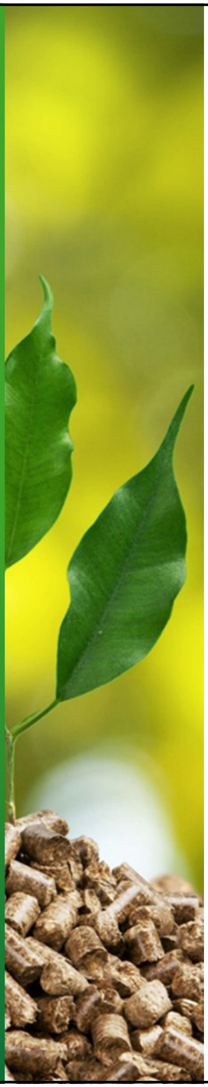


BEST
Bioenergy and Sustainable Technologies

GrateAdvance – Advanced adjustable grate solutions for future fuel flexible biomass combustion technologies

Graz, January 23rd 2020

Gabriel Barroso, Michel Essl, Sabine Feldmeier, Ramin Mehrabian, Thomas Nussbaumer, Marcus Öhman, Thomas Reiterer, Markus Schwarz, Ali Shiehnejad-Hesar, Elisabeth Wopienka

FFG
COMET Competence Centers for Excellent Technologies
Bundesministerium Digitalisierung und Wirtschaftsstandort
Bundesministerium Verkehr, Innovation und Technologie
wirtschafts agentur wien Ein Fonds der Stadt Wien
Das Land Steiermark
SFG NEUES DENKEN. NEUES FÖRDERN.

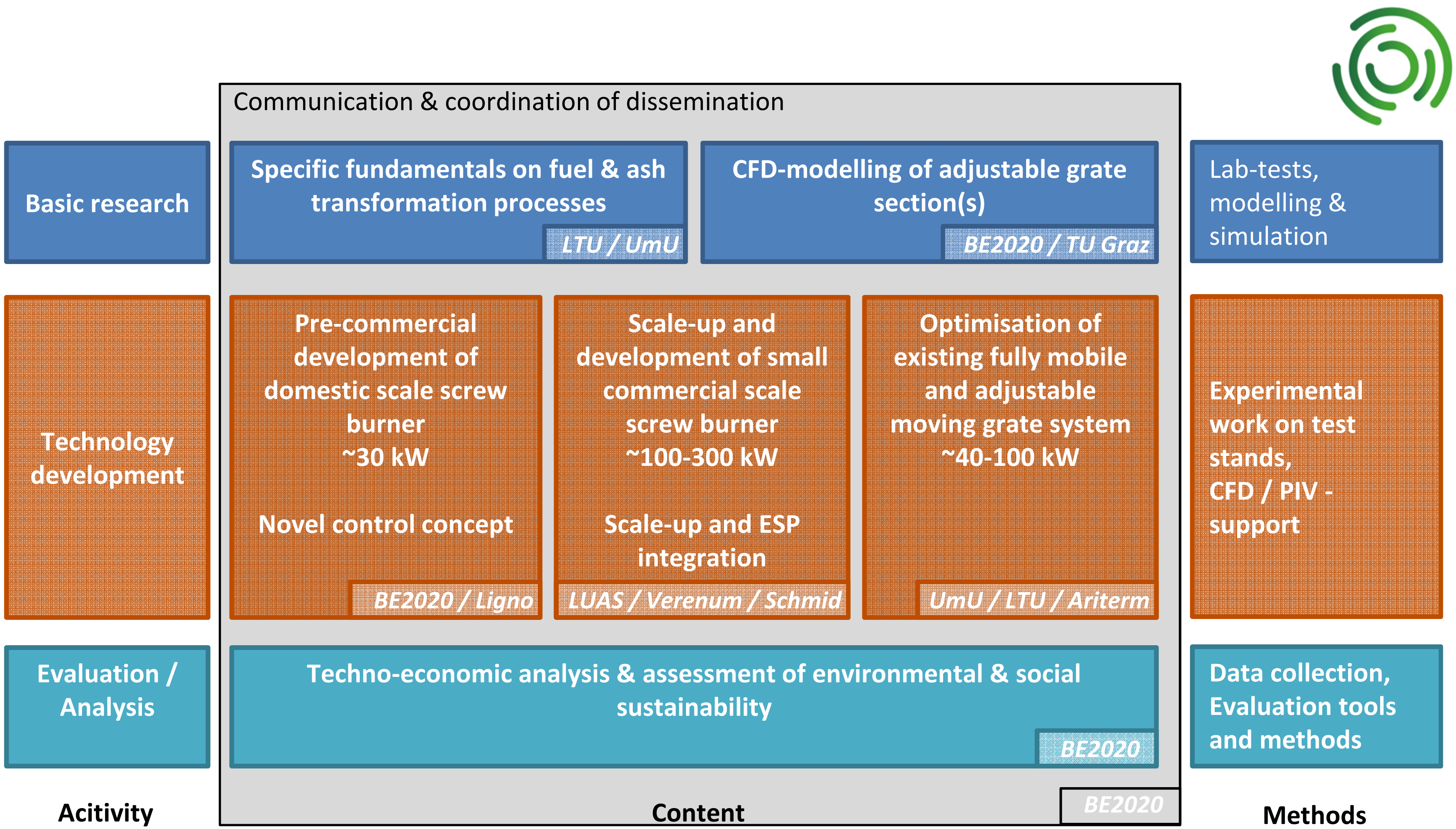
Inhalt

- Background
- Objectives
- Project structure
- Consortium
- Selected results
  - Fuel conversion
  - Modelling of the grate section
  - Development of control system
  - Scale-up

Background & objective

- Initial situation:
  - Combustion appliances are optimized for wood pellets
  - Risk of increased emission release and slag formation when using lower quality biomass pellets
- Required / crucial technological factors (to avoid/reduce slag formation and minimize the release of PM emissions):
  - Low temperatures in the fuel bed
  - Well-directed air supply
- Influencing factors:
  - Residence time of fuel on the grate
  - Structure of the fuel bed

➡ **Flexibly adjustable grate systems!**


Communication & coordination of dissemination
Basic research
Specific fundamentals on fuel & ash transformation processes
LTU / UmU
CFD-modelling of adjustable grate section(s)
BE2020 / TU Graz
Lab-tests, modelling & simulation
Technology development
Pre-commercial development of domestic scale screw burner ~30 kW
Novel control concept
BE2020 / Ligno
Scale-up and development of small commercial scale screw burner ~100-300 kW
Scale-up and ESP integration
LUAS / Verenum / Schmid
Optimisation of existing fully mobile and adjustable moving grate system ~40-100 kW
UmU / LTU / Ariterm
Experimental work on test stands, CFD / PIV - support
Evaluation / Analysis
Techno-economic analysis & assessment of environmental & social sustainability
BE2020
Data collection, Evaluation tools and methods
Acitivity
Content
BE2020
Methods

Consortium

- BIOENERGY2020+ GmbH
- TU Graz Institute of thermal engineering
- Schmid Energy Solutions (Austria)

- Verenum
- Lucerne University of Applied Sciences
- Schmid Energy Solutions (Switzerland)

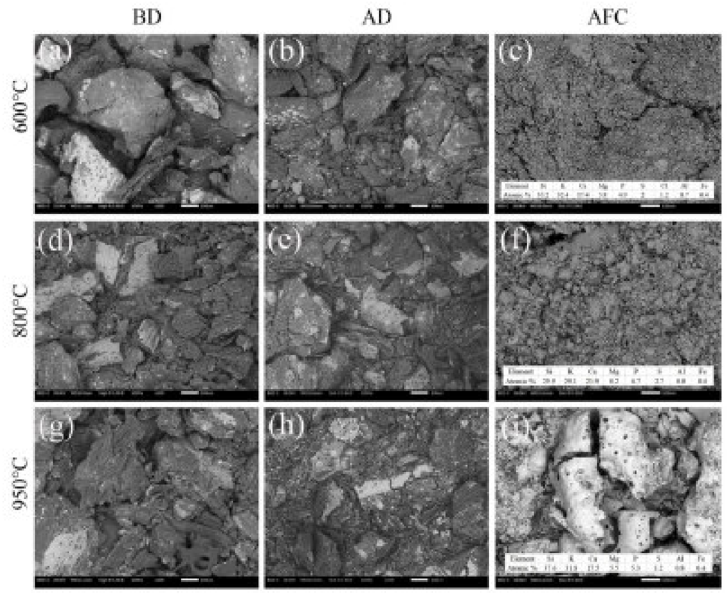
- Lulea University of Technology
- Umea University

The GrateAdvance project is funded by the FFG within the 9th Call: Bioenergy Concepts.

ERA-NET Bioenergy

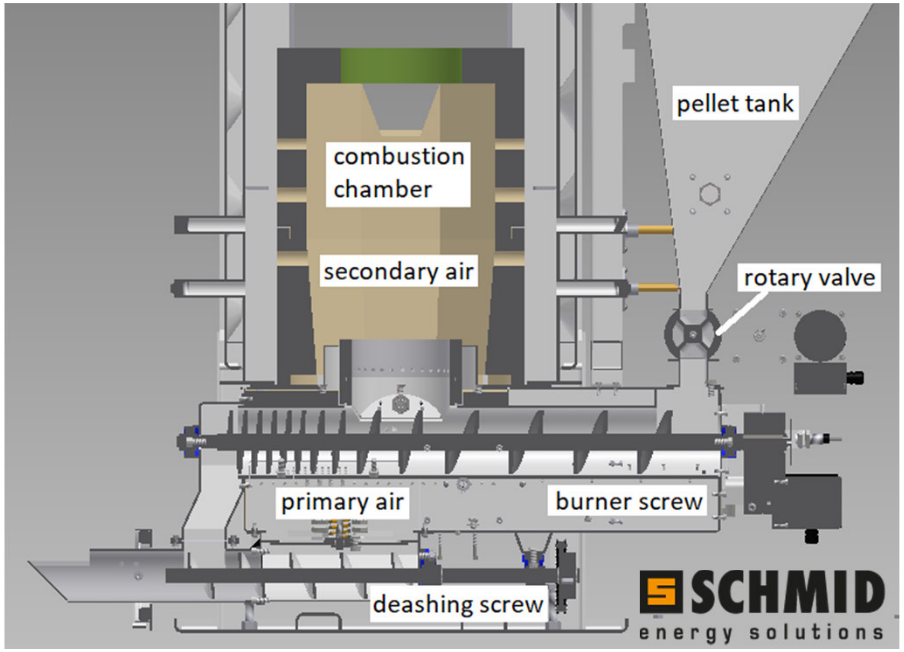
Results – Ash transformation processes
Fundamental investigations

- Single-pellet combustion of agricultural biomass fuels
- Focus on K and P
- Macro-TGA reactor at three different furnace temperatures, namely, 600, 800, and 950 °C
- Different stages of thermal conversion - before and after devolatilisation and after complete char conversion
- SEM-EDS and XRD – morphology, spatial elemental composition, crystalline phases



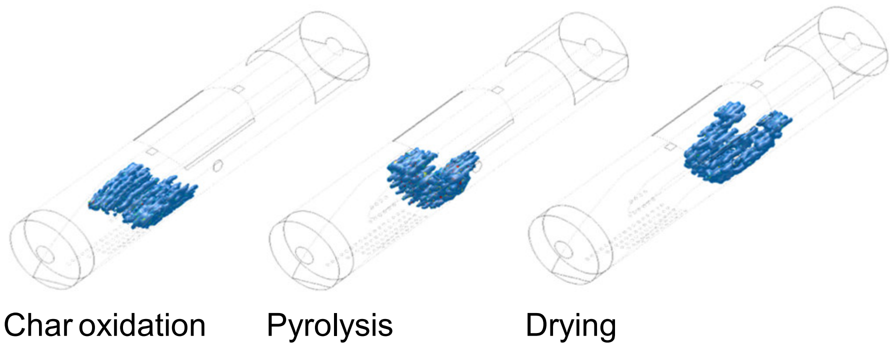
Biomass boiler

Screw Burner prototype, 35 kW

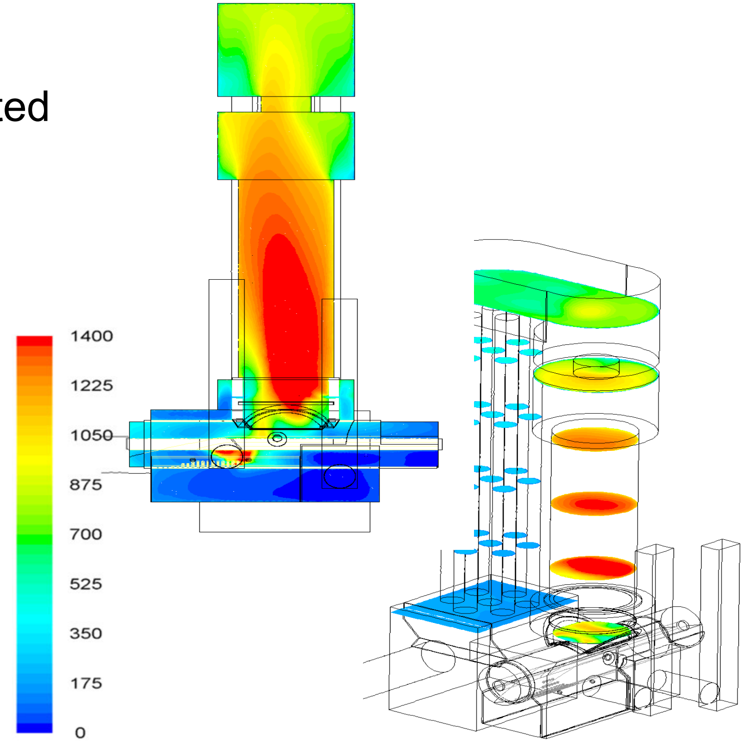


Results – Modelling of grate section

- In-house 3D CFD packed bed model adapted
- Simulation of the screw burner
- Extension of combustion model regarding
  - NO_x release precursors
  - Ash forming elements

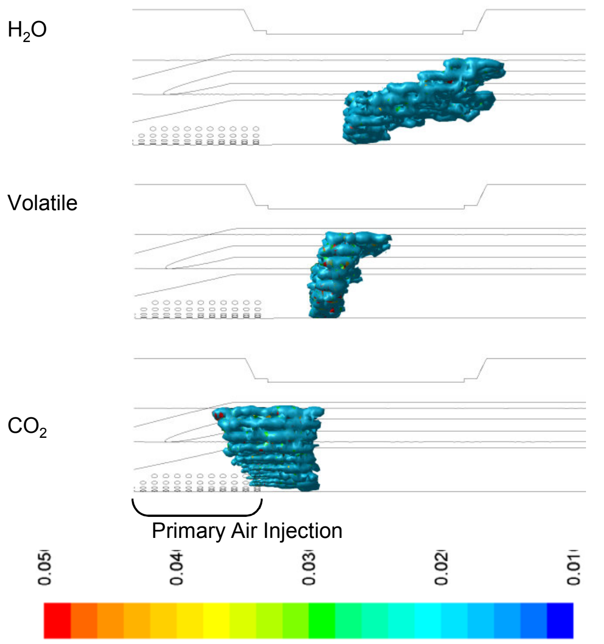


Position of thermal conversion sub-processes in the fuel bed

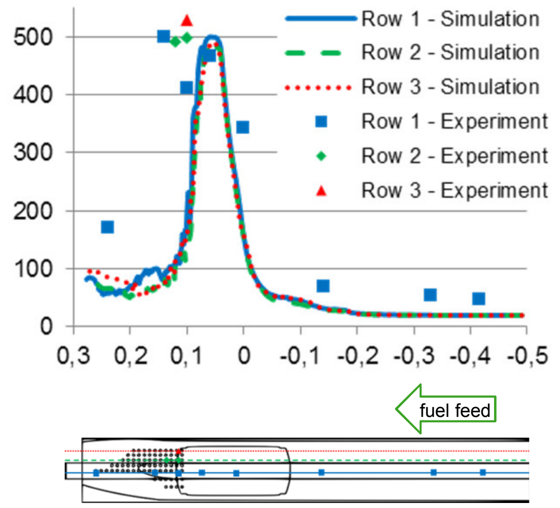


Contours of flue gas temperature (°C)

Results – Modelling of grate section



Release rates [mg s-1] of the main species from the fuel bed.



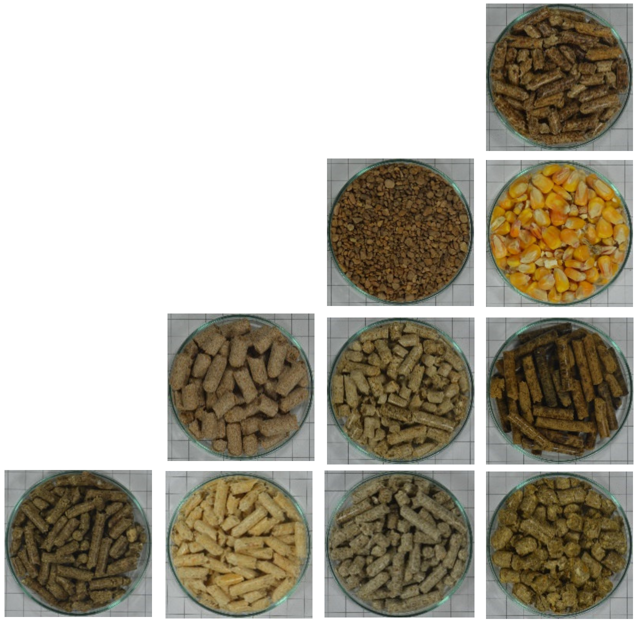
Temperature distribution in the burner tube.

Results – control concept

Parameter variations and identification of relevant operational conditions

Biomass test fuels:

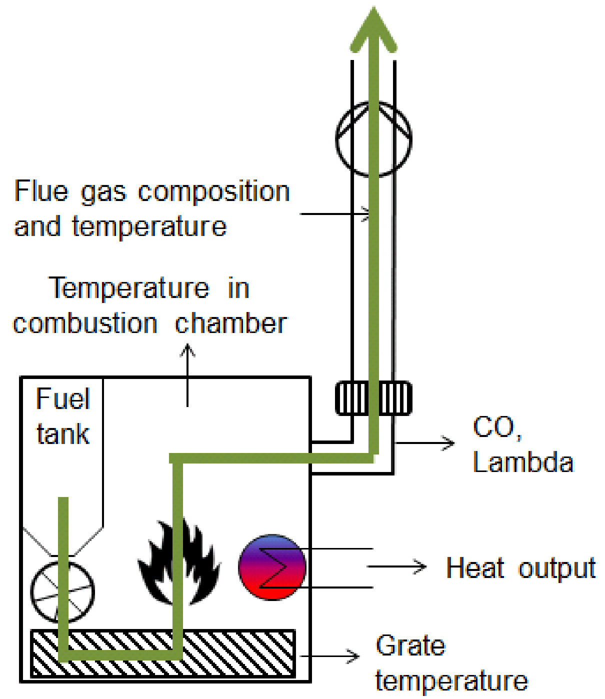
- Spruce pellets (ISO A1)
- Grain mill residues
- Virginia mallow
- Willow (SRC)
- Bamboo
- Grain husks
- Miscanthus
- Hey & vineyard pruning
- Maize (mycotoxin contaminated)
- Olive stone groats



Results – control concept

Parameter variations and identification of relevant operational conditions

- Conduction of standardized practical tests
- 100%, 60% and 30% of nominal load
- Parameter variation:
  - rotary valve → heat output
  - burner screw → residence time
  - air supply → CO, lambda



Experimental setup and selected measurement points.

Results – control concept

Parameter variations and identification of relevant operational conditions

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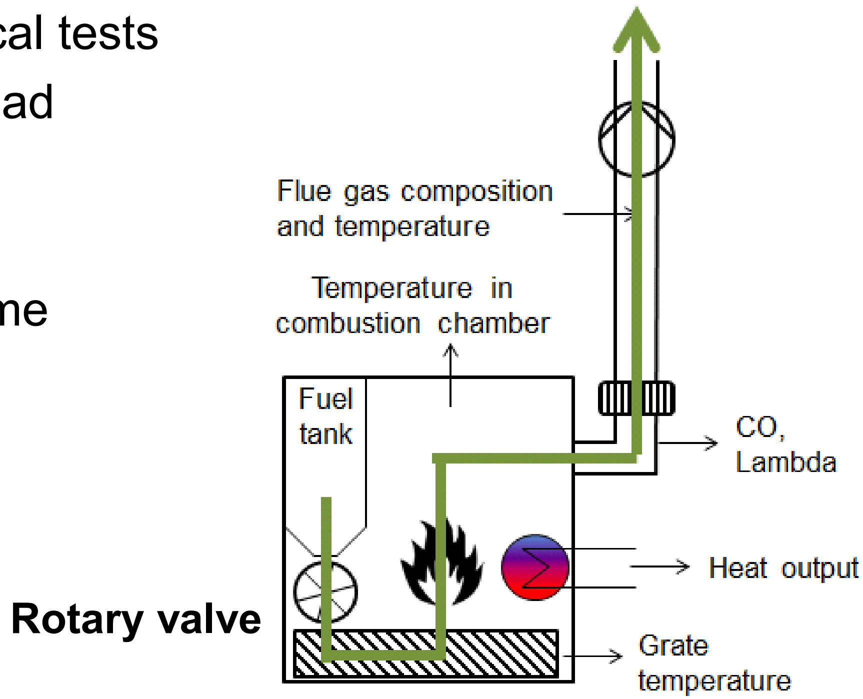

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Results – control concept

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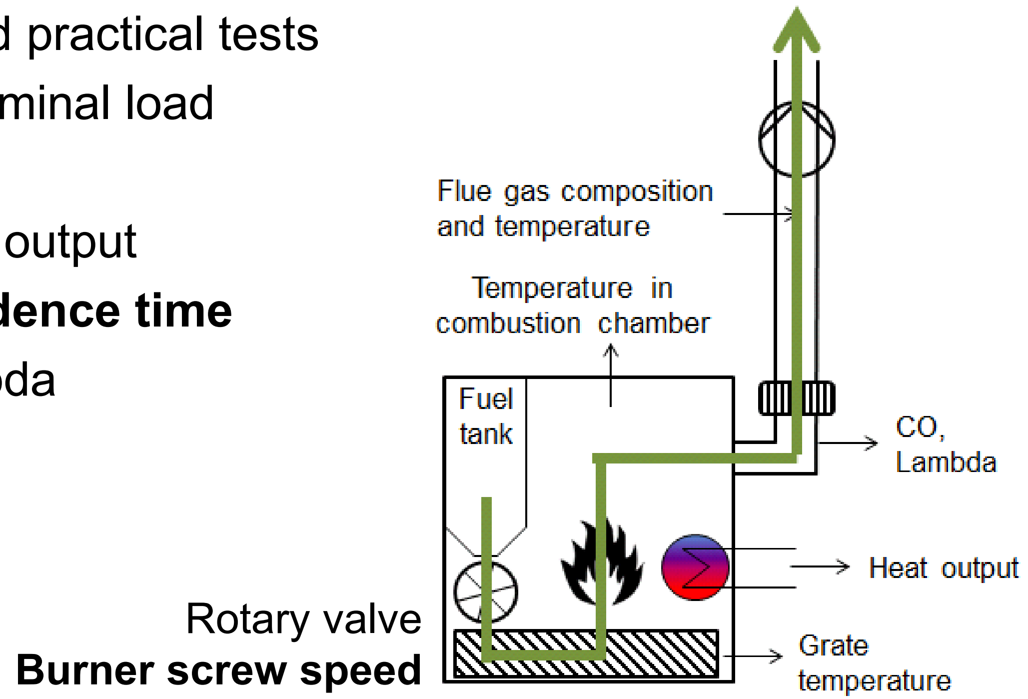

Experimental setup and selected measurement points.

Results – control concept

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- Conduction of standardized practical tests
- 100%, 60% and 30% of nominal load
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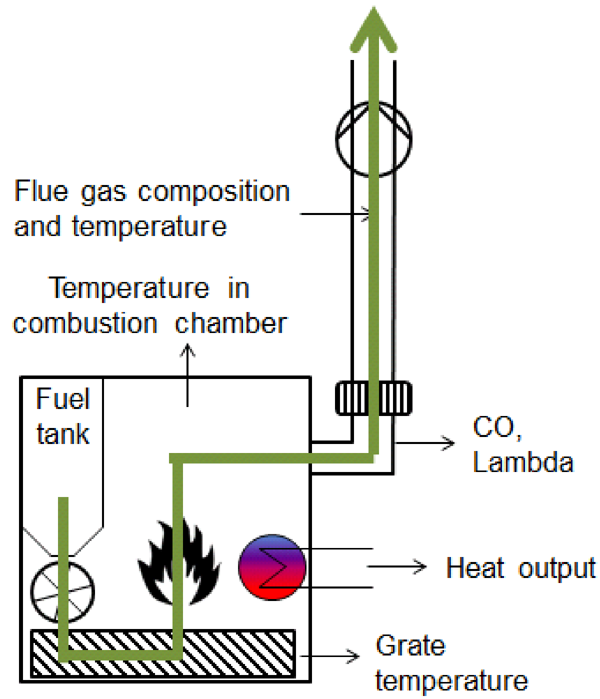
  - **air supply → CO, lambda**
- Identification of relevant operational conditions

Air supply
Rotary valve
Burner screw speed

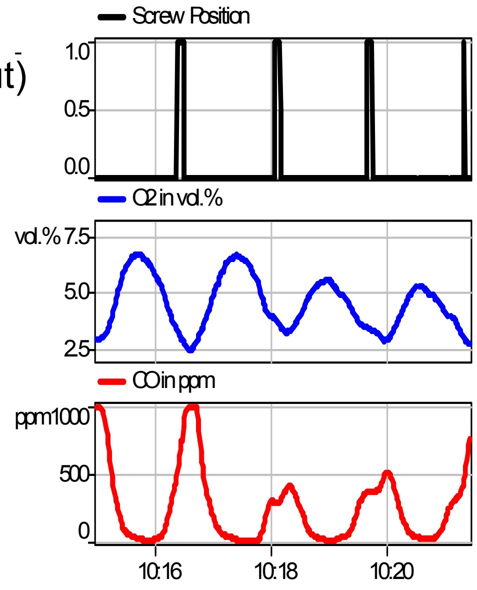


Experimental setup and selected measurement points.

Results – control concept

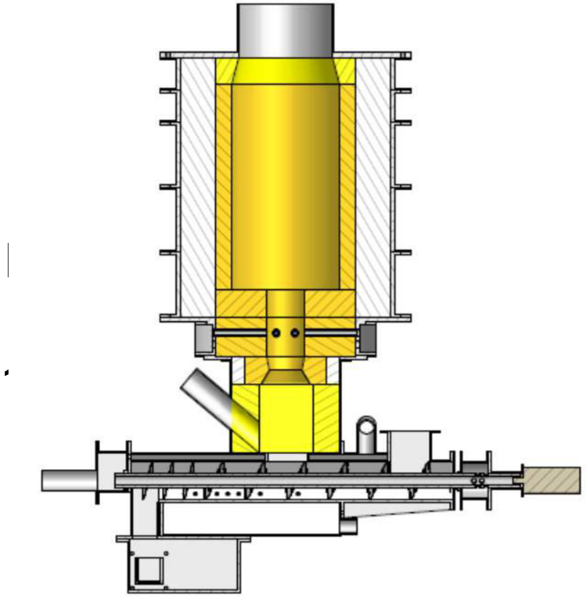
Parameter variations and identification of relevant operational conditions

- Adaption of fuel feed rate
  - Control parameters adapted (fuel properties / heat output)
  - Speed of rotary valve correlated with heat output
  - Different slopes for different test fuels
- Adaption of residence time
  - Adaption via burner screw
  - Indicators: ash temperature and light barrier sensor
- Adaption of air supply
  - Primary air correlated to fuel feed
  - Secondary air controlled via lambda probe
  - Challenges
    - Individual CO-Lambda-characteristic
    - Non-linear Air-supply



Results – Scale-up
Scale-up concept

- Scaling concept (simplified)
  - Section 1: grate – fuel conversion
  - Section 2: combustion chamber – gas
- Scaling factor based on heat output Q
  - Grate: thermal grate load
  - combustion chamber: residence time / (dimension H/D)
  - Secondary air injection (considering momentum current densities and nozzle diameter)



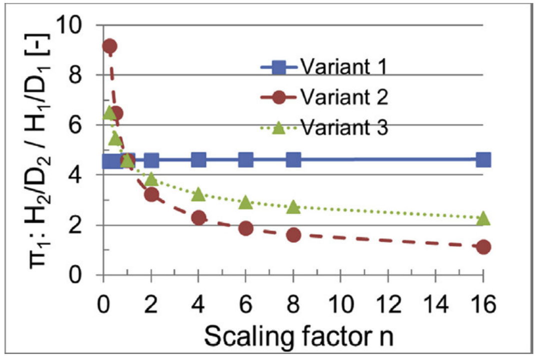
Results – Scale up

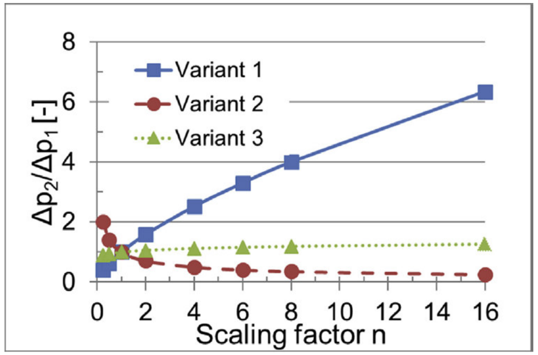
Zone	Part	Scaling rule Var 1	Var 2	Var 3
Grate	screw diameter	$n^{0.5}$	$n^{0.5}$	$n^{0.5}$
	screw length	$n^{0.5}$	$n^{0.5}$	$n^{0.5}$
Grate/CC	CC diameter and SA inlet	$n^{0.5}$	$n^{0.5}$	$n^{0.5}$
CC	CC height	$n^{0.33}$	1	$n^{0.166}$
	CC diameter 2	$n^{0.33}$	$n^{0.5}$	$n^{0.417}$
	CC diameter 3	$n^{0.33}$	$n^{0.5}$	$n^{0.417}$

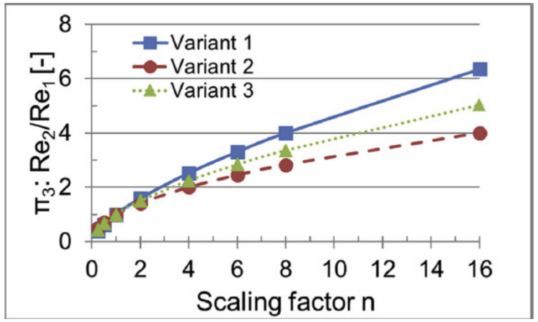
Evaluation via simulation shows good results regarding CO emissions!

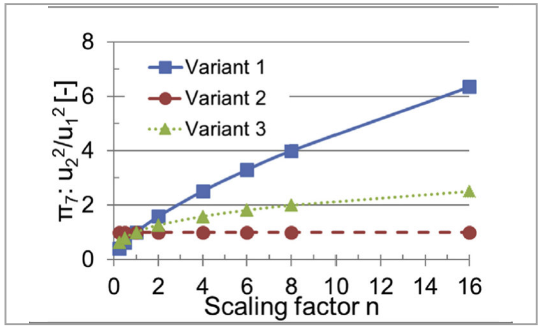
Simulation validated with test at 35 kW appliance.

Results – Scale up
Influence of scaling factor









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Thank you for your attention.