Particle Emissions From Burning of Waste in Wood-Burning Stoves

Maj Frederiksen
Centre for Chemistry and Biotechnology, Danish Technological Institute

19th ETH-conference on Combustion Generated Nanoparticles, June 30 2015

Background

DANISH TECHNOLOGICAL INSTITUTE

- The more than 750,000 wood burning stoves in Denmark
  - Particle emissions
  - Emission of compounds harmful to the health and environment
  - Especially problem when burning illegal materials
- Strict legislation and the local authority must supervise
- Difficult to prove burning of illegal materials – A tool or method is needed

Photo: Danish Technological Institute

The project

DANISH TECHNOLOGICAL INSTITUTE

- Co-funded by the Danish Environmental Protection Agency
- Collaboration with councils and chimney sweepers and DTI
- Main focus: developing sampler to detect burning of illegal materials in private wood-burning stoves
- Several test burnings for proving the usefulness of the "sampler" have been conducted
- In parallel with these tests particle emissions (number and mass) have been measured online
- Project runs until December 2015

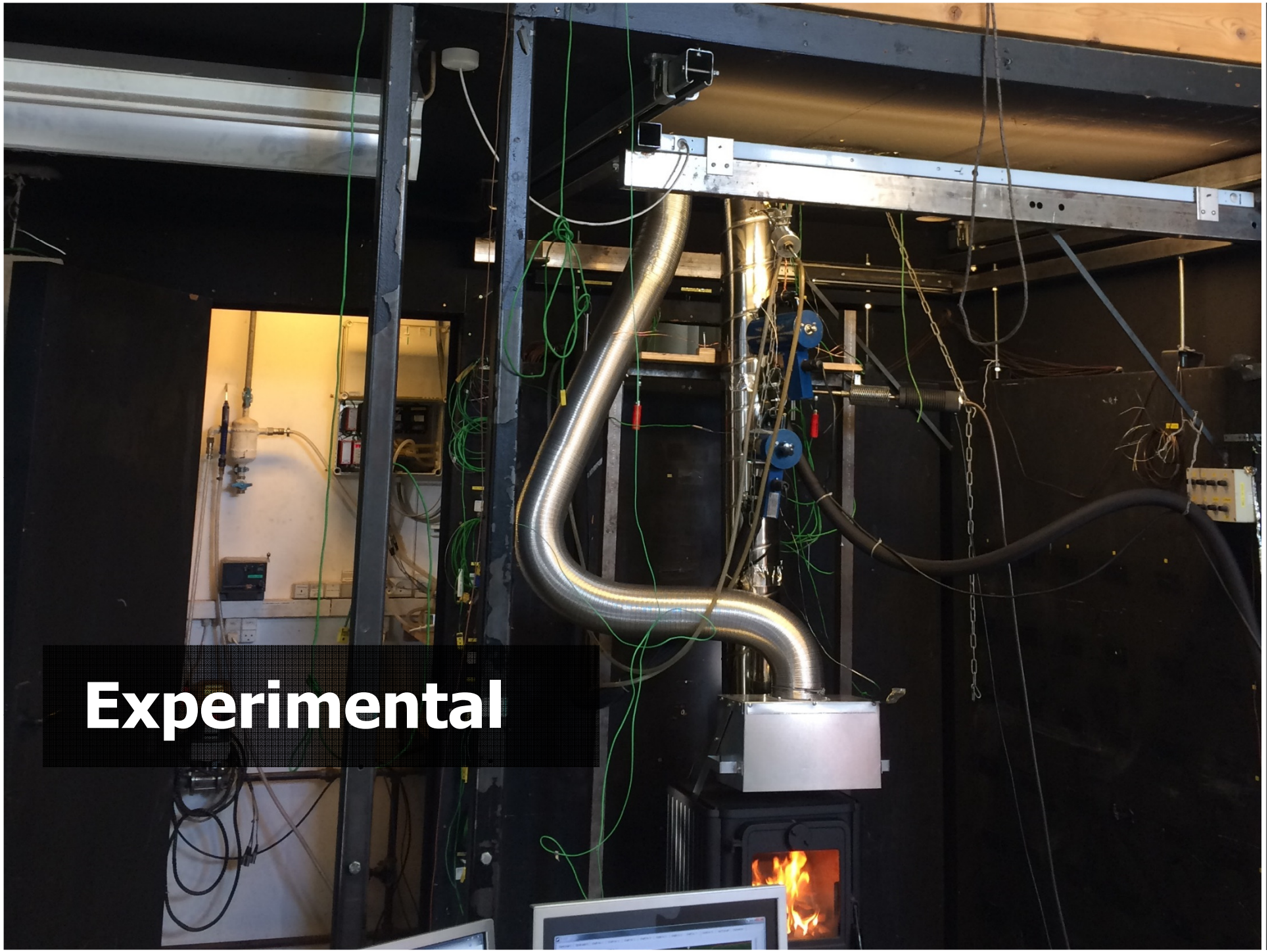
Types of illegal materials

DANISH TECHNOLOGICAL INSTITUTE

- Chromated copper arsenate (CCA) wood
- Creosote-treated wood
- Milk cartons, gift wrapping paper and papers
- Painted wood
- Wood containing PCBs

- References: pure birch wood

- No results yet: laminate wood and wood from pallets


Experimental

Experimental set-up

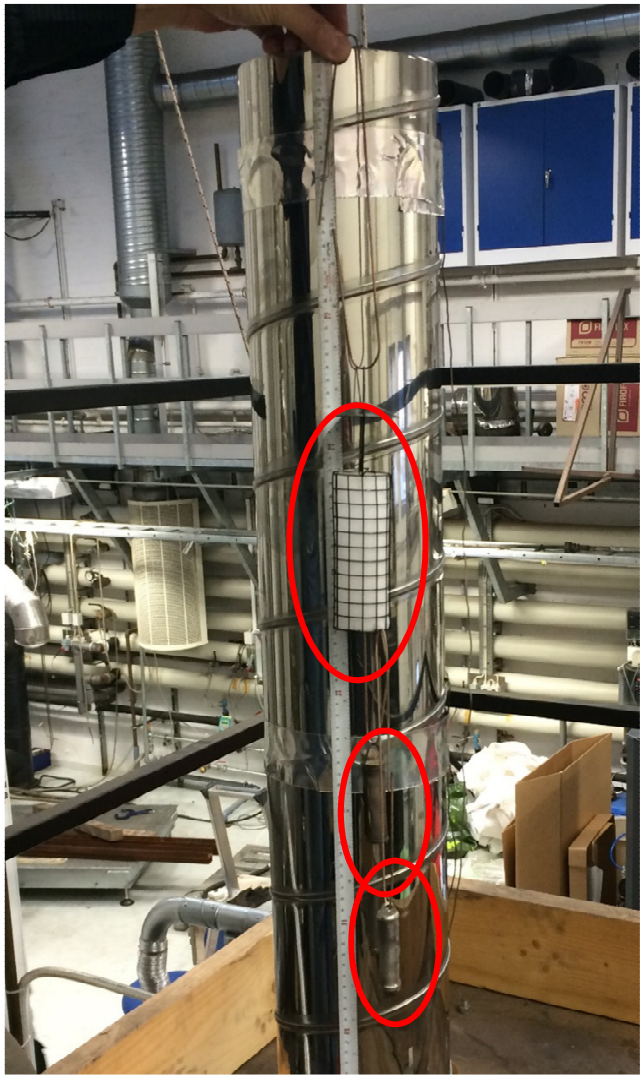
DANISH TECHNOLOGICAL INSTITUTE

- Morsø 1440
  - Standard wood burner in Denmark
- Ignition phase, pre-charge and three to four charges
- 1.6 kg material for each charge (less for milk cartons)

Set-up – chemical samples

DANISH TECHNOLOGICAL INSTITUTE

- Samples for chemical detection of burning of waste (illegal materials)
- "Samplers" in chimney: polyurethane foam, silicone film, XRD (absorbent powder)
- Soot samples from chimney
- Ash samples from wood burner



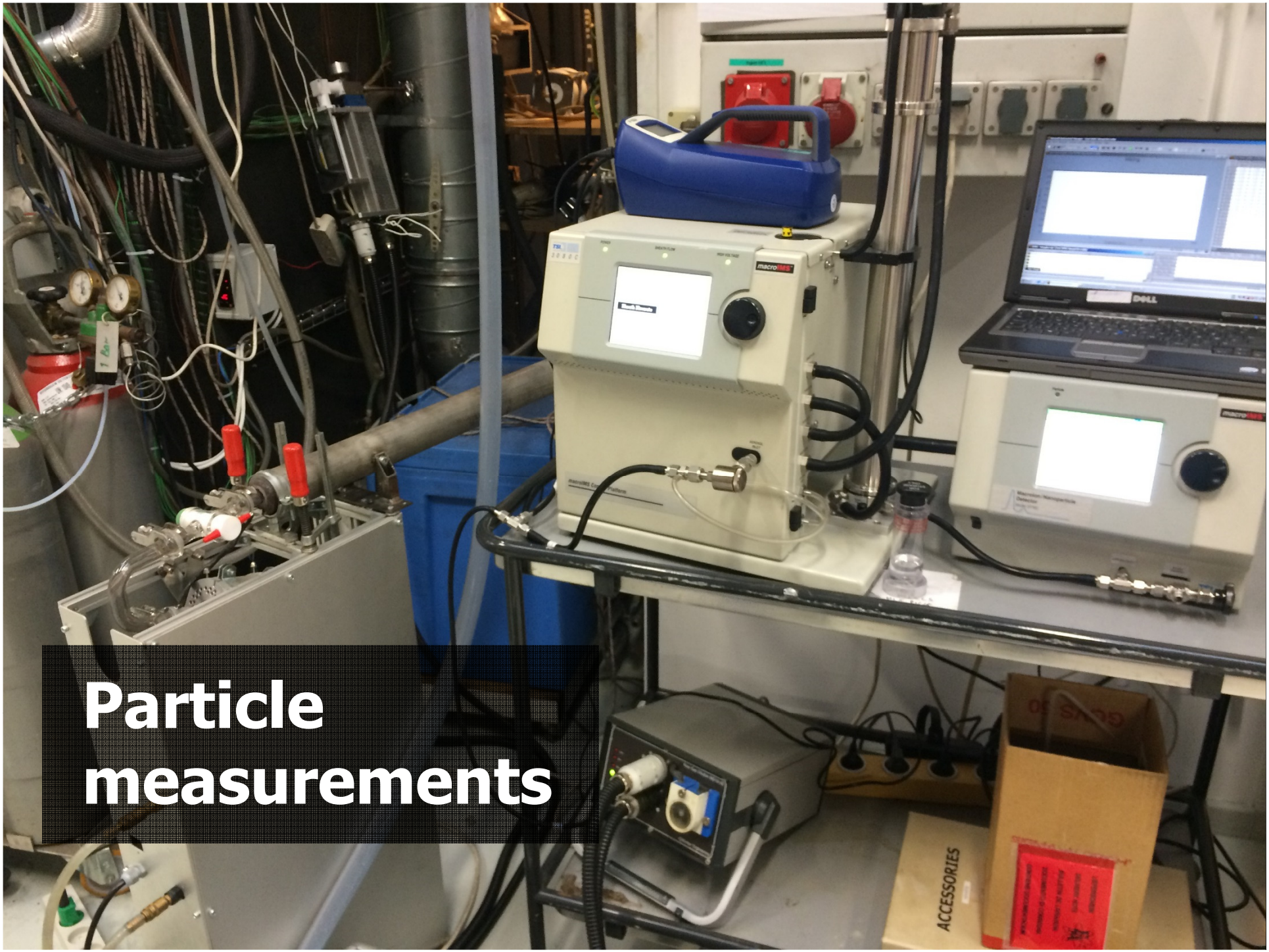
Before burning

Set-up – chemical samples

DANISH TECHNOLOGICAL INSTITUTE

- Samples for chemical detection of burning of waste (illegal materials)
- "Samplers" in chimney: polyurethane foam, silicone film, XRD (absorbent powder)
- Soot samples from chimney
- Ash samples from wood burner

After burning


Particle measurements
ACCESSORIES

Particle measurement equipment

DANISH TECHNOLOGICAL INSTITUTE

- SMPS (TSI):

Particle size and number concentration are measured in the size interval 14-710 nm with a time resolution of 3 minutes.

- P-trak (TSI)

Instant peak measurements of particle number concentration in the size interval 20-1,000 nm with a time resolution of 1 sec. For more frequent measurements than SMPS

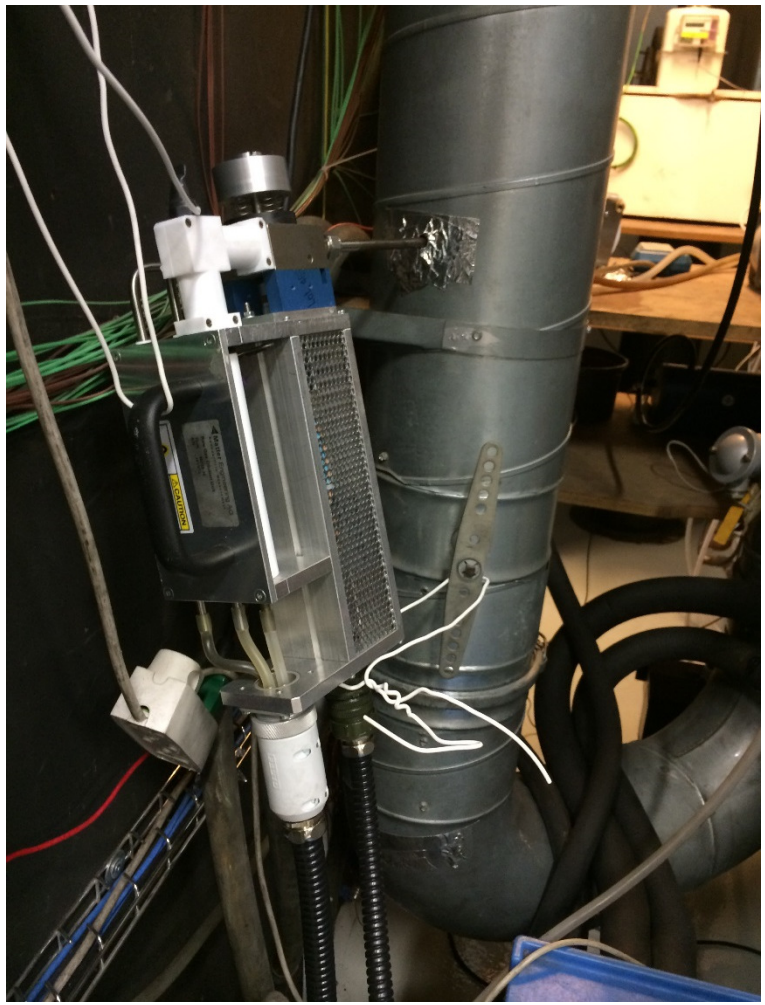
- DustTrak DRX (TSI)

Determining total particle mass (PMtotal), also continuously logging PM1, PM2.5, PM4, PM10.

Sampling and dilution

DANISH TECHNOLOGICAL INSTITUTE

- Dilution in chimney/ventilation system: 25-30 times (calculated for each charge)
- Gas temperature 30-35°C at outlet
- Isokinetic sampling (approximately) for DustTrak
- Rotating disk diluter (Matter): 30 times dilution for SMPS and P-Trak

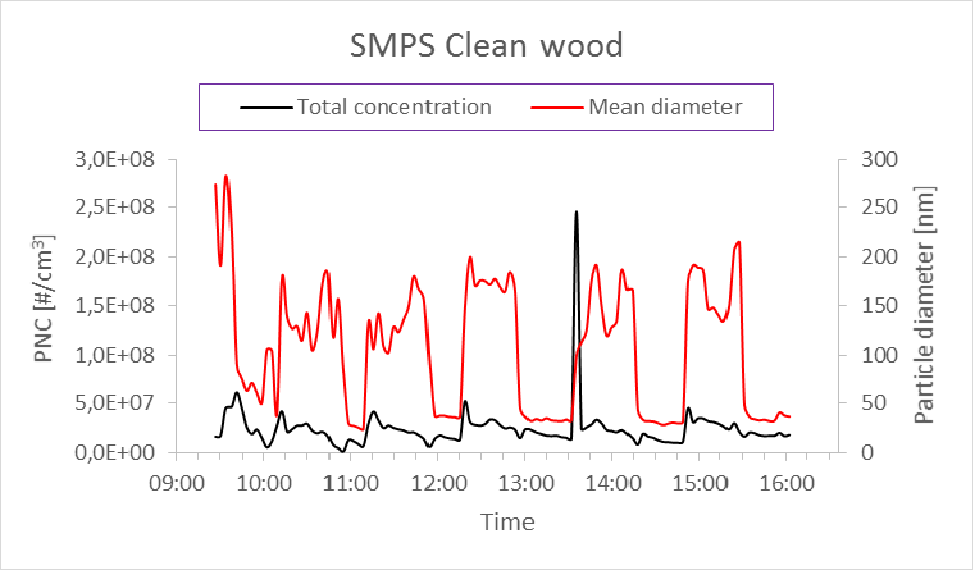


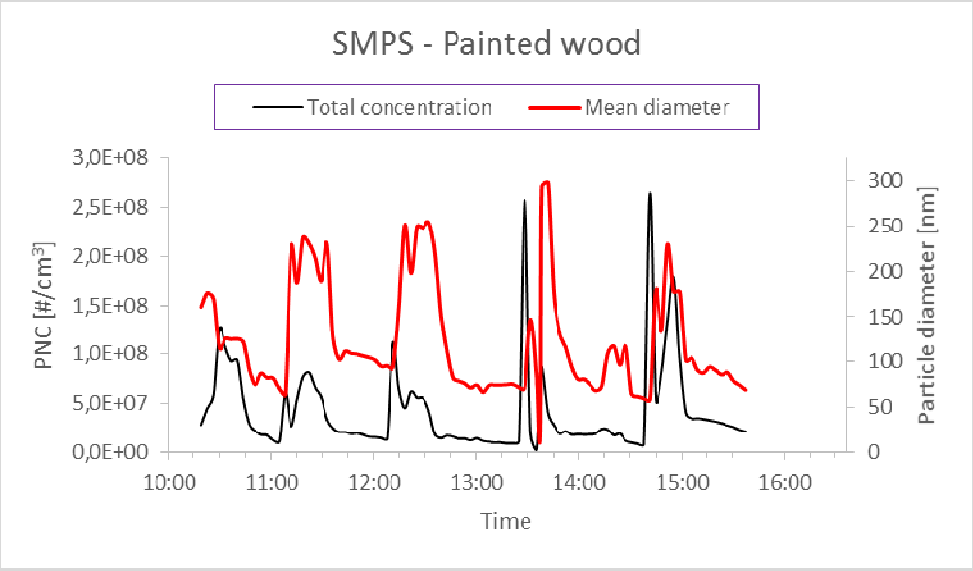

Results

Birch wood (clean) vs. painted wood

DANISH TECHNOLOGICAL INSTITUTE

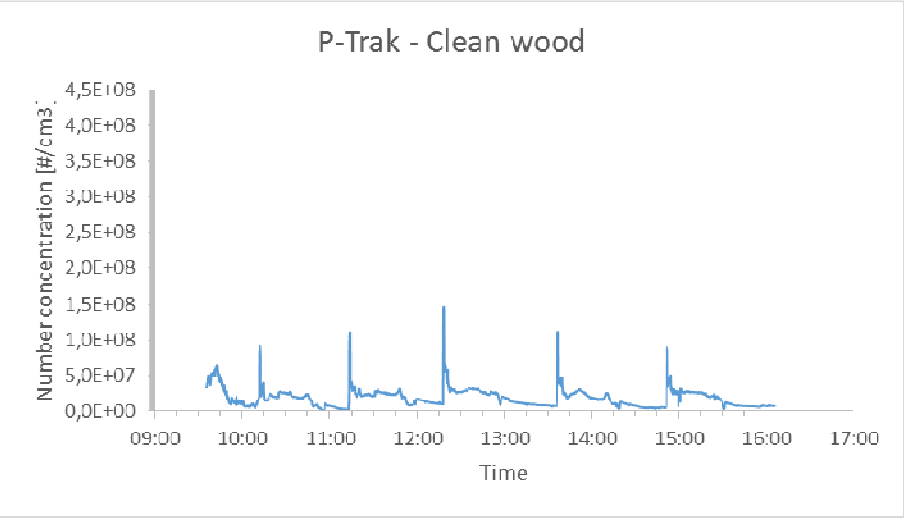
- SMPS data:
  - Number concentration
  - Mean diameter
- Data from ignition, pre-charge and 3 or 4 charges
- The number concentration is generally higher and slower to go down for the painted wood

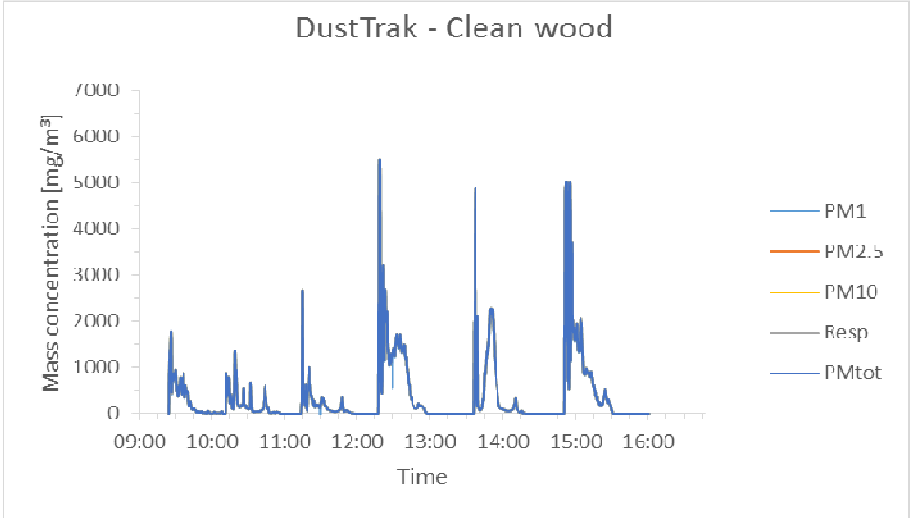


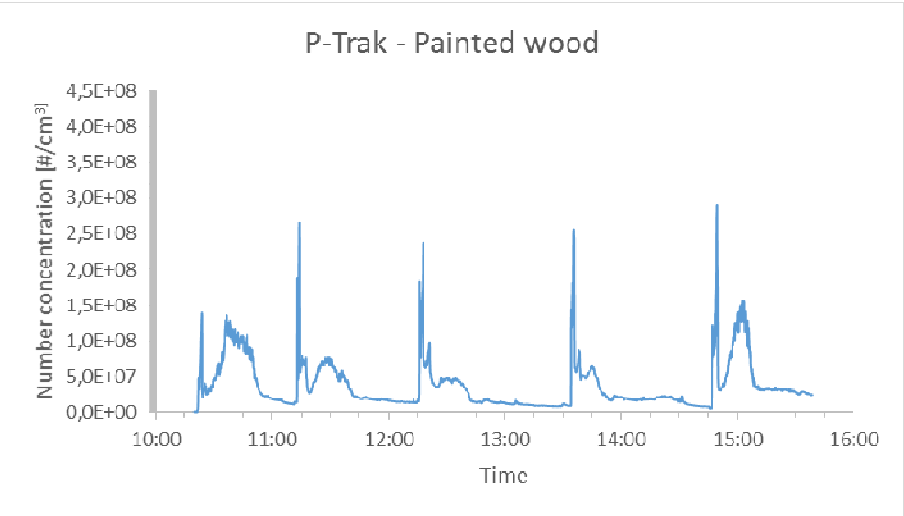


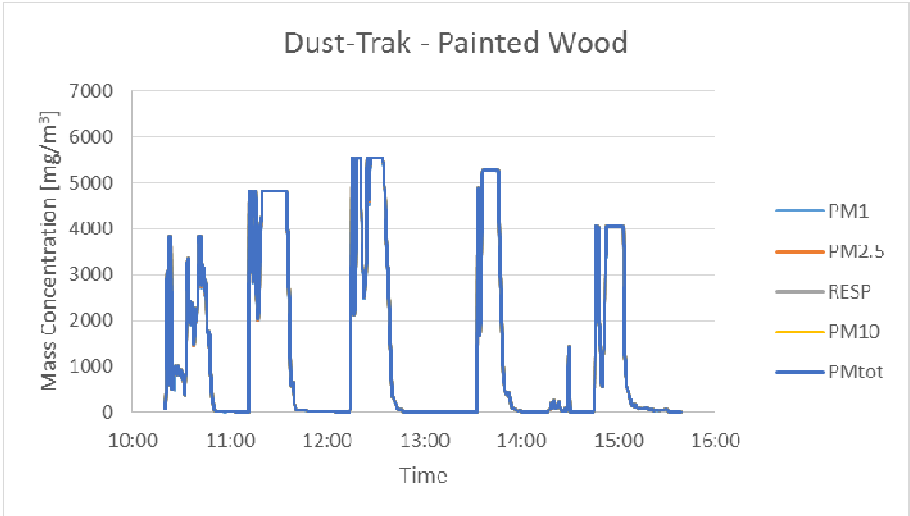
Birch wood (clean) vs. painted wood

DANISH TECHNOLOGICAL INSTITUTE



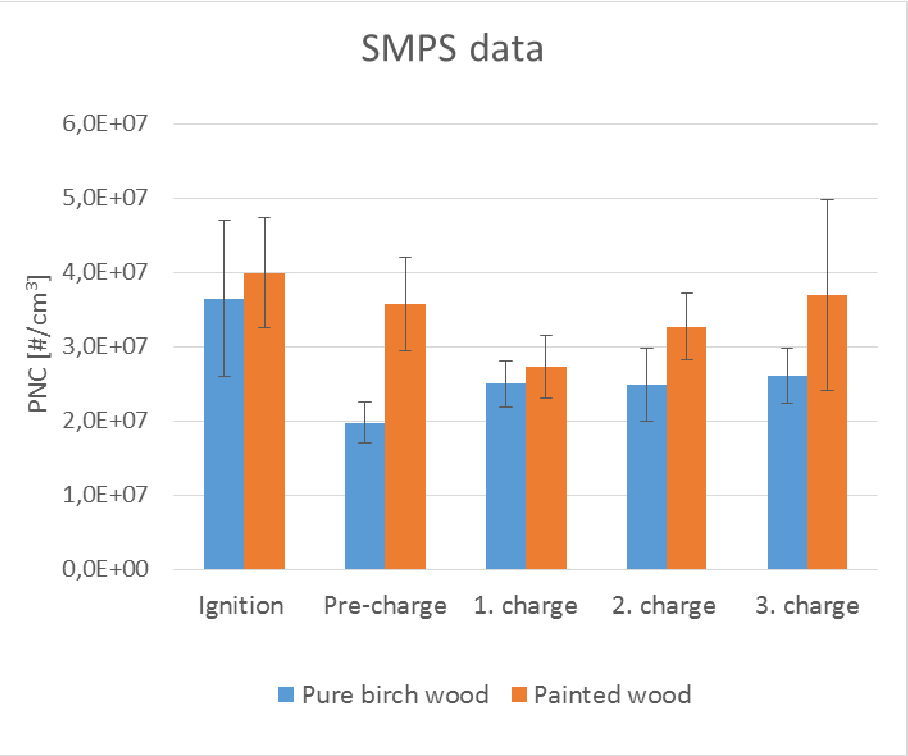


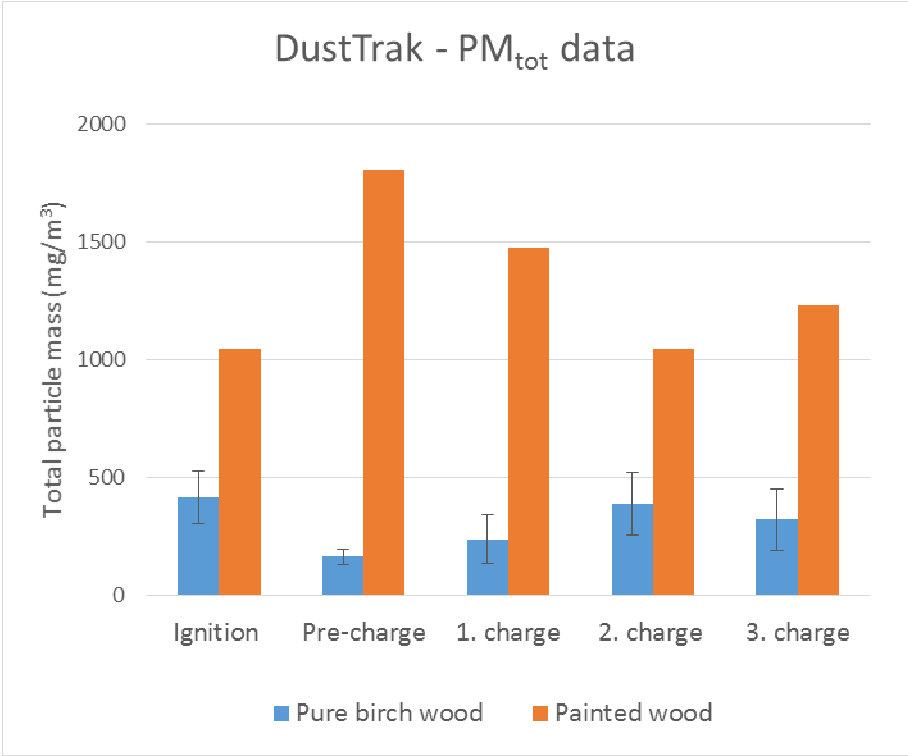




Birch wood (clean) vs. painted wood

DANISH TECHNOLOGICAL INSTITUTE





- Particle number concentrations comparable for pure and painted wood
- Total particle mass concentration is higher for painted wood than for pure wood

- Note: DustTrak values are too low for the painted wood due to long periods of saturation

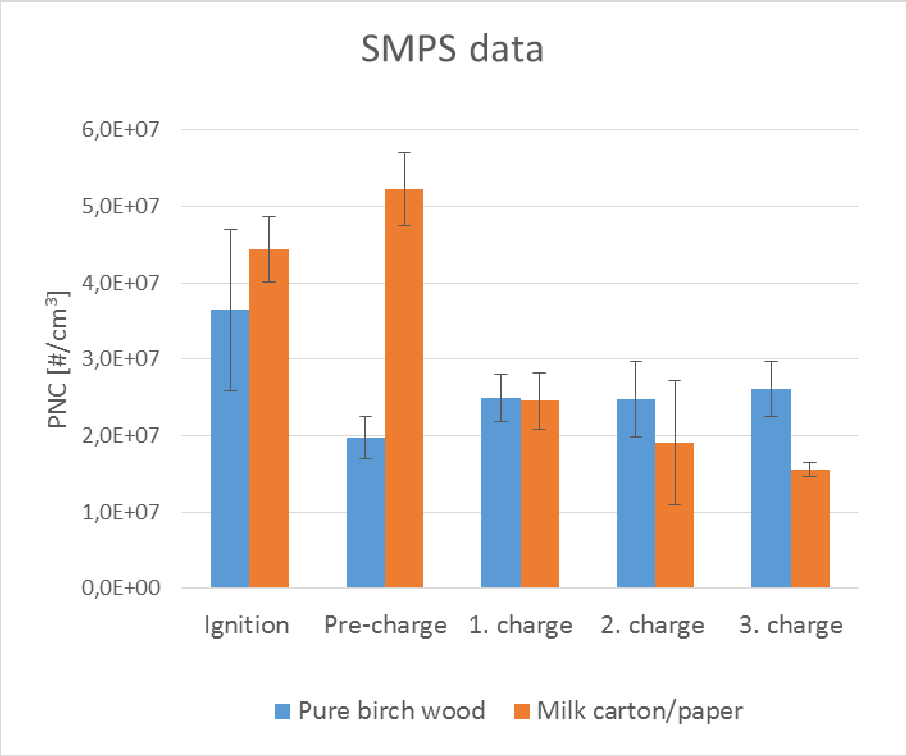
Milk cartons and papers

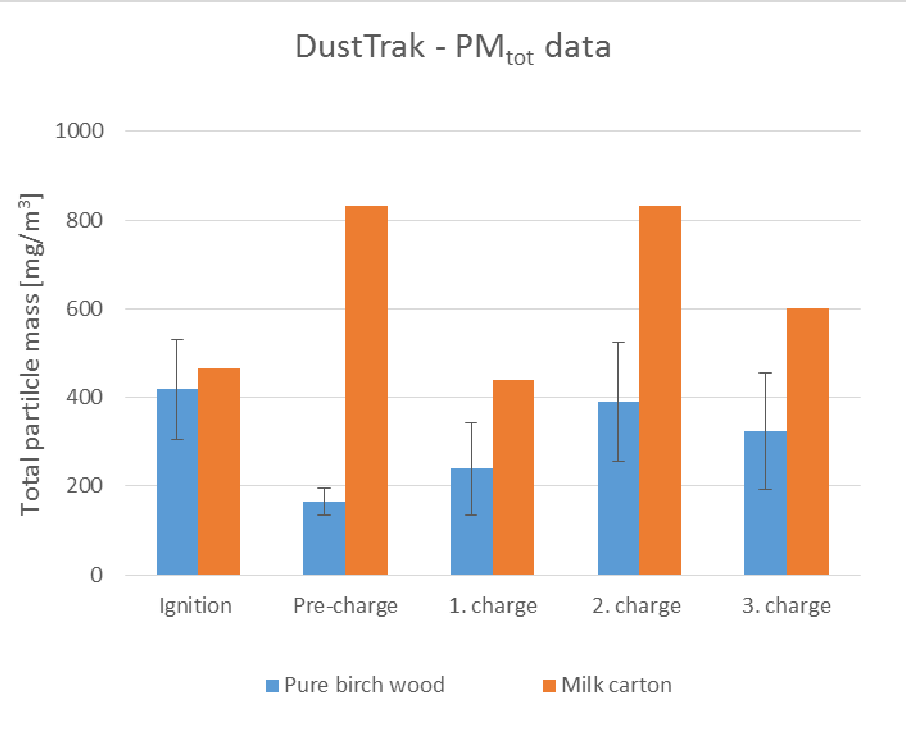
DANISH TECHNOLOGICAL INSTITUTE

- On enquiry from the Danish Environmental Protection Agency (funding body)
- Difficult to keep burning and very low flow
- A lot of ash
- Dirty combustion –> DustTrak in saturation and P-Trak error

Milk cartons and papers

DANISH TECHNOLOGICAL INSTITUTE



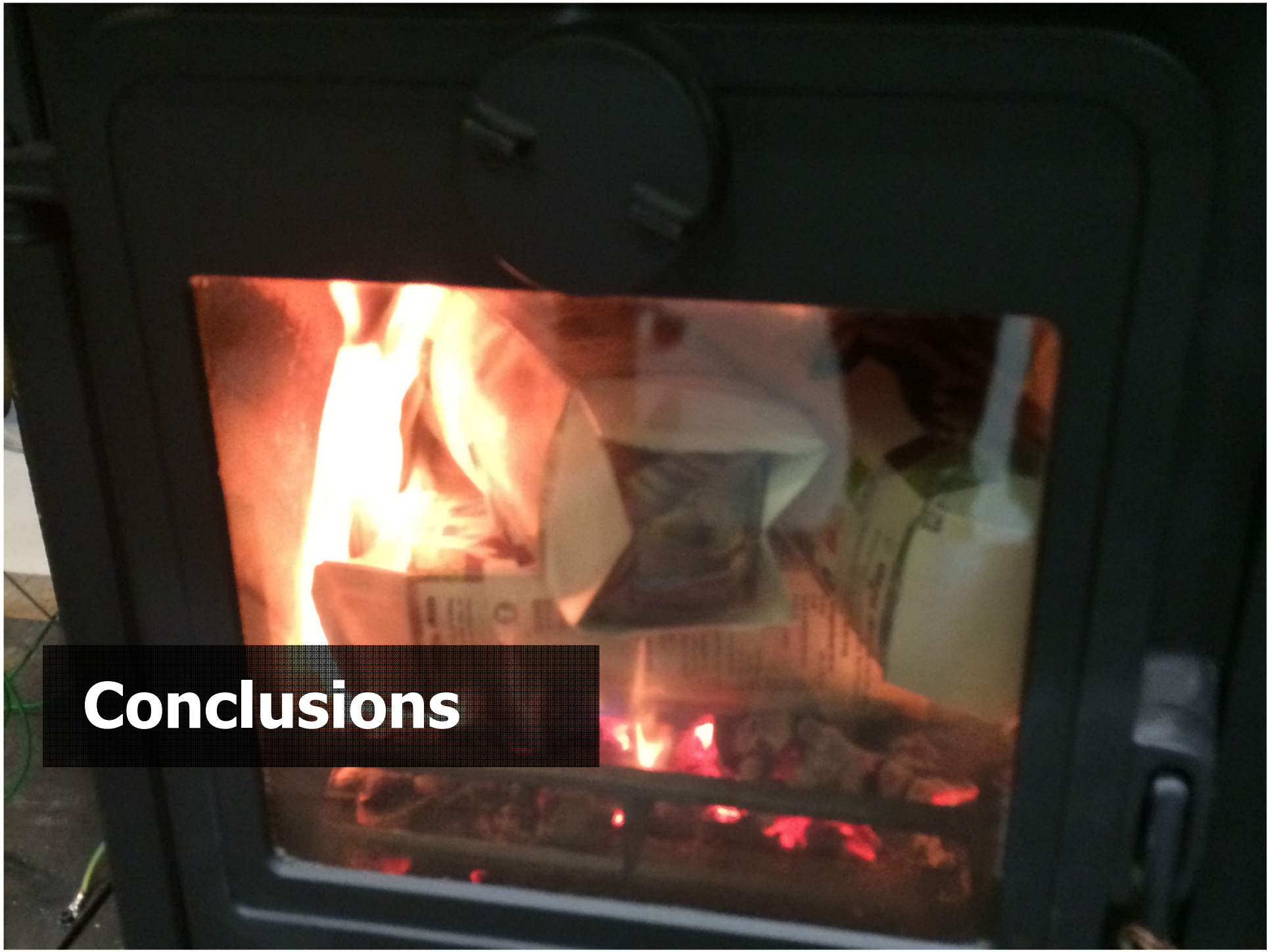


- Ignition with pure wood and limited mass loaded in each charge for milk carton/paper experiments
- Total particle number/mass is generally higher for milk cartons/papers than for pure wood
- DustTrak values are too low for the milk cartons/papers due to periods of saturation

Other materials

DANISH TECHNOLOGICAL INSTITUTE

- Creosote wood: burned surprisingly well and with comparable particle emission as pure wood
- PCB wood: contained paint and behaved like painted wood
- CCA wood: higher particle emissions than pure wood


Conclusions

Conclusions

DANISH TECHNOLOGICAL INSTITUTE

- Chemical analysis of soot and "sampler" under way
- Extreme conditions – not normal to use purely illegal materials
- Particle measurements give very interesting knowledge on burning of illegal materials for future references
- Painted wood: higher total particle mass than pure wood
- Milk cartons and paper: poor burning and higher particle emissions than pure wood
- Creosote wood: particle emissions similar to pure wood

Acknowledgements

- Thanks to all parties involved
  - *Odense Counsil*
  - *Vejle Counsil*
  - *Esbjerg Counsil*
  - *Skive Counsil*
  - *Chimney sweeper master Henrik B. Jensen*
  - *Chimney sweeper master Kim Laue Christensen*
  - *Chimney sweeper master Martin H. Andersen*
  - *Mikrolab Aarhus A/S*

- Peter Bøgh Pedersen, DTI, project manager

- Financial support from the Danish Environmental Protection Agency

Thank You!

Maj Frederiksen, PhD, Consultant
Contact: mafr@teknologisk.dk