Aerosols in Biomass Combustion

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Fine particle emissions from fluidized bed combustion of peat and wood

Veli Linna, VTT Processes

POWER PLANT

Forssan Energia Oy

Fluidized bubbling bed

Peat and wood fired

Power 66 MW (thermal)

- district heat
- electricity

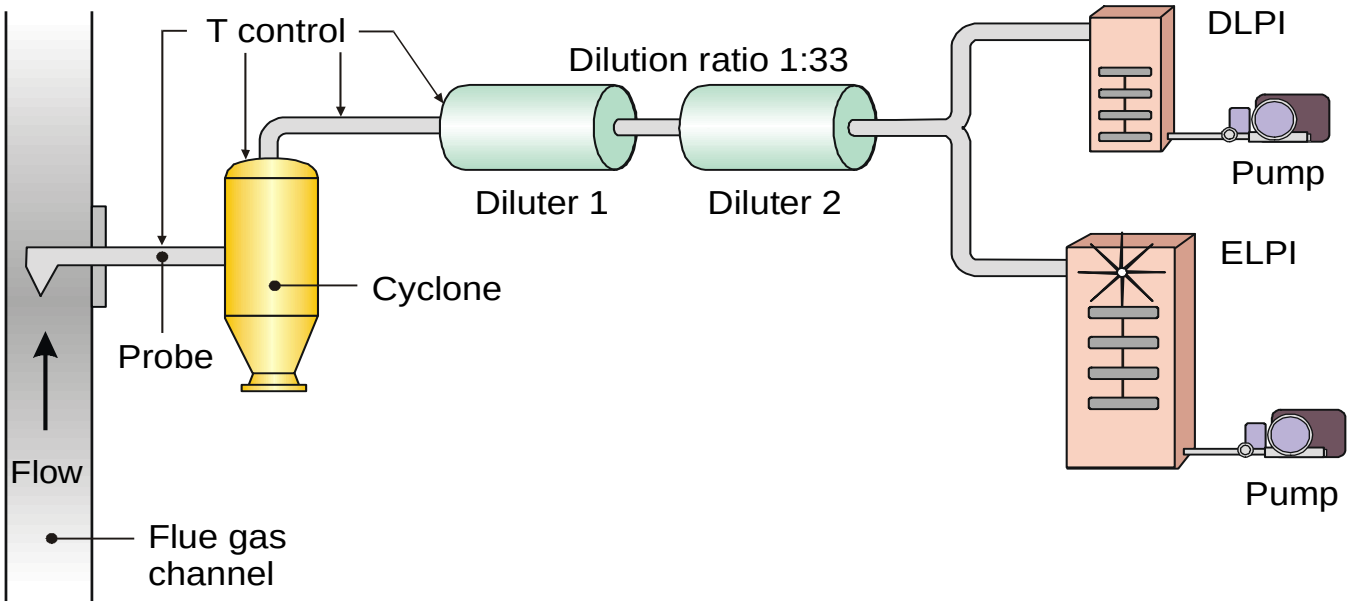
Particle separation by double field electrostatic precipitator (ESP)

FUELS

	PEAT	PEAT + WOOD	WOOD
Moisture, %, (wet basis)	50.7	46.6	46.8
Volatile matter, %, in dry matter	68.3	77.2	79.7
Ash content, %, in dry matter	5.5	2.9	1.8
Net calorific value in dry matter, MJ/kg	20.35	19.43	19.14
Net calorific value as received, MJ/kg	8.80	9.24	9.04
Carbon content, %, in dry matter	53.4	51.4	51.2
Hydrogen content, %, in dry matter	5.5	5.9	6.0
Nitrogen content, %, in dry matter	1.66	0.84	0.52
Sulfur content, %, in dry matter	0.16	0.04	0.02
Chlorine, Cl, %, in dry matter	0.036	0.028	0.027
Total concentrations, mg/kg in dry matter			
- Potassium, K	730	1,600	2,100
- Calcium, Ca	2,400	2,600	3,300
- Sodium, Na	350	200	140
Soluble nutrients (ion-exchangeable), mg/kg in dry matter			
- Potassium, K	85	1,400	2,100
- Calcium, Ca	1,600	1,200	1,500
- Sodium, Na	48	45	78

Wood: mixture of bark, sawdust, cutter chips and forest residue chips
Peat + wood: peat 30 % (volume)

IMPACTOR SYSTEM



Particle mass size distribution by DLPI (Dekati Low Pressure Impactor)

Particle number size distribution by ELPI (Electrical Low Pressure Impactor)

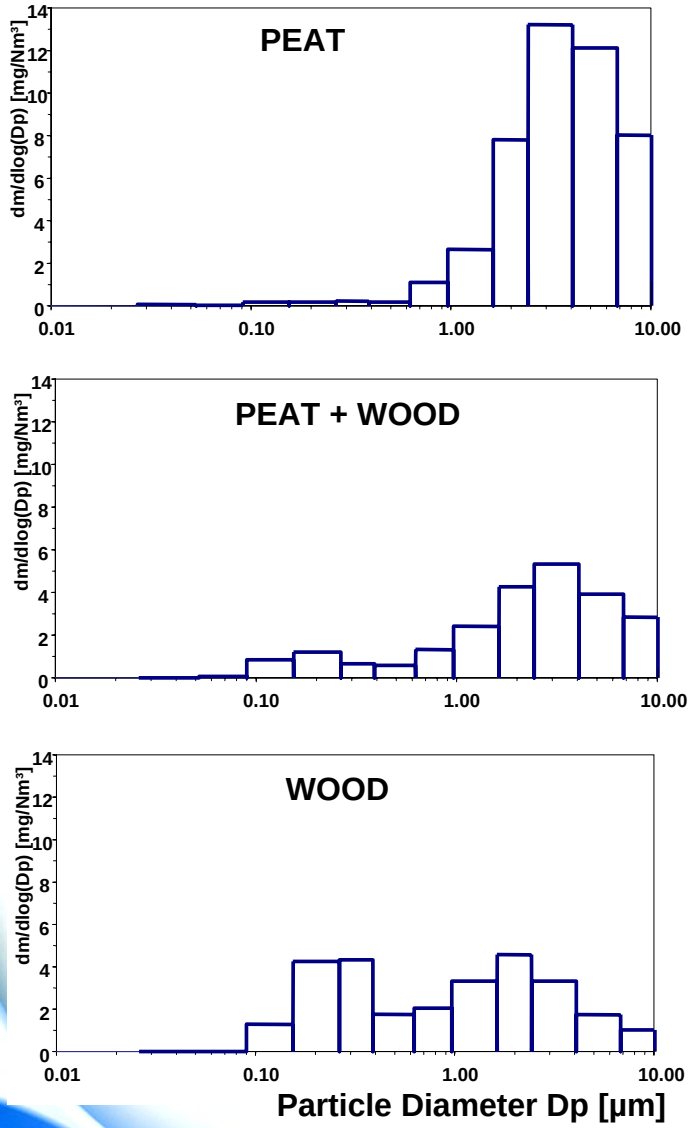
OPERATING VALUES OF THE BOILER

Measured variable	PEAT	PEAT+ WOOD	WOOD
Steam capacity of the boiler, MW	64.3	57.9	58.9
Temperature of the furnace, °C	928	837	825
Bed temperature °C	812	823	870
Flue gas temperature, °C	135	137	139
Oxygen content of flue gases, % (moist gas)	4.5	5.1	4.0
Temperature of live steam, °C	510	509	510
Pressure of live steam, bar	58.8	58.8	58.1

MEASURED GAS CONCENTRATIONS

	PEAT	PEAT+ WOOD	WOOD
O2 , % (dry gas)	5.9	6.0	5.4
CO, ppm (dry gas)	52	992	226
NOx, ppm (dry gas)	319	167	116
NOx , mg/m3n, as NO2, red. 6 % O2	651	343	229
NOx , mg/MJ, as NO2	258	133	90
SO2, ppm (dry gas)	131	-	-
SO2 , mg/m3n, red. 6 % O2 (dry gas)	380	-	-
SO2 , mg/MJ	151	-	-
HCl-content of flue gases, ppm	14	4	0.4
HCl-conversion, % 1)	53	19	2
Flue gas temperature, °C	133	135	135

1) HCl-conversion was calculated on the basis of the Cl concentration of the fuel and the in-plant measurements



FINE PARTICLE EMISSIONS

Mass concentrations (red. 6 % oxygen content)

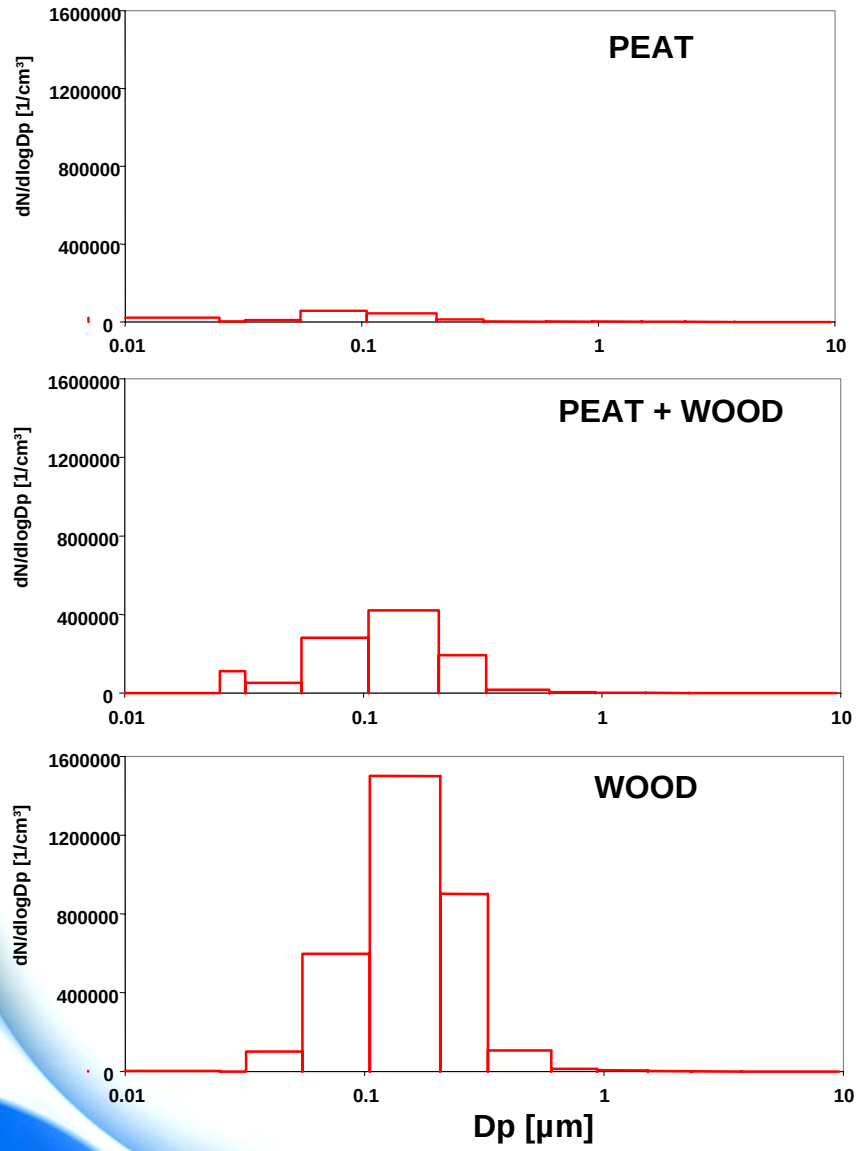
	PM10 mg/Nm^3	PM2.5 mg/Nm^3
peat	10.1	5.2
peat + wood	5.1	2.3
wood	5.5	4.1

Wood

- mass size distribution double peak shaped, first top at accumulation mode range, where ESP penetration is high

Peat

- very low emission at accumulation mode region



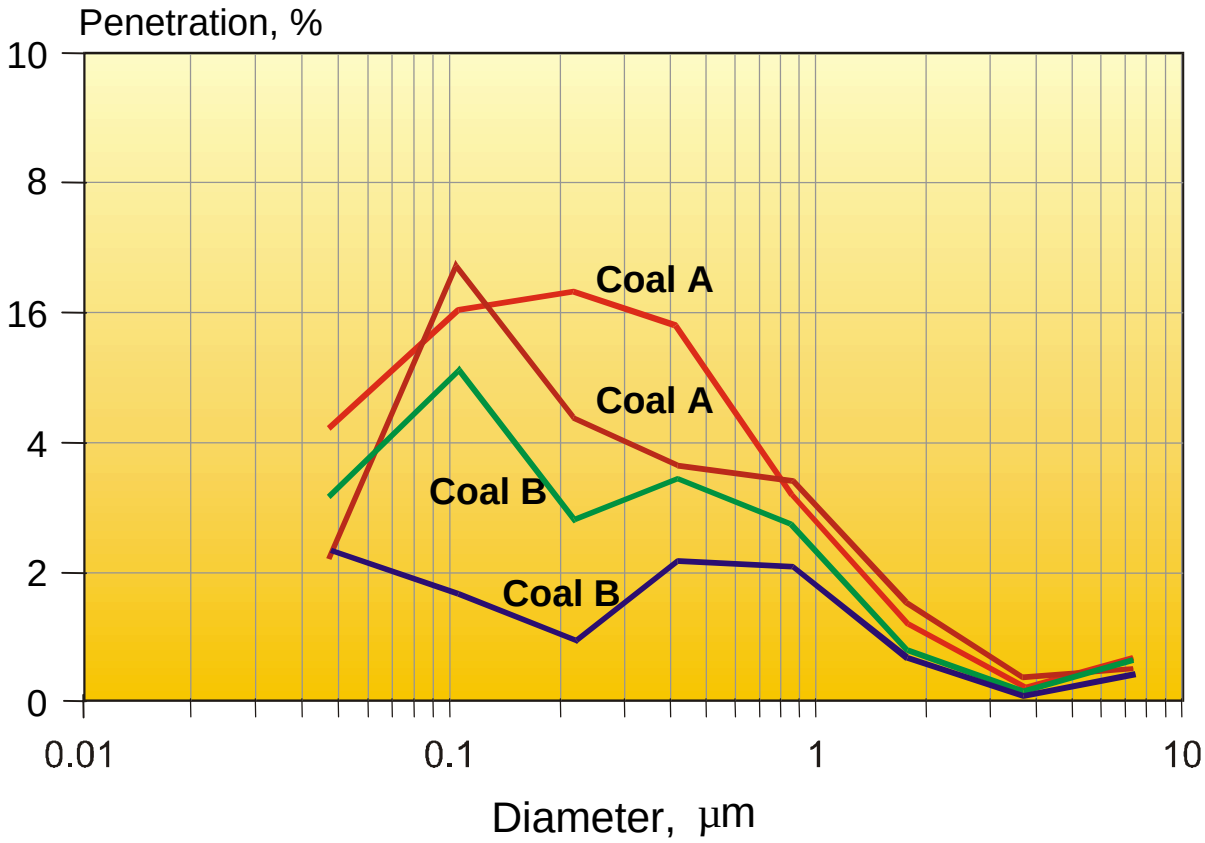
FINE PARTICLE EMISSIONS

Number concentrations (red. 6 % oxygen content)

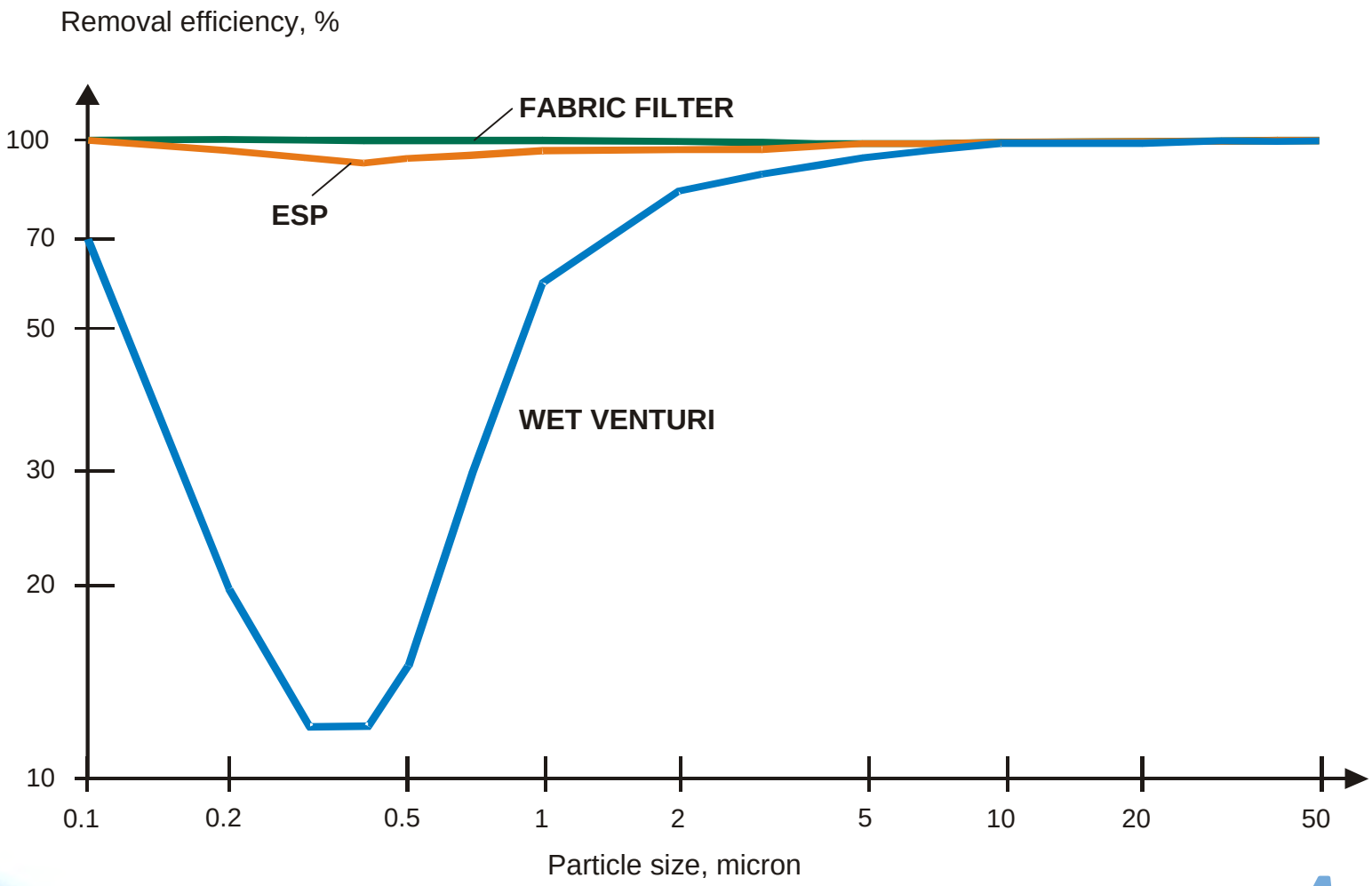
	N/cm^3
peat	0.5*10^5
peat + wood	2.7*10^5
wood	8.5*10^5

- smallest particles from wood combustion
- 30 % peat mixing reduces number concentration to third

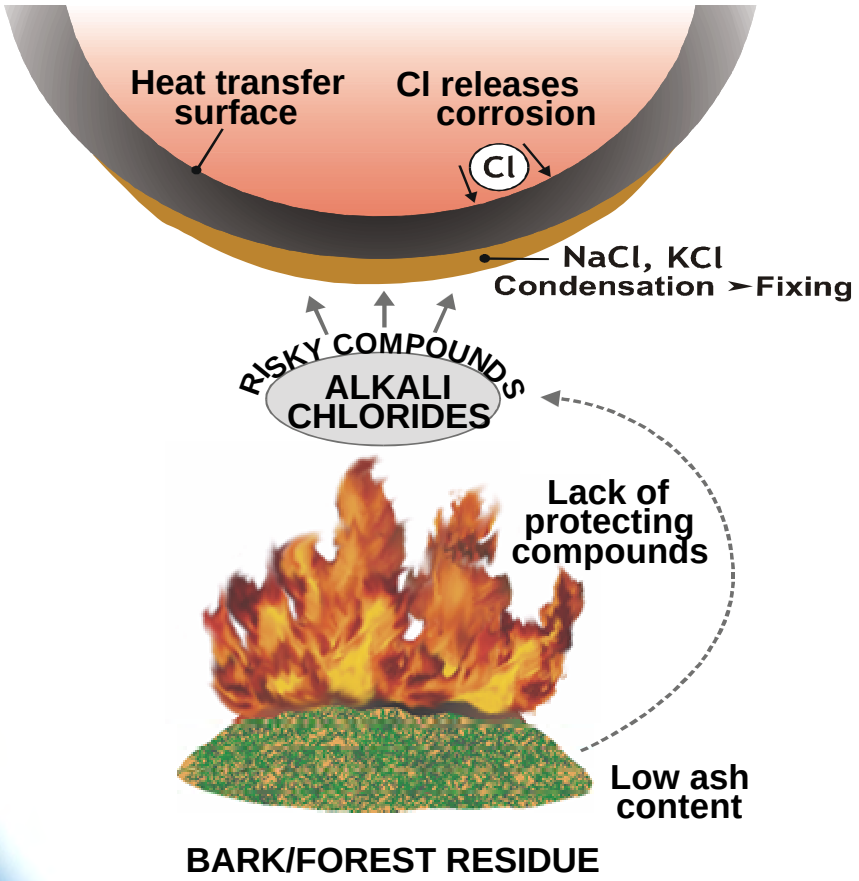
ESP: FINE PARTICLE PENETRATION



REMOVAL EFFICIENCIES



HOW



Direct connection to fouling and corrosion risk of the boiler

Alkali chlorides (from wood combustion) react with SO2 (from peat combustion) forming alkali sulfates

- Cl is releasd to flue gases (HCl) → reduced corrosion risk
- alkali metals to sulfates → larger and less harmful particles and reduced SO2 emission

COMPARISON TO OTHER FUELS AND BOILERS

Fine particle emissions

Depend strongest on the boiler size category and dust separation devices (usually at least ESP used)

	mg/MJ
Pulverized combustion of coal	1 – 30
Recovery boilers (black liquor)	12 – 77
Pulverized combustion of peat	5 – 8
Bubbling fluid bed combustion of peat and wood (Forssa)	1 – 2

CONCLUSIONS

Peat and wood: **Very good combination**

- peat reduces fouling and corrosion risks of wood combustion
- wood reduces sulfur dioxide emissions of peat combustion
- peat reduces emissions of most harmful fine particles from wood combustion → favorable from human health point of view
- good availability of peat ensures continuous operation by local fuels

Disadvantages

- control of burning is more demanding compared to pure fuels
- higher air ratio needed to keep CO emissions low