Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

Measurement and Reducing Particulate Number Emission at Single Room Wood Log Stoves

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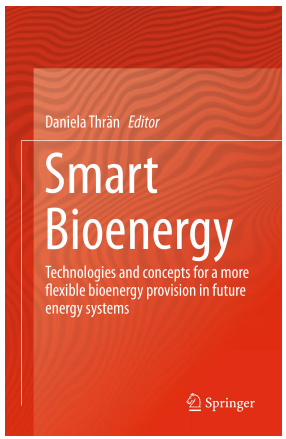
Our vision: Smart Bioenergy

Secure, clean, integrated and smart use of bioenergy for a sustainable economic system

- Integrated, free competition and demand-oriented energy supply
- Combined production of bio-based fuels
- Development of high efficient and clean technologies
- Fully comprehensive sustainability monitoring
- Optimal value chain from biomass



Goal: A carbon-neutral bio-economy based on renewable resources

Future in Biomass use for Heat (and Electricity)

Stop climate change!

Stop pollution!

- Use only residual and waste biomass without further recycling option
- Net zero GHG emissions on conversion by 2050
- Almost no air pollutants (comparable with oil and gas combustion systems)
- No waste water and ash with environmentally hazardous properties
- Maximum possible system contribution: Energy supply, grid stability, utilization of residual biomass, negative CO_2 emissions, coupled use of natural raw materials

Why emission abatement?

- **Biogenic solid fuels in small plants can contribute to GHG reduction if CO_2 neutrality is maintained.**
- **Environmental pollution caused by emissions from wood combustion units must be further reduced: Toxicology and climate!**
- **Air pollutants can also have a GHG potential, e.g. soot particles.**

Green house gases	20 Years	100 Years
Carbon dioxide CO_2	1	1
Methane CH_4	84	28
Nitrous oxide N_2O	264	265
Black Carbon particles	210 – 1,500	210 – 1,500

Carbon dept
Incomplete wood combustion
Biomass production
Incomplete combustion

Source: IPCC AR5, Agostini,A., Giuntoli, J., Boulamanti, A.: carbon accounting of forest bioenergy. European Commission. Joint Reseach Centre, Ispra 2014

GHG reduction by abatement of soot

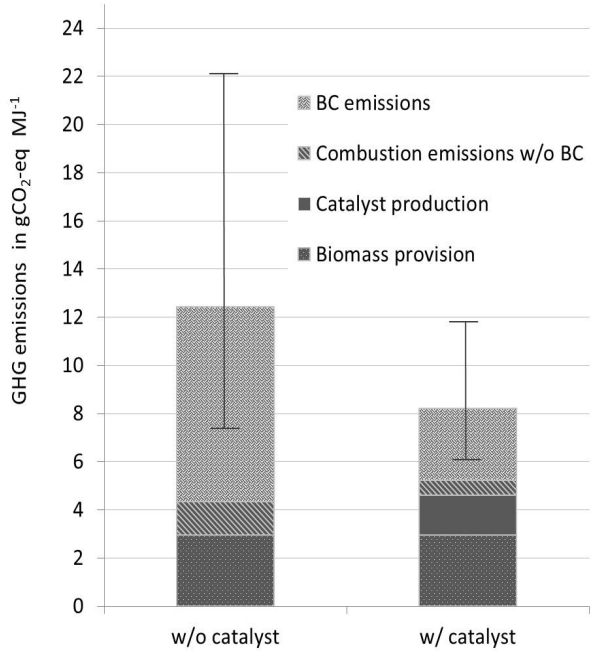
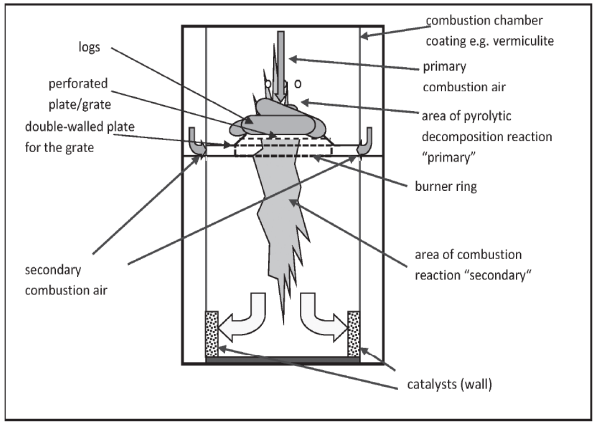


Table 2. Comparison of the reference stove "xeoos" (without catalyst) and the newly developed stove "NEKO" (with catalyst) according to the measured emission values.

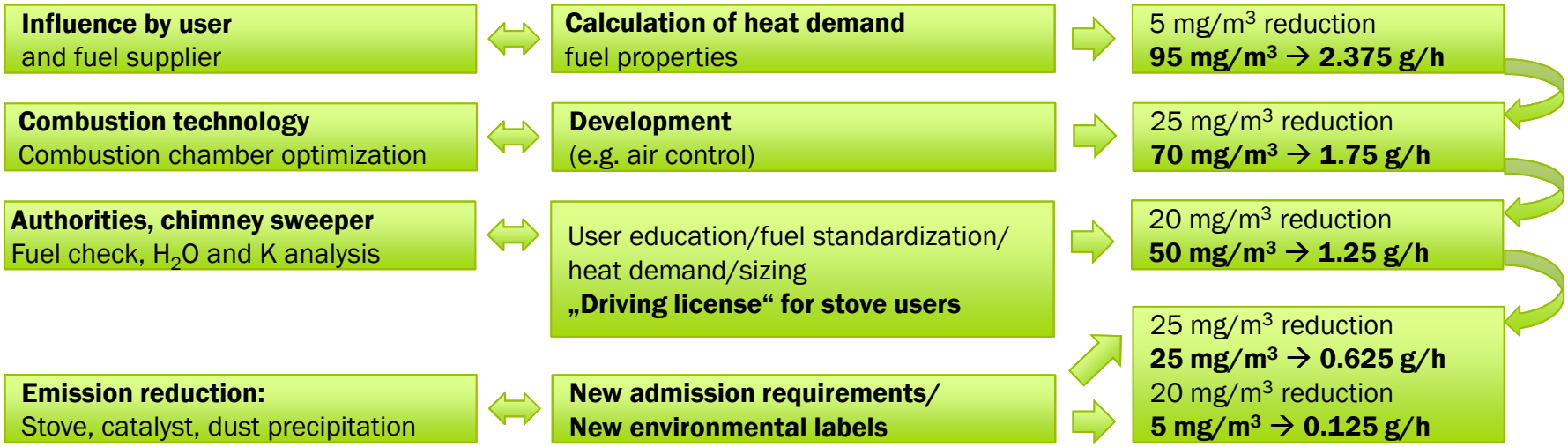
parameters	emission values "xeoos" mg/m³, normal conditions 13 % O_2	emission values "NEKO" mg/m³, normal conditions 13 % O_2
CO	1,718	621
VOC (C1-equivalent)	156	36
total dust concentration	19	9



Source: Oehmichen, K., Majer, S., Hartmann, I., & Lenz, V. (2017). Global warming potential of flue gas from log-fired single room heaters–double effect of catalytic emission control. GEFAHRSTOFFE REINHALTUNG DER LUFT, 77(1-2), 19-24.

Scheme for emission reduction

Total amount of PM from wood log stoves in the field: **100 mg/m³** (13 % O_2) → corresp. to **2.5 g/h** (10 kW)



→ Testing under field conditions → **New test method necessary**

„Blauer Engel“ environmental label

Background

- Voluntary label for wood log stoves
- Label for very environmentally friendly stoves

Contributors

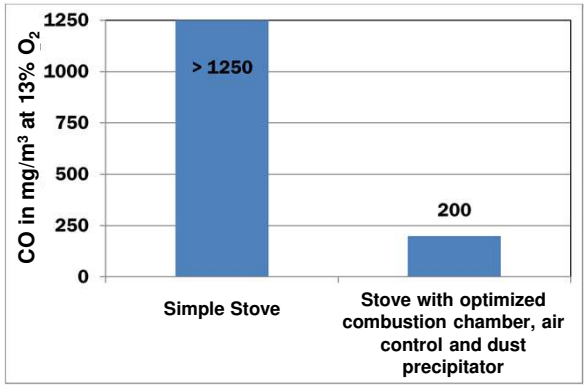
- Federal Ministry of the Environment, Nature Conservation and Nuclear Safety,
- The German Environment Agency (Umweltbundesamt - UBA)
- RAL gemeinnützige GmbH (sign authority)
- Stove manufacturer
- Environmental associations: DUH e.V. applied for the opening of a procedure for the development of the environmental label for wood log stoves

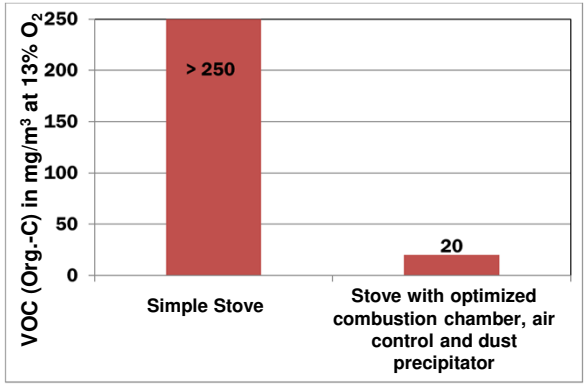
Current status: in progress…

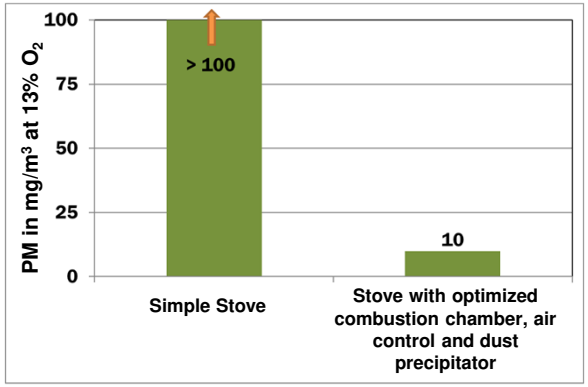
Proposal for a new test method „Blauer Engel“

- Parallel (simultaneous) measurement of CO, CO_2, O_2, H_2O, Org.-C (VOC), total dust, number of particles, all burning cycles are scored and averaged overall
- 3 measurement sections:
  - 1: Cold start (ignition + first burning cycle)
  - 2: Nominal load (four burning cycles)
  - 3: Partial load (two burning cycles)
- Lighting ("cold start") and first two burns with natural draft: chimney specification according to manufacturer
- Test with beech, commercially available logs: water content 15 wt.%, dimensions according to manufacturer (e.g. L = 33 cm and D = 50 cm)
- **Continuous measurement over all burning cycles: From "cold" to "basic embers"**

Specified targets for “Blauer Engel”-label from DBFZ point of view







New test method, closer to practice, with following emission limits (related to 13% O_2):

CO	**< 200 mg/m³**
VOC	**< 20 mg/m³**
PM (total amount)	**< 10 mg/m³**
Particle number:	**No limit proposed yet, method under development**

ZEBS: Project Funding: BMBF-DLR

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

DBFZ

EUREKA
innovation across borders

Project title: **Abgasreinigungsanlage für emissionsfreie Biomasseöfen (engl.: „Exhaust gas purification plant for emission-free biomass stoves")**
EUREKA Chile - Pilot Call, Funding reference: 01DN17040A

Project acronym: ZEBS (Zero **E**mission **B**iomass **S**tove)

Relevance of the project to the objectives of the call for proposals
Focus: Sustainable use of natural resources

Project partner
Chile
AdSolem Ltda.
Germany
ETE EmTechEngineering GmbH
DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH

Basic experimental set-up

Simple wood log stove:
Justus Falun, 5 kW

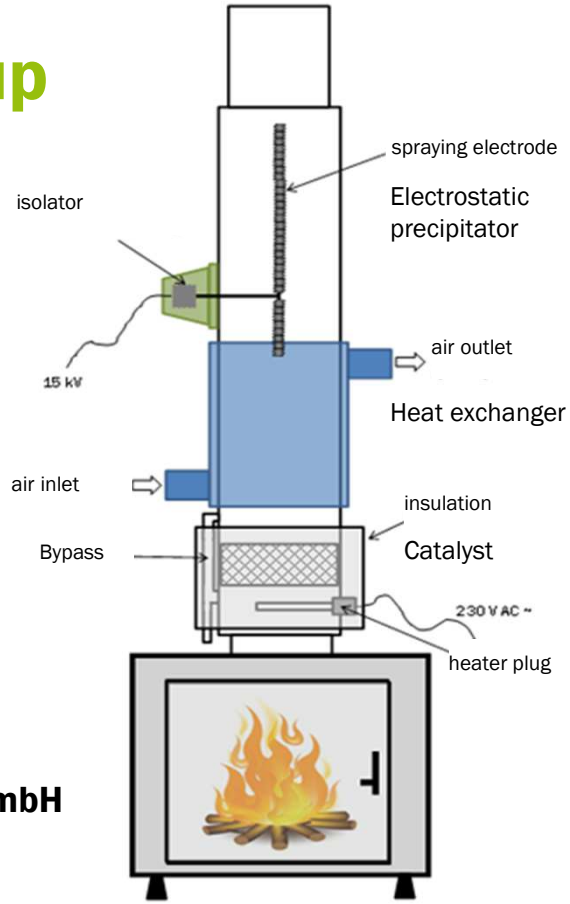
Catalyst system from
company ETE EmTechEngineering GmbH

Heat exchanger developt by DBFZ

Electrostatic precipitator:
OekoTube-Inside by OekoSolve

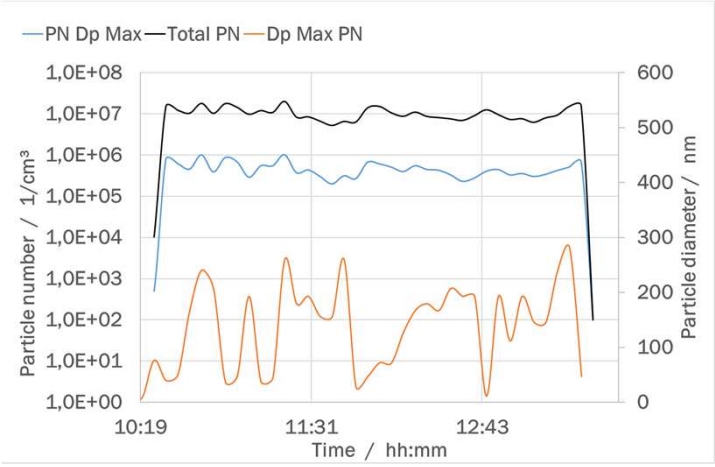
Emission measurement:
FTIR, Gasmet CX 4000, ANSYCO
Isokinetic dust measurement ITES Paul Gothe GmbH

Particle number concentration:
SMPS (Tropos) with external two stage dilution (FPS by Dekati)

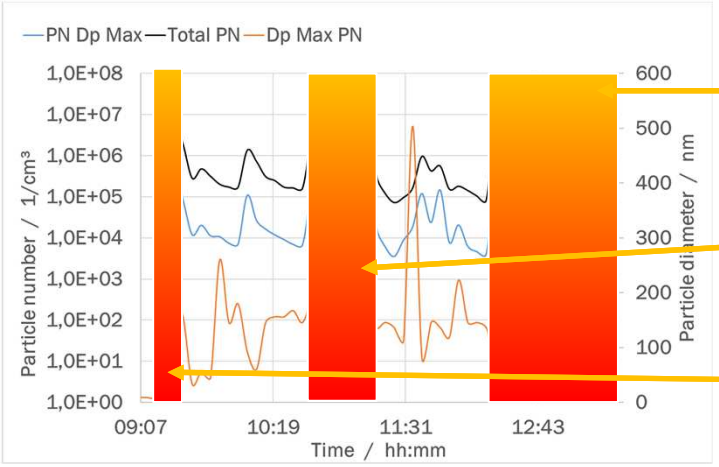


Results

Reference without cat and precipitator



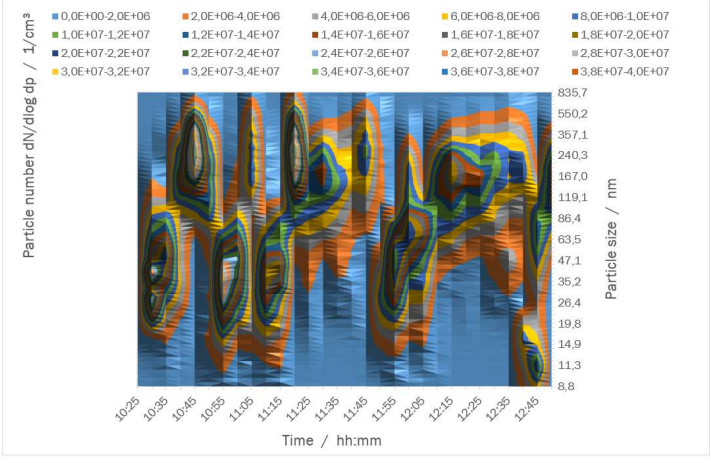
System with cat and precipitator, withou heat exchanger

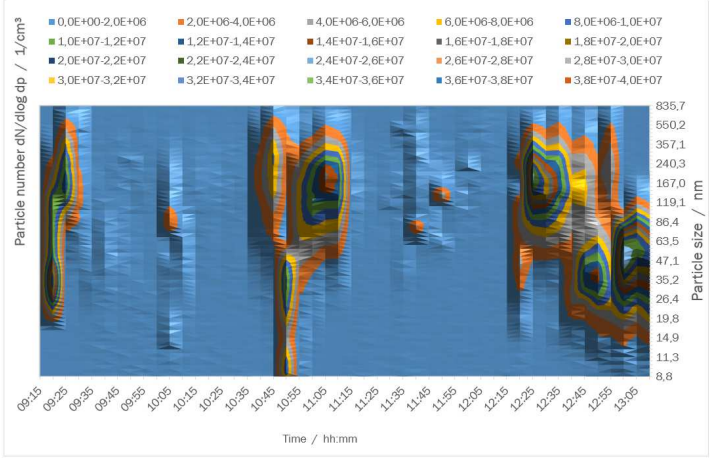


ESP off!
Intended, ignored

ESP off!
To high temperature
> 250 °C taken into
account for the analysis

ESP off!
To low temperature
in cold start
taken into account
for the analysis

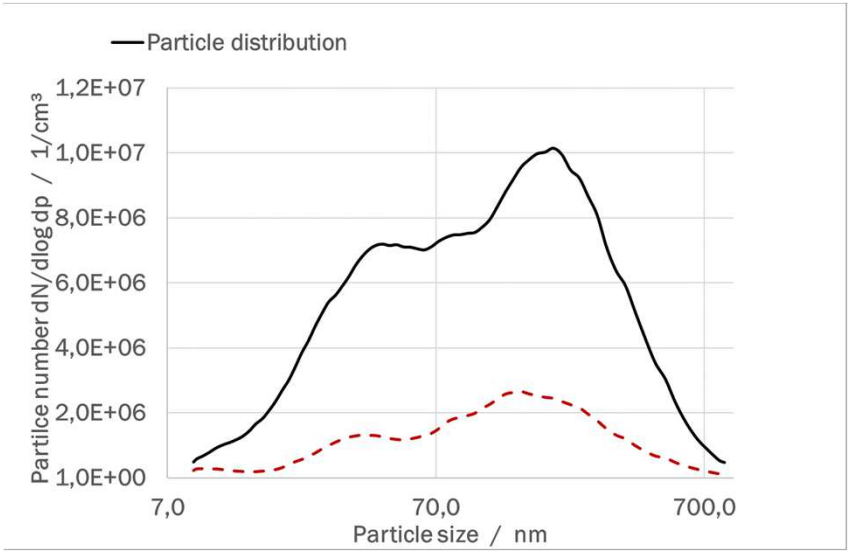


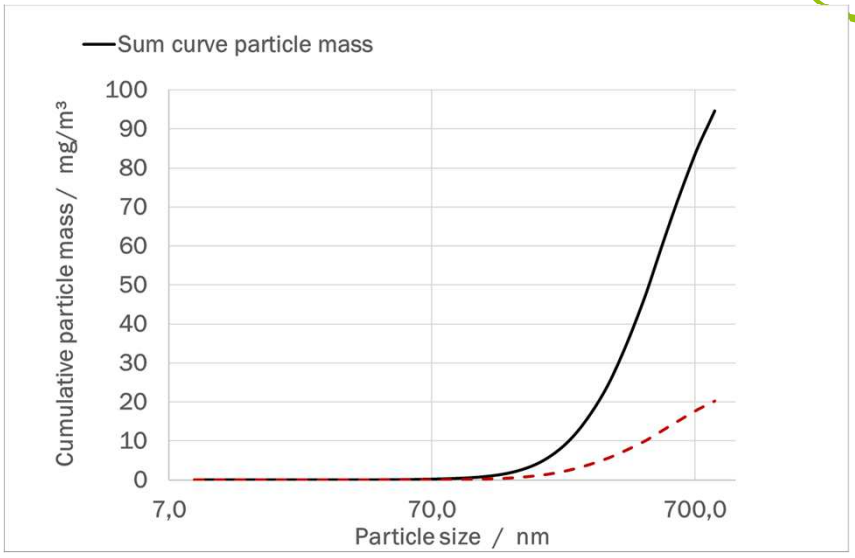


Results

Reference without cat and precipitator

System with cat and precipitator, without heat exchanger





Experiment	O2 / Vol.-%	CO / mg/m³	VOC / mg/m³	CH4 / mg/m³	C2H2 / mg/m³	Sum volatile Aromatics / mg/m³	NOx / mg/m³	PM / mg/m³	SMPS PM / mg/m³	SMPS PN / 1/cm³
Average numbers without cat and ESP	12,7	1635	217	60	12	65	128	78	91	1,02E+07
Average numbers with cat and ESP	12,1	573	171	69	4	45	132	42	18	2,08E+06
Abatement in %	4,5	64,9	21,0	-15,1	67,7	31,3	-3,6	46,9	80,0	79,7

Conclusions

- **<u>Emission abatement at wood combustion units by new combustion chamber concepts, electronic combustion control, catalysts and precipitators is necessary</u>**
- For the long-term very low emission values comparable with oil and gas combustion systems (2050: real operation <1 and full load < 0.1 mg/m³ i.N. at 13% O_2) are needed
- First Step: “Blauer Engel” eco label for wood log stoves (end of 2019 or begin of 2020)
- Particle number limit values will become relevant in the future: First estimate for next years: < 10^6 1/cm³
- Properties of the particles: PAH content, soot content, size distribution, inorganic components and heavy metals have to be taken into account for toxicology reduction.
- Extensive research work has to be carried out:
  - Research into combustion processes
  - Further furnace development
  - Catalyst and precipitator development (under high temperature conditions)
  - Comparison with toxicological studies necessary

ZERO EMISSIONS

New concepts

New technology

New Cooperations

Let us together define the future of

Zero-emission small wood combustion

units.

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Smart Bioenergy – Innovations for a sustainable future

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