Central European Biomass Conference 2011, Graz
Workshop: Fine particulate emissions from small-scale biomass furnaces

The effect of gasification-combustion technology on emissions

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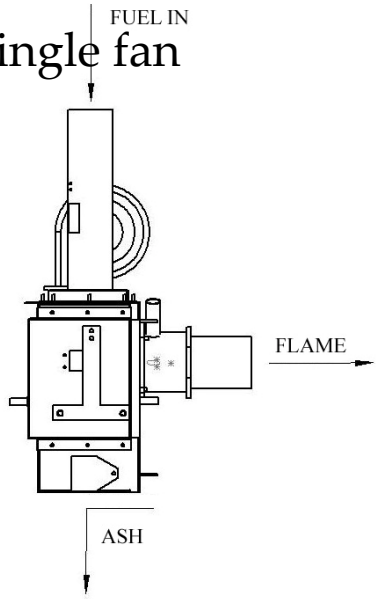
Pyro-Man Burner – 15 kW

Features

- Small scale fixed-bed counter-draft gasifying pellet burner
- Desinged to replace oil burner using the old boiler system
- Staged primary/secondary/tertiary air feeding with a single fan
- Fully computer controlled
- Fuel bed ignition with electric heater
- First gasifies the wood pellet and
  Then burns produced syngas in a ceramic burner head



Gasification

- Thermal counter-draft fixed bed gasification on grate
  - –Process which converts fuel to a combustible gas with a partial/ controlled oxygen level.

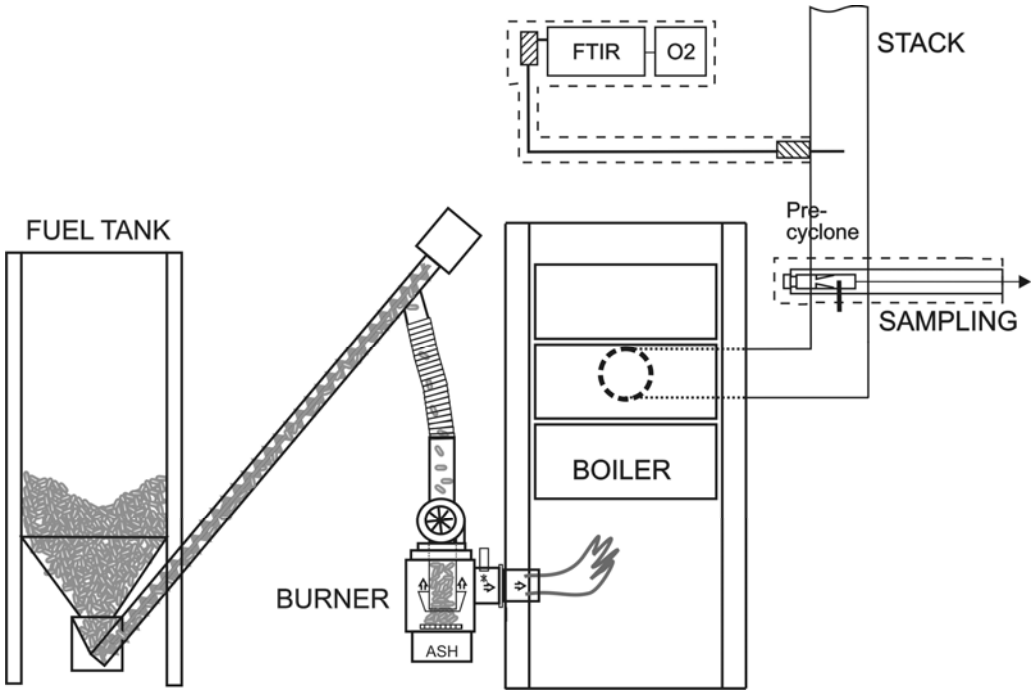
- Oxidant – air

- Product – Syngas (H_2, CO, CH_4, CO_2, H_2O, tars)

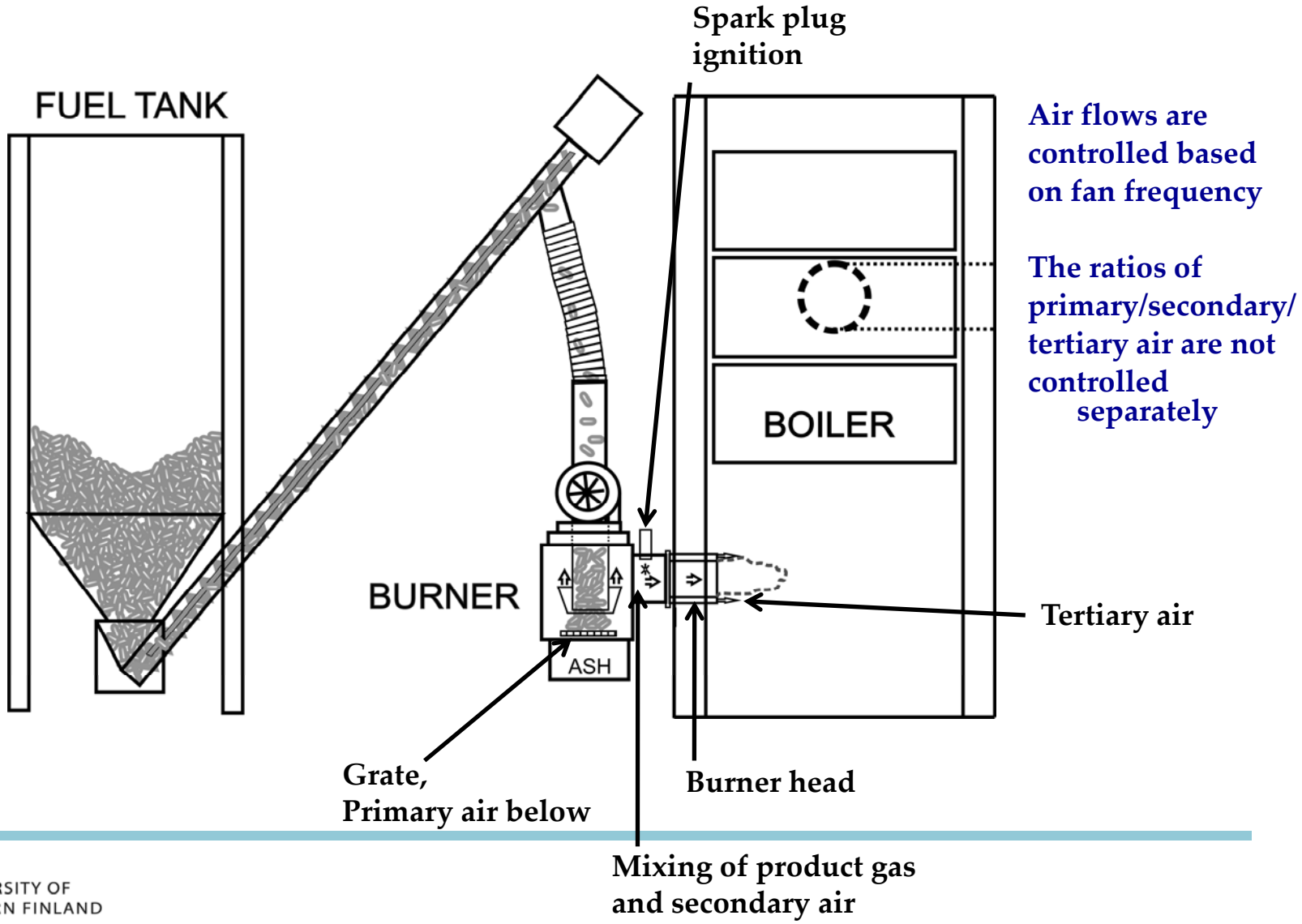
- Syngas heating value 10-12 MJ/Nm^3 – low compared to other combustible gases (CH4 heating value 38 MJ/Nm^3)

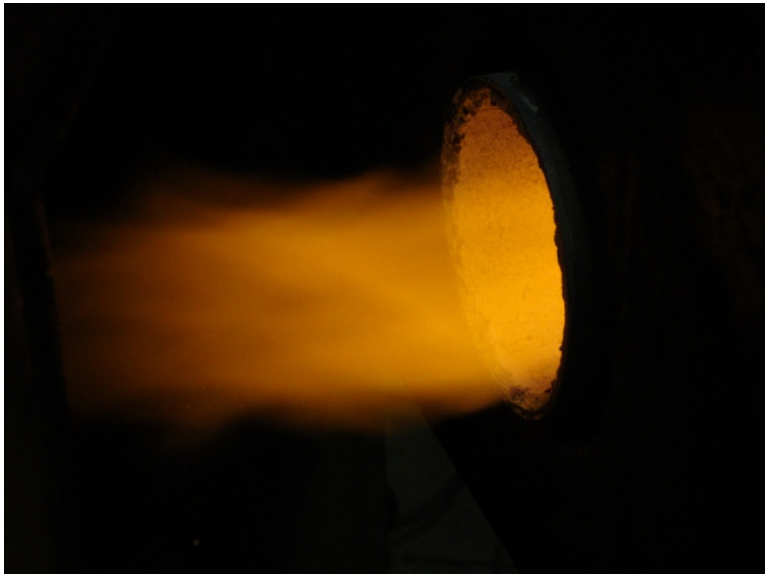
Burner setup

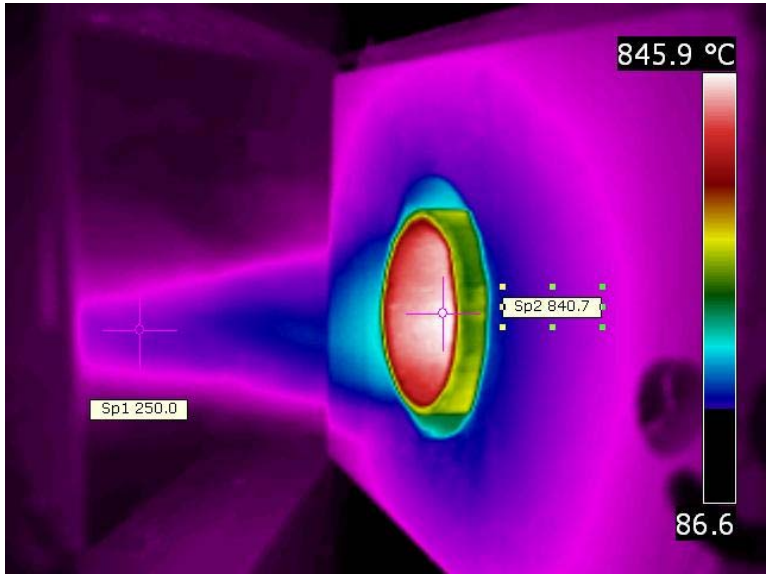
- Pellet feeding with screw conveyer
- IR-sensor detects fire from grate and controls the fuel feeding
- Ignition of the syngas with a spark plug
- Power modes: Idle, Partial, Full
- Tests were made with full load



- Product gas temperature is measured continuously and taken as input into the gasification control
- Optical sensor installed on top of the gasifier is used in fuel supply control






845.9 °C
Sp2 840.7
Sp1 250.0
86.6

Fuel properties

- Moisture 6,2 %
- Dry Matter 93,9 %
- Ash 0,36 % (included in dry matter)
- Lower heating value, (dry) 18,95 MJ/kg

Fuel Chemical Composition		
Ca	892	mg/kg
K	717	mg/kg
Si	260	mg/kg
Na	249	mg/kg
Mg	142	mg/kg
Cl	100	mg/kg
Zn	1	mg/kg
S	0.02	mg/kg

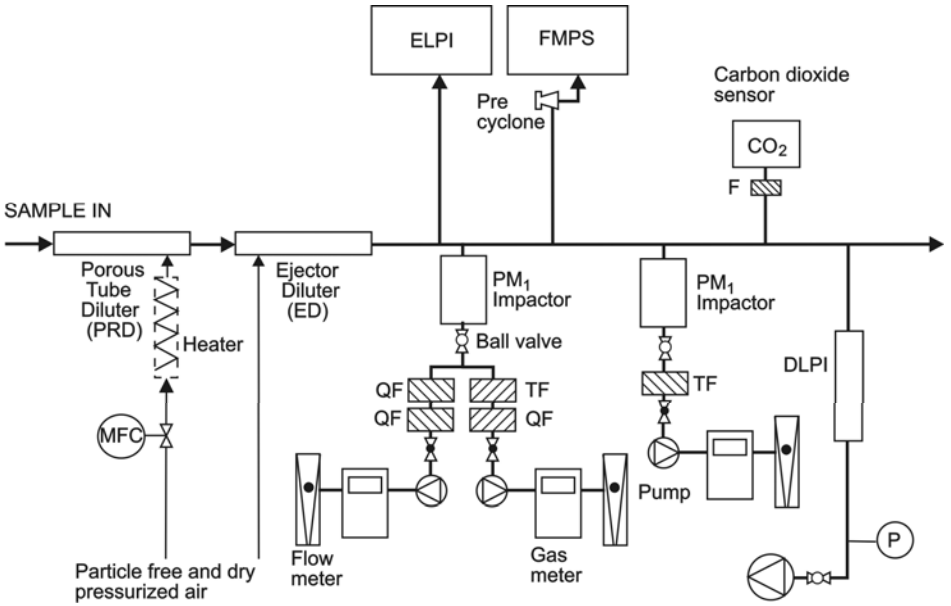
Emissions measurement setup

•Dilution with porous tube & ejector

•PM1 chemical analyses:
- •Thermal-Optical carbon analysis
- •ICPMS - analysis
- •Ion Chromatography

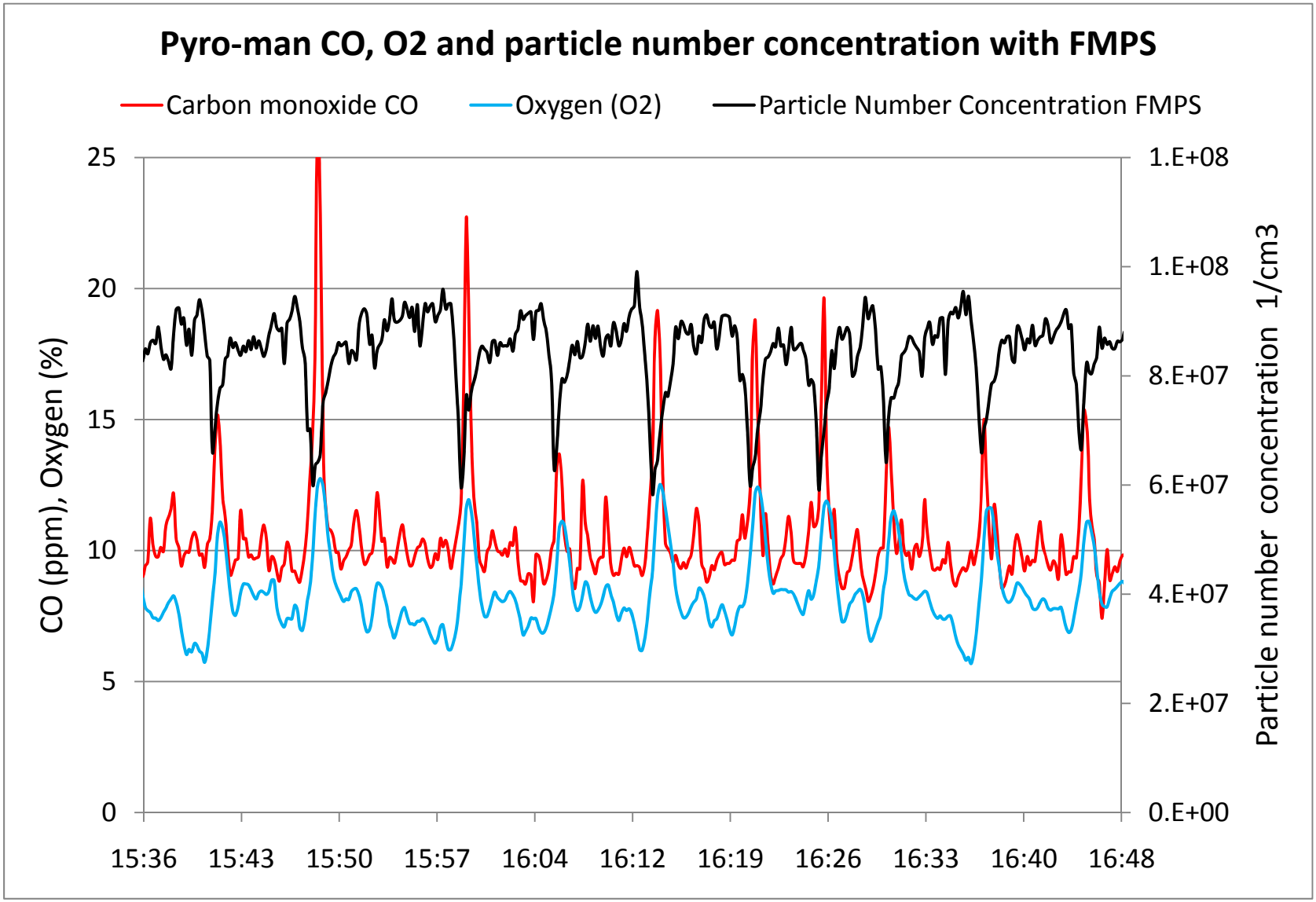
• Particle number concentration:
- •ELPI
- • FMPS

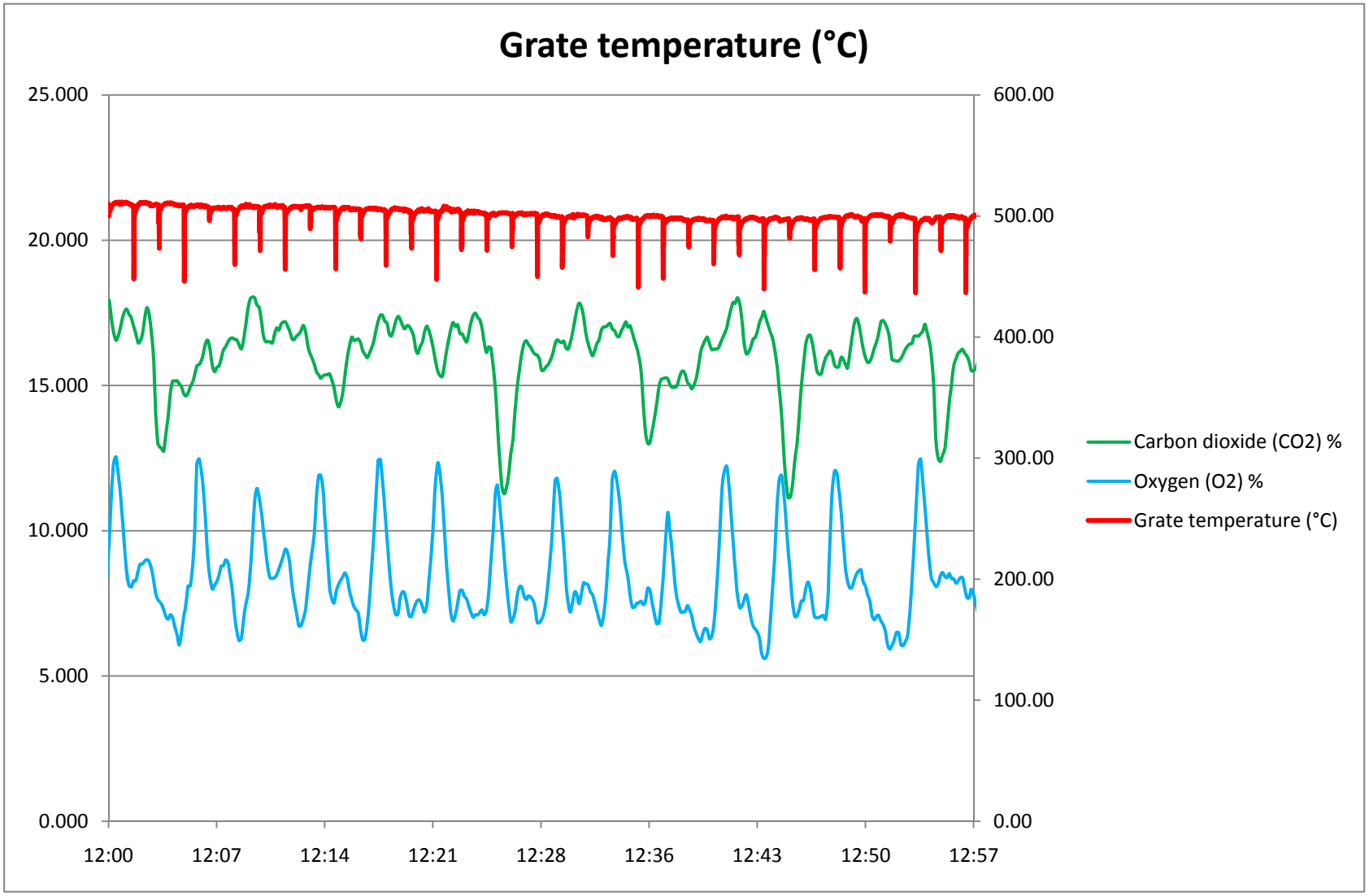
• Particle mass concentration:
- •PM1
- •APM



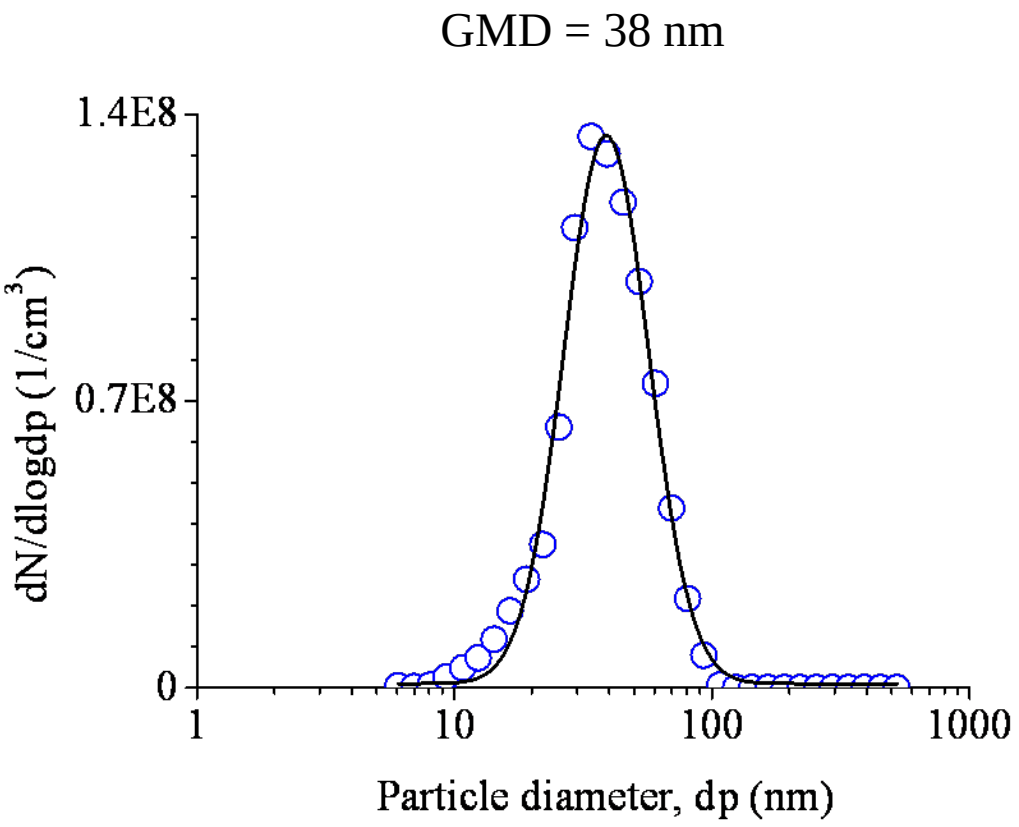
Emission measurement results

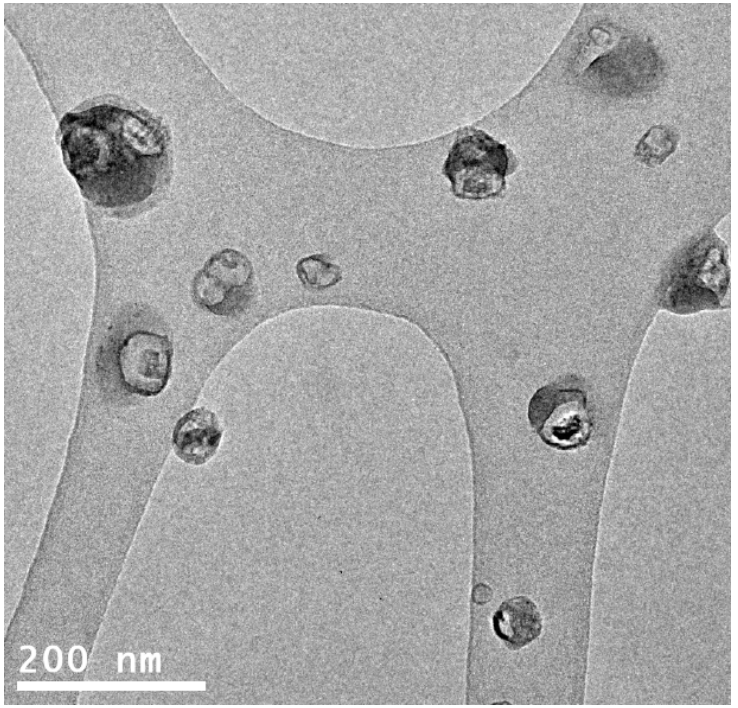
- PM1 emission 1,4 – 2,4 mg/MJ (27- 43 mg/kg)
- TSP 1,8-2.0 mg/MJ
- CO – 4,8 to 6 mg/MJ
- NO – 120-140 ppm / 60-80 mg/MJ
- Particle number emission 1.8×10^{13}/MJ.


Pyro-man CO, O2 and particle number concentration with FMPS
Carbon monoxide CO
Oxygen (O2)
Particle Number Concentration FMPS
CO (ppm), Oxygen (%)
Particle number concentration 1/cm3
25
20
15
10
5
0
1.E+08
1.E+08
8.E+07
6.E+07
4.E+07
2.E+07
0.E+00
15:36
15:43
15:50
15:57
16:04
16:12
16:19
16:26
16:33
16:40
16:48


Grate temperature (°C)
25.000
20.000
15.000
10.000
5.000
0.000
600.00
500.00
400.00
300.00
200.00
100.00
0.00
12:00
12:07
12:14
12:21
12:28
12:36
12:43
12:50
12:57
Carbon dioxide (CO2) %
Oxygen (O2) %
Grate temperature (°C)

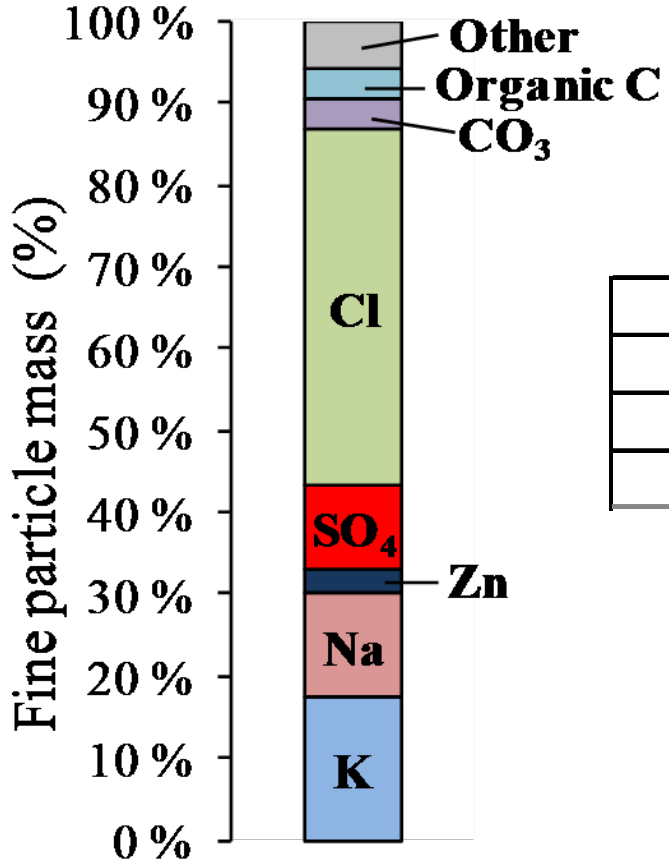
Particle size distribution





-Fine particle density 1000-1300 kg / m^3
-Measured with APM

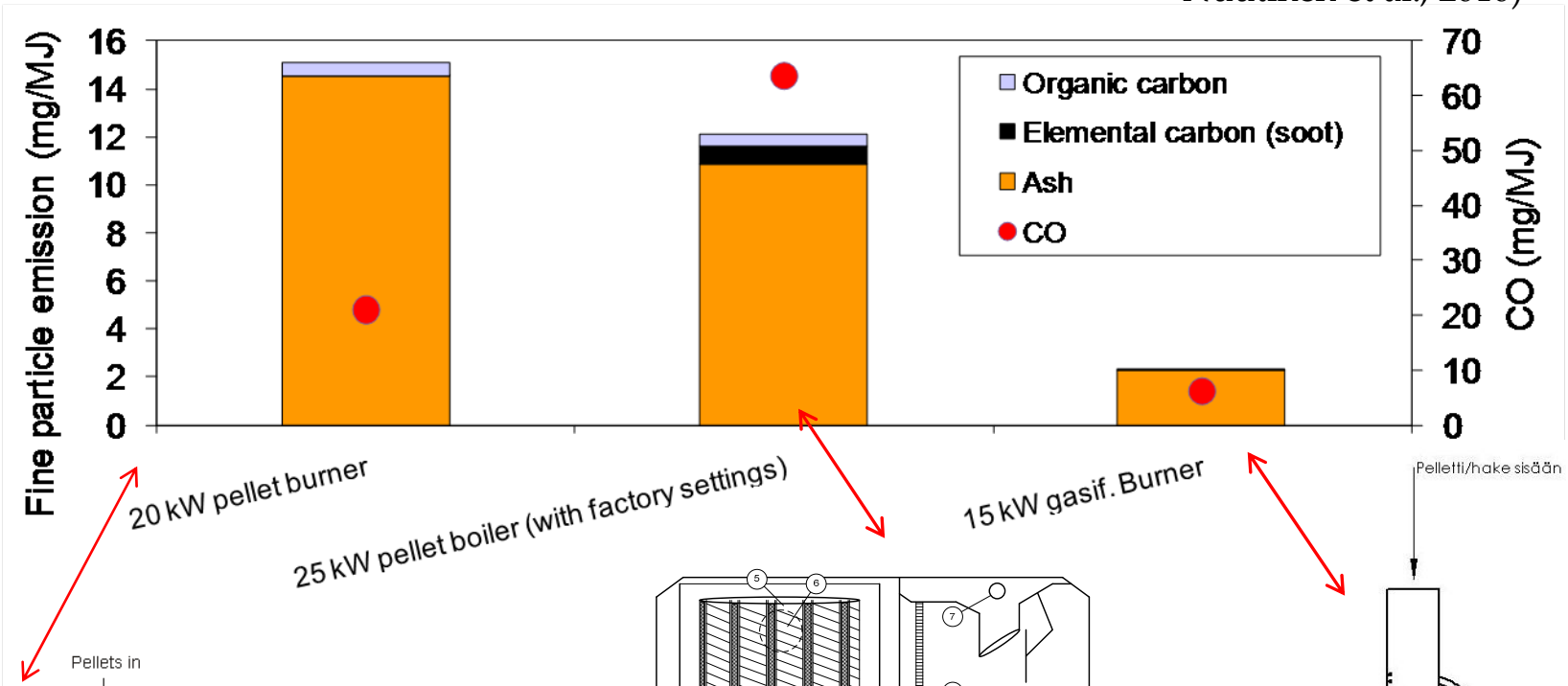
Fine particle chemical composition

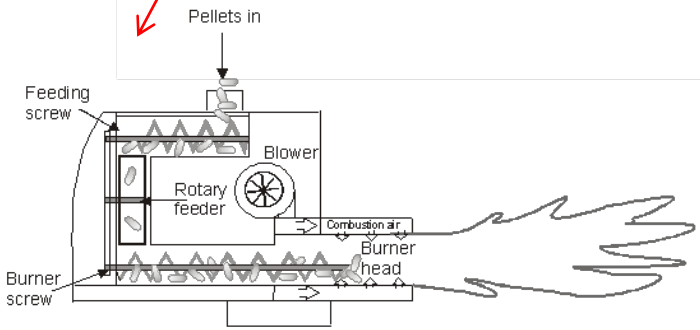


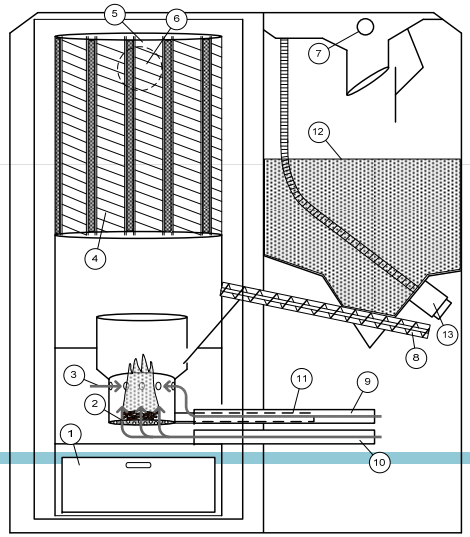
Element	PM1 Release fraction (%)
Cl	8-17
Na	1.8-2.8
K	0.8-1.7

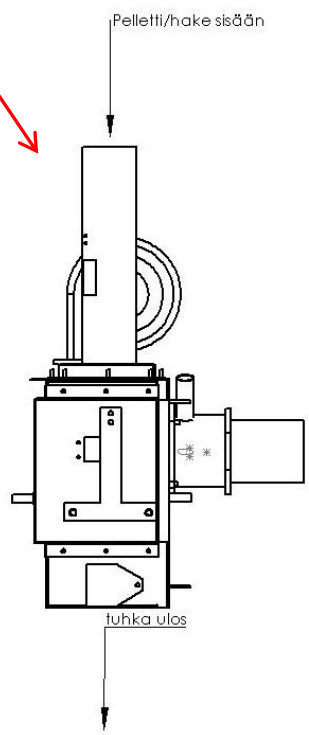
Comparison of technologies: Residential scale

(Tissari et al., 2008, Lamberg et al., 2009, Nuutinen et al., 2010)









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Conclusions – Pyro-Man pellet burner

- Low Flue Gas O_2-level / High CO_2-level
- Low emissions of combustible carbon
- Very low CO – emissions

= > high efficiency

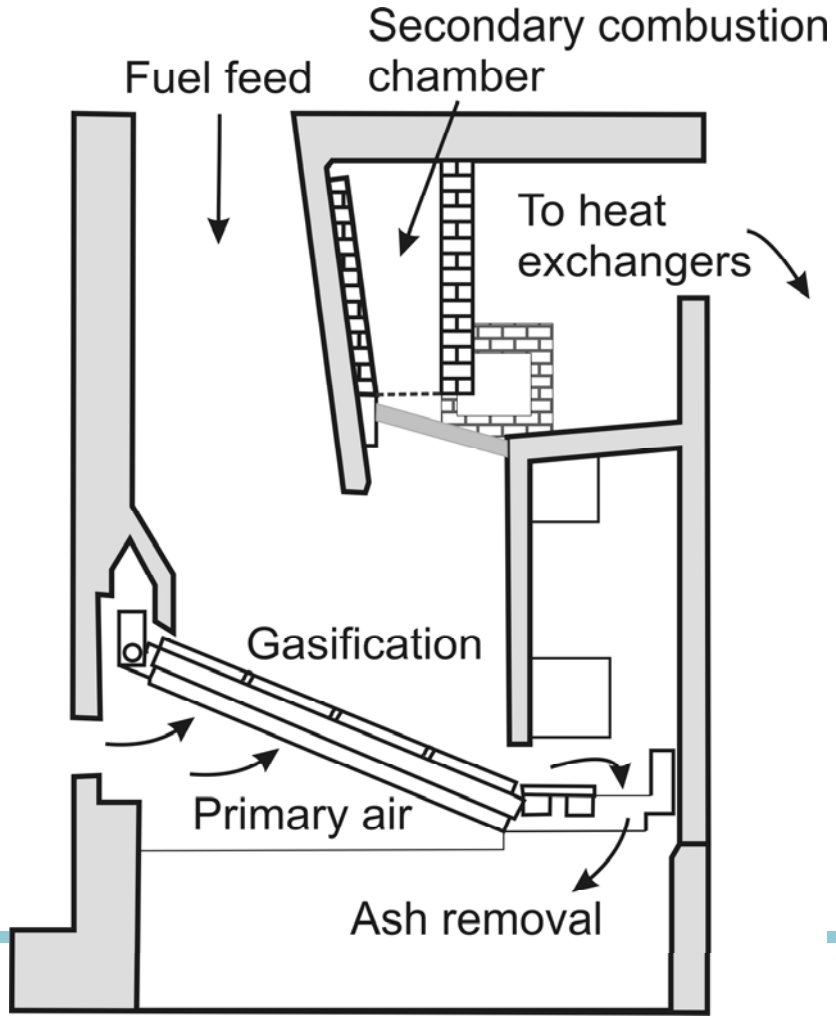
- There is still potential for decreasing the total air-to-f ratio (and efficiency) without increasing emissions

- Ultra low PM1 emissions - 2 mg/MJ

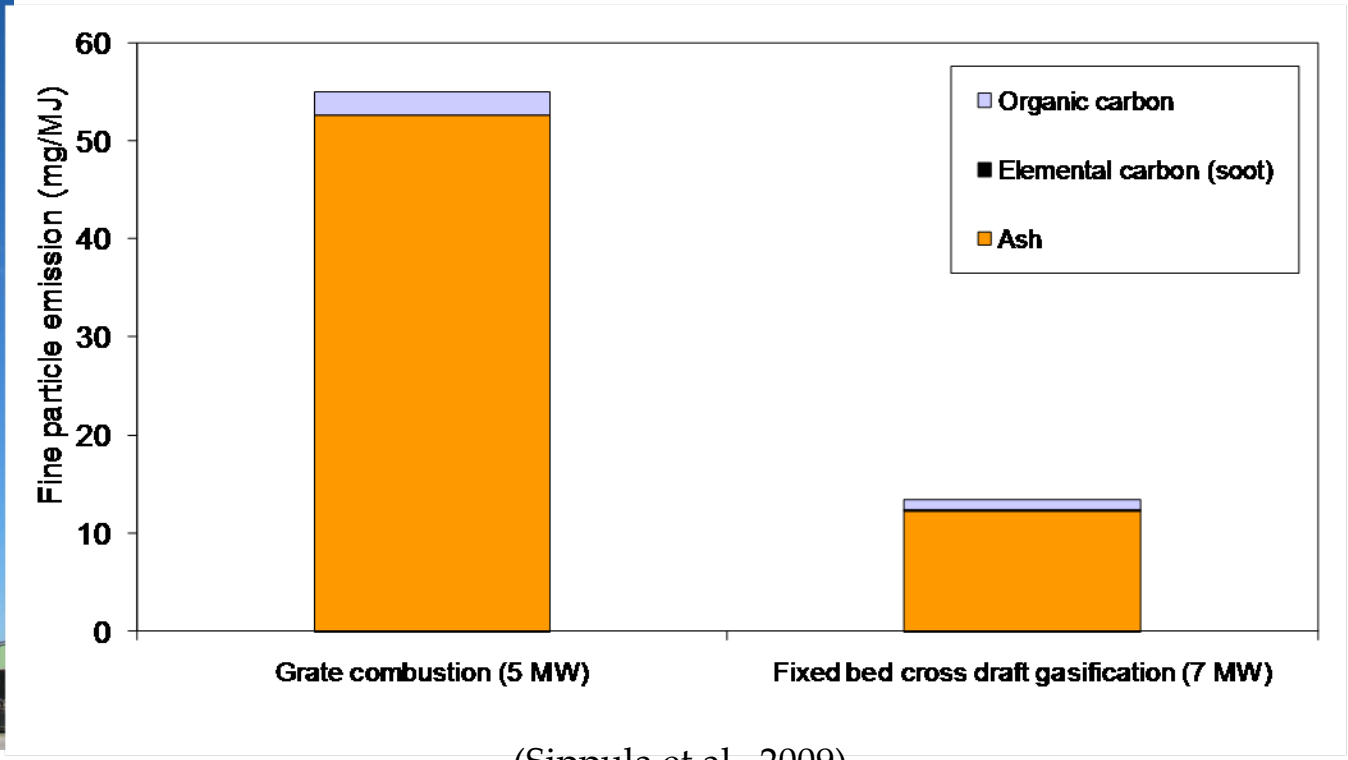
  compared to current PM1 emission levels of typical pellet burners 10-20 mg/MJ
- 38 nm particle size - > ultrafine particles
- Particle number concentration 8.0 * 10^7 1/cm^3 -> very high concentration

Fixed bed cross draft gasification combustion

for the production of district heat (7 MW) Laatukattila Ltd.



Comparison of technologies: small district heating units



(Sippula et al., 2009)

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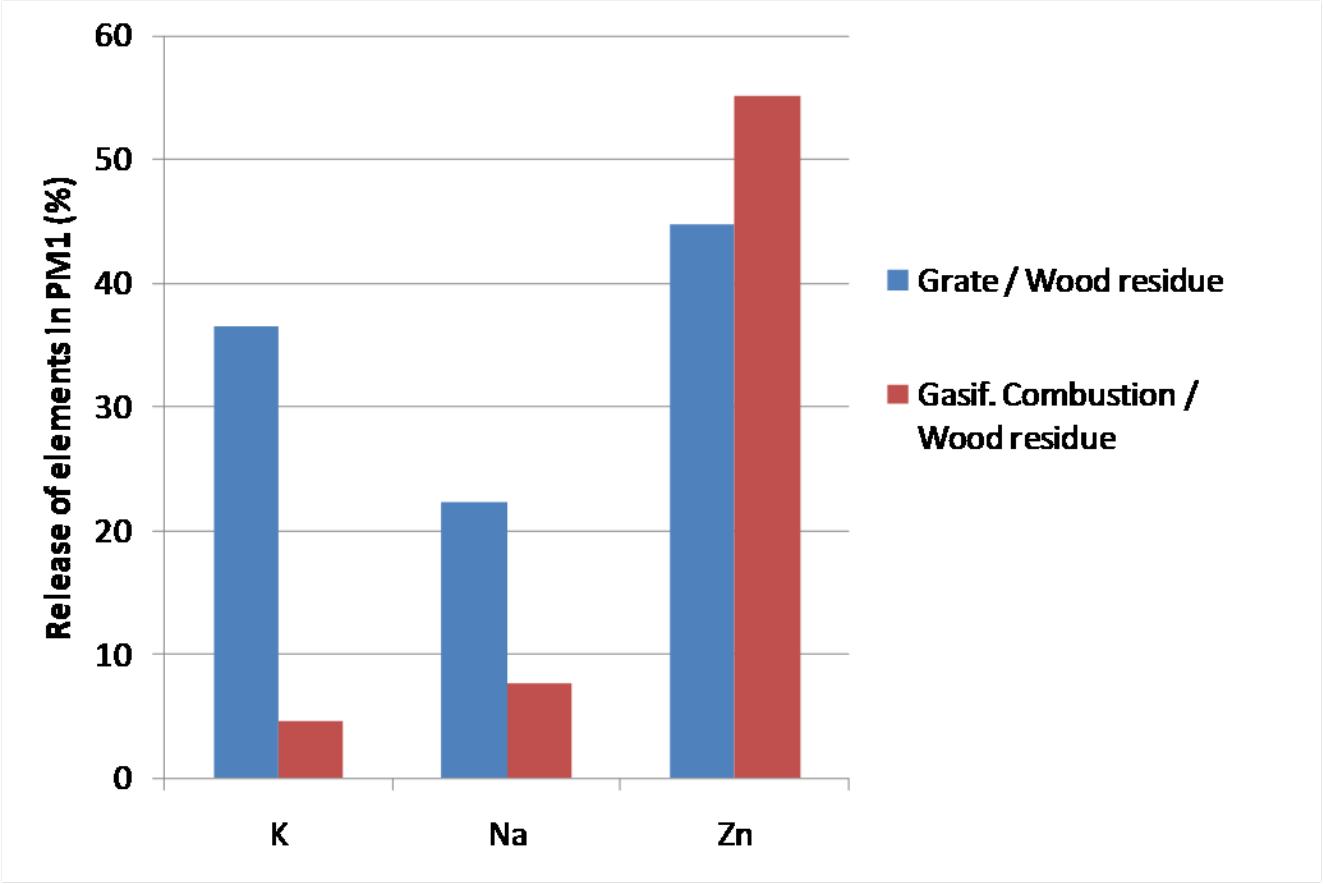

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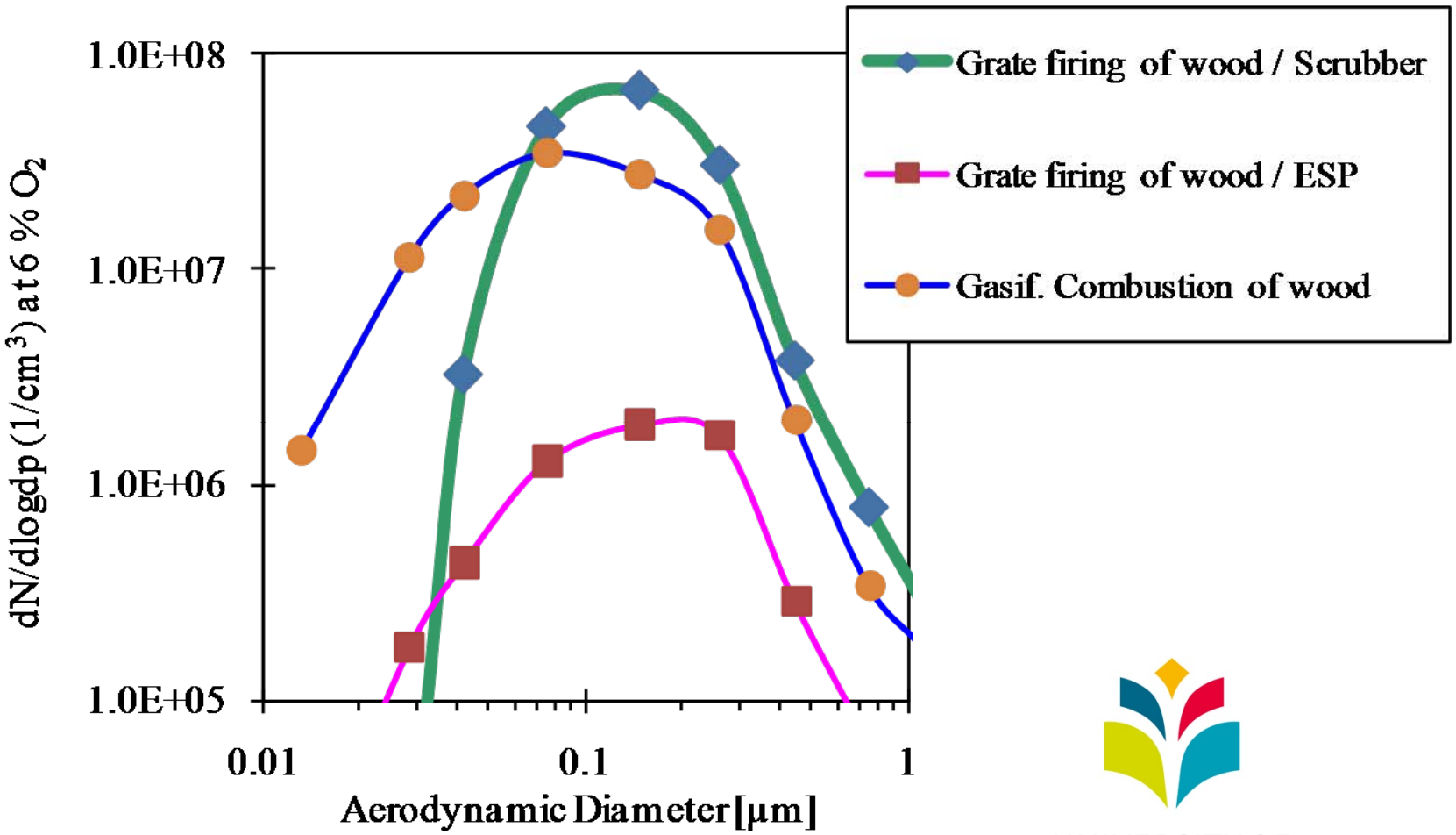

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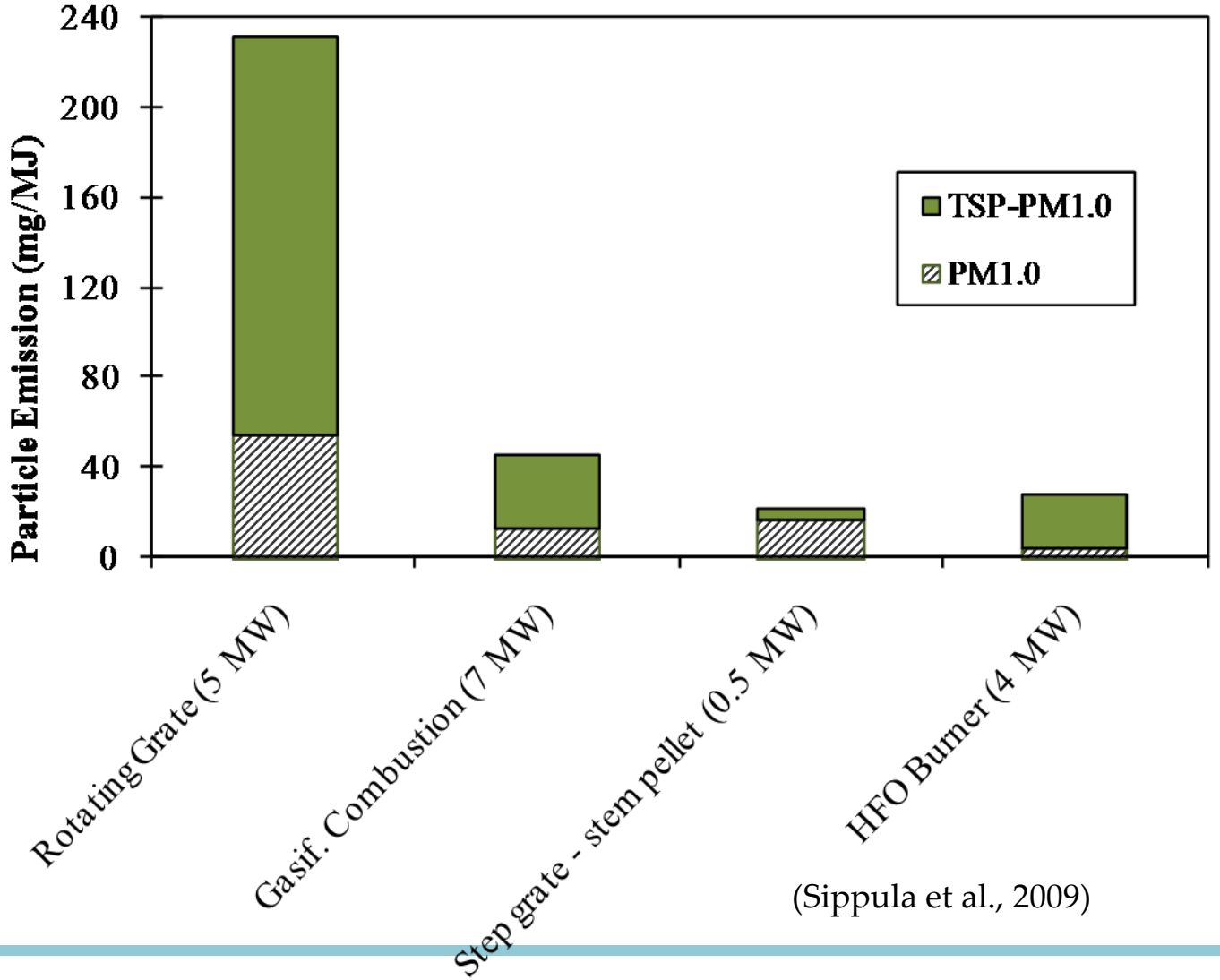

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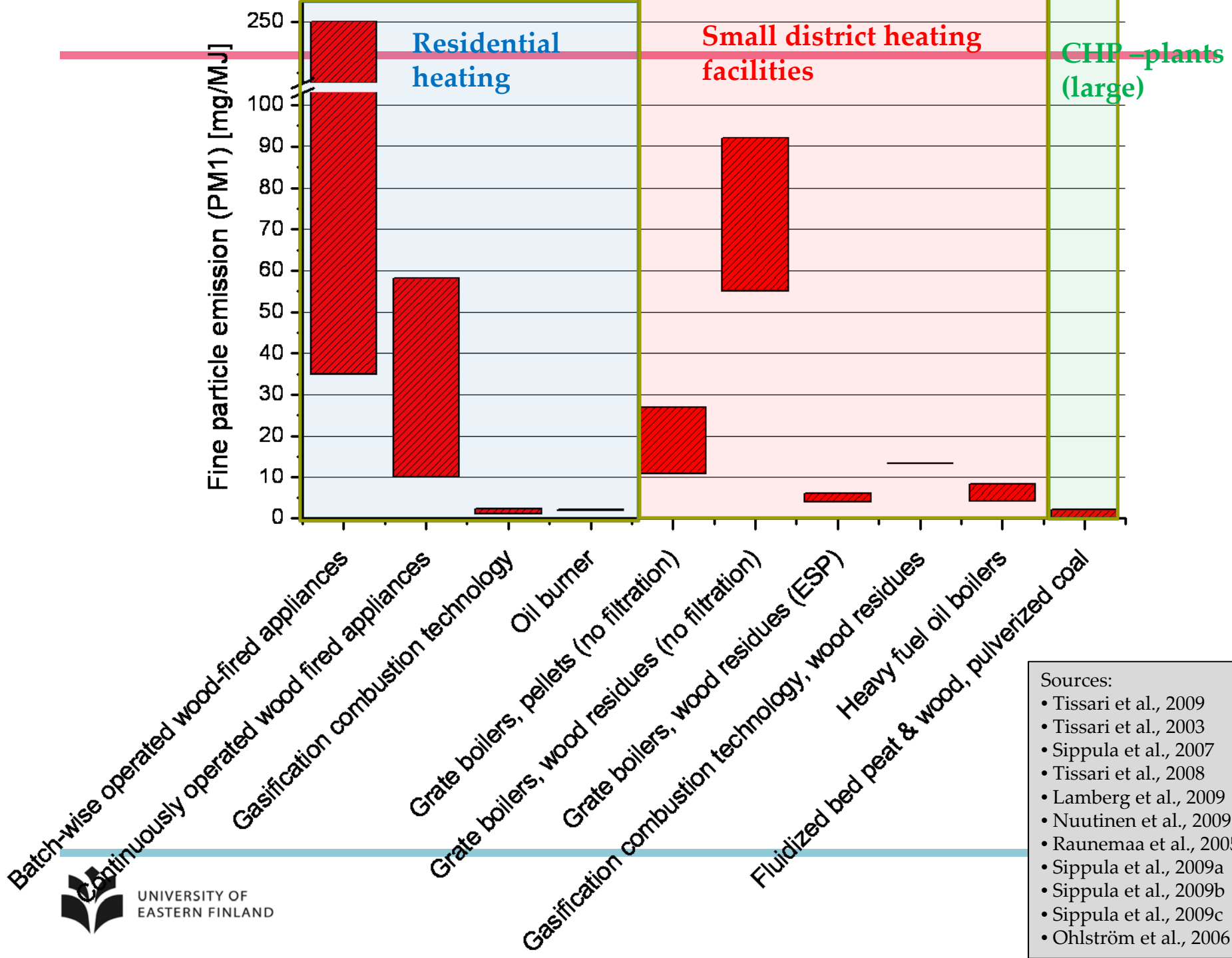

Sources:
- Tissari et al., 2009
- Tissari et al., 2003
- Sippula et al., 2007
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- Lamberg et al., 2009
- Nuutinen et al., 2009
- Raunemaa et al., 2005
- Sippula et al., 2009a
- Sippula et al., 2009b
- Sippula et al., 2009c
- Ohlström et al., 2006

Thank you for attention!

Acknowledgements

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