Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

Prisvindende brændeovn som en forgasningsovn - Awardwinning stove as a gasification stove

René Bindig, Ingo Hartmann





Fagligt seminar 2019: Biomassekedler og brændeovene,
At Teknologisk Institut, Aarhus, 12.06.2019

Outline

Our Vision: Smart Bioenergy

Remarks on the environmental label „Blauer Engel“

The „Seebeck“-Stove

The „Wood Stove Design Challenge 2018” in Washington D.C.

Our Vision: Smart Bioenergy

Safe, clean, integrated and intelligent use of bioenergy for a sustainable economic system

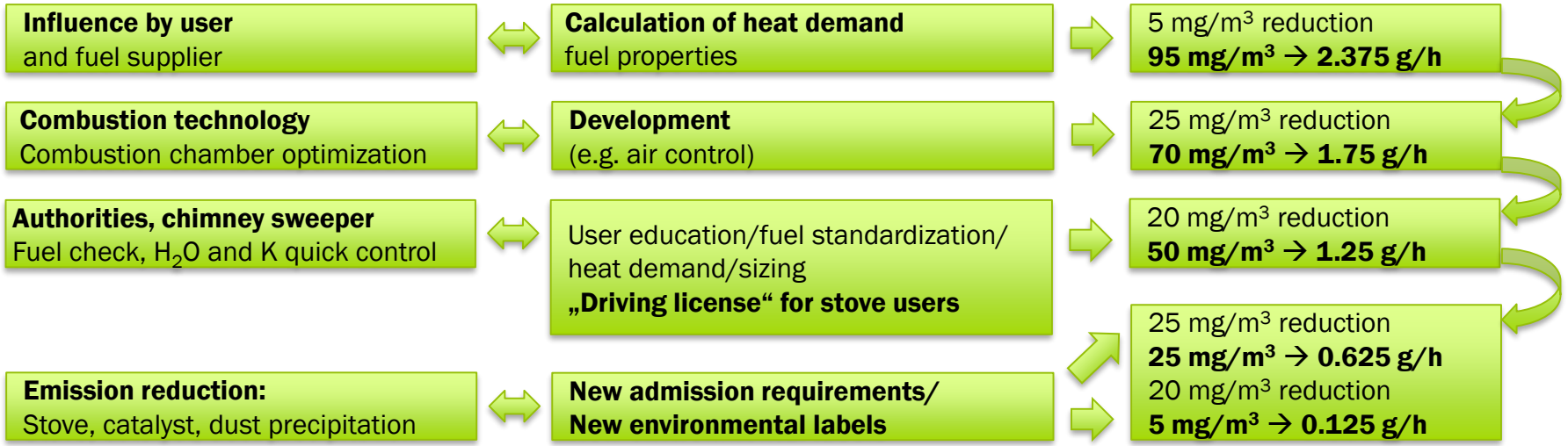
- Integrated, competitive and demand-oriented energy supply
- Joint-product generation of bio-based energy carriers
- Development of highly efficient and clean technologies
- Comprehensive sustainability monitoring
- Optimum value-added chains from biomass

Goal: A climate-neutral bioeconomy based on renewable resources

Source of this slide: Presentation of Ingo Hartmann “Sicht des DBFZ auf die Anforderungen „Blauer Engel“ → Partikelanzahlmessungen“ at „Partikelanzahlmessung bei Kaminöfen im Rahmen des Blauen Engels“, at TFZ in Straubing, 27. März 2019

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**

K = potassium;
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„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

Current status: in process…

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
- Lighting ("cold start") and first two burn-ups with natural draft: design of chimney according to manufacturer's specifications
- Test with beech: Commercially available logs: water content 15 wt.% (10 to 20), dimensions according to manufacturer's specifications (e.g. L = 33 cm and D = 50 cm)
- **Continuous over all burns: From "cold" to "basic embers"**

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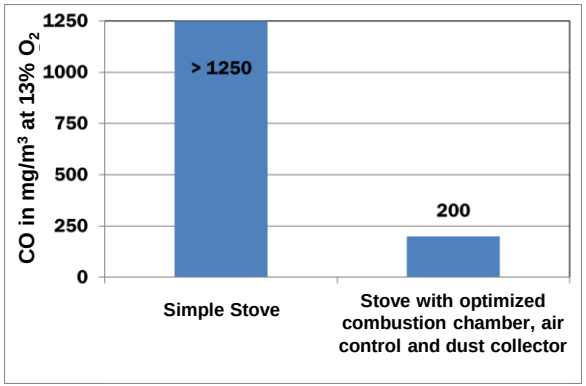
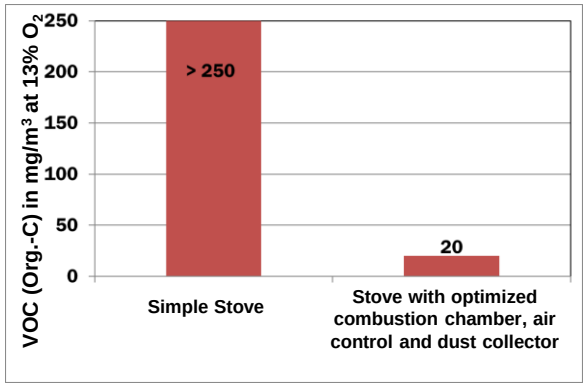
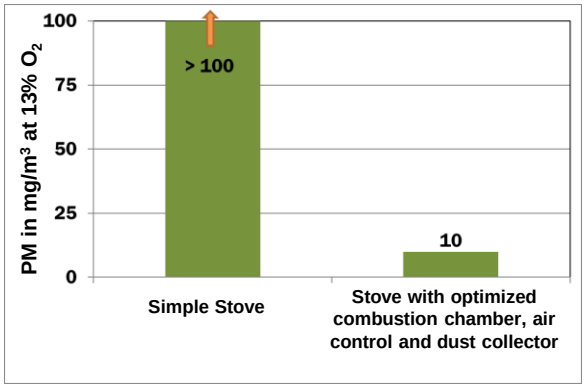
Specified targets for “Blauer Engel”-label from DBFZ point of view







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**

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

	expected average	best of the measured stoves
Total PM	100 – 150 mg/m^3	44 – 61 mg/m^3
CO	1 000 – 3 000 mg/m^3	494 – 763 mg/m^3
VOC (measured as OGC)	100 – 800 mg/m^3	57 – 103 mg/m^3

(all values in mg/m^3 i.N. related to 13% O_2)

“i.N.” = “under standard conditions”: T = 273,15 K, p = 101,325 kPa

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Why particle number measurement?

- Reduction of soot particles as harmful and climate-relevant emissions is important!
- Future low dust mass concentrations require the introduction of an additional/different measuring method
- Number concentration for particles smaller than 1 µm allow a better toxicological evaluation?
- Total mass of particles smaller than 1 µm will be vanishingly small in future – hardly recorded by gravimetric methods
- Continuous and ultimately simpler measuring procedure; direct readability

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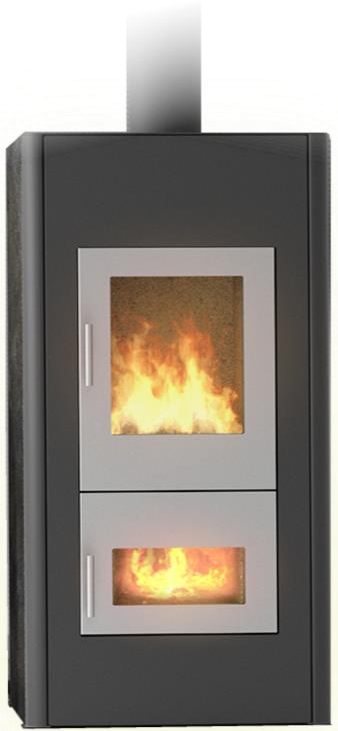
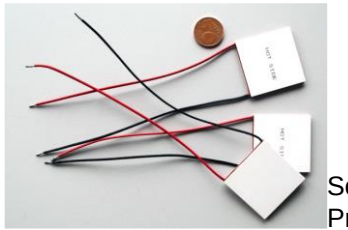
The „Seebeck“ stove



Source: Prell/Thermoelect GmbH

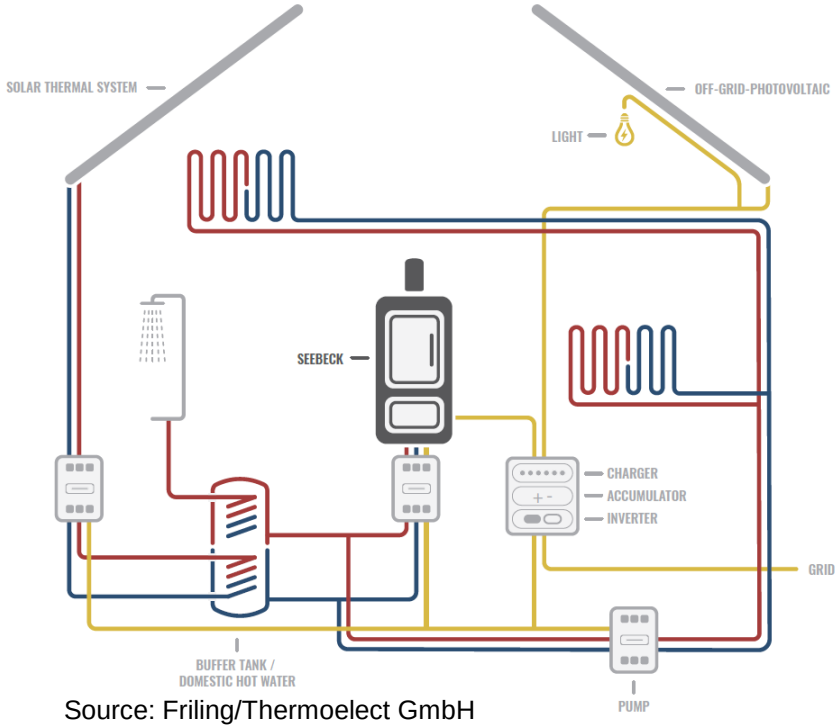
- Manufacterer: Thermoelect GmbH
- Downdraft wood log stove
- Produces space heating, hot water and electric power
- Space heating: 10 bis 20 kW
- Electric power: 250 W via thermoelectric generators (TEG)



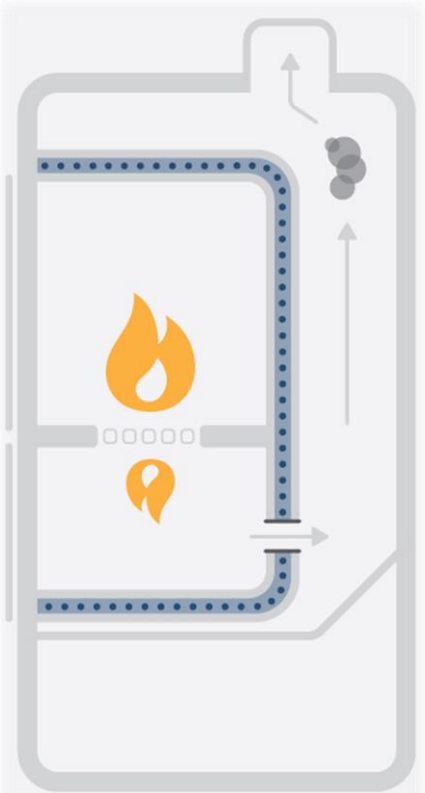
Source:
Prell/Thermoelect GmbH

The „Seebeck“ stove

Integration into the energy infrastructure of a building:



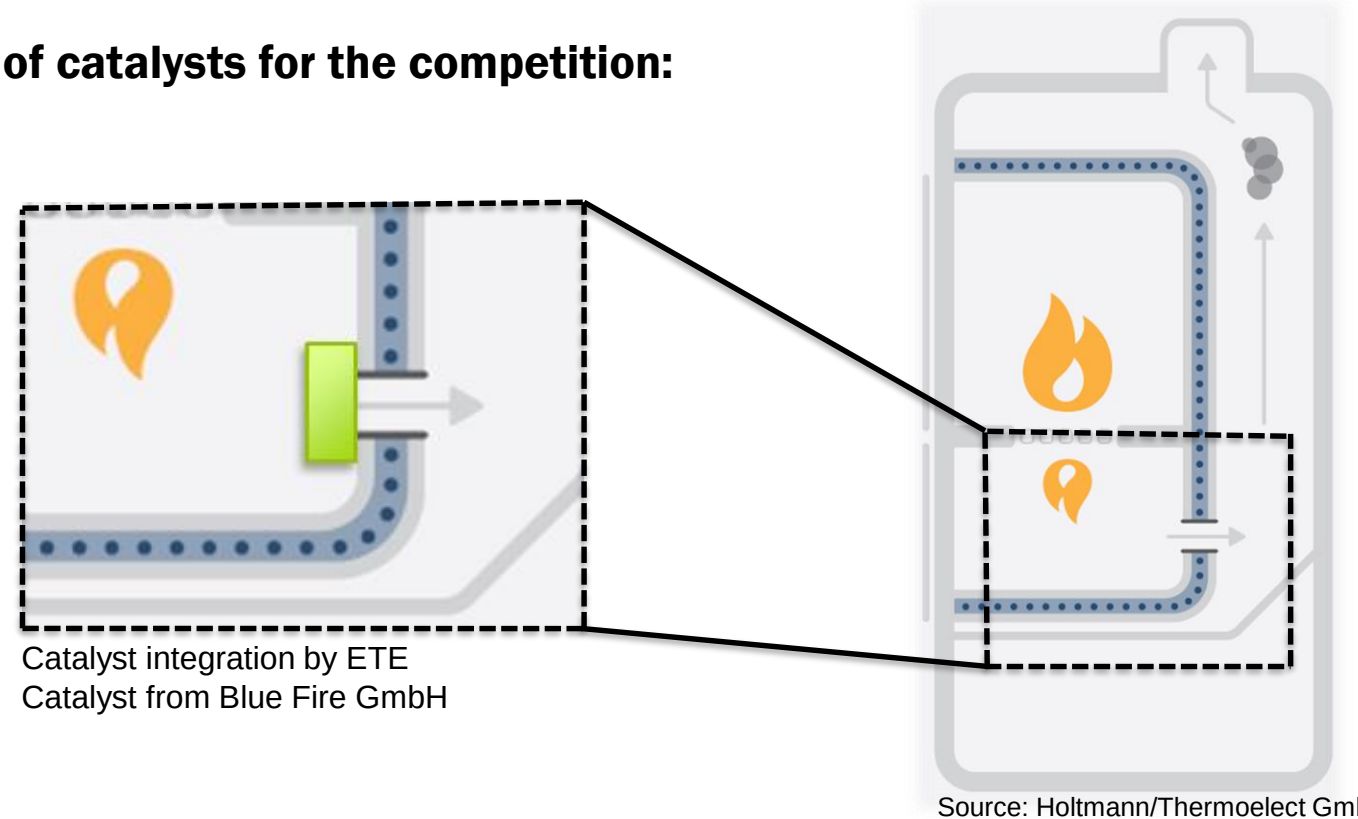
Source: Friling/Thermoelect GmbH



Source: Holtmann/Thermoelect GmbH

The „Seebeck“ stove

Integration of catalysts for the competition:



Catalyst integration by ETE
Catalyst from Blue Fire GmbH

Source: Holtmann/Thermoelect GmbH

The fourth Wood Stove Design Challenge

- Sponsored by the **US-Department of Energy (DOE) Bioenergy Technology Office (BETO)**, the **New York State Energy Research and Development Authority (NYSERDA)** and the **Osprey Foundation**
- Measurements were carried out by **Brookhaven National Laboratory (BNL)**
- **http://forgreenheat.org/2018-stovedesign/stovedesign.html**
- **National Mall in Washington, DC** from **09.11.** to **13.11.2018**

Source:
Ingo Hartmann/DBFZ

Source of this slide: Dr. Ingo Hartmann, DBFZ, 10. Fachgespräch Partikelabscheider in häuslichen Feuerungen, 20th March 2019, TFZ, Straubing

Teams

10 Teams as finalists

http://forgreenheat.org/2018-stovedesign/award.html

The Green Box Stove by SBI	→	Wood log, automated
The VCV Kiwi 2.1 by Flamekeepers	→	Wood log, automated
The E-Stove by Wittus	→	Wood log, wood gasification, automated, TEG
The Lumburnator by Stony Brook University	→	Wood log, automated
The Continental by George Washington University SEAS	→	Wood log, TEG
Downdraft Rocket by ASAT	→	Cookstove, automated, TEG
The Kd3 By Unforgettable Fire ™	→	Wood log, wood gasification, TEG
The Wiseway by Hi-Z Technology	→	Pellet stove, TEG
The Pellematic e-max → ÖkoFEN	→	Pellet boiler, Stirling-Motor
The Optimum by 509 Fabrications	→	Brikett stove, automated

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Team Wittus

Members:

- Thermoelect GmbH,
- Wittus – Fire by Design,
- ETE EmTechEngineering GmbH
- DBFZ

Working title:

- The “E-Stove”

Photo source: Kittner/BNL

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Preset measurement protocol for E-Stove

Integrated Duty Cycle (IDC) Test Protocol developed by NESCAUM

Beech or maple logs with 18 to 25 % water content; Start-up: 30 min

- Fuel loading density: 0.064 kg/L
- Kindling amount: shall not exceed a mass of 0.816 kg
- Quantity of logs for starting: 2.449 kg +/- 5% (5.4 lbs +/- 5%)
- Minimum weight of a log for starting = 0.318 kg
- Up to 2 changes of the air settings during the start phase, **not possible for E-Stove**!

1st reload (= 1st burn): 45 min

- Fuel loading density: 0.080 kg/L
- Allowable weight of logs: 0.635 – 1.270 kg
- Target number of wood log: 4
- Total amount of fuel: 4.082 kg +/- 5%
- No adjustment of the air setting allowed, otherwise deduction of points

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Preset measurement protocol for E-Stove

2nd reload (= 2nd burn): 30 min

- Number of wood logs: 2
- Allowable weight of logs: 1.270 kg +/- 5%
- No adjustment of the air setting allowed, otherwise deduction of points

3rd reload (= 3rd burn): 75 min

- Allowable weight of logs: 0.635 – 2.268 kg
- Target number of wood log: 5 – 8, batch should consist of 50% of smaller logs and 50% of larger logs
- Total amount of fuel: 8.074 kg +/- 5%
- No adjustment of the air setting allowed, otherwise deduction of points

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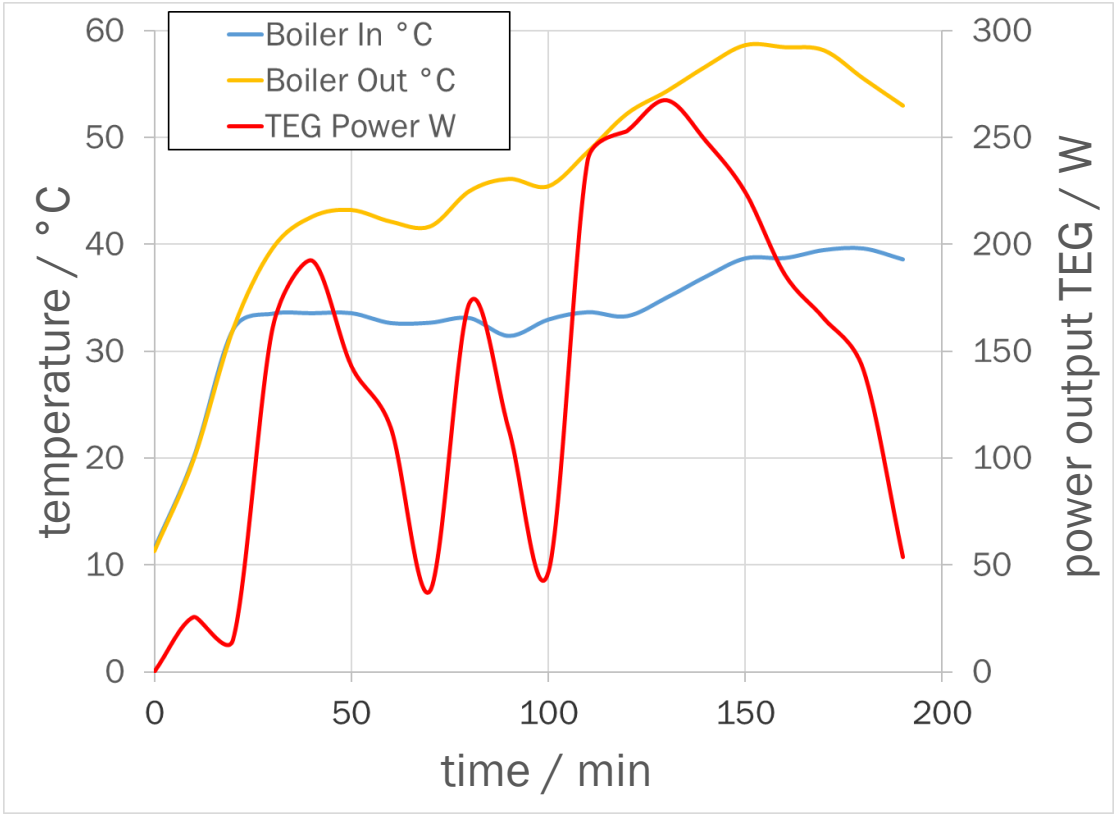
Example measurement of power output



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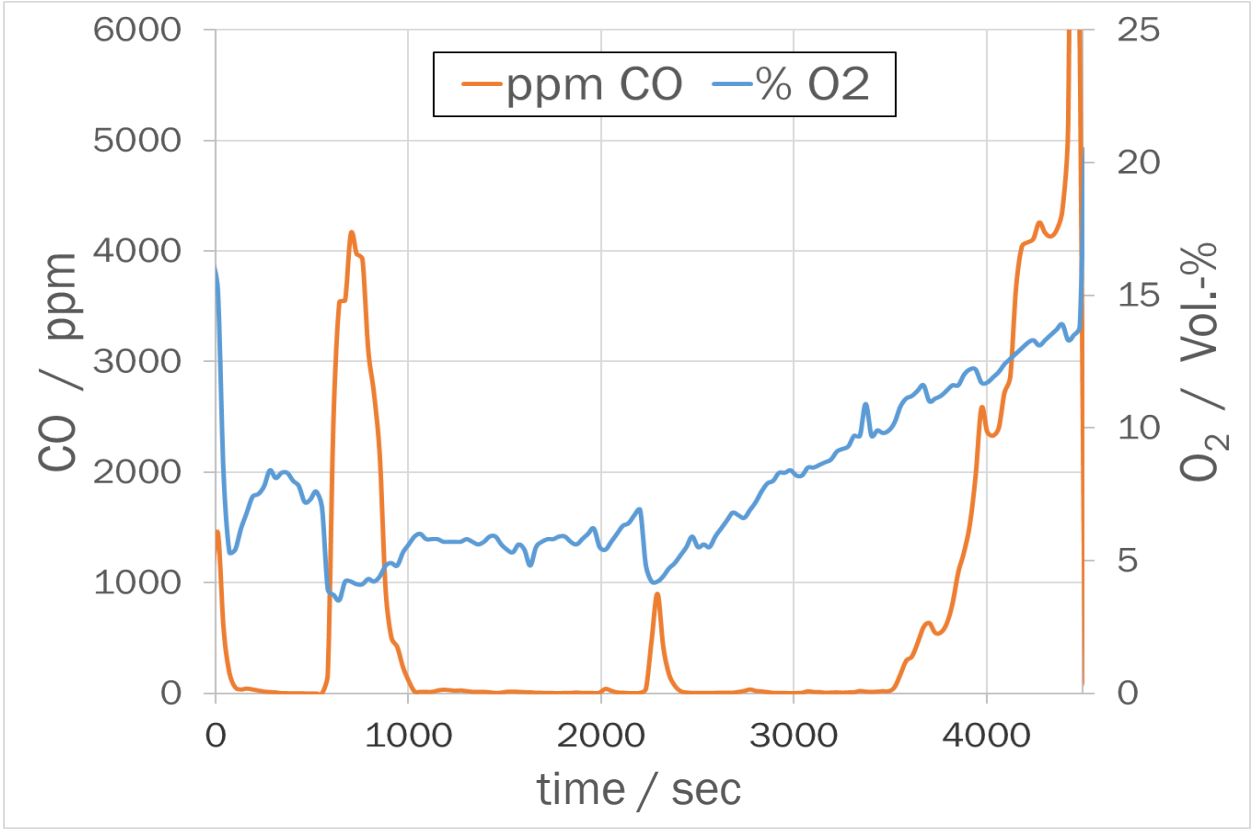
Example measurement of emissions, 3rd Burn



Source of this slide: Dr. Ingo Hartmann, DBFZ, 10. Fachgespräch Partikelabscheider in häuslichen Feuerungen, 20th March 2019, TFZ, Straubing

Results, dust measurement with Condar

TEG Stoves Judges' Stack Testing Data Summary

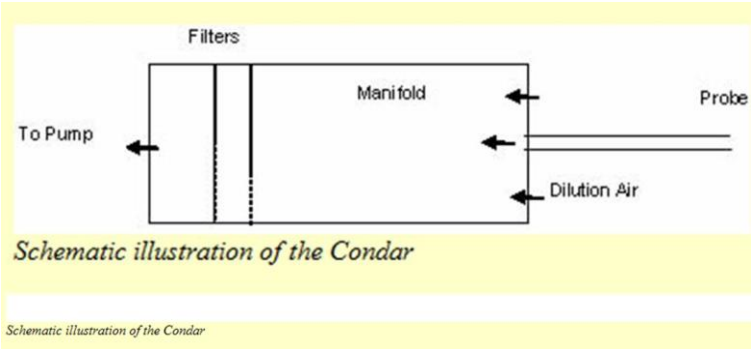
Stove	PM g/kg	CO g/kg	Efficiency
E-Stove	0,87	10,1	82,9

O2 %	CO ppm	Stack T, (F)
11,19	788,2	192,4

0,19	*2,24*	g/kWh
69	*803*	mg/m³, 13 % O_2

TEG:
161 W on average, 2.5 h measuring time
268 W max

Condar: Condar Portable Dilution Tunnel



Source of images: Norbert Senf, Summary of Studies with the Condar Portable Dilution Tunnel, Masonary Heater Association of North America, January 19, 2018

Source of this slide: Dr. Ingo Hartmann, DBFZ, 10. Fachgespräch Partikelabscheider in häuslichen Feuerungen, 20th March 2019, TFZ, Straubing

Scoring of the competition

„Automated“

1. PM Emissions, 2. Automation and Innovation, 3. CO and Safety,

4. Delivered efficiency, 5. Consumer appeal

„Thermoelectric“

1. Innovation-Thermoelectric, 2. PM emissions, 3. CO and Safety

4. Automation, 5. Thermal Efficiency

The People’s Choice Award

Voting Online unter surveymonkey.com

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Results of the competition

„Automated“

1. place: **E-Stove Team Wittus** (Thermoelect GmbH, Wittus, ETE, DBFZ)
2. place: The Green Box Stove by SBI

„Thermoelectric“

1. place: **E-Stove Team Wittus** (Thermoelect GmbH, Wittus, ETE, DBFZ)
2. place: The Wiseway by Hi-Z Technology

The People’s Choice Award

The Optimum by 509 Fabrications

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Outlook

- **Demonstration project with E-Stove until the end of 2021**
  - Energy supply concept with extended economic considerations
  - Energy supply of buildings on the basis of the E-Stove
  - Development of overall system control for energy supply of buildings
  - CFD-supported further development of the combustion chamber and the air supply
  - Development of a robust combustion controlling system
  - Verification of the function of the integrated catalysts under practical conditions
  - Dust precipitator adaptation and integration
  - Development of optimized prototypes and field test equipment of the E-Stove
  - Demonstration measurements
  - **Target emission values**:
    (i.N. related to 13% O_2)

CO	< 200 mg/m³
VOC	< 20 mg/m³
PM (total amount)	< 10 mg/m³

"i.N." = "under standard conditions": T = 273,15 K, p = 101,325 kPa

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Smart Bioenergy – Innovations for a sustainable future

Contact persons

Prof. Dr. mont. Michael Nelles
Daniel Mayer
Prof. Dr.-Ing. Daniela Thrän
Dr.-Ing. Jan Liebetrau
Dr.-Ing. Volker Lenz
Dr.-Ing. Franziska Müller-Langer
Dr.rer.nat. Ingo Hartmann

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH
Torgauer Straße 116
D-04347 Leipzig
Phone: +49 (0)341 2434-112
E-Mail: info@dbfz.de
www.dbfz.de