State of the art-small scale biomass combustion in stoves

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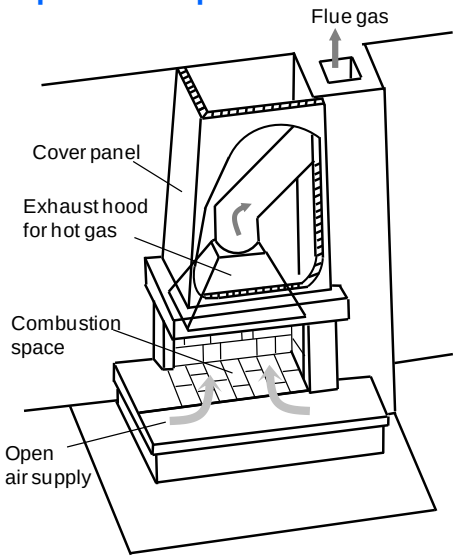
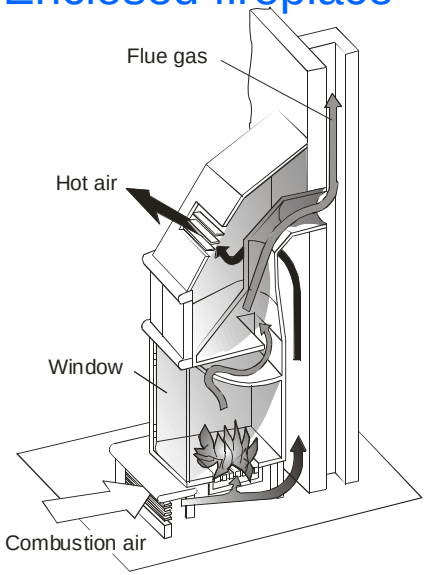
Content

Types of stoves for log wood

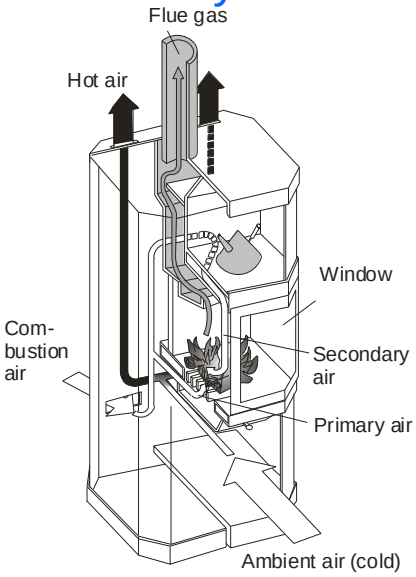
Open fireplace



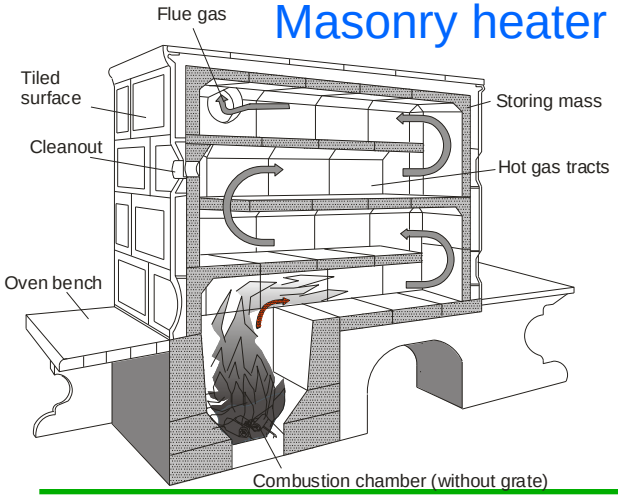
Enclosed fireplace



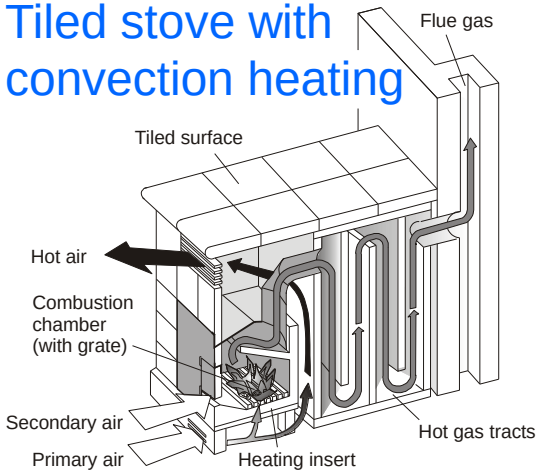
Chimney stove



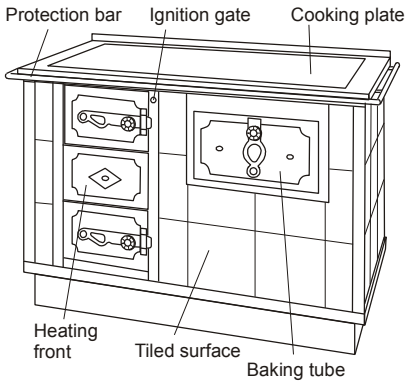
Masonry heater



Tiled stove with convection heating



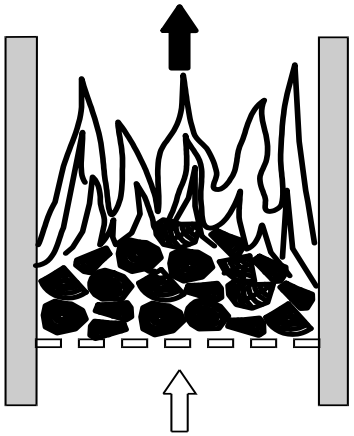
Cooking stove



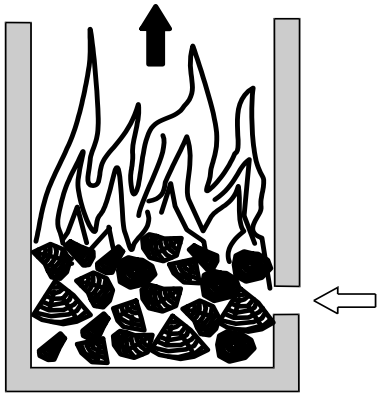
Combustion principles for wood logs

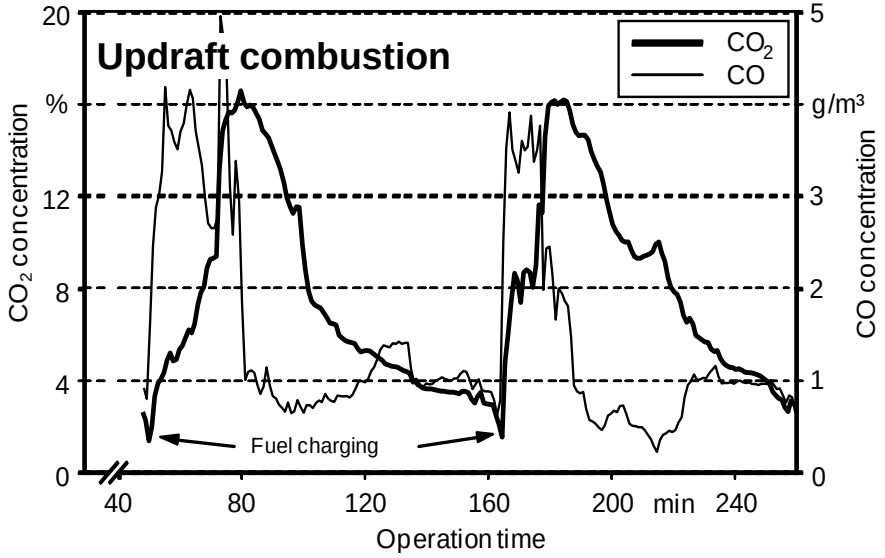
Updraft combustion

with grate

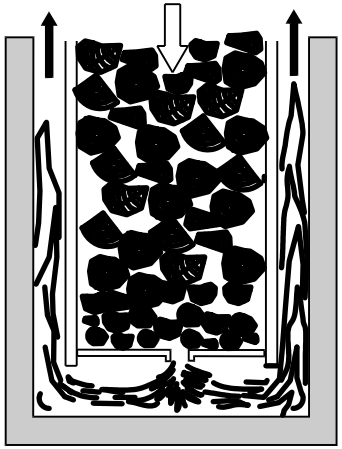


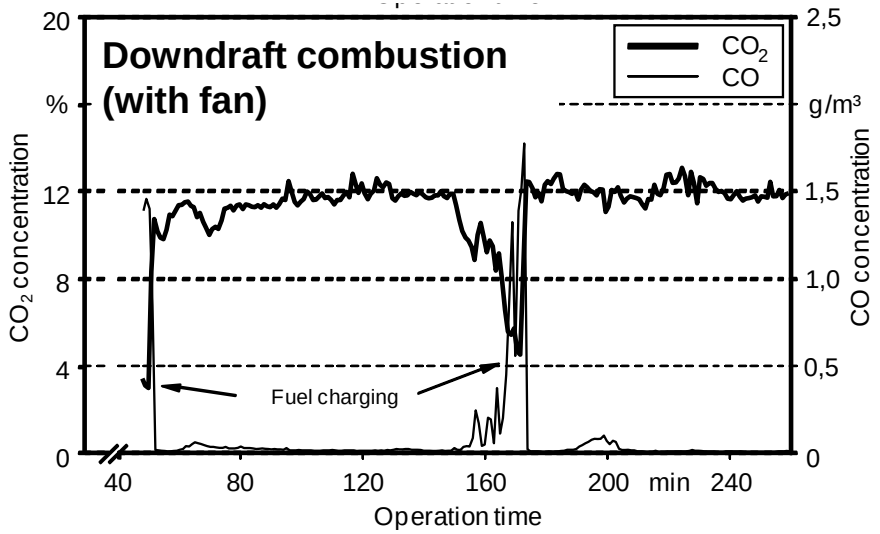
without grate





Downdraft combustion





Features of modern chimney stoves

Photos: Wodtke

- correctly dimensioned combustion chamber with chamotte walls (allowing high temperatures and high gas residence time)
- round shaped edges and corners in combustion chamber (to reduce dead zones)
- deflecting parts for increased turbulences and mixing of pyrolysis gases with oxygen
- separate primary- and secondary air inlets
- single crank mechanism for primary/ secondary air distribution
- preferably small windows (or none)
- preferably high and slim than wide furnace body geometry
- preferably long vertical pipe to chimney (for higher heat radiation into the room)

Useful components for inceased performance

Bleed air flap at chimney bottom (in the basement)

→ to avoid excessive draught in critical stages of combustion

Temperature display for stoves

→ to avoid too high temperatures (by reduced charging)

Microelectronic control units

→ retrofit units or integrated air control flaps (for stoves with central air insert sockets)

Emission and efficiency requirements (Example: Germany)

Requirements for type tests (according to emission directive “1. BImSchV“ from 2010)
All emissions are given at 13 % O_2-concentration).

Furnace type	**Step 1:** erected after 22.03.2010		**Step 2:** erected after 31.12.2014		erected after 22.3.2010
	CO [g/m³]	Dust [g/m³]	CO [g/m³]	Dust [g/m³]	minimum efficiency [%]
Room heaters (flat furnace)	2,0	0,075	1,25	0,04	73
Room heaters (filling furnace)	2,5	0,075	1,25	0,04	70
Heat storage stoves	2,0	0,075	1,25	0,04	75
Closed fireplaces	2,0	0,075	1,25	0,04	75
Tiled stoves (flat furnace)	2,0	0,075	1,25	0,04	80
Tiled stoves (filling furnace)	2,5	0,075	1,25	0,04	80
Cooking stoves	3,0	0,075	1,50	0,04	70
Central heating&cooking stoves	3,5	0,075	1,50	0,04	75
Pellet stoves without water jacket	0,40	0,05	0,25	0,03	85
Pellet stoves with water jacket	0,40	0,03	0,25	0,02	90

Flue gas treatment: Electrostatic precipitators

Separators for flue gas tube integration
(living rooms)

ESP-chimney systems

Chimney-top separators

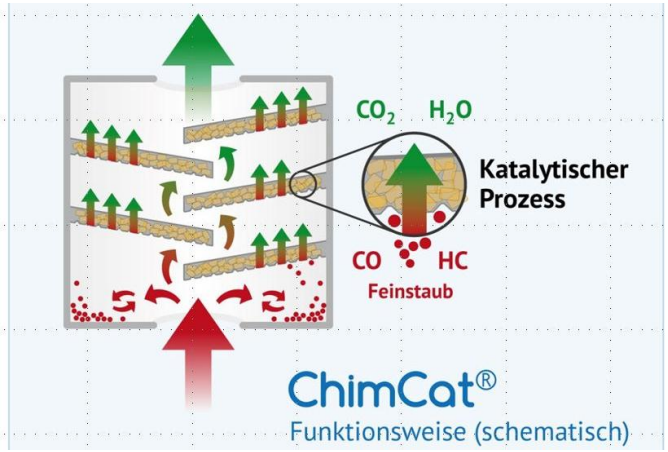
Separators for central heating boilers

Flue gas treatment: Filters and catalysts

Foam ceramic insert (barrier filter)

- filter type: foam ceramic as full flow barrier filter in combustion chamber outlet
- manual cleaning by operator (washing, blowing, etc.)
- thermal regeneration in furnace

photos by Hark GmbH



- catalyst type: activated ceramic granulate modules
- integrated or retrofit units
- mainly for CO- and carbohydrates reduction, minor effect on particles expected

Images by Dr. Pley Environmental

Ignition: „Top-down ignition method“ (recommended)

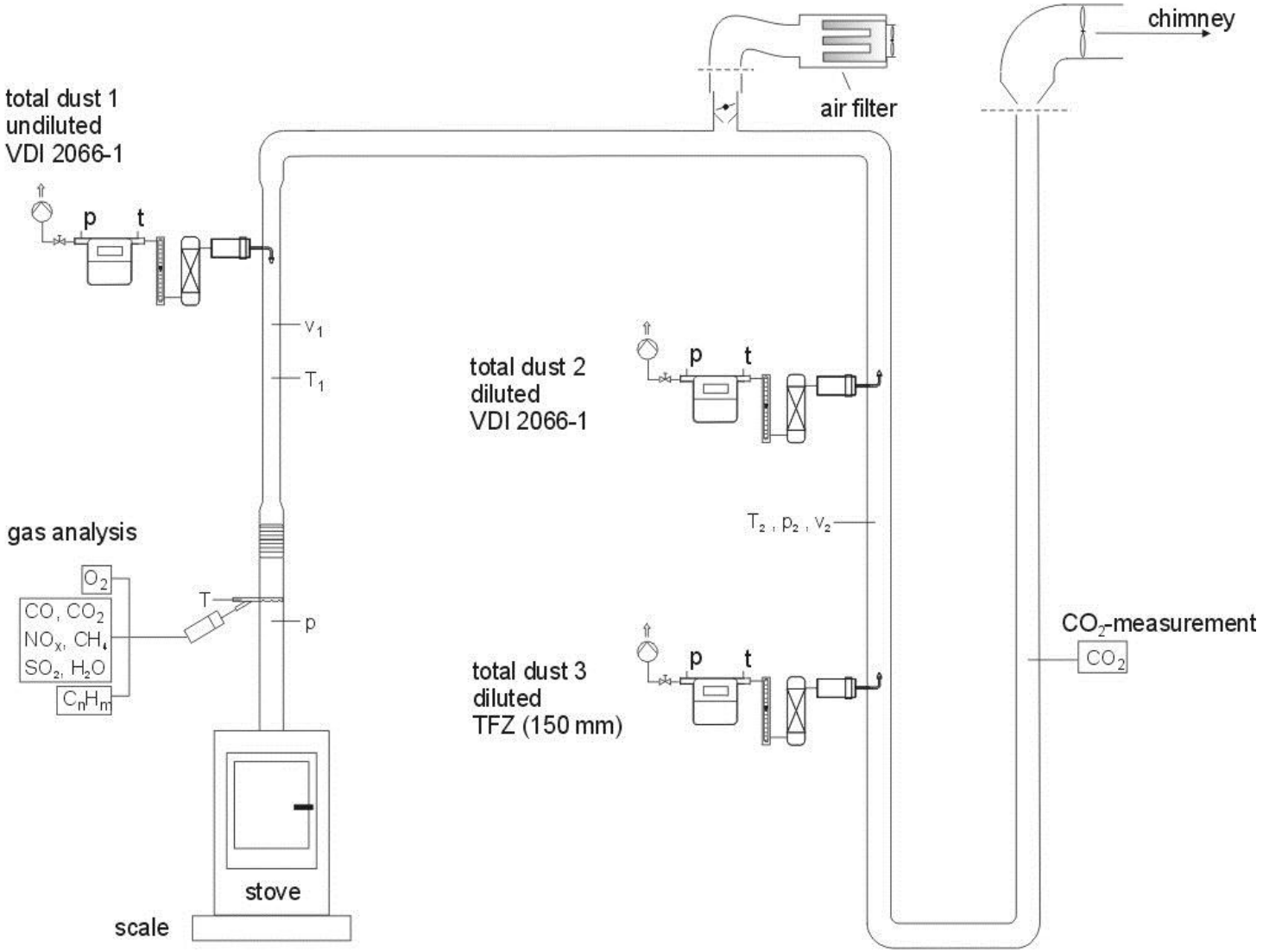
4 firewood pieces of 3x3x20 cm and ignition agent (waxed wood wool rolls)

wood sticks crosswise and ignition agent below

“ignition module“ on top of wood logs

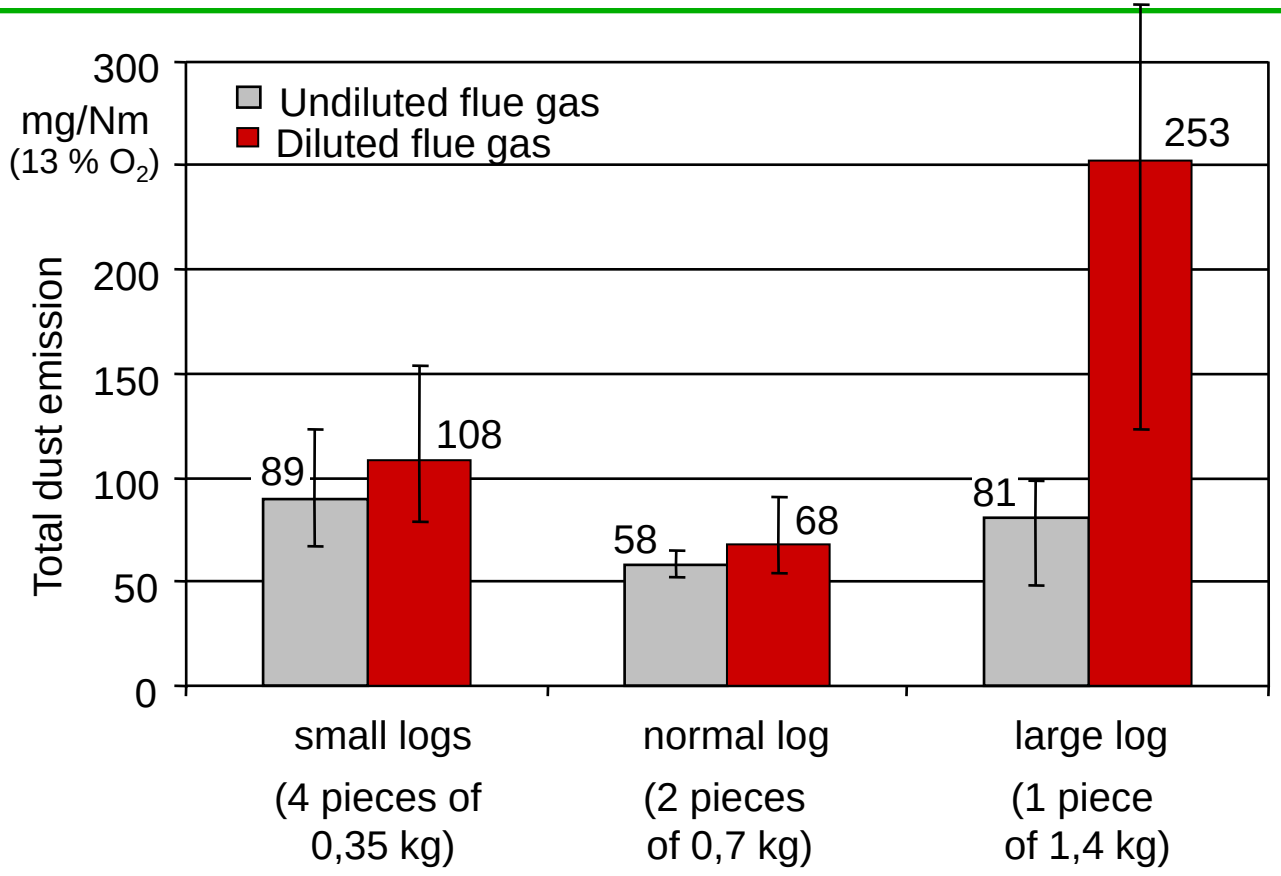
Source: Swiss brochure “Richtig Anfeuern“

Experimental setup for chimney stove trials



Buderus blueline No.12,
8 kW

Log size influence - Stove 1: Total dust emission



Chimney stove Wodtke "Moon" (7 kW, updraft)

Log size influence - Stove 2: Fuels used

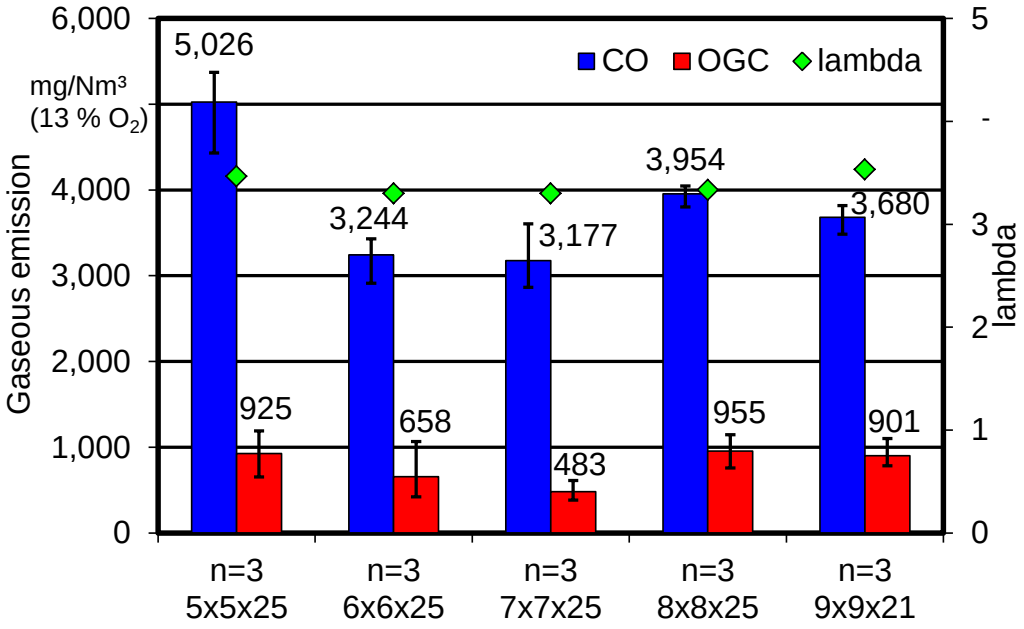


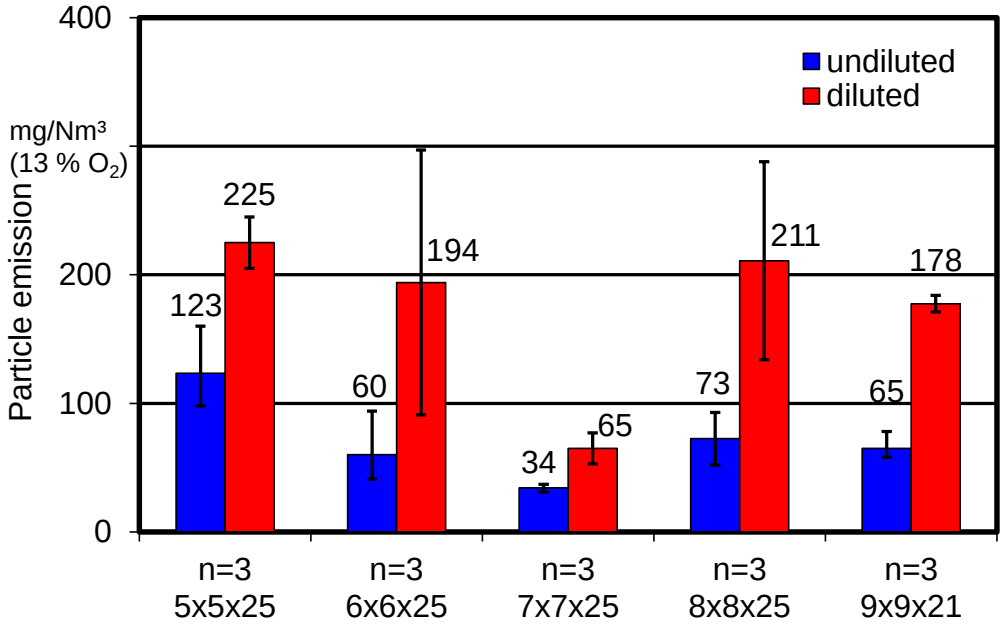


5x5x25 cm	6x6x25 cm	7x7x25 cm	8x8x25 cm	9x9x21 cm

- beech wood without bark
- fuel load: always about 2.5 kg
- uniform moisture content: 15.5 %

Log size influence - Stove 2 : CO and total dust emissions





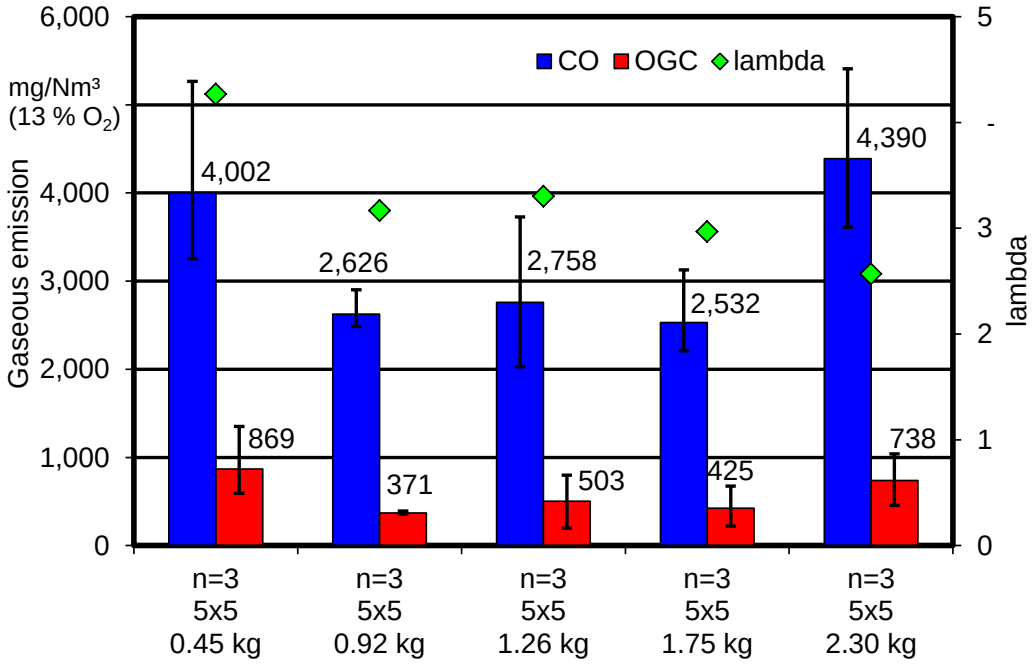
Chimney stove
Buderus blueline 8 kW

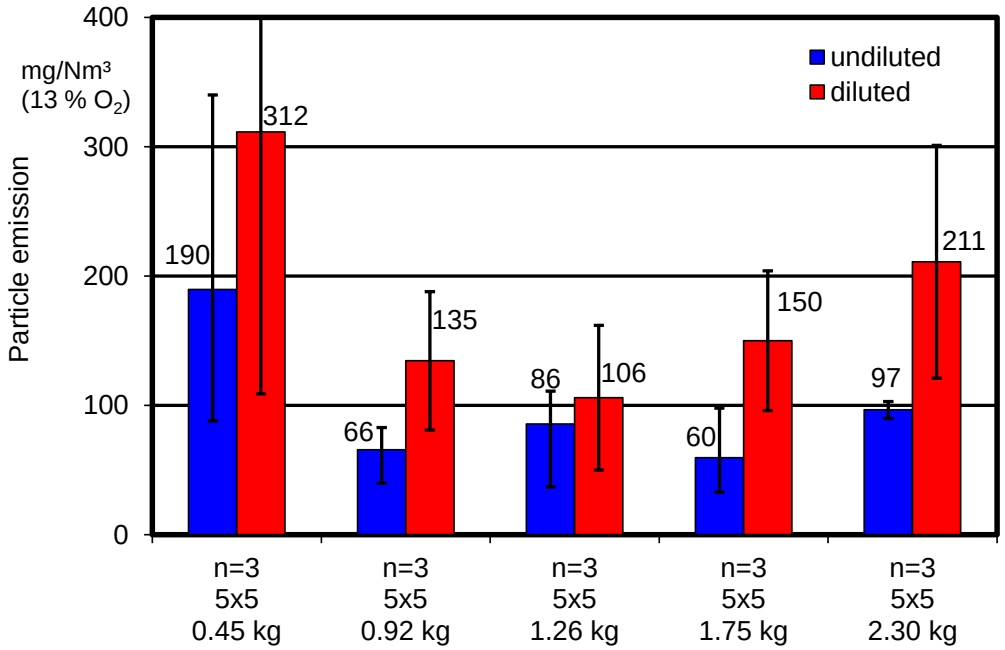
Loaded fuel mass influence - Stove 2: Fuels used

0.45 kg	0.92 kg	1.26 kg	1.75 kg	2.30 kg

- beech wood without bark
- log size with 5x5x25 cm with increasing number of logs
- moisture content of about 14 %

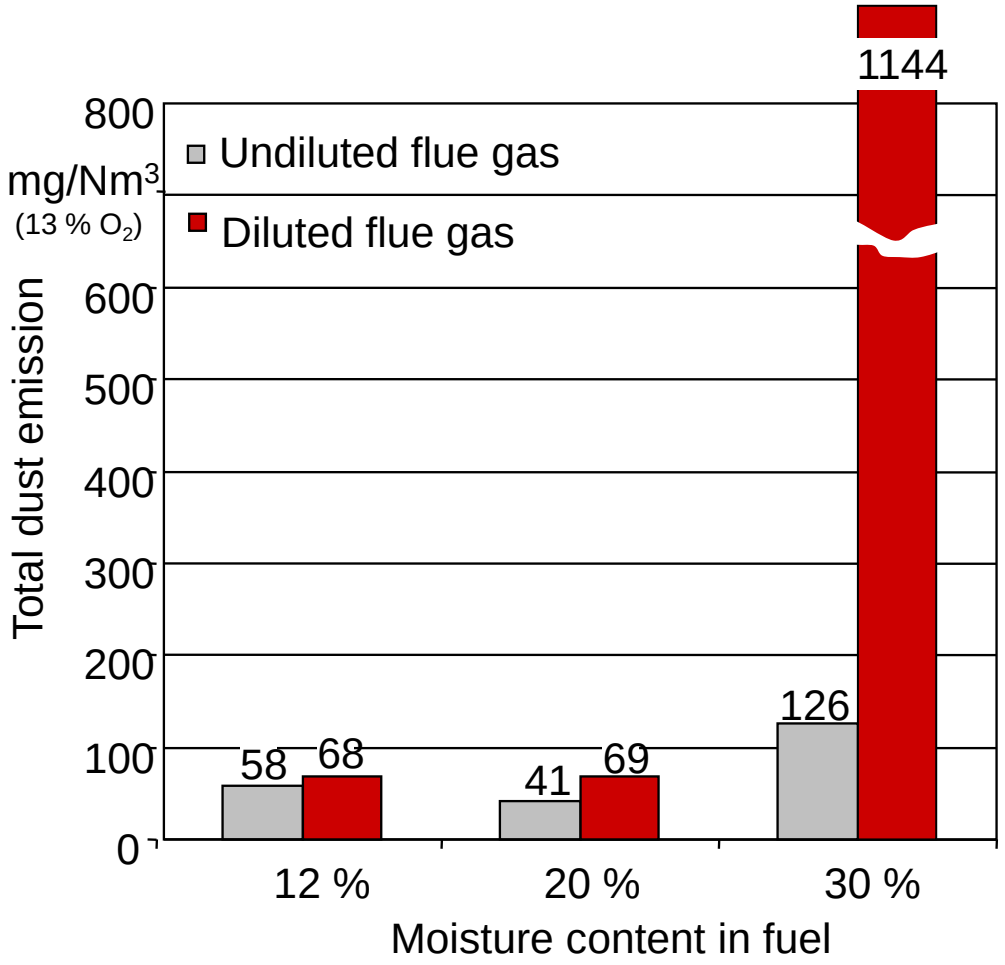
Loaded fuel mass influence: CO and total dust emissions





Chimney stove
Buderus blueline 8 kW

Fuel moisture influence - Stove 1: Dust emission



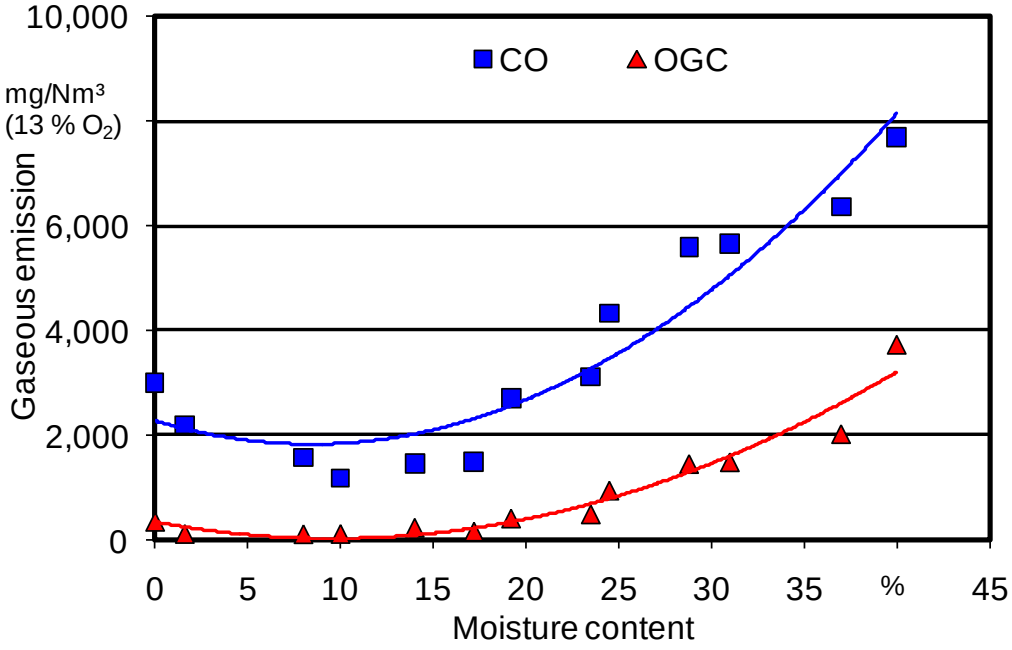
Fuel used: beech logs (25 cm)

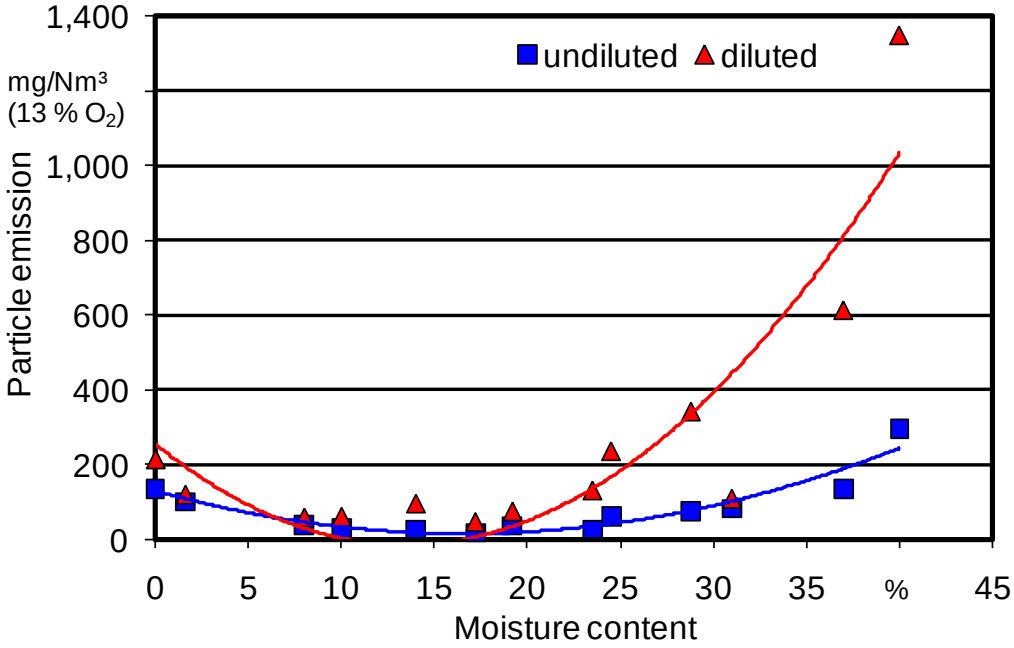
Chimney stove Wodtke "Moon" (7 kW, updraft)

Fuel moisture influence - Stove 2: CO and total dust emissions

Chimney stove
Buderus blueline 8 kW

standard test fuel used : 7x7 cm beech wood





- lowest emissions: between 8 - 17 % moisture content
- below 8 %: emissions increase (→ avoid immediate use of technically dried wood)
- above 30 %: smoldering of wood leads to very high emissions

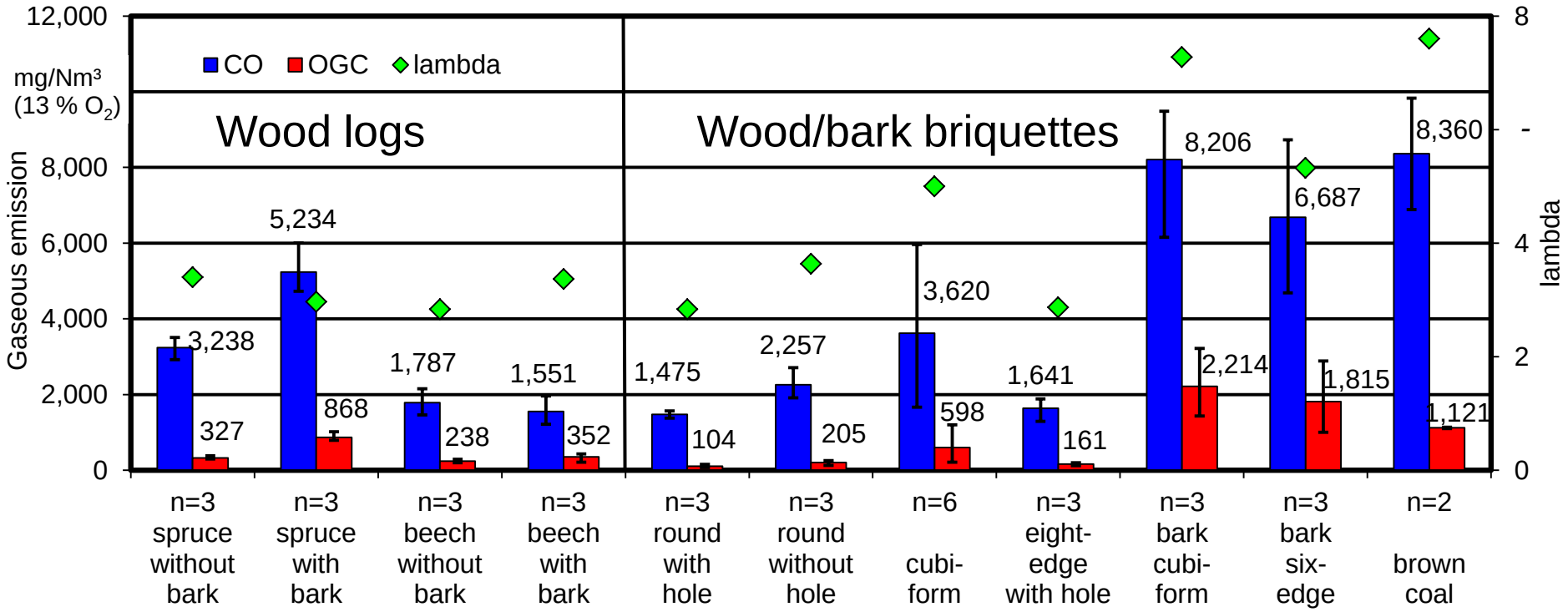
Combustion of briquettes - Procedure

spruce without bark	spruce with bark	beech without bark	beech with bark

round with hole	round without hole	cubiform	eightedge with hole	bark cubiform	bark sixedge	brown coal

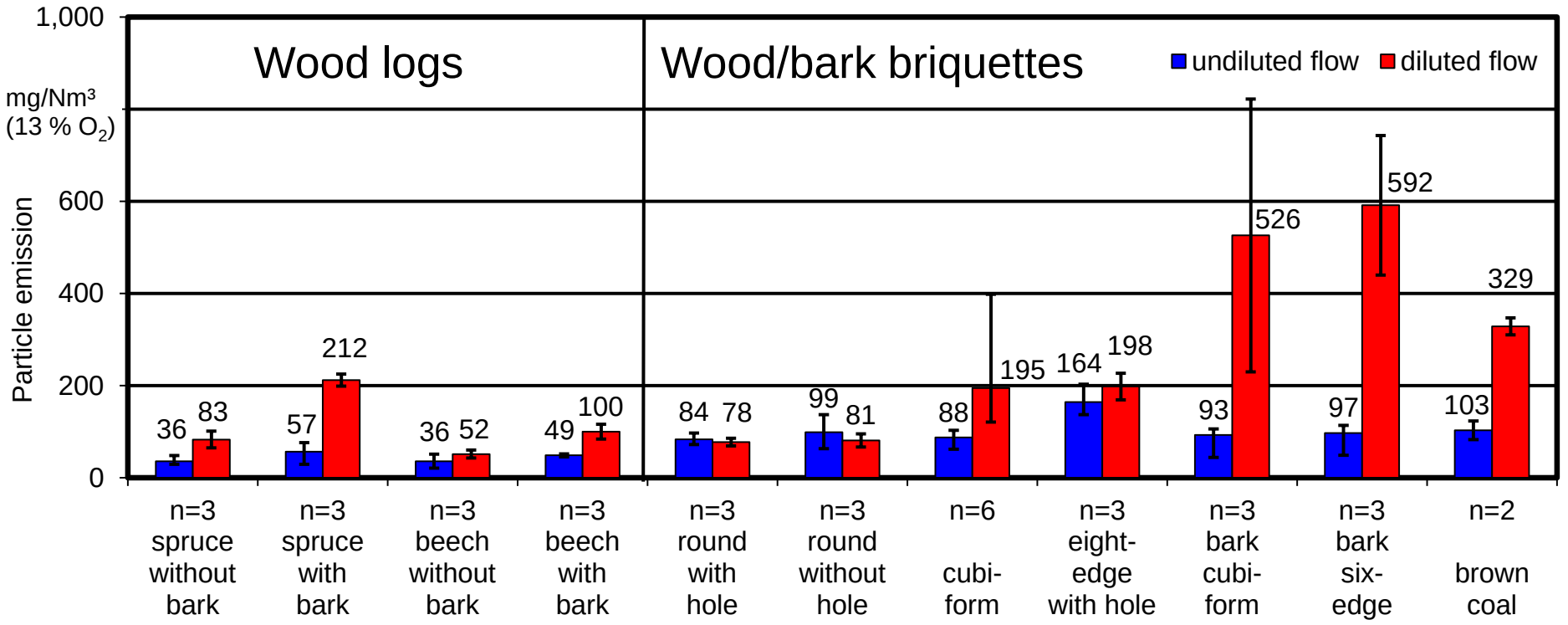
- ignition performed with spruce wood without bark for briquette trials
- fuel load was always about 1.6 kg per batch

Combustion of briquettes – Gaseous emissions



Chimney stove
Buderus blueline 8 kW

Combustion of briquettes – Total dust emissions



Chimney stove
Buderus blueline 8 kW

Summary and conclusions

- Loading mass per charging and log size have an important impact on emissions.
- Too high and too low fuel moisture content can be harmful.
- Pure bark briquettes are less suitable for chimney stoves.
- Excessive particle emissions due to an incomplete combustion can better be identified by flue gas dilution/cooling before sampling.

Thanks for listening!

www.tfz.bayern.de