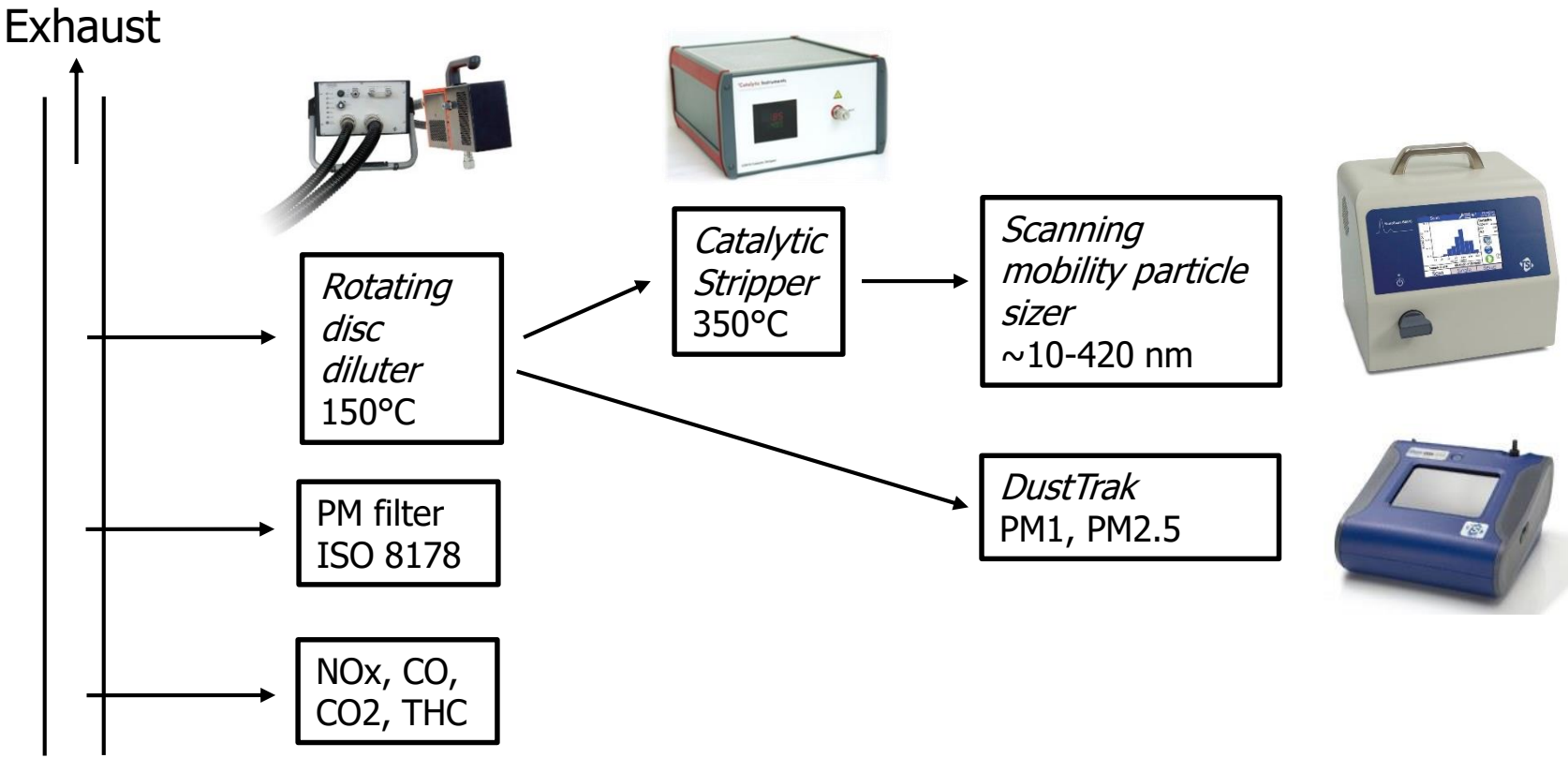

Case 1: Activities on board…

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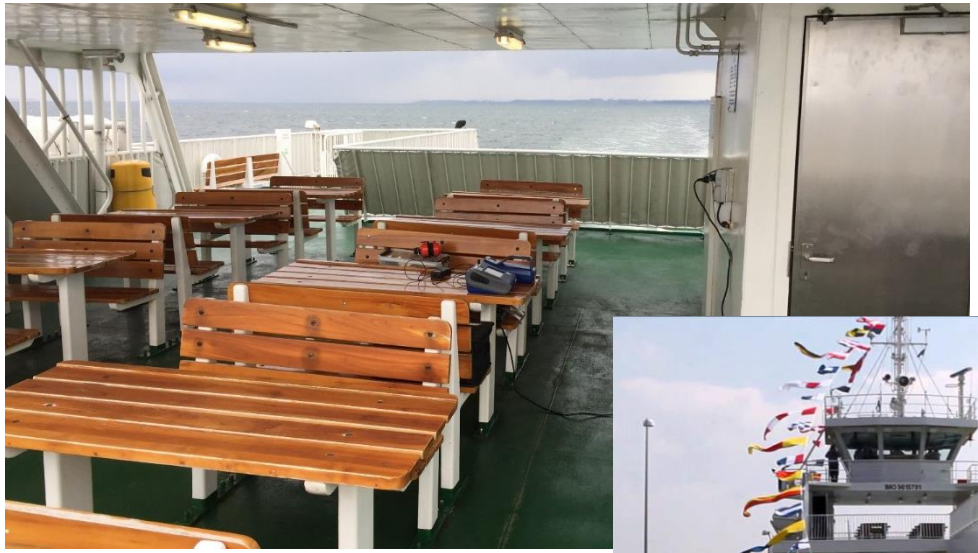

PSD as function of load – 3 cases

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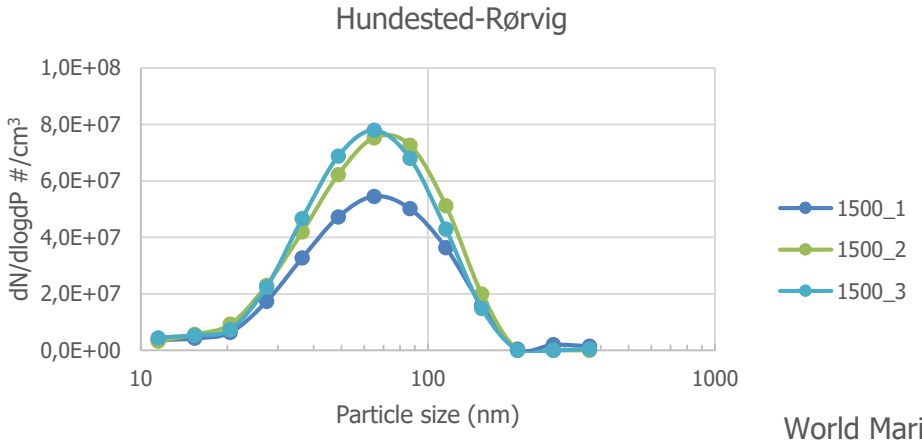

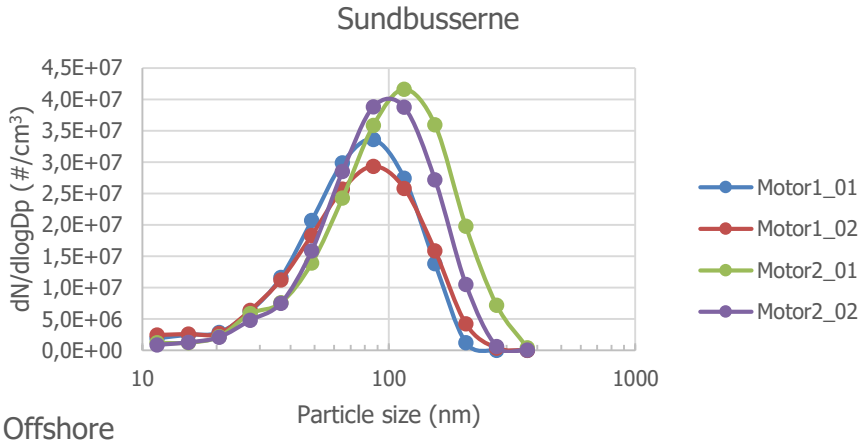

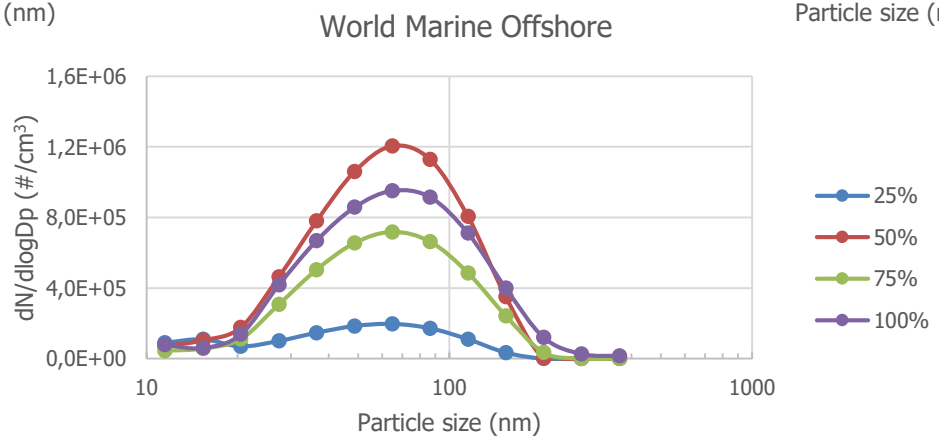

Measurements

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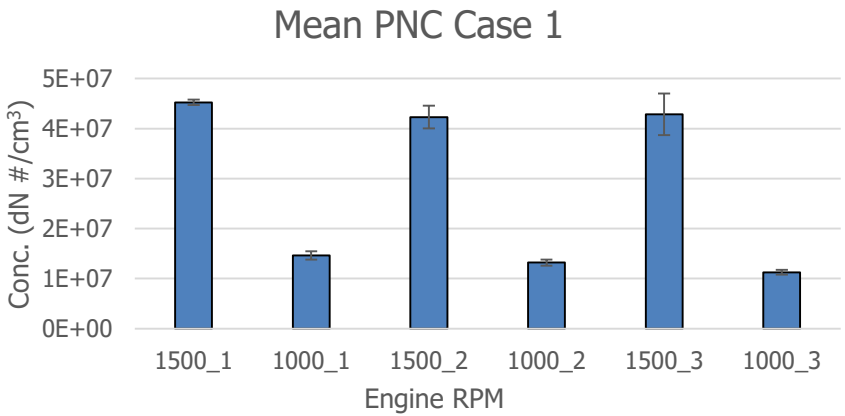
	Case 1	Case 2	Case 3
NOx	5-700 ppm	900-1400 ppm	1700-2200 ppm
PN	4-5x10^7 cm^{-3}	4-8x10^6 cm^{-3}	2-3x10^7 cm^{-3}
Solution	DPF	DPF+SCR	DPF+SCR



Case 1: PM as function of load

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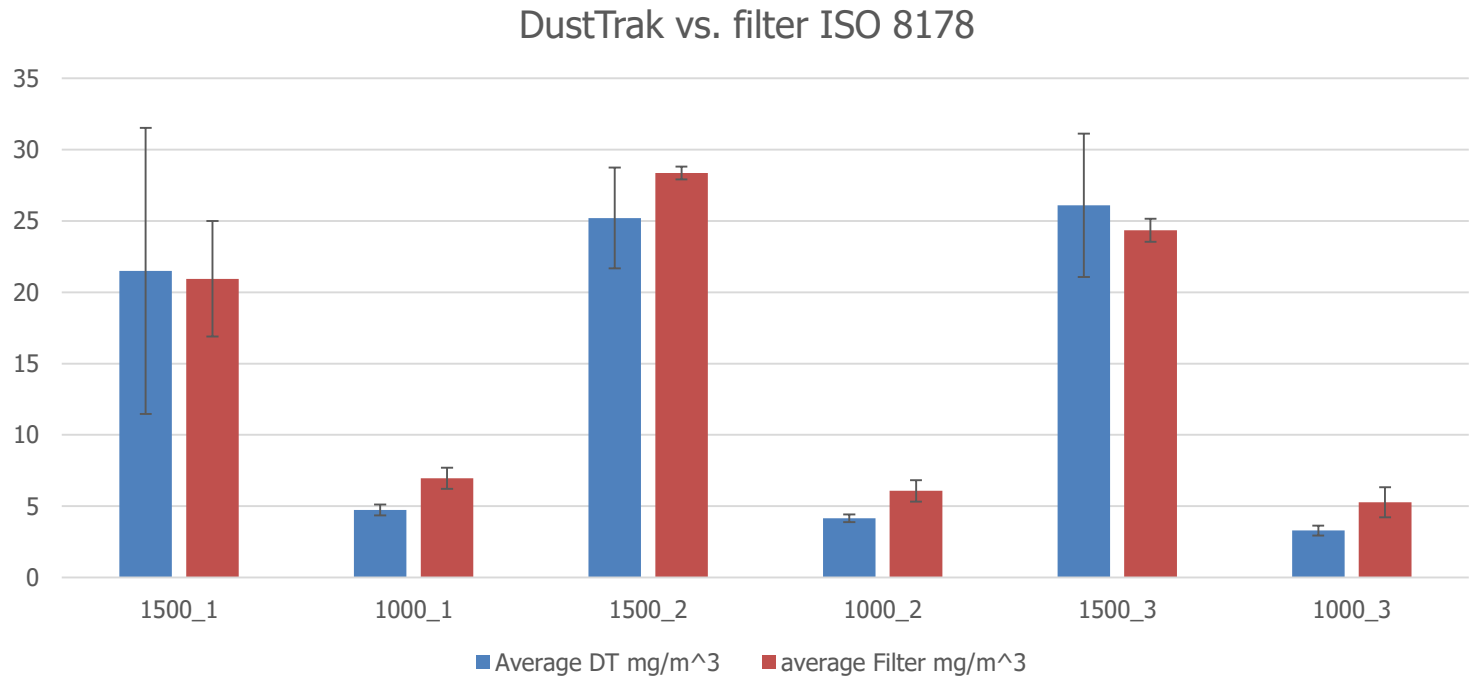

- Good correlation between real-time measurements and traditional PM sampling

Conclusion

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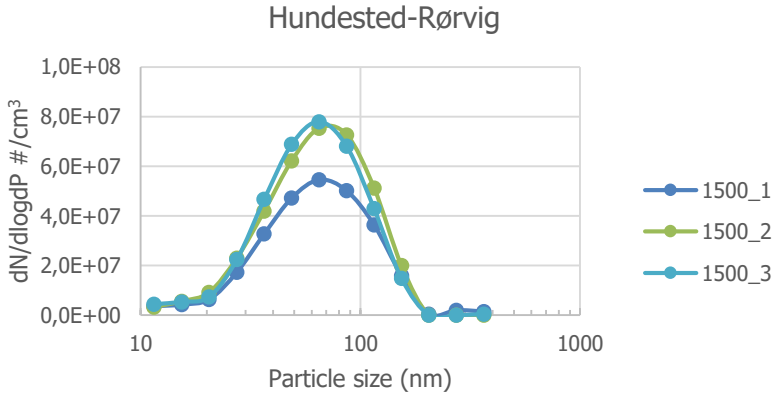
- Increased Danish and global focus on ship emissions, not least near cities and coastal areas
- Emissions have been characterized for 3 ships/ferries operating in Danish waters
- Presently, one installation is finalized with the two others in progress
  - Significant noise reduction (~10 dB outside)
  - High PM/PN reduction expected
- Good correlation between different PM measurement methods – to be further investigated



Next steps in the project

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- Finalize retrofit DPF/SCR solutions for 2nd and 3rd case
- Measure effectivity of all solutions
- Further comparisons between PM measurement equipment – focus on simple monitoring. Also with Pegasor equipment.
- Ambient measurements – focus on measuring the ”true” effect on passengers and crew.

Acknowledgements

- Hundested Rørvig Færgefart
- Sundbusserne
- World Marine Offshore
- Exilator ApS
- Amminex Emissions Technology
- Purefi A/S
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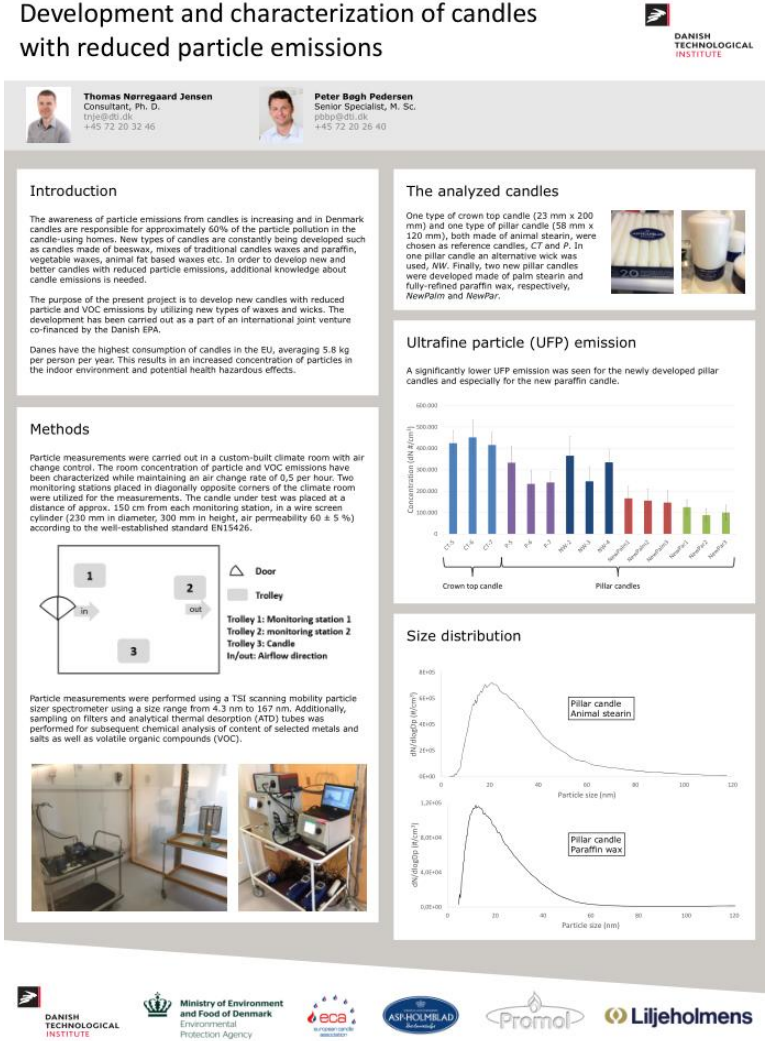
- Danish Maritime

- Financial support from the Danish EPA

Poster no. 24

- Candles are responsible for ~60% of the particle pollution in candle-using homes



Development and characterization of candles with reduced particle emissions

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Introduction

The awareness of particle emissions from candles is increasing and in Denmark candles are responsible for approximately 60% of the particle pollution in the candle-using homes. New types of candles are constantly being developed such as candles made of beeswax, mixes of traditional candles waxes and paraffin, vegetable waxes, animal fat based waxes etc. In order to develop new and better candles with reduced particle emissions, additional knowledge about candle emissions is needed.

The purpose of the present project is to develop new candles with reduced particle and VOC emissions by utilizing new types of waxes and wicks. The development has been carried out as a part of an international joint venture co-financed by the Danish EPA.

Danes have the highest consumption of candles in the EU, averaging 5.8 kg per person per year. This results in an increased concentration of particles in the indoor environment and potential health hazardous effects.

Methods

Particle measurements were carried out in a custom-built climate room with air change control. The room concentration of particle and VOC emissions have been characterized while maintaining an air change rate of 0,5 per hour. Two monitoring stations placed in diagonally opposite corners of the climate room were utilized for the measurements. The candle under test was placed at a distance of approx. 150 cm from each monitoring station, in a wire screen cylinder (230 mm in diameter, 300 mm in height, air permeability 60 ± 5 %) according to the well-established standard EN15426.

Particle measurements were performed using a TSI scanning mobility particle sizer spectrometer using a size range from 4.3 nm to 167 nm. Additionally, sampling on filters and analytical thermal desorption (ATD) tubes was performed for subsequent chemical analysis of content of selected metals and salts as well as volatile organic compounds (VOC).

The analyzed candles

One type of crown top candle (23 mm x 200 mm) and one type of pillar candle (58 mm x 120 mm), both made of animal stearin, were chosen as reference candles, *C7* and *P*. In one pillar candle an alternative wick was used, *NW*. Finally, two new pillar candles were developed made of palm stearin and fully-refined paraffin wax, respectively, *NewPalm* and *NewPar*.

Ultrafine particle (UFP) emission

A significantly lower UFP emission was seen for the newly developed pillar candles and especially for the new paraffin candle.

Size distribution

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Ministry of Environment and Food of Denmark
Environmental Protection Agency
eca european candle association
ASP-HOLMBLAD
Promot
Liljeholmens