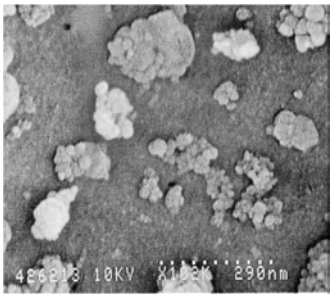
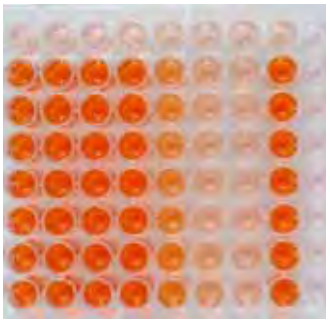


IEA Workshop on Small Scale Combustion, Dublin, 18.10.11

Health Issues in Biomass Combustion



Thomas Nussbaumer

Verenum, Zurich
Lucerne University of Applied Sciences, Horw

SWITZERLAND

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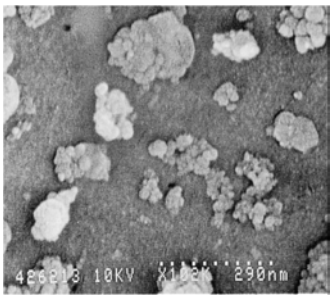

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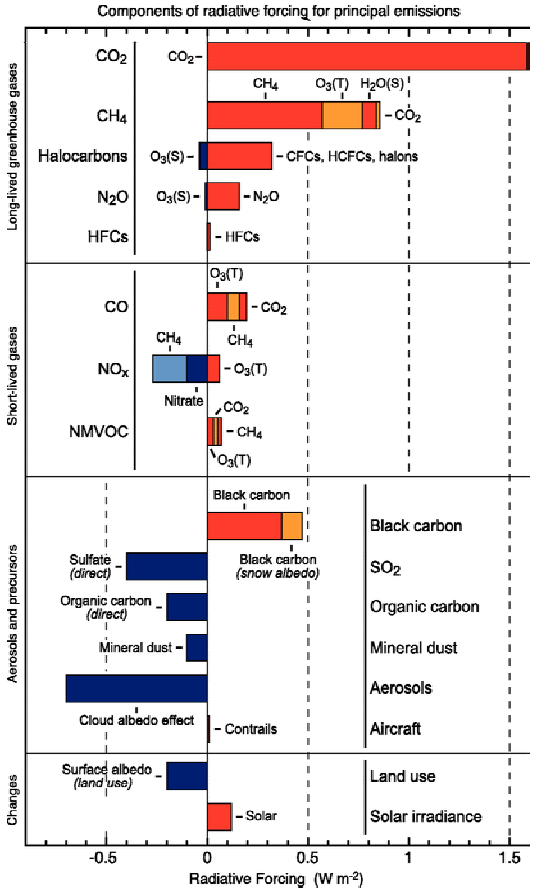
Effect of aerosols on climate change



[IPCC 2007]

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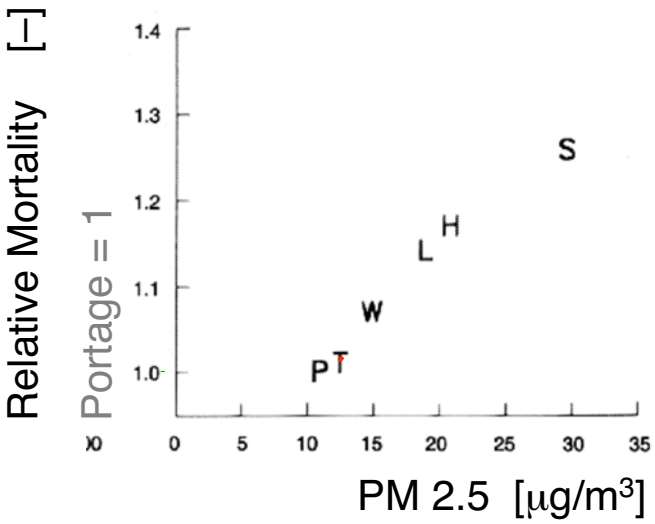
Air Pollution and Mortality in Six U.S. Cities



P = Portage, T = Topeka, W = Watertown, L = St. Louis, H = Harriman, S = Steubenville.

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Dockery et al. New England J. Med. Vol 329 (1993): 1753-1759

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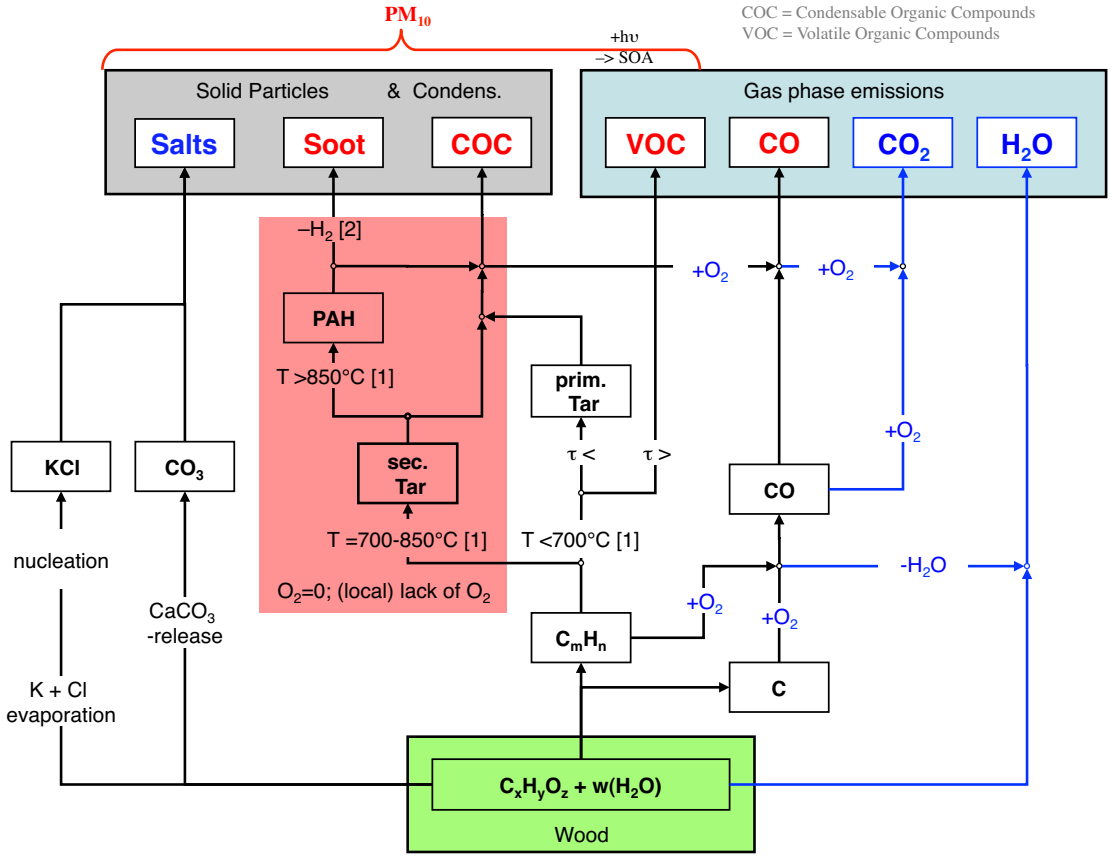
Particle Formation



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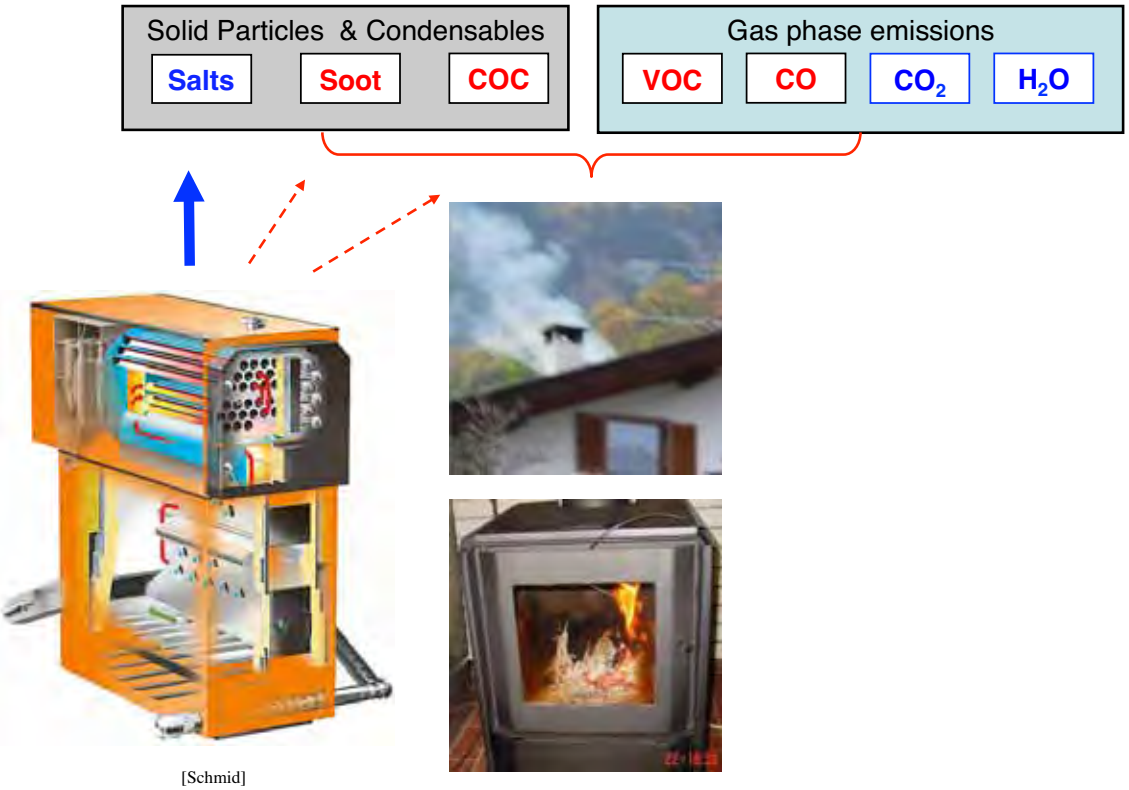
Graph: [Nussbaumer & Lauber 2011]

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

Particle Sources



[Schmid]

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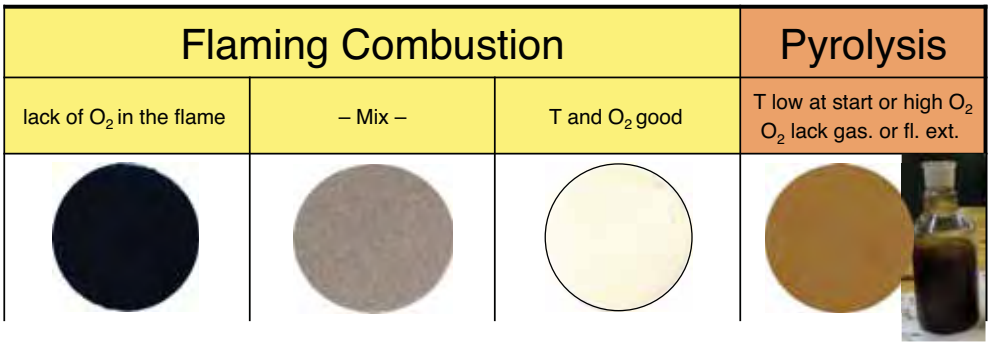

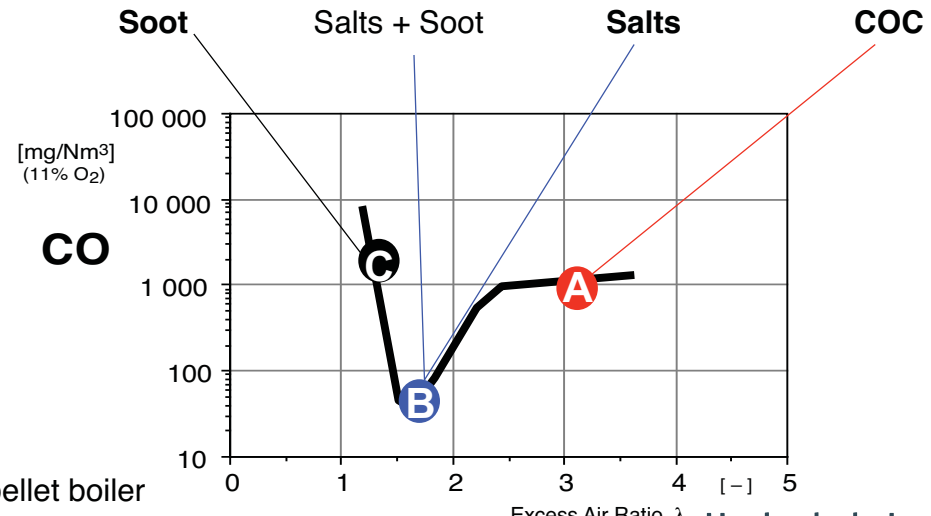

Example of pellet boiler

Verenum [A. Lauber & T. Nussbaumer, ETH Conf. 2009; T. Nussbaumer, *Energy & Fuels 2003, 17*]

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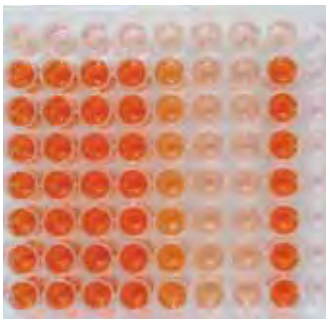

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Source 1: Euro 3 Diesel engine without DPF

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Test-bench at EMPA Dübendorf

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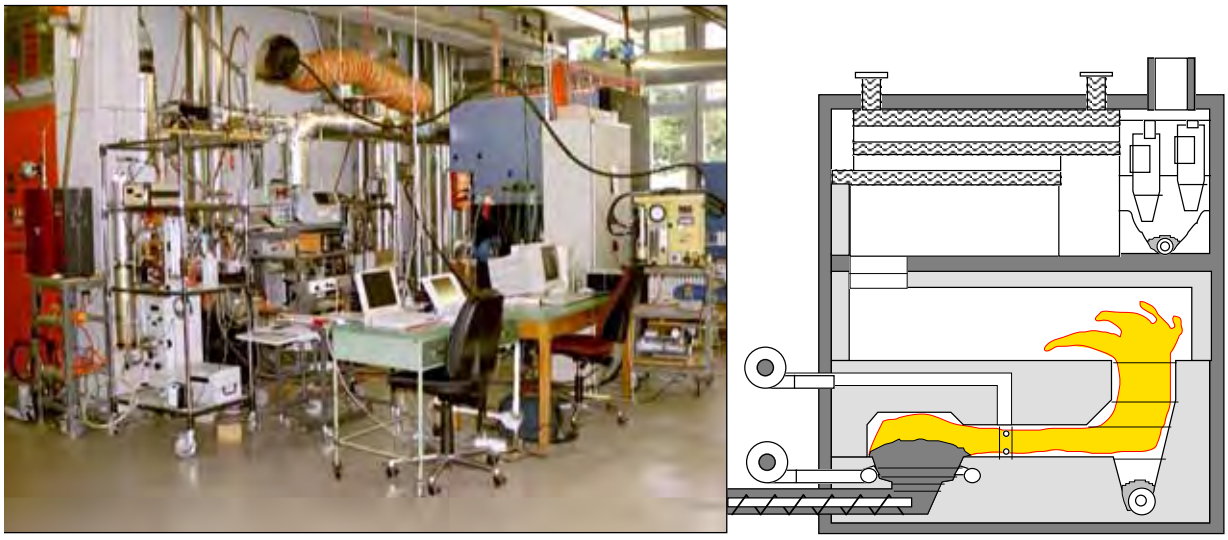
Source 2: Automatic wood combustion plant



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[Verenum / EMPA / Müller AG]

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Source 3: Wood Stoves

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Samples

Diesel soot

Automatic wood boiler

Wood stove

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Investigation of cell cultures

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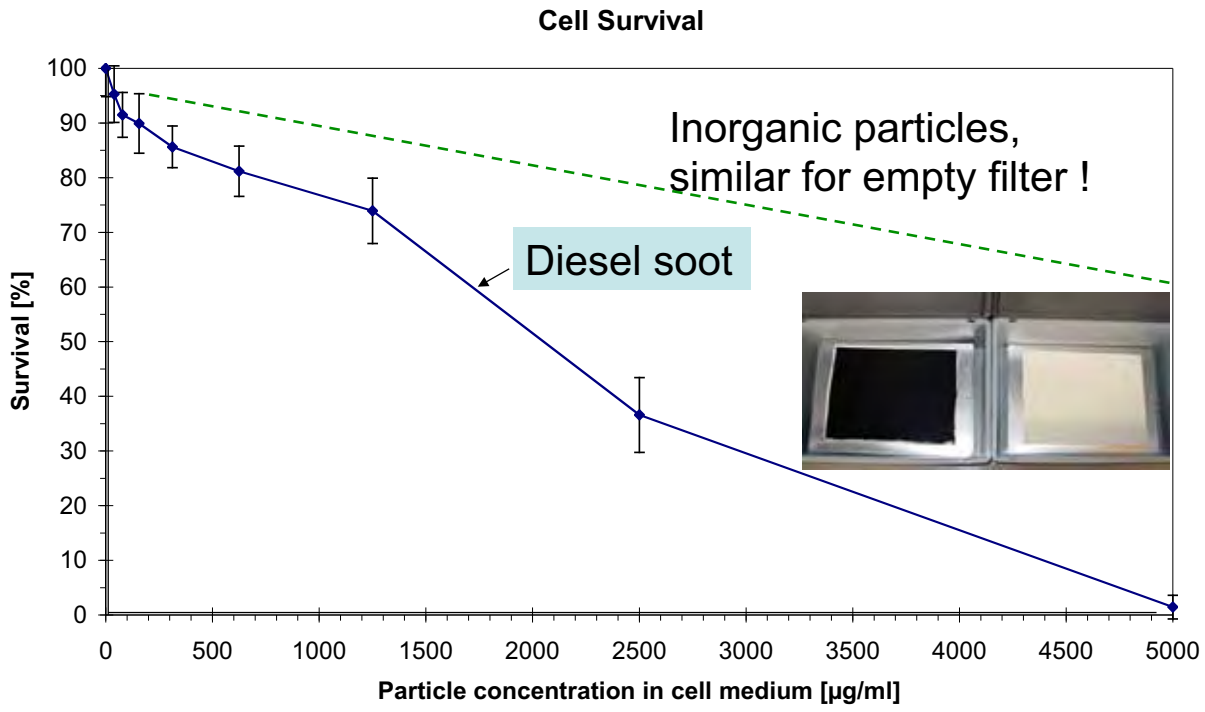
Cytotoxicity tests on lung cells of Chinese hamster



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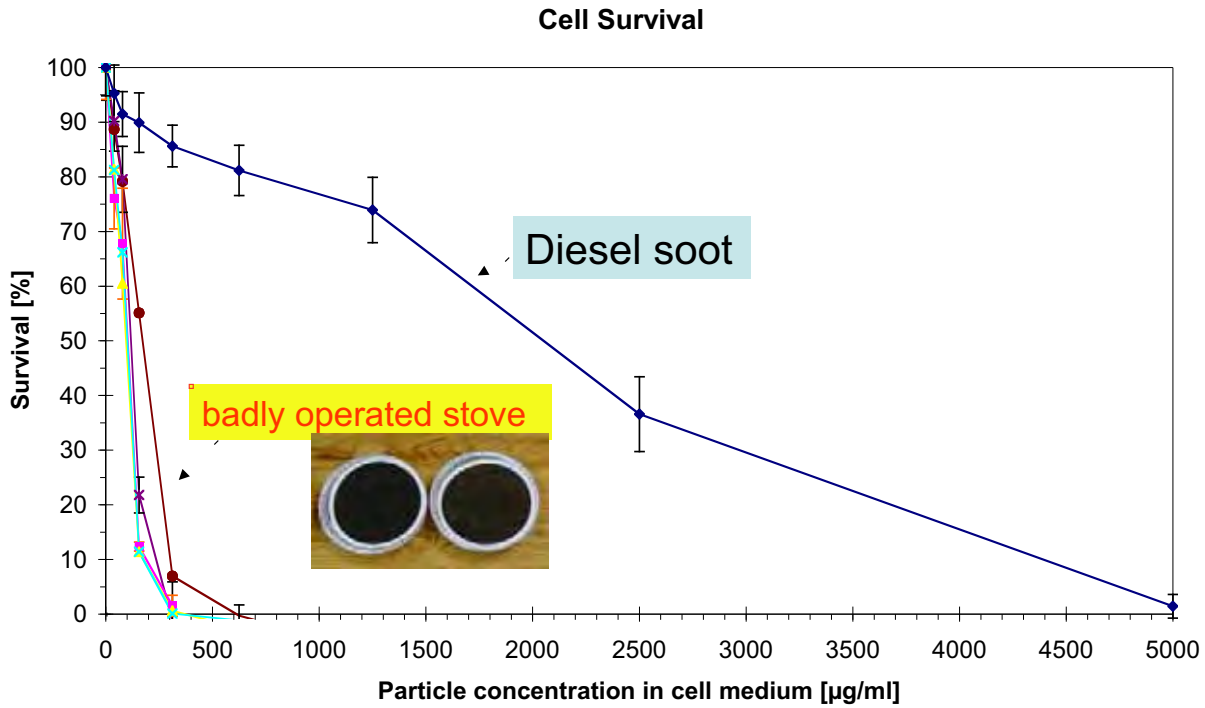

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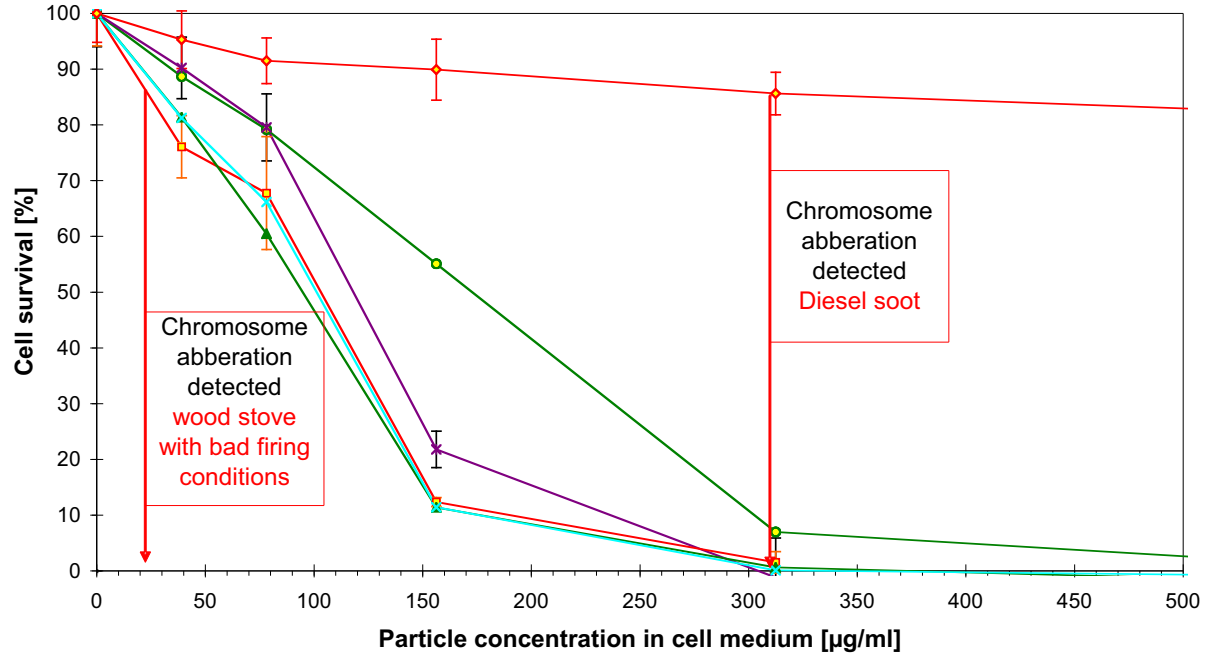
Carcinogenic potential estimated by chromosome defects



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Alte Version !

	Flaming Combustion			Pyrolysis
	lack of O_2 in the flame	– Mix –	T and O_2 good	T low at start or high O_2 O_2 lack gas. or fl. ext.
View				
PM	**Soot**	Salts + Soot	**Salts**	**COC**
Composition	EC / BC chemical / optical C/H > 6...8	◄ ►	CC + Minerals carbonate C + inorg. M	OC = TC–EC–CC C/H < 2
Colour	black	grey	white	brown l none
Health effect		◄ ►	–	
Climate effect	▲ absorbs light and heats atmosphere*	◄ ►	▼ scatters light and cools surface	▶ weakly absorbs and scatters

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* [T. Bond, Testimony, US House of Repr. 10.18.07]: BC = 2000 x CO_2 for 20 y
[ICCT, June 2009]: BC responsible of 0.34 Wm^{-2} of total 1.6 Wm^{-2}

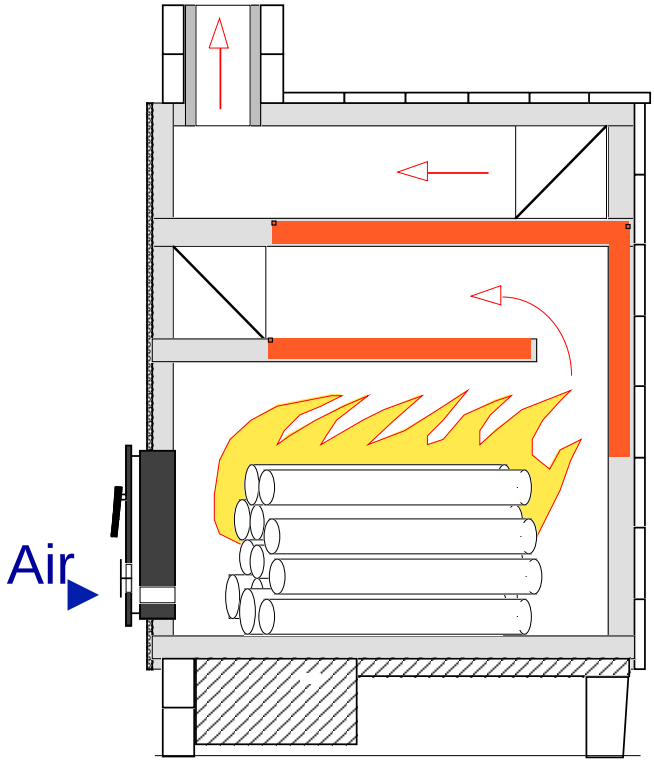
Holzenergie SCHWEIZ

Richtig Anfeuern

Holzfeuerungen mit oberem Abbrand

[www.bfe.admin.ch] oder [www.holzenergie.ch]

1-stage Combustion with Combustion Chamber



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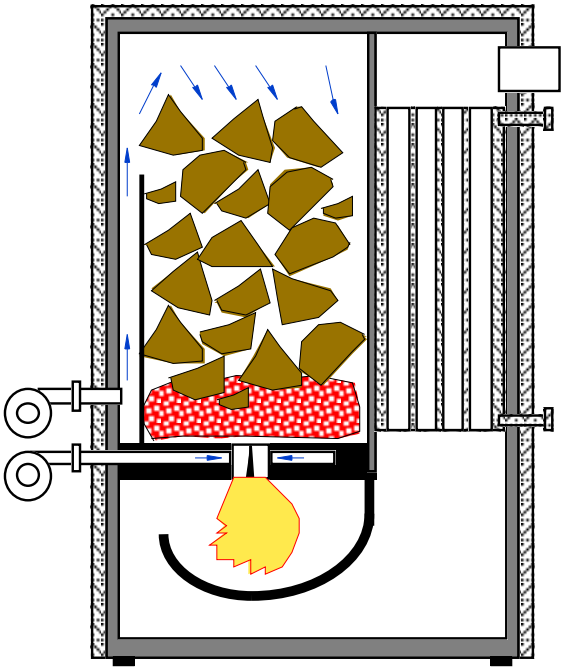
2-stage Combustion with forced Downdraft



Wood: **C H O**

+ Air $\lambda < 1$

O_2 + N_2

CO, H_2, C_xH_y
CO_2, N_2

+ Air $\lambda > 1$

O_2 + N_2

CO_2, H_2O, N_2

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Eta > 90% – But: Heat Storage Tank needed !

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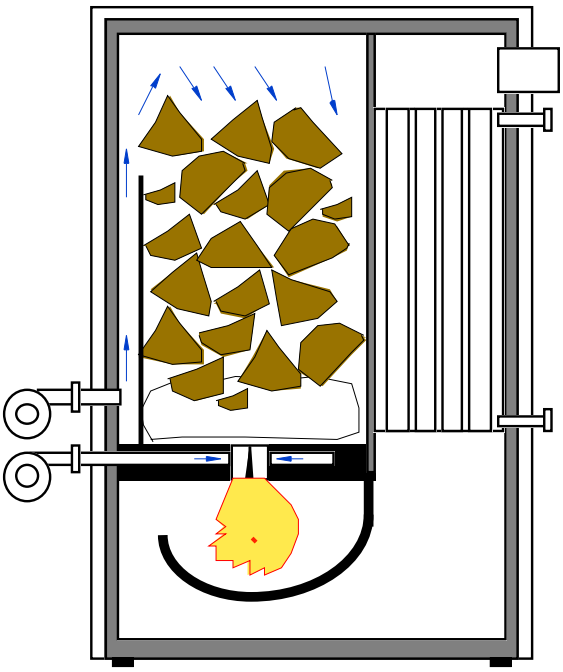
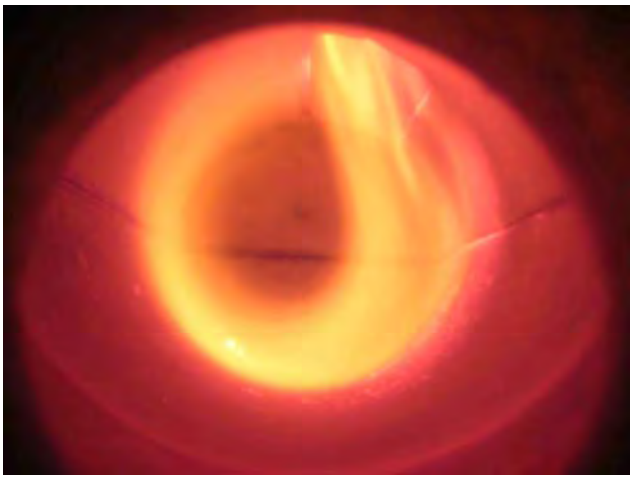
2-stage Combustion with forced Downdraft





Fröling S4 Turbo 28 kW, Foto: R. Mettler 2008

Premixed flame

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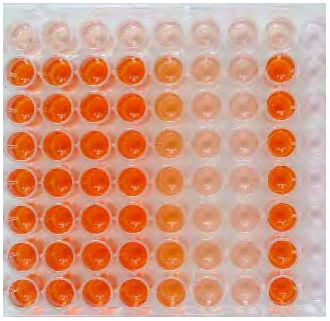

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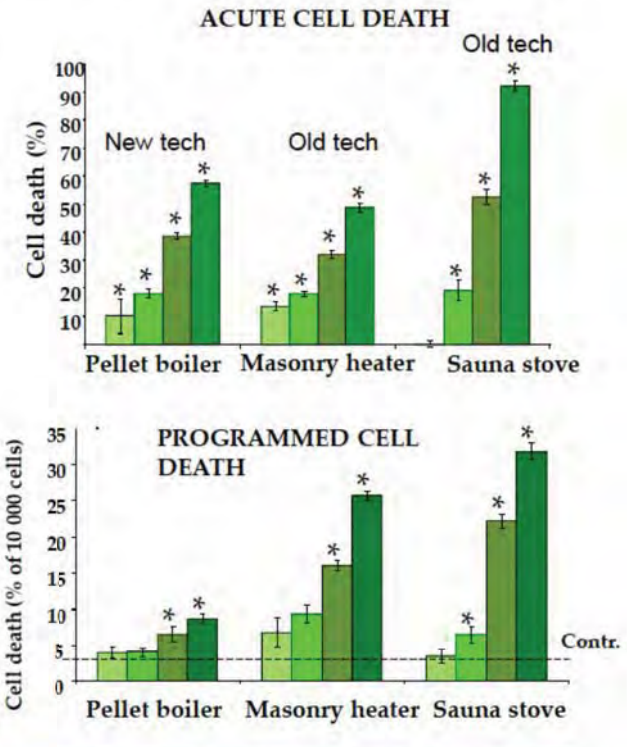
Jokiniemi et al results on health effects published in [Tapanainen et al, Atm. Env., accepted 2011]

Particles produced in poor combustion conditions induce extensive cell death

- All the studied emission particles caused acute and programmed cell death in macrophages
- The particles emitted from sauna stove were the most cytotoxic



Tapanainen et al, accepted in Atm Env. 2011

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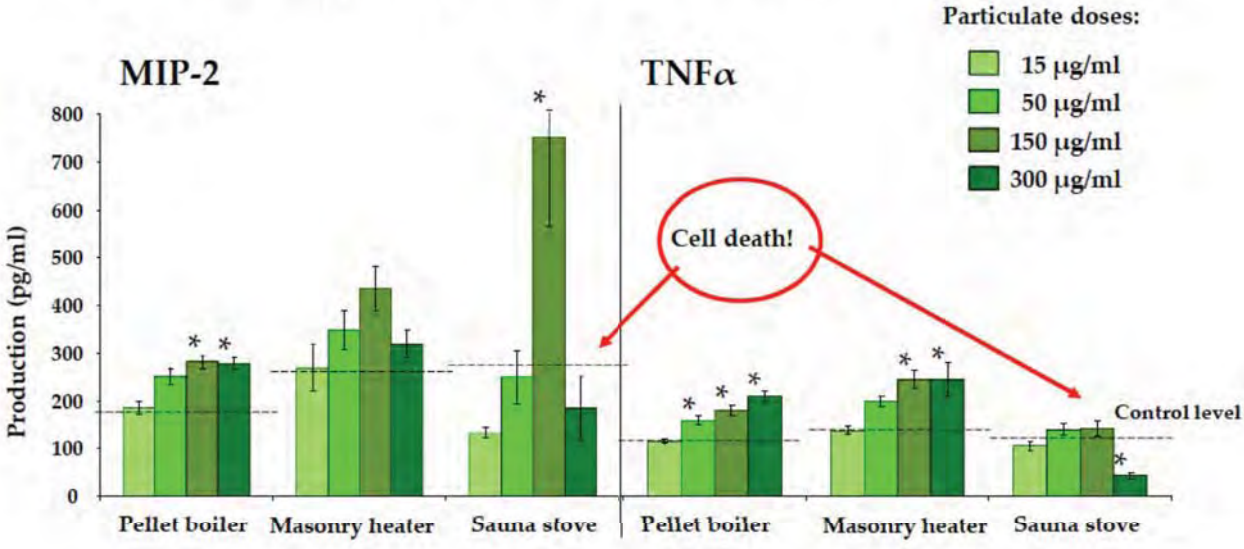
Jokiniemi et al results on health effects published in [Tapanainen et al, Atm. Env., accepted 2011]

Wood combustion particles induce weak inflammatory responses in macrophages



Tapanainen et al, accepted in Atm Env. 2011

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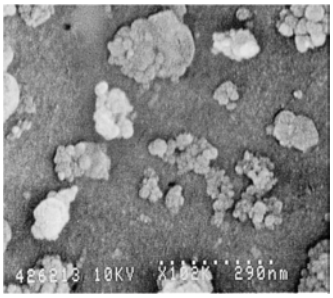

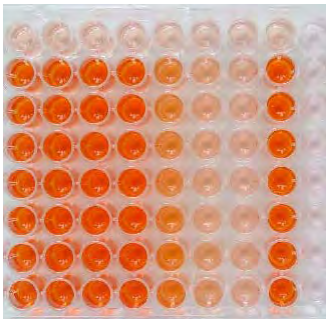

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Conclusions

1. PM in the ambient is highly health relevant
   consisting of
   Primary *and* Secondary Aerosols (PA and SA)

2. Biomass combustion contributes significantly to PA *and* SA

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3. Biomass combustion is related to three different types of PA, i.e.: Condensables (COC), soot, and ash related salts.
   Biomass combustion causes Secondary Organic Aerosols (SOA)
4. Combustion conditions influence health relevance of PA and SA:
5. PM from incomplete combustion conditions is highly health relevant (cytotoxicity and chrom. abb. 10 x more than Diesel soot, masonry heater 3 x pellet boiler). This is due to soot *and* COC (incl. PAH)
6. PM from near-complete combustion of native wood (non contaminated!) is much less health relevant than Diesel soot.
7. Hence high temperature and good gas/air mixing is crucial (automatic)
8. There are huge differences according to a) combustion type (manual/ automatic), b) fuel (moisture in small scale), c) operation
9. However, fuel constituents need to be considered too: Heavy metals, PCDD/F due to Cl and Cu highly cancerogenic/toxic. In addition, Ca and Na are associated with inflammatory activity [Jokiniemi et al.].

Acknowledments

Swiss Federal Office of Energy
Swiss Agency for the Environment
International Energy Agency

Further Information: www.verenum.ch

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