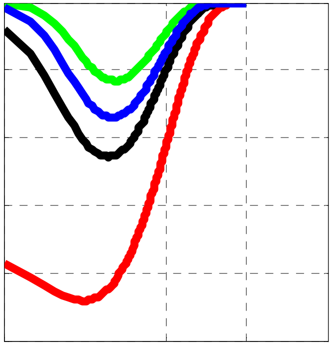

Design and operation characteristics for electrostatic precipitators for wood combustion particles as function of combustion conditions

Adrian Lauber[1]
Thomas Nussbaumer[1,2]

[1]Bioenergy Research Group
Lucerne University of Applied Sciences
[2]Verenum Research
SWITZERLAND

13th ETH Conference on Combustion Generated Nanoparticles
Zurich, 22 – 24 June 2009

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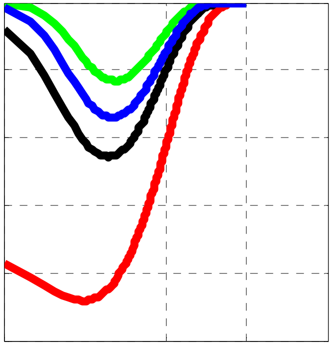

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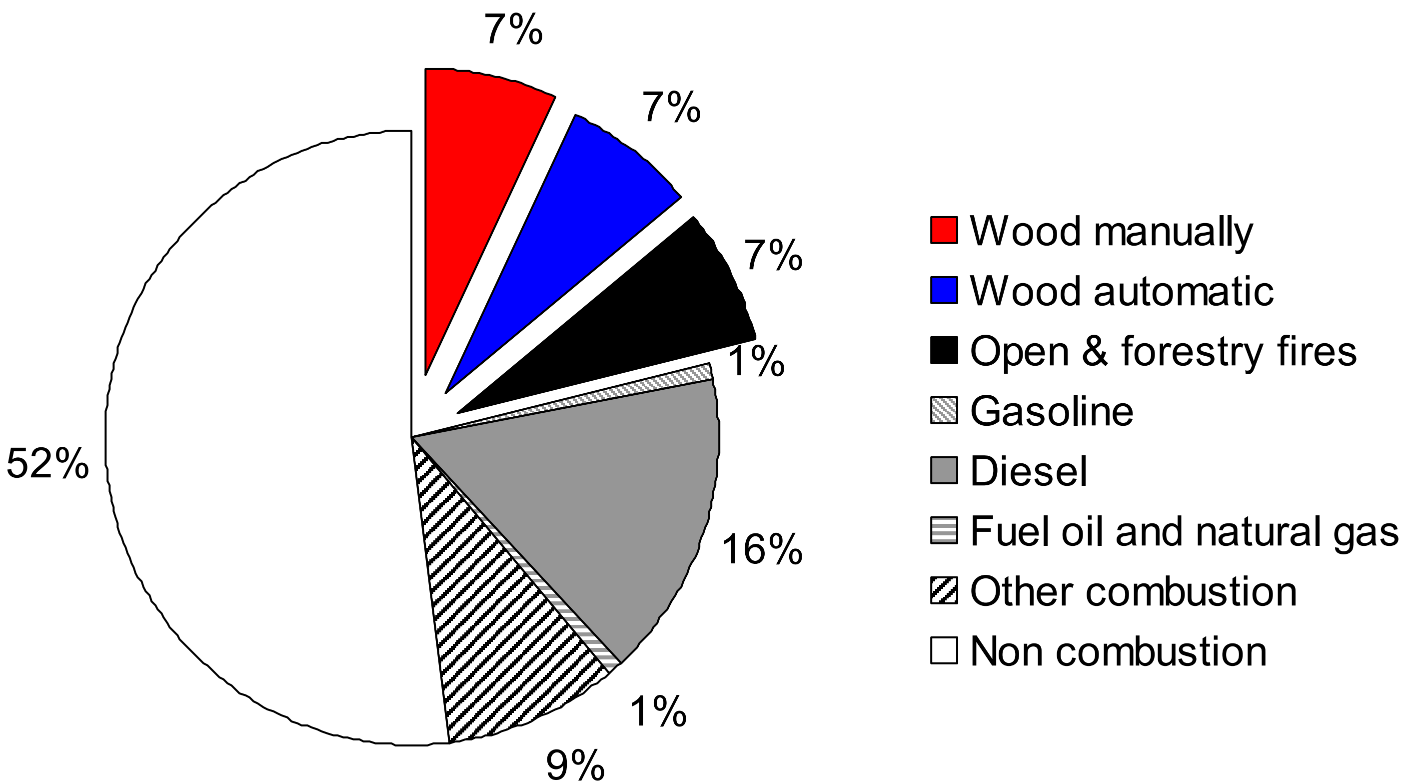
PM10 from Wood Combustion

In Switzerland, biomass combustion contributes significantly to PM10 in the ambient air.



[BAFU, 2005]

ESP for Wood Combustion

- Electrostatic precipitation (ESP) is commonly applied for particle separation in large scale utility boilers. Design parameters are well known for coal, e.g. [White, 1963]

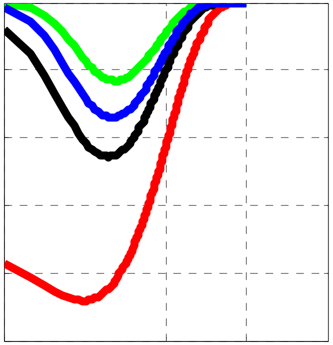
- Today, ESP's are applied for small and medium-scale applications for heating purposes:

for wood boilers > 500 kW

[Scheuch]

for wood stoves < 70 kW

[Oekotube]



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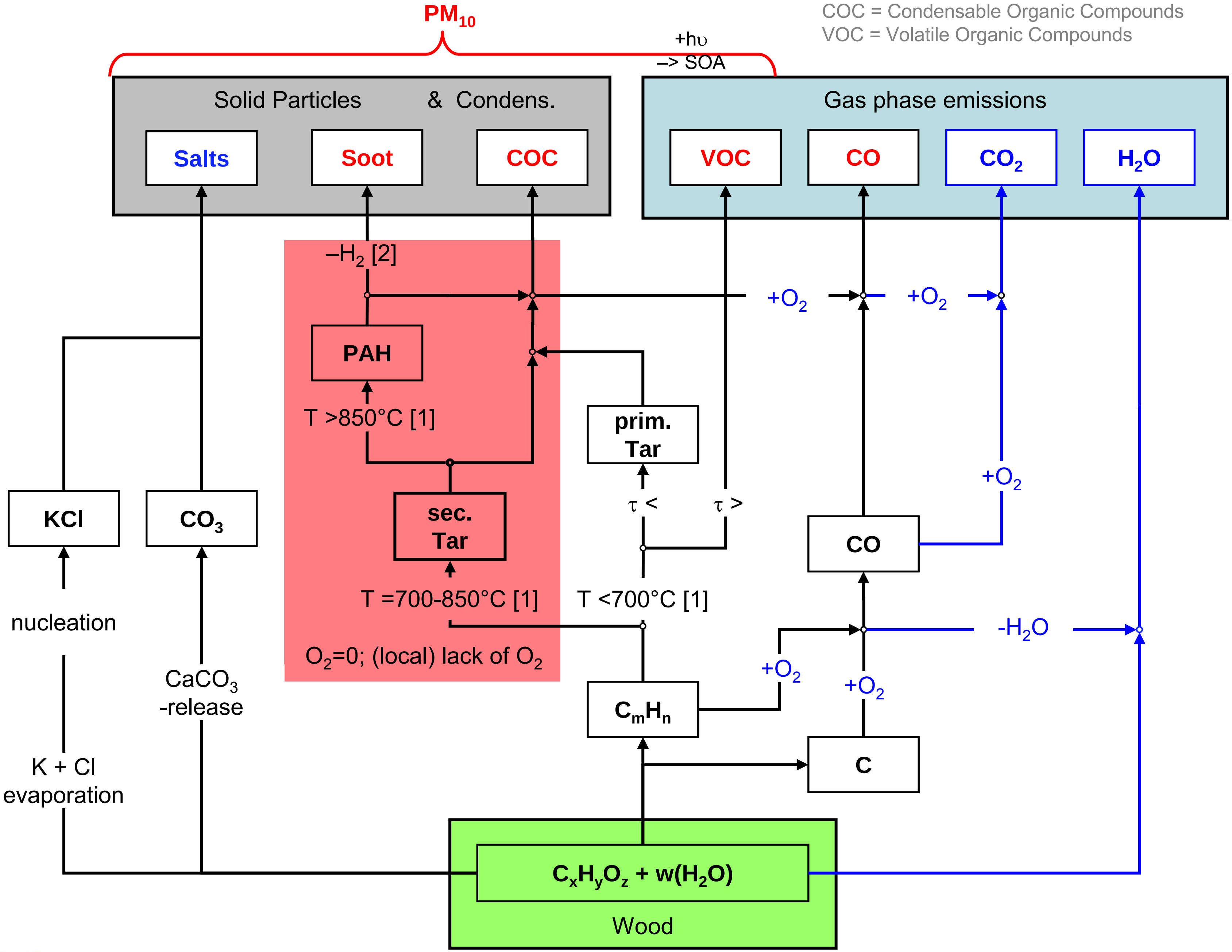
Particle Formation



[1] : Evans and Milne, 1987
[2]: Jess, 1996

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Particle Sources

Solid Particles & Condens.

Salts | Soot | COC

Gas phase emissions

VOC | CO | CO_2 | H_2O

[Schmid]

Particle Properties

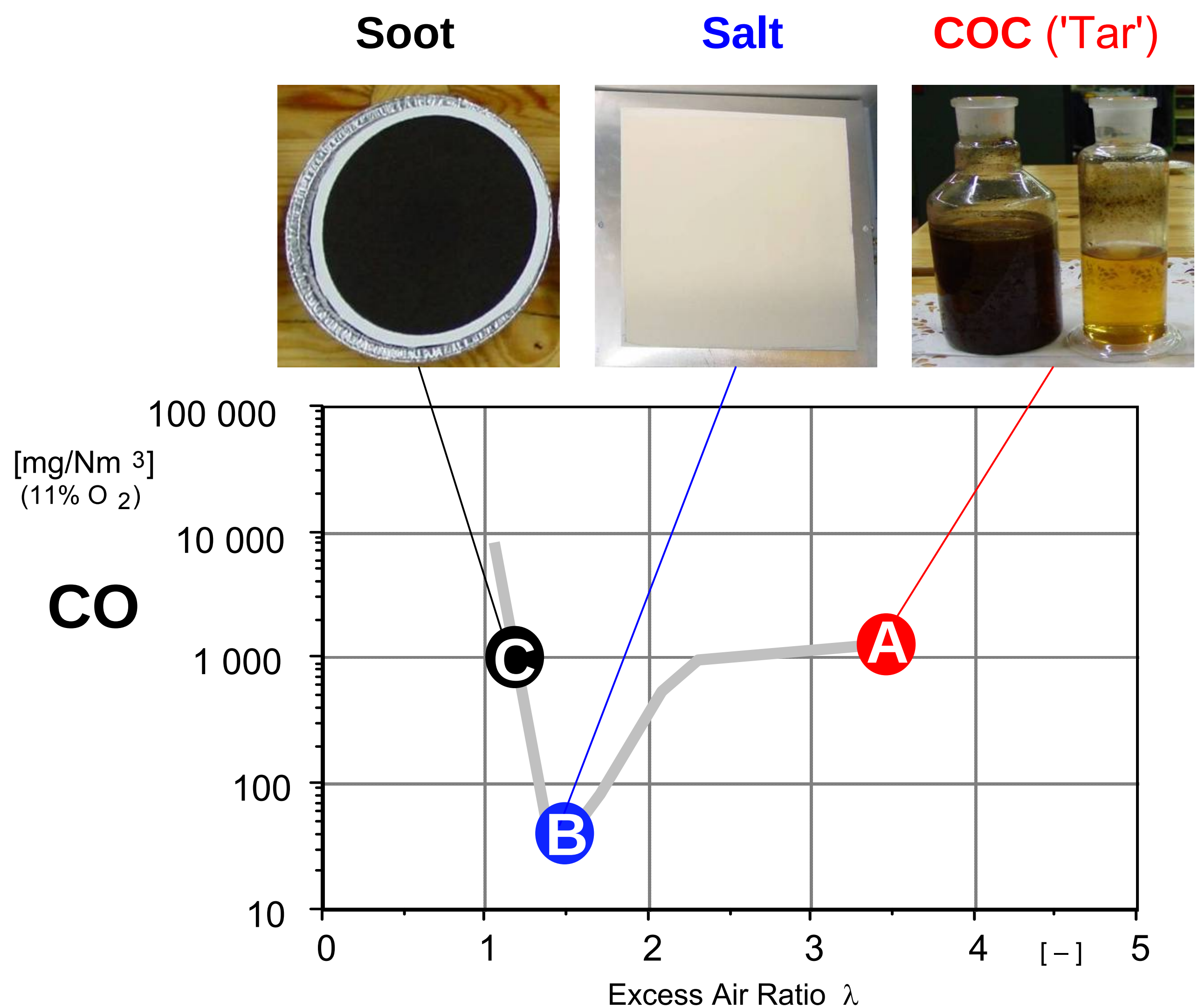
Solid Particles		& Condens.	Gas phase emissions			
Salts	**Soot**	**COC**	**VOC**	**CO**	**CO_2**	**H_2O**

C/H	–	> 6 – 8 [5]	≈1 (< 2)
Electrical conductivity	medium	high	low (isolating)*
ESP [3]	ideal	re-entrainment	back-corona

*primary tar: isolating, Secondary tar and PAH: semiconductiv [4]

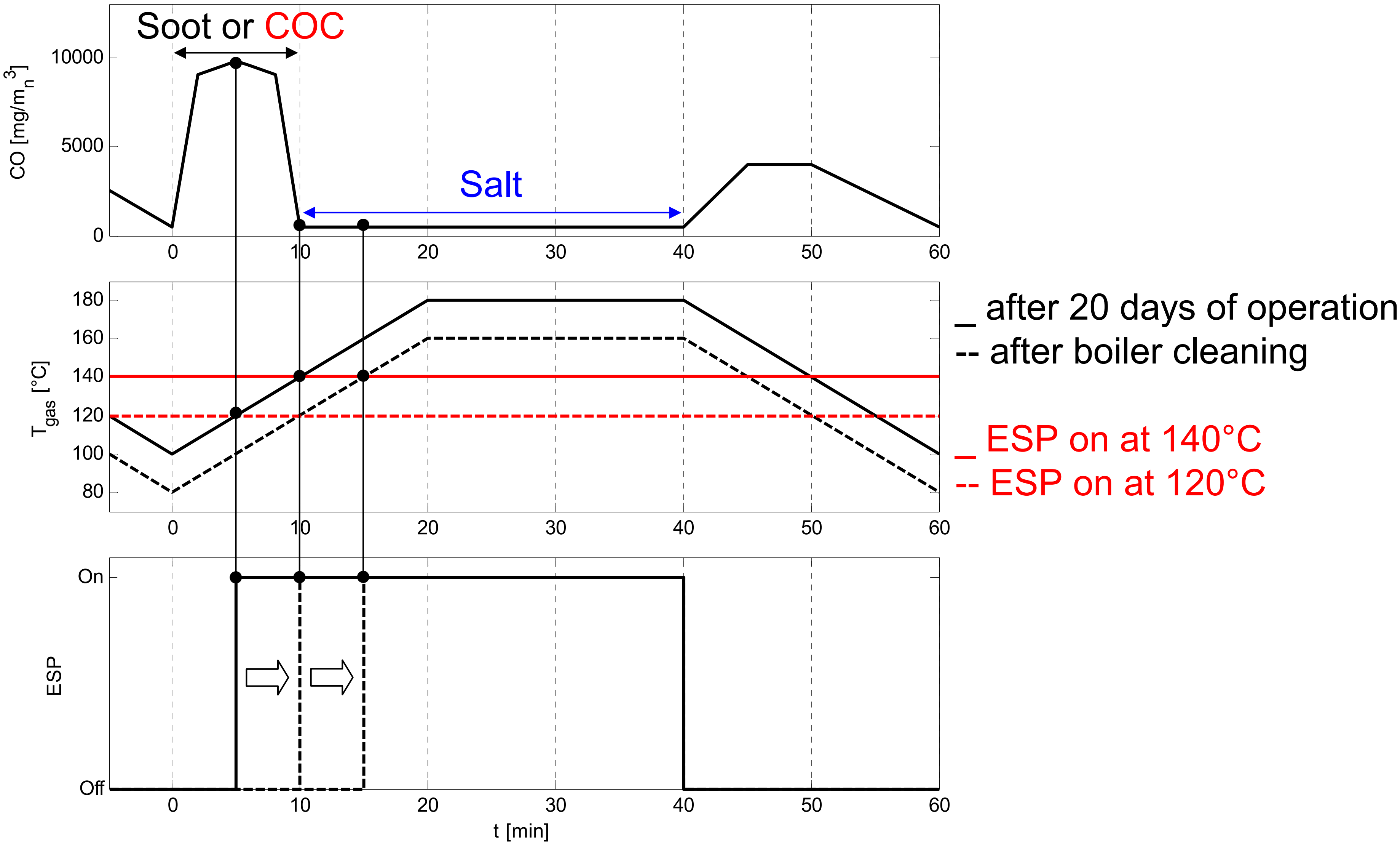
[3]: Parker, 1997
[4]: Roempp, 1989
[5]: Leuckel and Römer, 1979

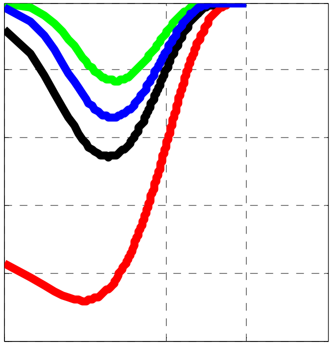
Particle Types



[Nussbaumer, *Energy & Fuels 2003, 17*]

ESP Operation with Automatic Wood Boiler





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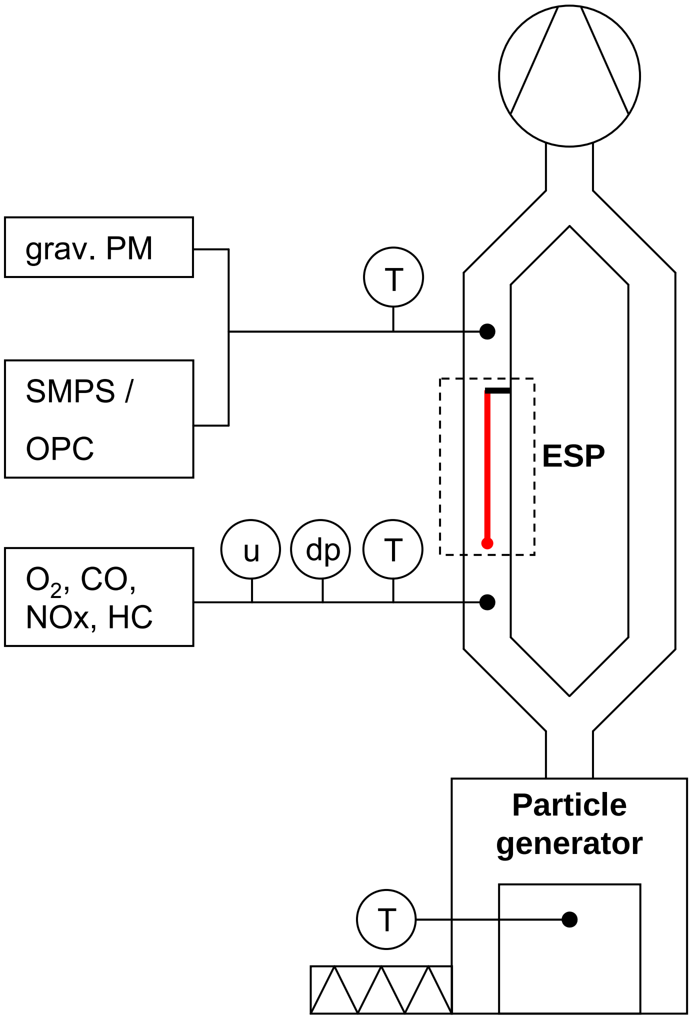
Experimental Setup

ESP:
- L 1000 [mm]
- D 100 [mm]
- U 1 [m/s]
- SCA 45 [s/m]
- U_{max} -65kV

Particle generator:
- Pellet boiler modified
- Q 15kW



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Experimental Setup

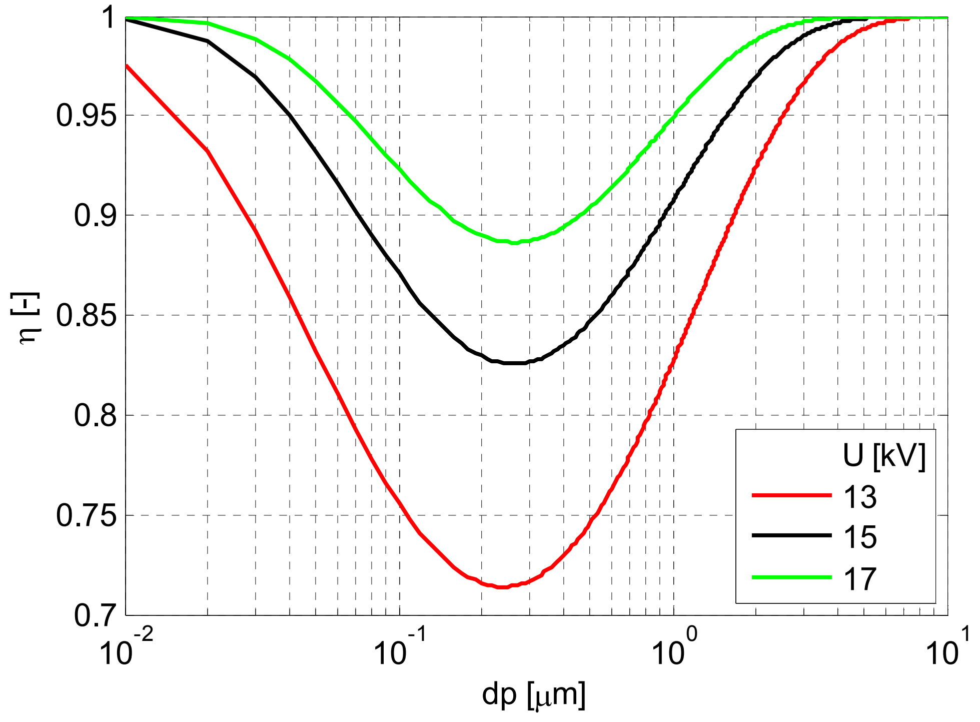
ESP:

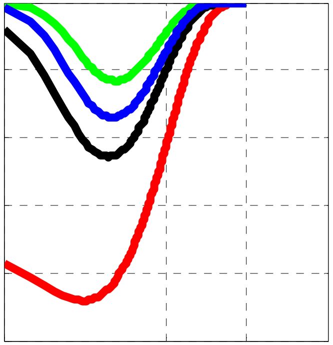
- L 1000 [mm]
- D 100 [mm]
- U 1 [m/s]
- SCA 45 [s/m]
- U_{max} -65kV

Particle generator:

- Pellet boiler modified
- Q 15kW

Calculated ESP efficiency depending on electric field strength





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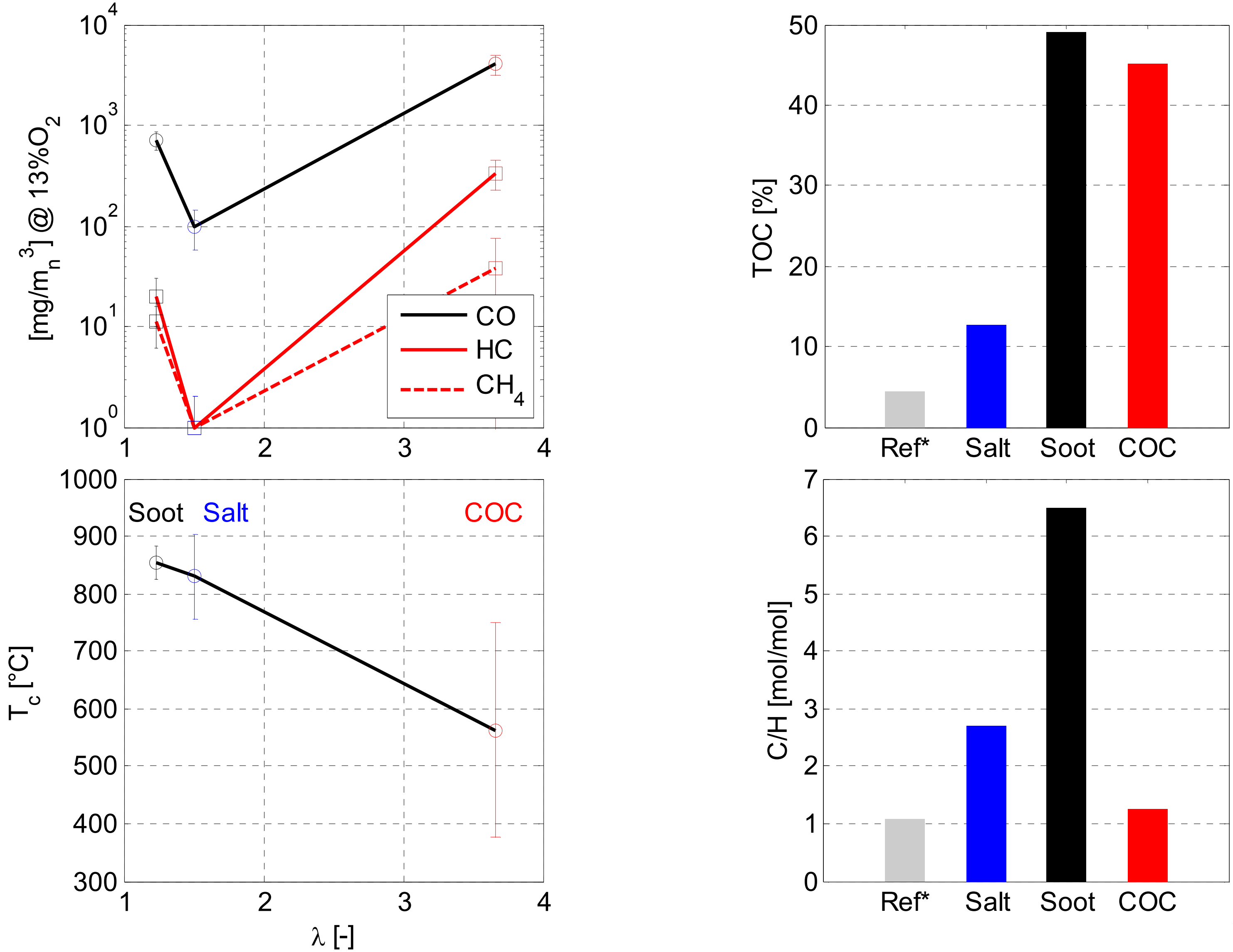
Gas and Chemical Analysis



*Ref: 1MW AWC

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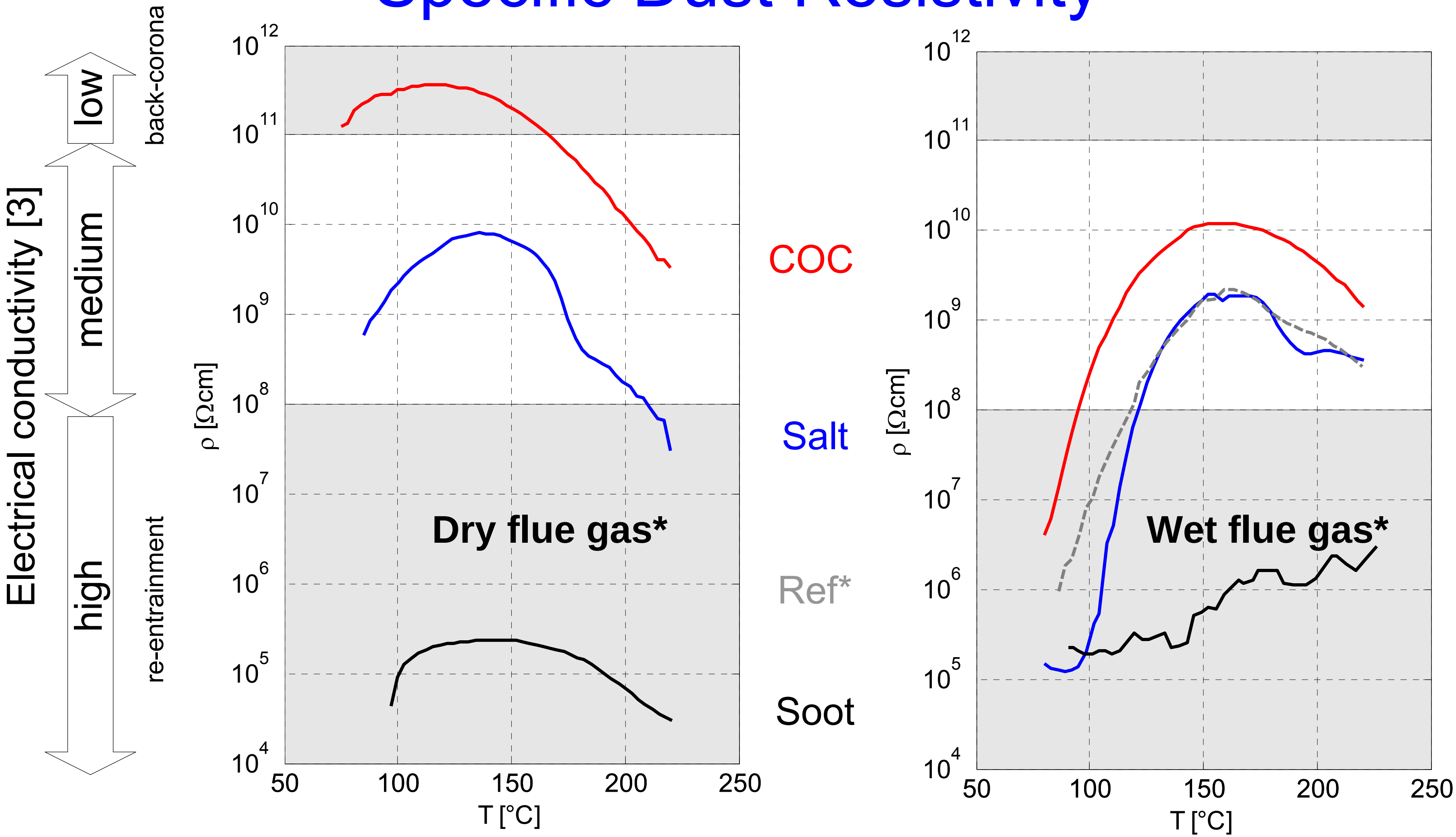
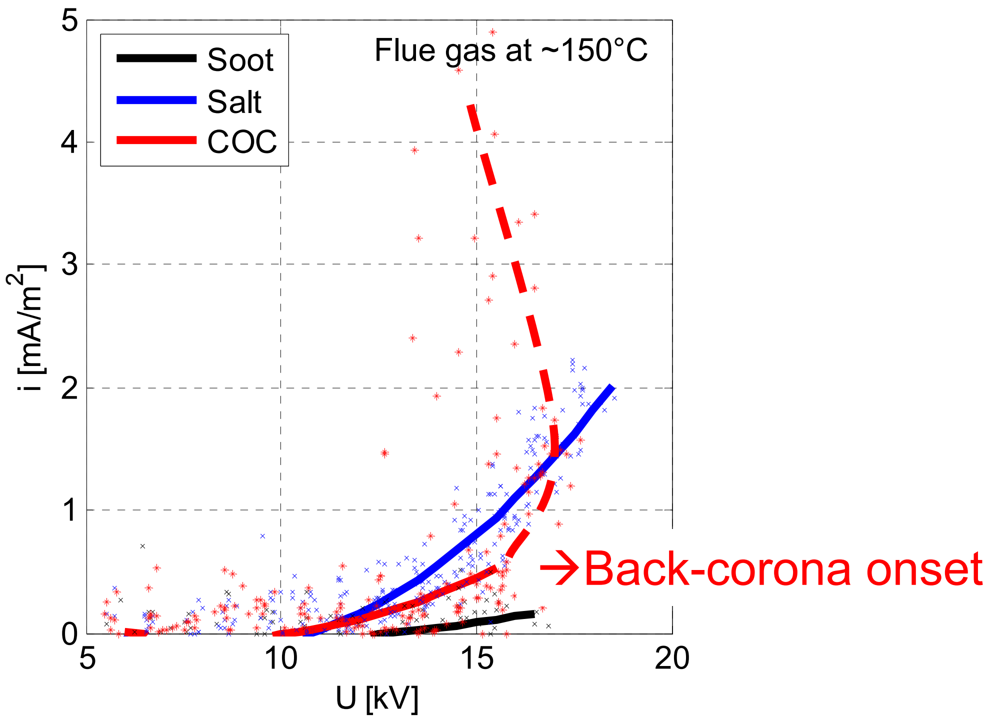
Specific Dust Resistivity

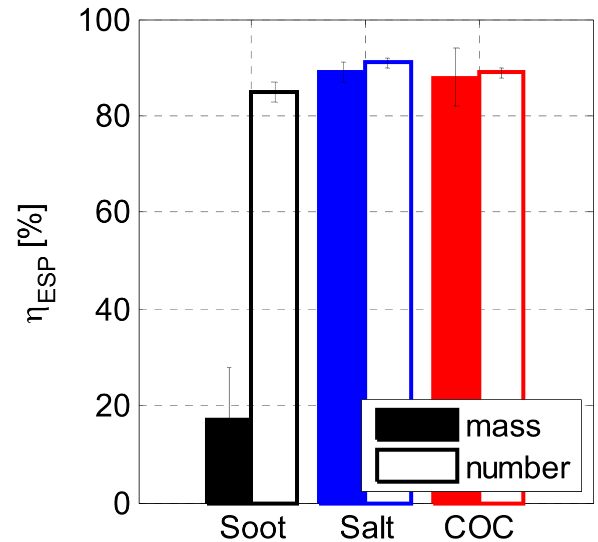


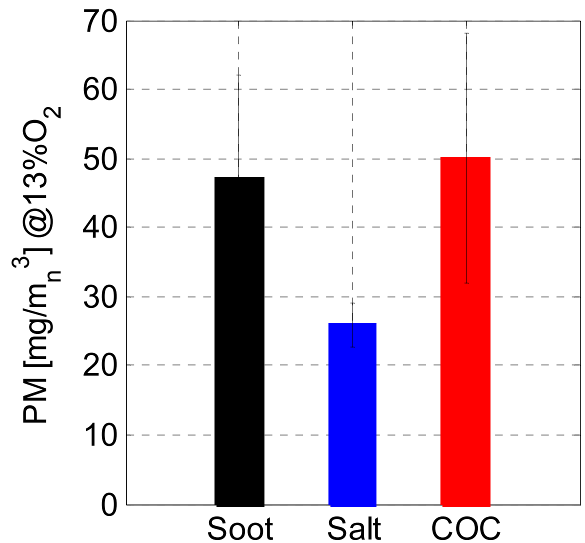
*Dry: 5 vol.-% H_2O e.g. excess air ratio 3 & wood moisture content 5%
*Wet: 20 vol.-% H_2O e.g. excess air ratio 1.2 & wood moisture content 50%
*Ref: 13 vol.-% H_2O: excess air ratio 1.5 & wood moisture content around 30%

[3]: Parker, 1997

IU Characteristic / ESP efficiency







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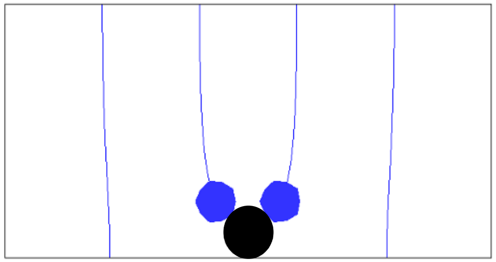
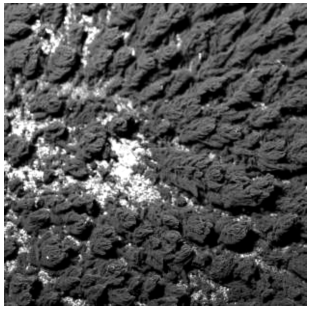
Dust Layer Build-up

Conductiv particles:
→'dendritic' build-up

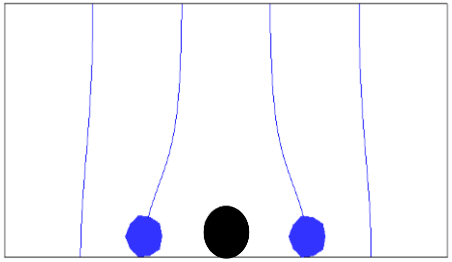


Soot



weak adhesion /
re-entrainment

Normal or isolating particles:
→ homogeneous build-up



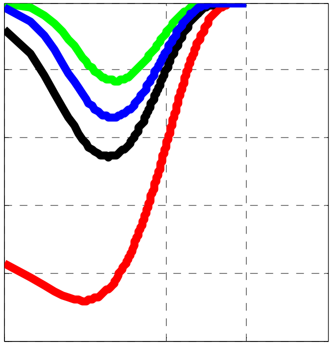
Salt

stable layer

COC

sticky layer

[Blanchard et. all., 2002]



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Conclusions 1/2

1. Three different particle types from wood combustion have been identified which correspond to different combustion regimes
2. The three particle types exhibit completely different physical and chemical properties, among which the electrical conductivity is most relevant for ESP operation
3. Particles from good combustion (mainly salts) exhibit ideal conductivity for ESP
4. Soot reveals high conductivity thus enabling high precipitation efficiency but severe re-entrainment of agglomerated particles
5. COC exhibit low conductivity thus leading to back-corona which limits ESP operation

Conclusions 2/2

6. ESP operation for good and stationary conditions during wood combustion with mainly inorganic particles causes no operation problems, while it may be critical e.g.

   - during start-up due to COC from low temperatures or

   - during throttled air, either due to COC at low temp. or due to soot from lack of oxygen.

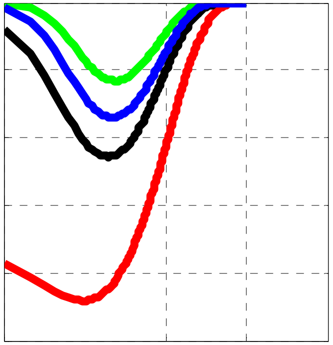
   Both conditions are common for heating applications.

Outlook

ESP availability is crucial and needs to be improved by three measures:

1. Stationary combustion operation and plant design with two boilers and two ESP for variable load
2. Process integrated control of ESP with specific information as indicators for the particle properties
   - flue gas temperature (as today) plus:
   - excess air ratio
   - combustion temperature
   - water content of the fuel

   This increases the operation regime of the ESP
3. Measures to avoid re-entrainment:
   - Limitation of gas velocity to < 1.5 m/s
   - optimised shape of collecting plates
   - shorter dedusting intervall during re-entrainment regimes



Acknowledgments

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