New developments in small scale ESP technology

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- Introduction
- Current developments of small ESP's for wood combustion and results from tests
- Outlook on filter test project by TFZ
- Test procedure
- Conclusions

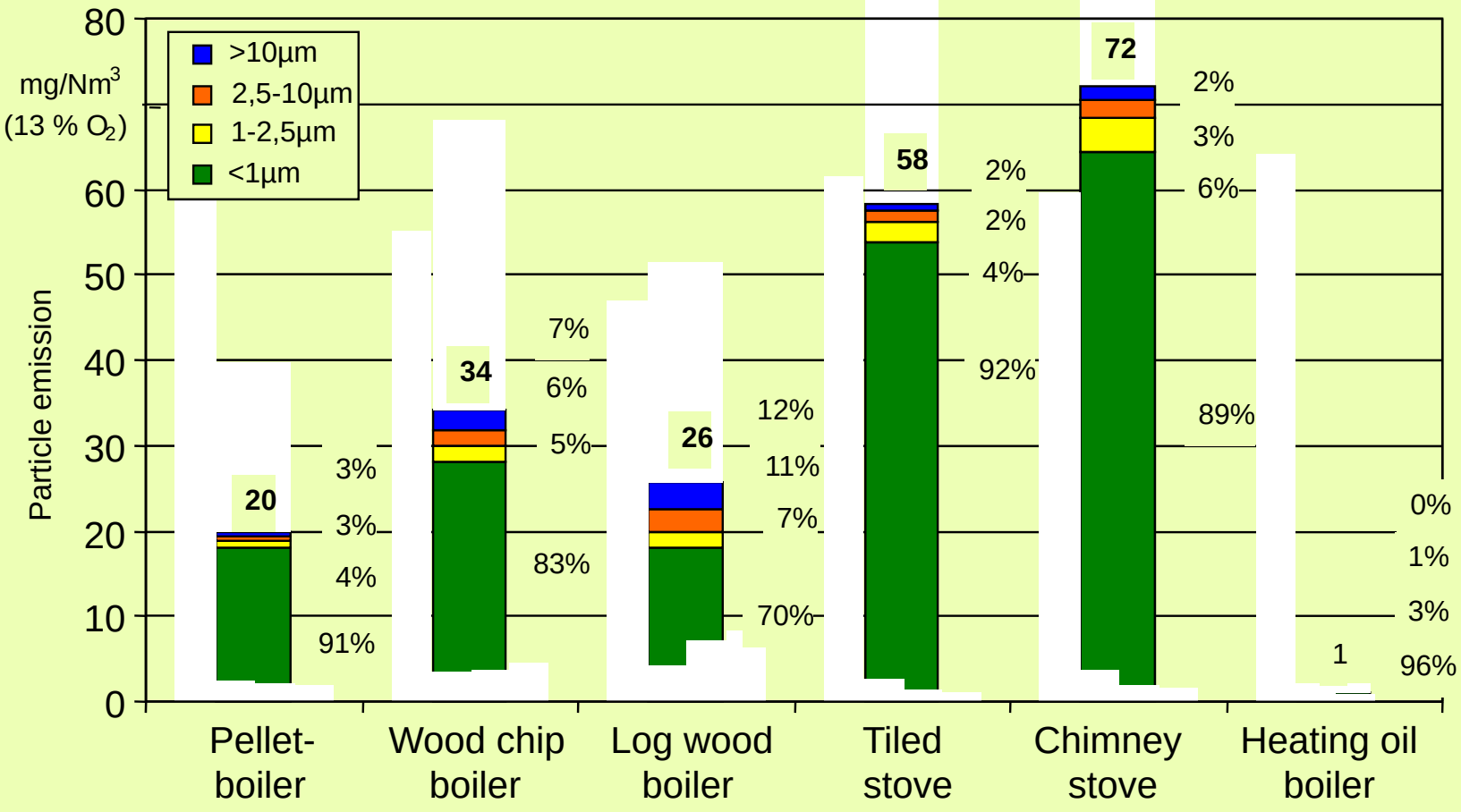
German emission directive – Proposed future limitations for **room heaters/stoves**

Requirements for type tests according to 1.BImSchV-amendment, emissions given at 13 % O_2-conc.
(here: no inspection by chimney sweep shall be required!)

Furnace type	**Step 1:** erected after regulation date		**Step 2:** erected after 31.12.2014		erected after regulation date
	CO [g/m³]	Dust [g/m³]	CO [g/m³]	Dust [g/m³]	minimum efficiency [%]
Room heaters with flat furnace	2,0	0,10	1,25	0,04	73
Room heaters with filling furnace	2,5	0,10	1,25	0,04	70
Heat storage stoves	2,0	0,10	1,25	0,04	75
Closed fireplaces	2,0	0,10	1,25	0,04	75
Tiled stoves (flat furnace)	2,0	0,10	1,25	0,04	80
Tiled stoves (filling furnace)	2,5	0,10	1,25	0,04	80
Cooking stoves	3,0	0,10	1,50	0,04	70
Central heating&cooking stoves	3,5	0,10	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

State-of-the-art wood furnaces in Germany – Recent measurements from practice oriented trials. Here: total dust and particle sizes

Average of 10 to12 measurements (per furnace) using hard and soft wood in the usual moisture range



Source: TFZ, unpublished

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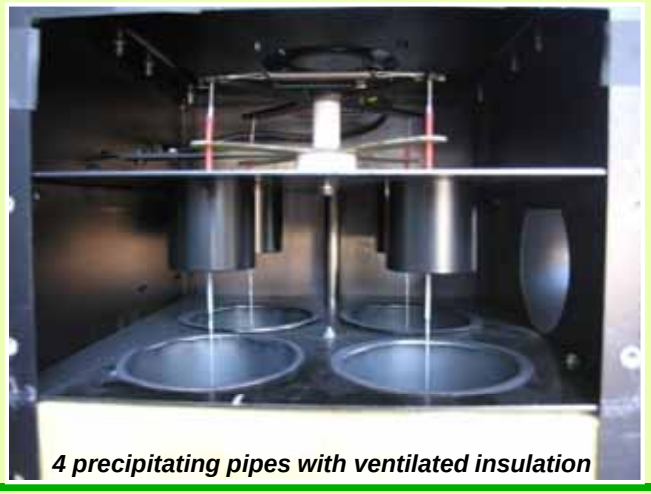
im Kompetenzzentrum für Nachwachsende Rohstoffe

Spanner ESP-type (Germany): SFF 20, SFF 50 and SFF 100
Electrostatic precipitator for small scale application

- Manufacturer: Spanner Re², Neufahrn,Germany
- Power of boiler: <30 kW, <85 kW and <150 kW
- Voltage: 15 kV (50 W transformer)
- Pressure drop: 40 Pa
- PM-emission: <10 mg/Nm³
- Automatic cleaning system by vibration (daily)
- State: field testing of prototypes
- Prospected price: around 1000,-/1500,- €

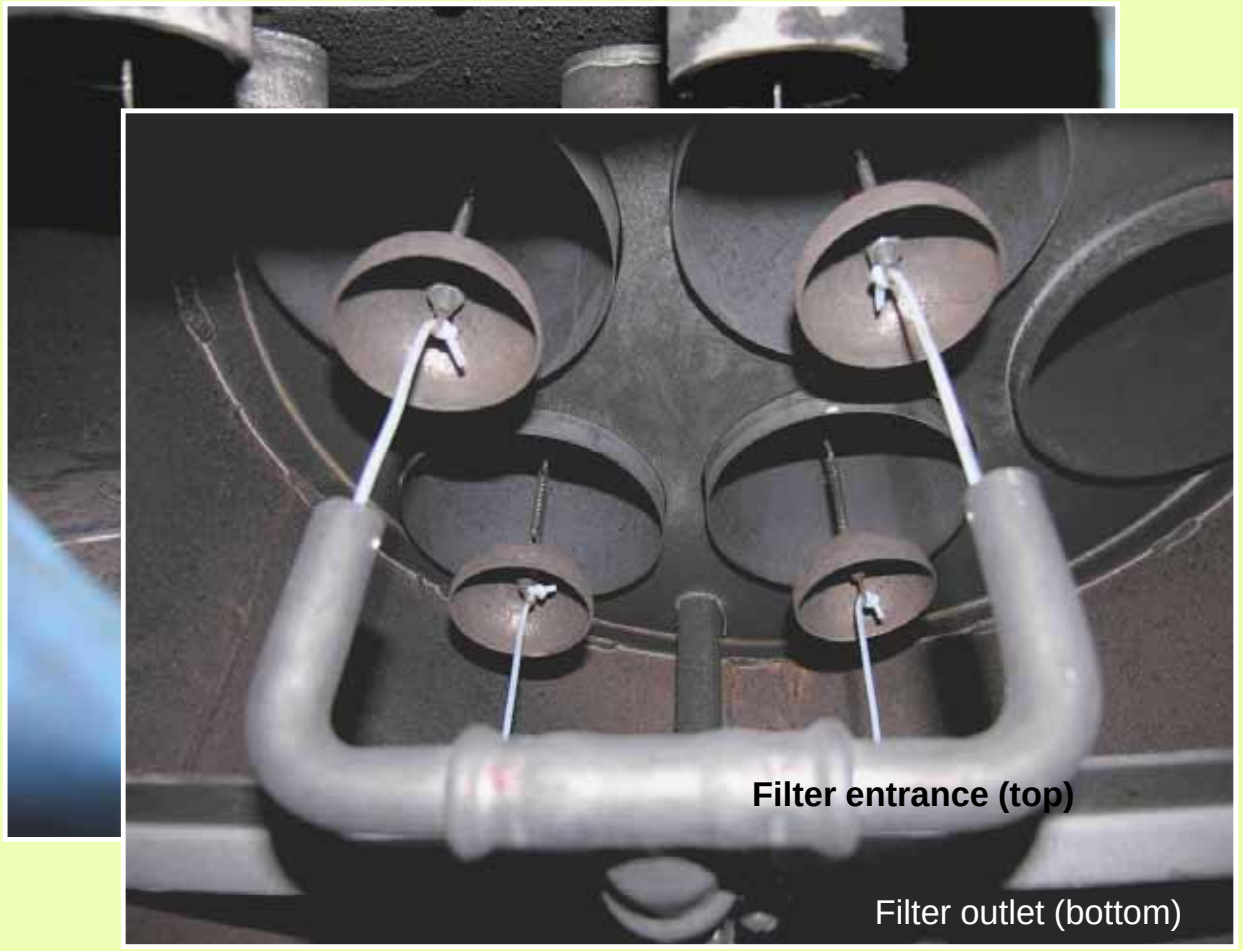


4 precipitating pipes with ventilated insulation

retrofit unit (20 kW)

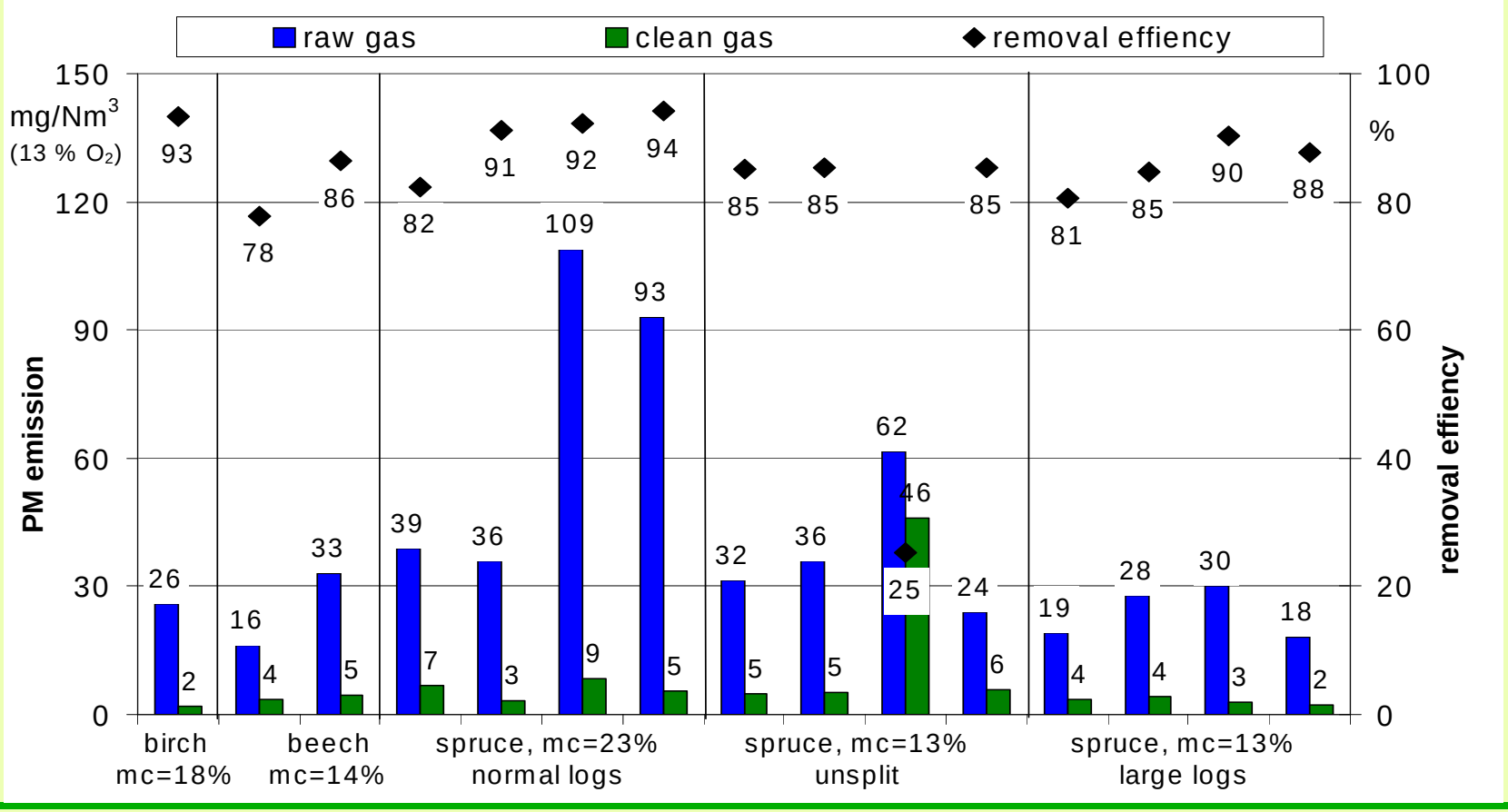
Integrated electrostatic precipitator (by Spanner) on top of pellet boiler

Spanner ESP-type: Large filter version (SFF 50)

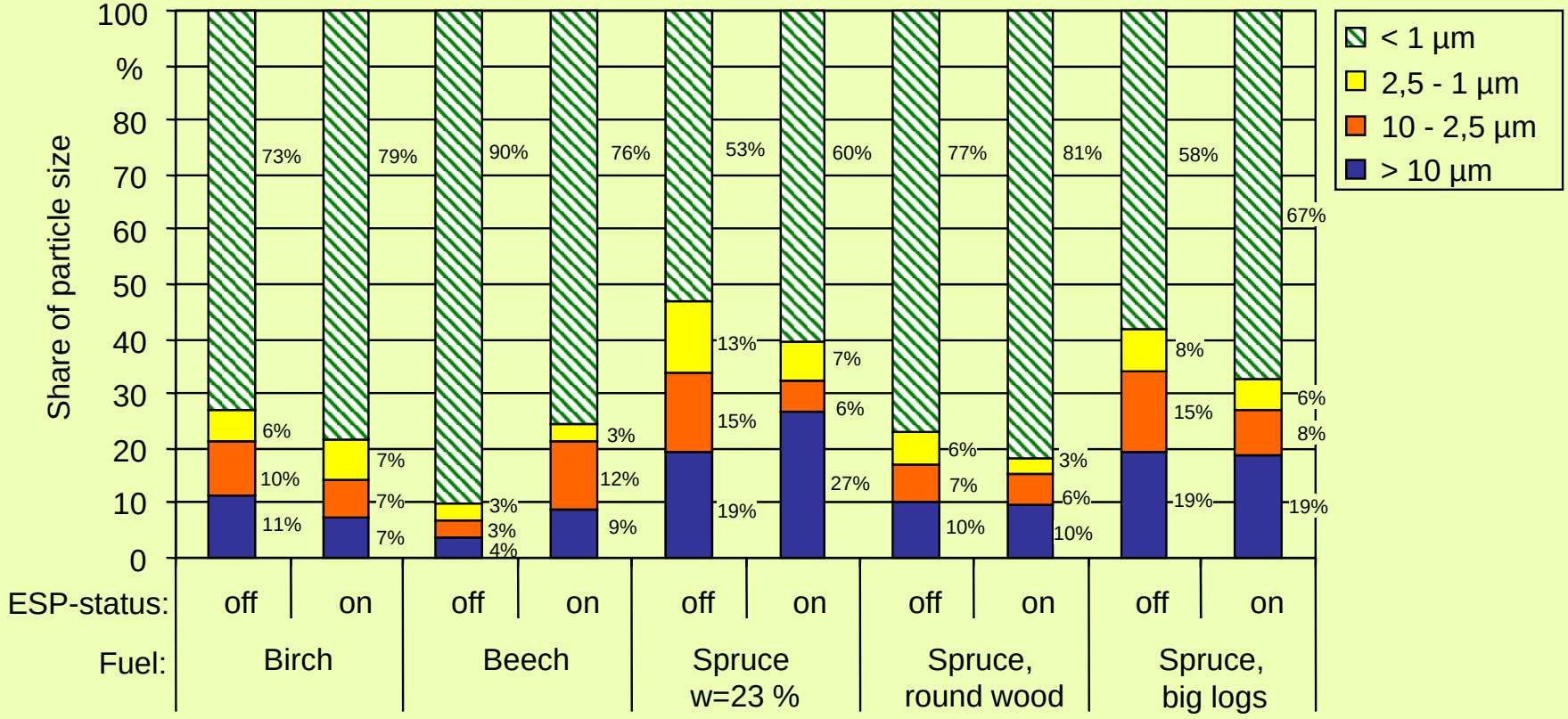


Test results with Spanner ESP-type (SFF 20): Particle removal from log wood boiler exhaust fumes

PM emissions and removal effiency measured with 30 kW log wood boiler at the TFZ test stand with different wood fuels (unpublished data by TFZ)



Test results with Spanner ESP-type (SFF20): Particle size distribution



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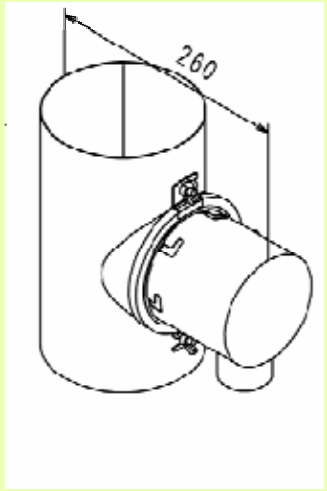
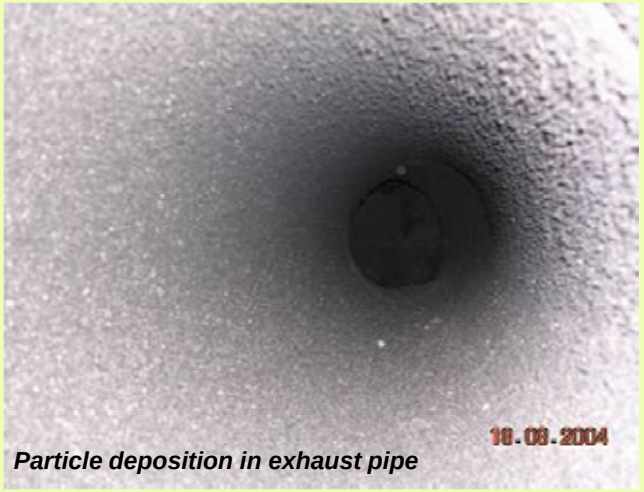
Ruegg- / K&W-type ESP (Switzerland/Germany): Electrostatic precipitator for small scale application

- Mainly for wood stoves
- Min. 1,5 m metal exhaust pipe required
- Voltage: 20 kV
- Cleaning by hand
- Electr. consumption: 12/3,6 W (on/standby)
- State: series (Switzerland), field testing (Germany)
- Price: around 1300,- €



Electrode and particle deposition in exhaust pipe

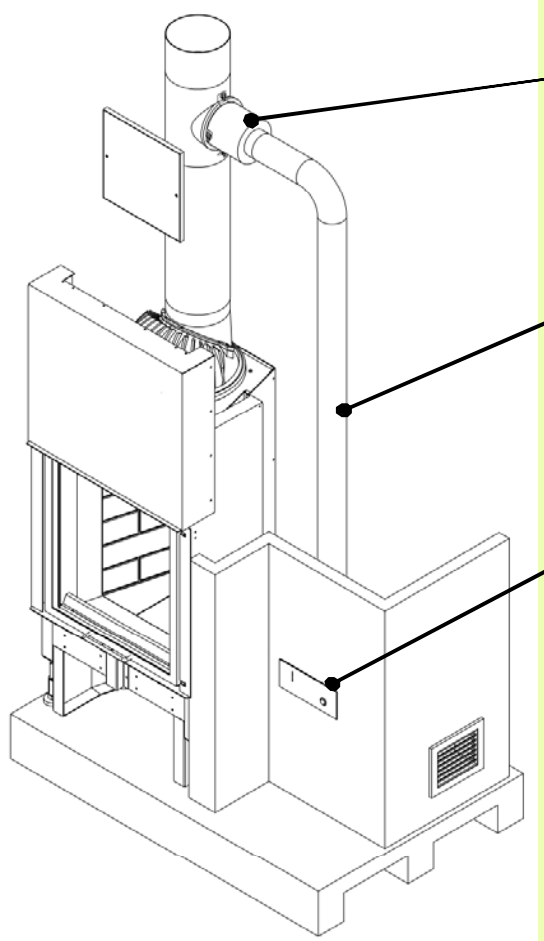


Particle deposition in exhaust pipe

Photos:
Ruegg, Switzerland

Ruegg- / K&W-type ESP: Examples of applications

Application in living rooms



Filter insert
- Electrode
- Thermostat

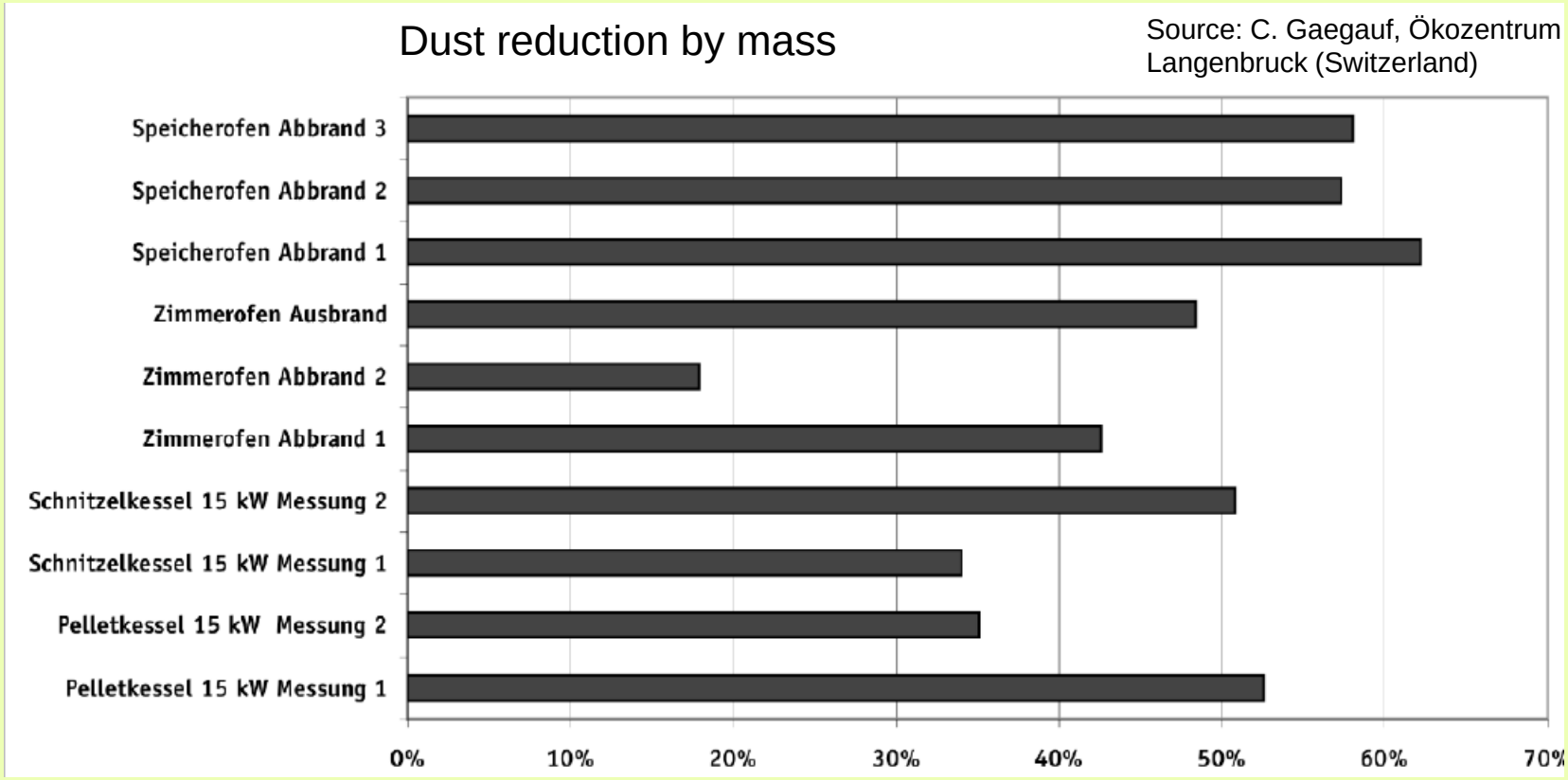
Feed pipe
- Purge air
- High voltage

Control module
- Contol unit
- Ventilator
- Electr. supply 230V

Source: Ruegg, Switzerland

Application in chimneys

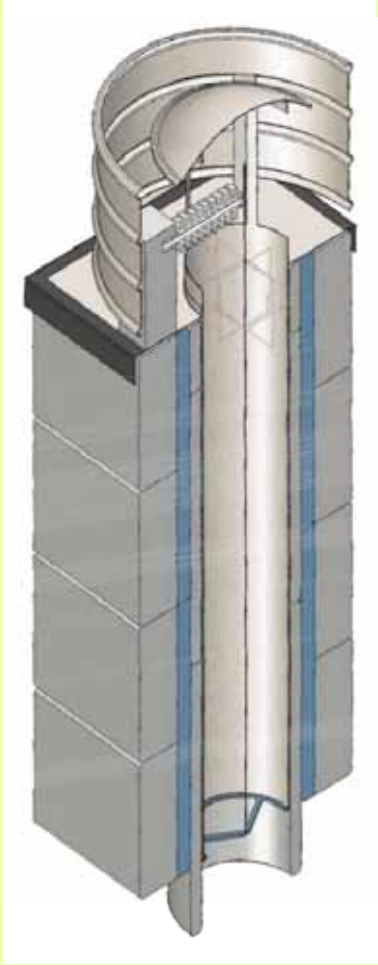
Test results with Ruegg- / K&W- type ESP



Further conclusion: - Particle reduction by mass is slightly lower than by particle numbers (SMPS)
- Separation is largely independent from total dust concentrations

APP-type ESP ($R_{esidential}$ESP, by APP Applied Plasma Physics, Norway): Electrostatic precipitator for chimney-top applications

- Mainly for wood or coal stoves and boilers
- Voltage: not specified
- Electr. consumption: not specified
- Price: yet unknown (below 1000,- €)
- State: field testing of prototypes

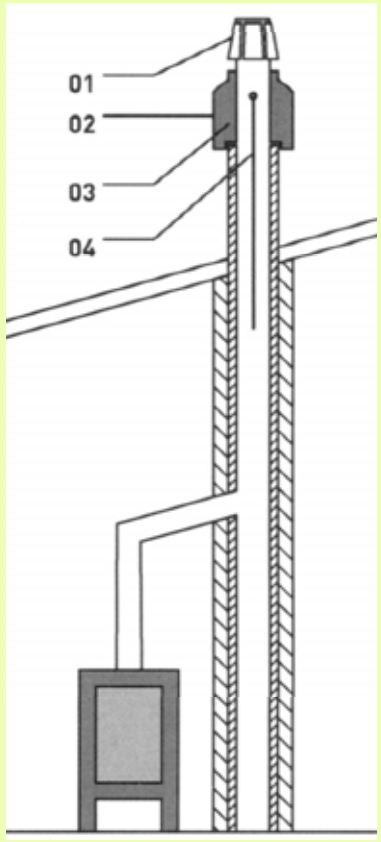


Source: APP, Norway

Oeko Tube ESP (by OekoSolve AG, Liechtenstein/Switzerland)
Electrostatic precipitator for chimney-top applications

- Mainly for wood stoves
- Max. power output: 35 kW
- Voltage: not specified
- Cleaning by hand (chimney sweep ?): first revision after 2 months
- Electr. consumption: 20 - 30 W
- Price: about 1400,- €
- State: series

01 Chimney head
02 Oeko Tube
03 Electrical connection
04 Electrode



Source: OekoSolve, Switzerland

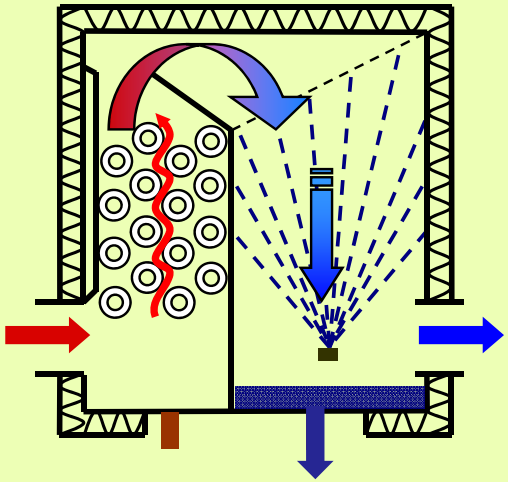
Spartherm ESP ("Airbox", Germany)
Electrostatic precipitator for living room applications

- Mainly for wood stoves or fireplaces
- Max. power output: 15 kW
- Manual bypass operation
- Voltage: not specified
- Cleaning by hand (every 100 hours, using vacuum cleaner)
- Electr. consumption: not specified
- Price: yet unknown
- Ptate: yet unknown

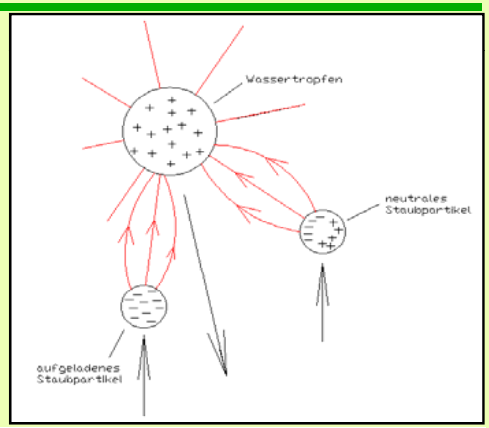
Source: Spartherm, Germany

Developing an "electrostatic scrubber" (Project FH Gelsenkirchen/Germany)

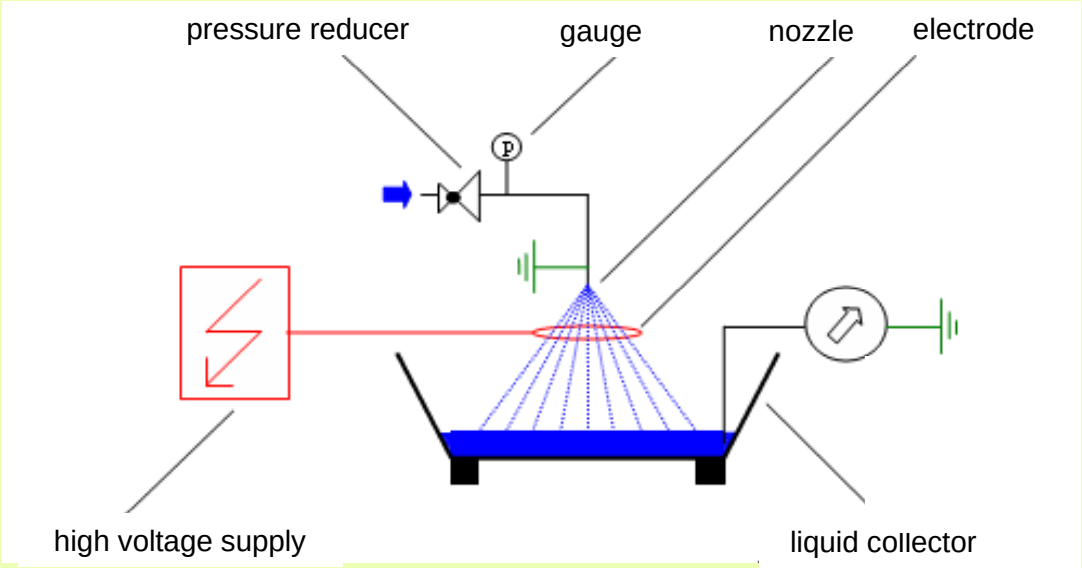
Scrubber by Schräder Abgastechnik



Load distribution and orientation of electrical field



Test setup for "electrostatic scrubber"



Source: Prof. R. Rawe, FH Gelsenkirchen, Germany

Filter test programme by TFZ (starting October 2008)

Field test: 10 filters installed in the City of Straubing:
4 x Ruegg/K&W; 3 x Spanner type, 3 x APP-type)

- Monitoring of function
- Cleaning requirements
- Operational errors

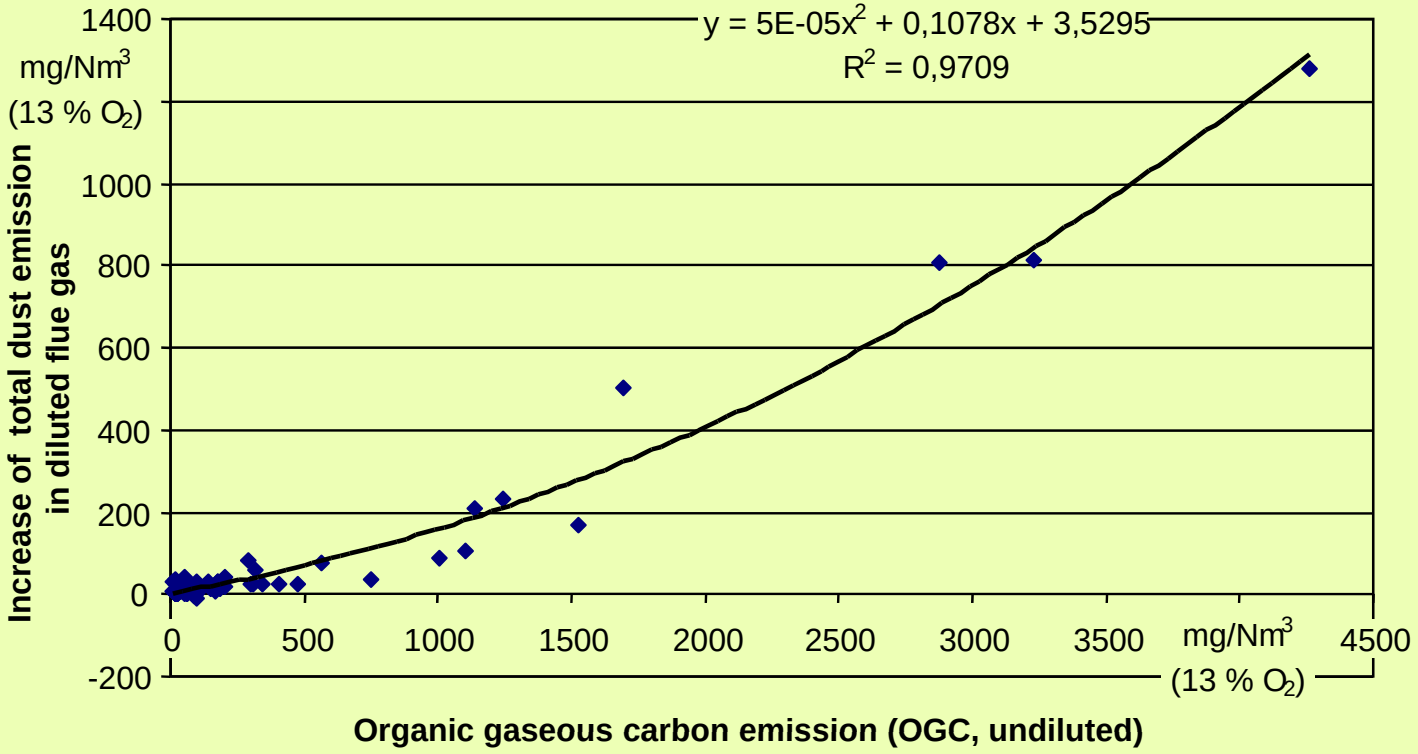
Test stand trials:

Each filter is tested over 6 weeks semi-permanent operation for

- Particle reduction (diluted/ undiluted flue gas) with old&new stove or boiler
- Monitoring of function
- Cleaning requirements (depositions)
- Dust composition changes
- Electricity consumption

Absolute increase of measured total dust emission after flue gas dilution as function of OGC-emission

Evaluation of 95 parallel measurements at a **chimney stove** and a **tiled stove** using various wood fuels at different operational modes (wood logs, briquettes, various moisture contents, charging modes and times etc.)

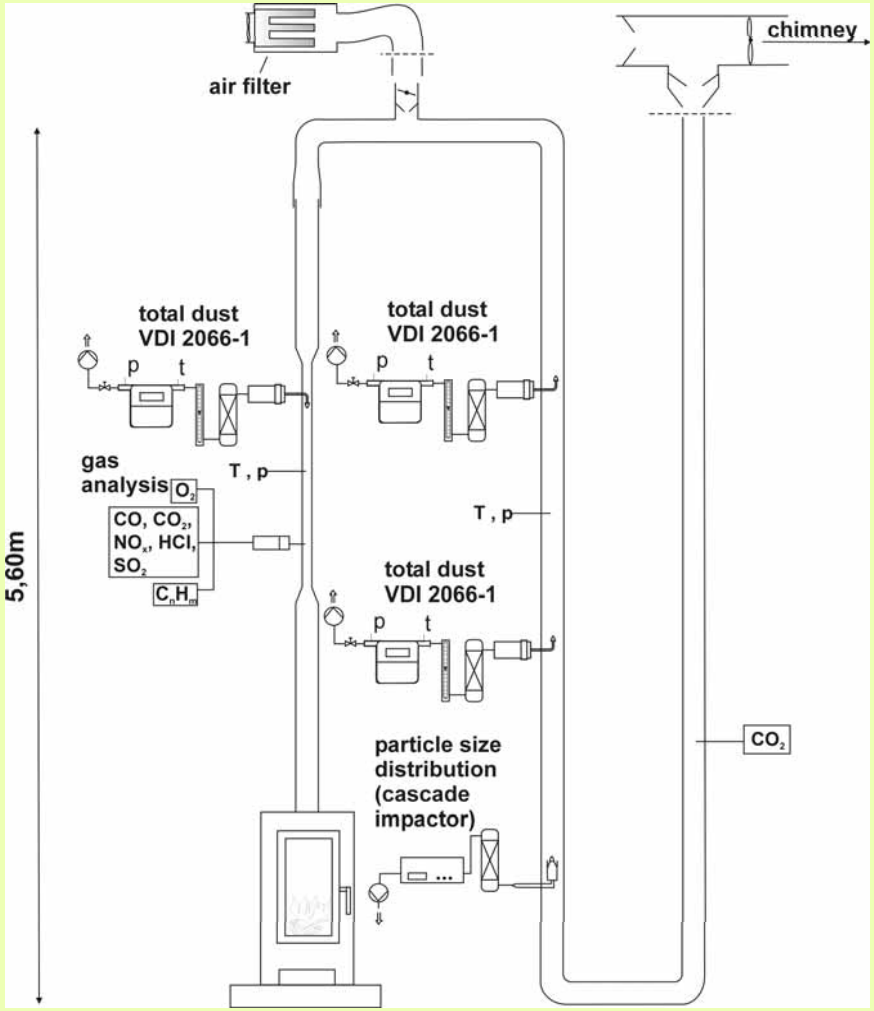


Source: TFZ unpublished (2008)

Particle sampling using dilution tunnel

Parameter	Mean value (from 95 trials)
CO_2, undiluted	4,8 Vol.-%
CO_2, diluted	0,9 Vol.-%
dilution ratio	5,7
flue gas temperature, undiluted	262 °C
flue gas temperature, diluted	56 °C

Dilution tunnel at TFZ



Open questions on filter test setup

- Testing with/without flue gas dilution? (TFZ: both variants!)
- Consideration of any purge air of the filters (relevant for Spanner- and Ruegg-type). $\Rightarrow$ similar air injection is required for dust sampling before filter (in parallel tests)
- Method for flue gas dilution (e.g. partial flow dilution combined with full flow dilution method?)
- TFZ: Partial flow dilution (2x): controlled air ratio adjusted to temperature requirements of <52 °C
  (acc. to engine standard ISO 8178)

Conclusions

- Several concepts or products for low cost ESP are currently available for small scale furnaces.
- Suitable in-room applications are rarely given (chimney based solutions are easier)
- Cleaning and withdrawl of precipitated dust is often not mechanized (high manual efforts)
- Still only few experimental data and long term experience are available

- **Internationally acceped testing procedures for ESP need to be developed !**

Thank you for your attention !

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