



BEST

Bioenergy and
Sustainable Technologies



Ein Fonds der
Stadt Wien



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

Graz, January 23rd 2020

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Inhalt

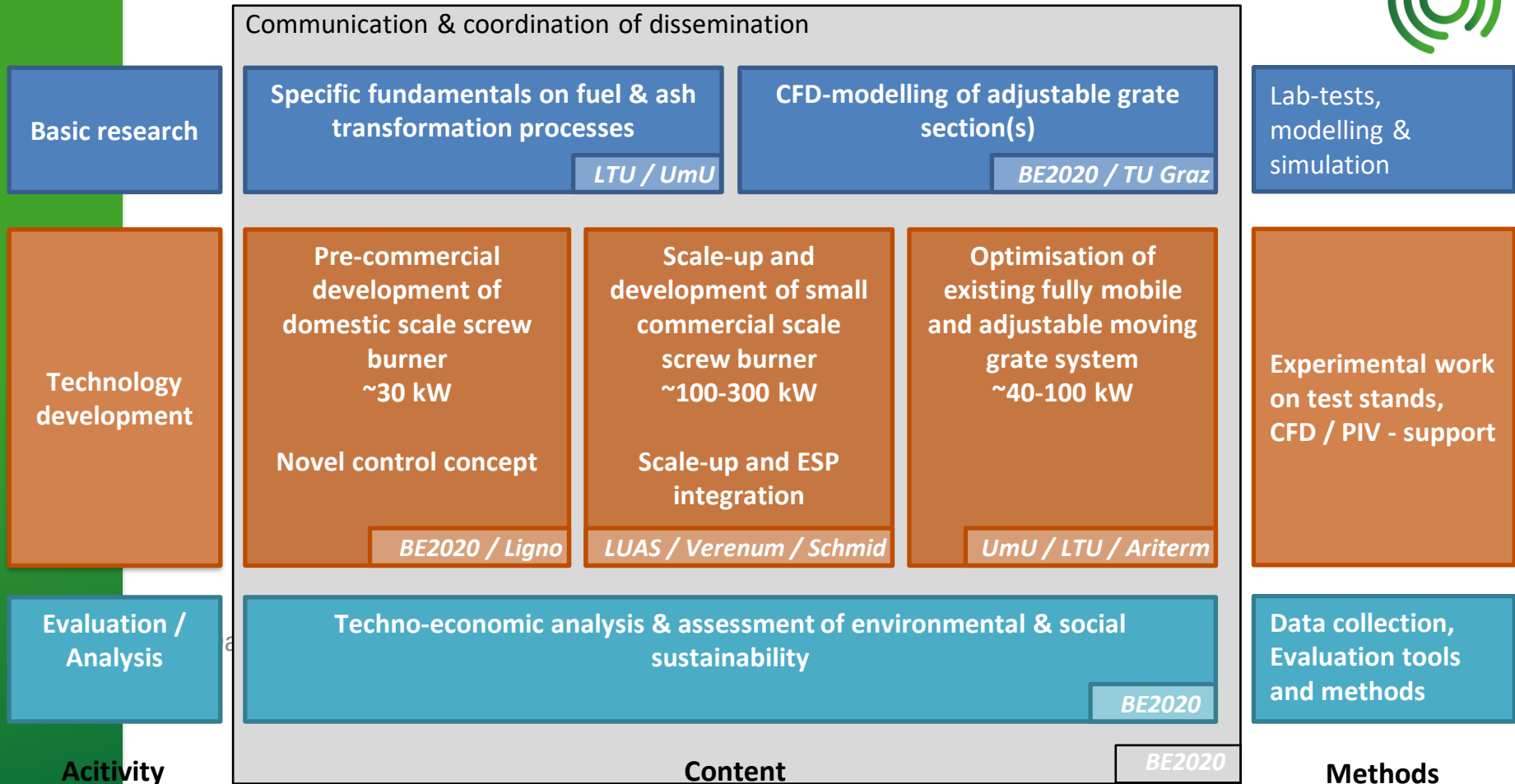
- Background
- Objectives
- Project structure
- Consortium
- Selected results
 - Fuel conversion
 - Modelling of the grate section
 - Development of control system
 - Scale-up



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!**





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.**

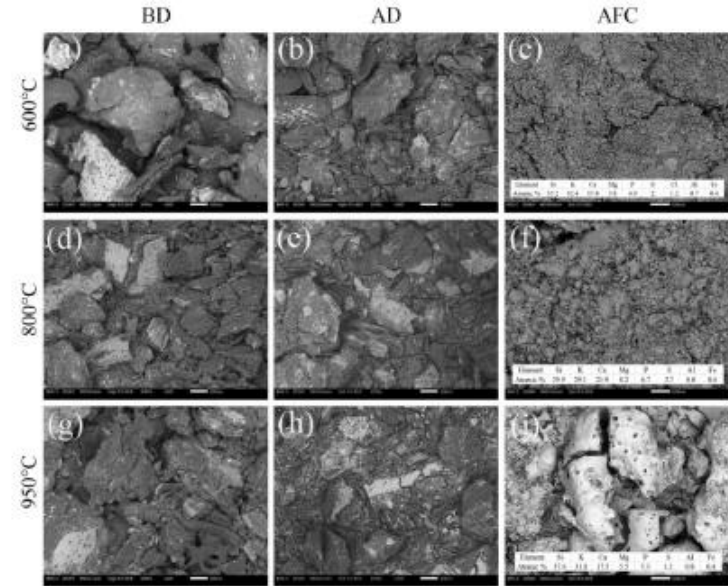




Results – Ash transformation processes

Fundamental investigations

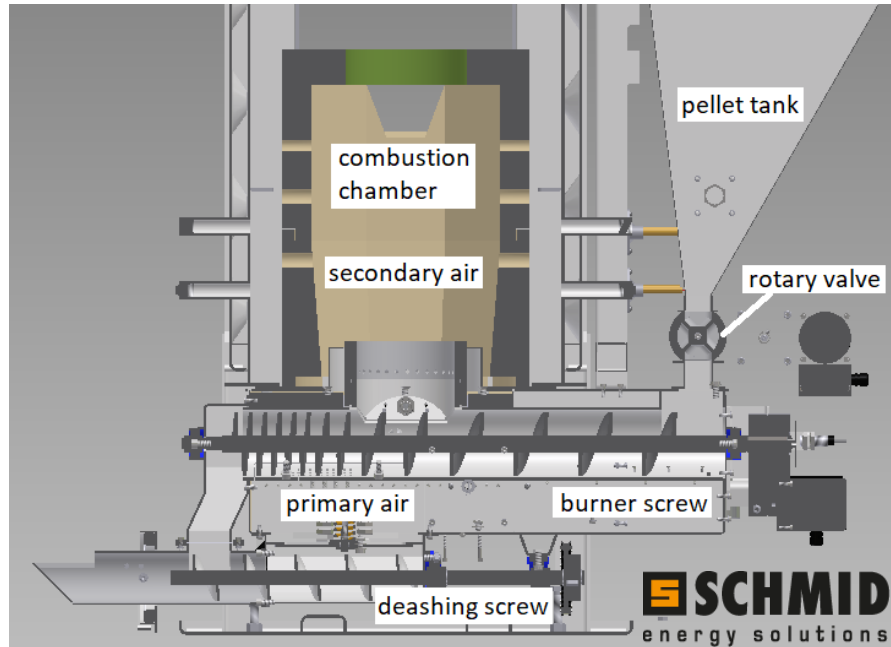
- Single-pellet combustion of agricultural biomass fuels
- Focus on K and P
- Macro-TGA reactor at three different furnace temperatures, namely, 600, 800, and 950 °C
- Different stages of thermal conversion - before and after devolatilisation and after complete char conversion
- SEM-EDS and XRD – morphology,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





Biomass boiler

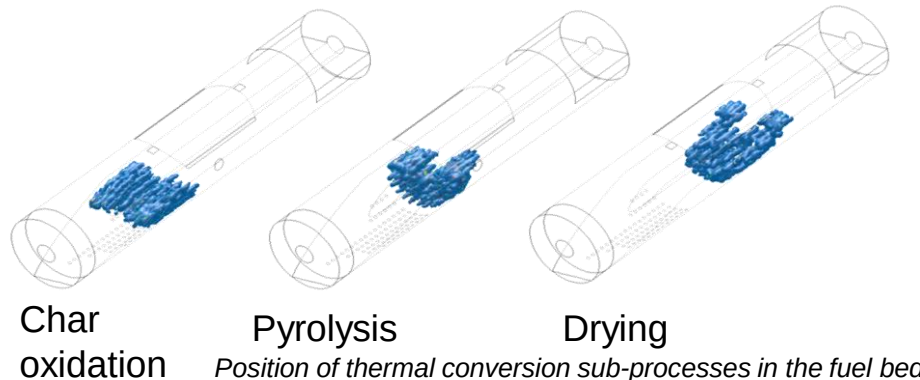
Screw Burner prototype, 35 kW





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

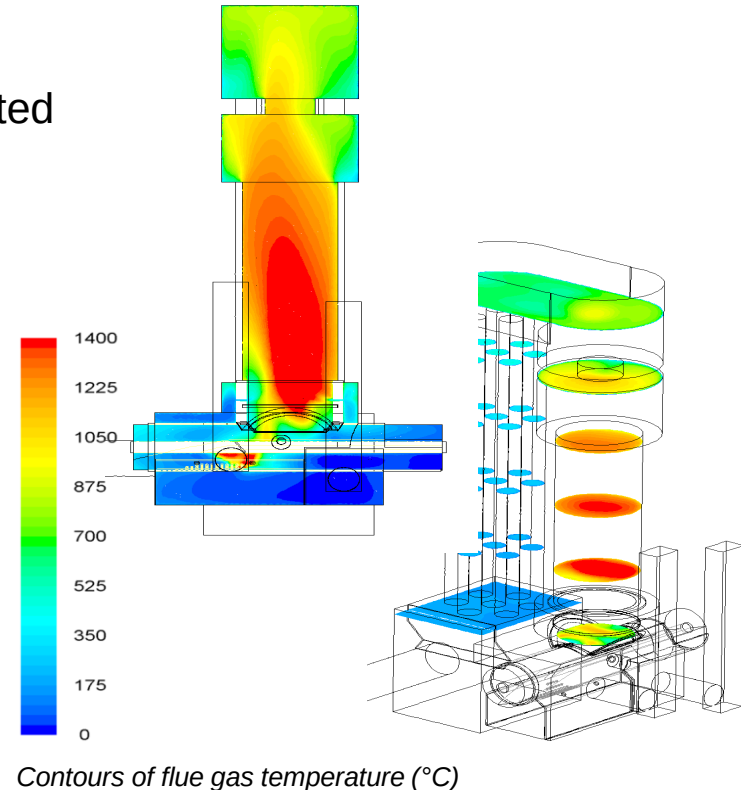


Char
oxidation

Pyrolysis

Drying

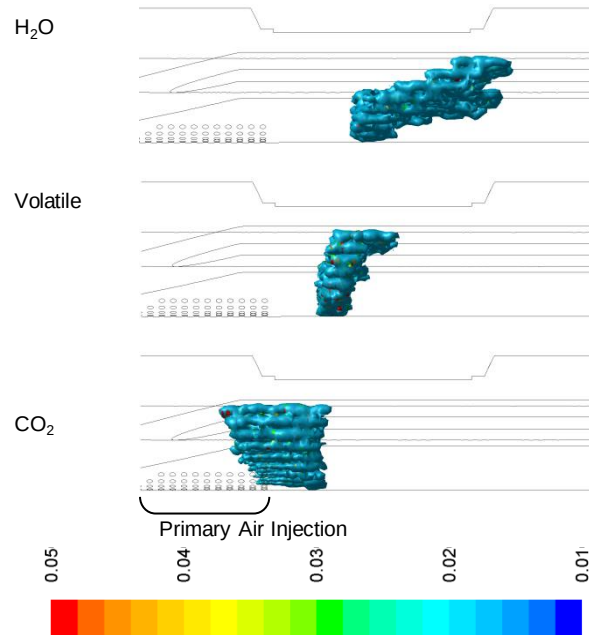
Position of thermal conversion sub-processes in the fuel bed



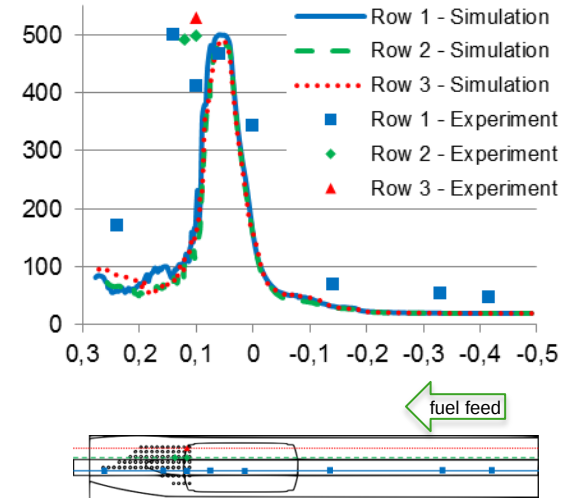
Contours of flue gas temperature (°C)



Results – Modelling of grate section



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



Temperature distribution in the burner tube.

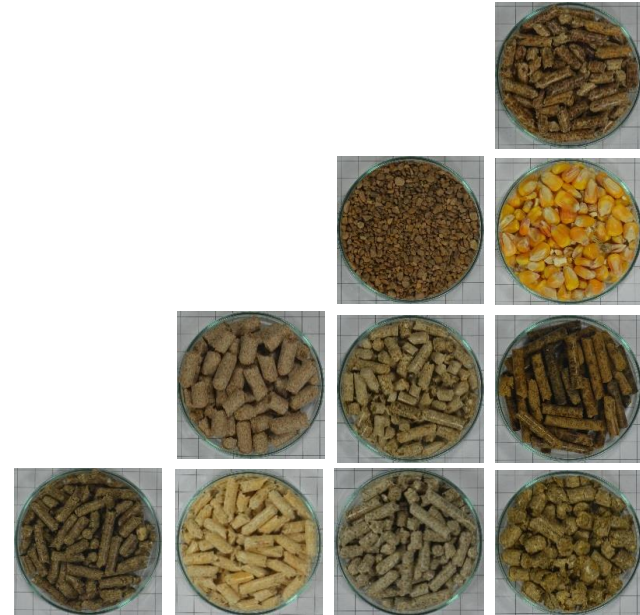


Results – control concept

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

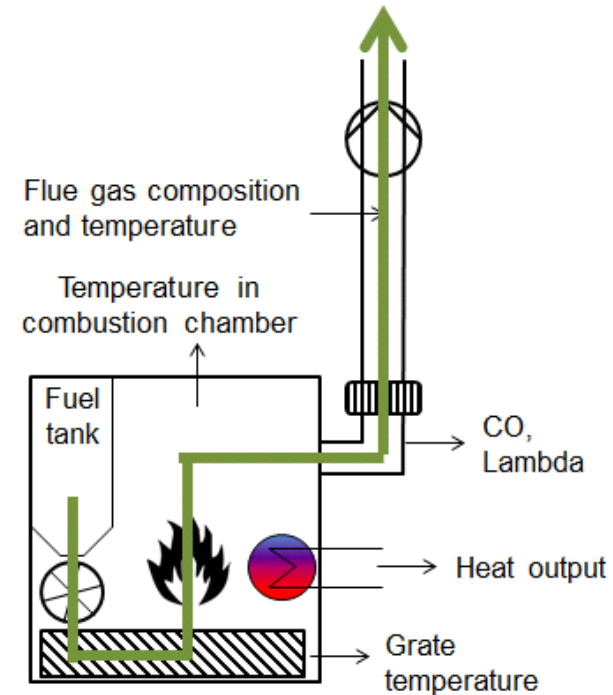




Results – control concept

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



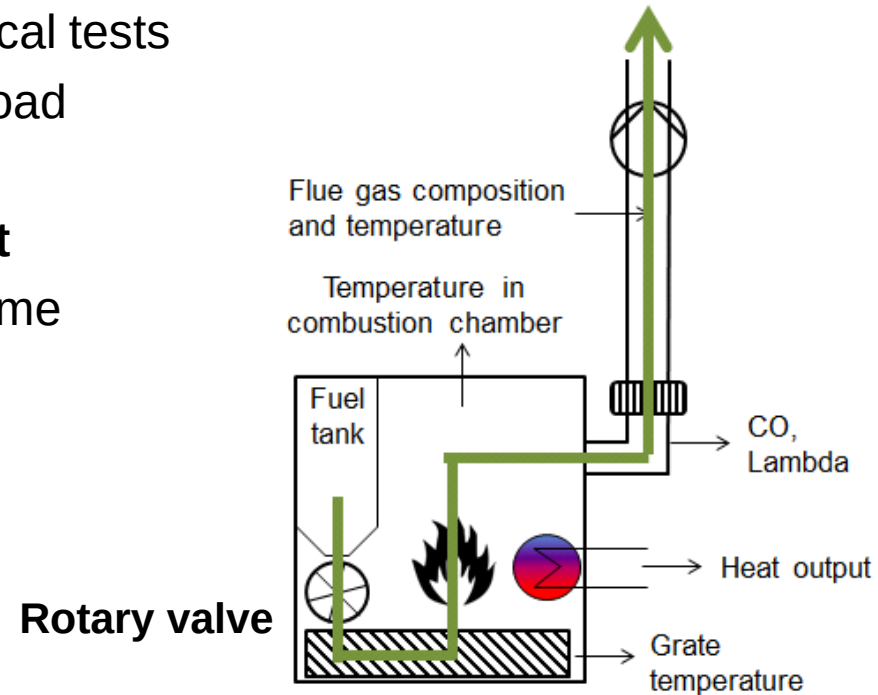
Experimental setup and selected measurement points.



Results – control concept

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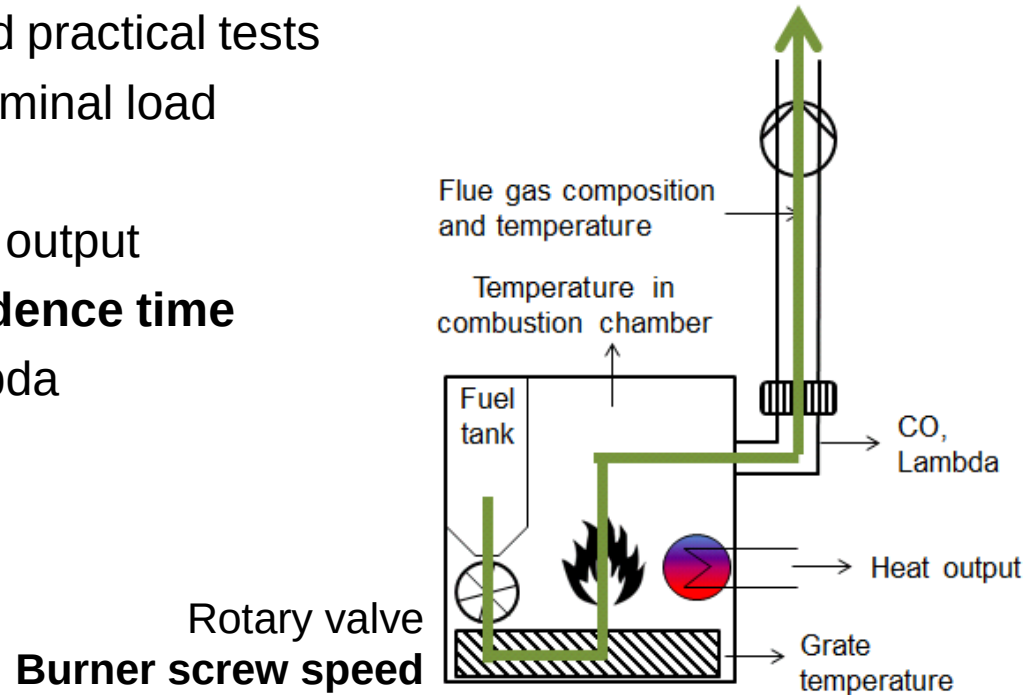
Experimental setup and selected measurement points.



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Experimental setup and selected measurement points.



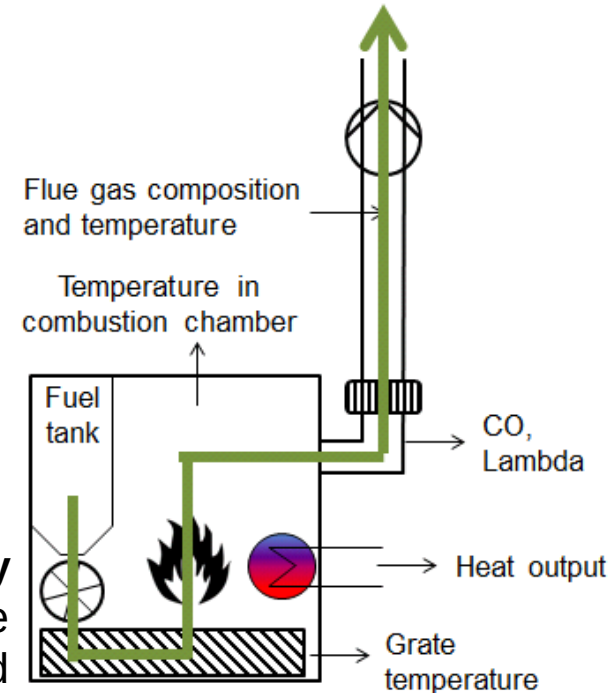
Results – control concept

Parameter variations and identification of relevant operational conditions

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 - rotary valve → heat output
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 - **air supply** → **CO, lambda**
- Identification of relevant operational conditions



Air supply
Rotary valve
Burner screw speed



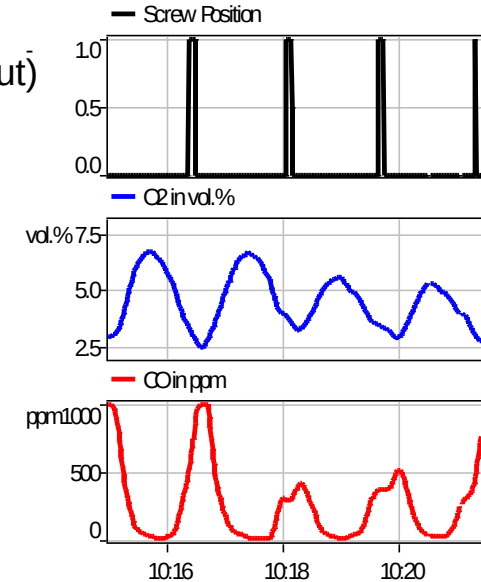
Experimental setup and selected measurement points.



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

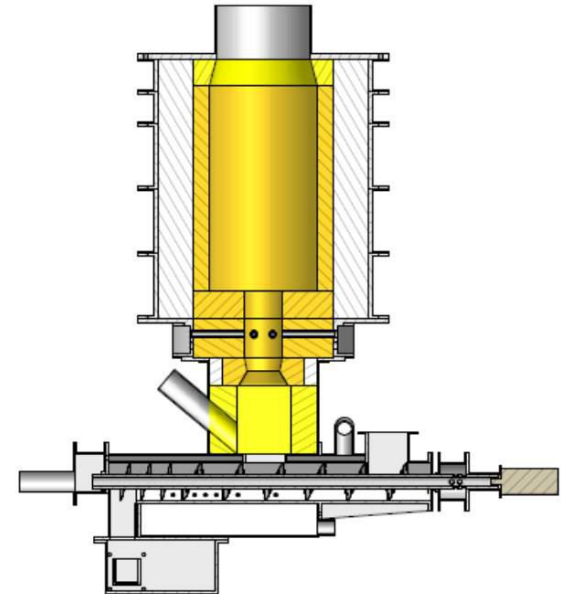




Results – Scale-up

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	$n^{0.33}$	$n^{0.5}$	$n^{0.417}$

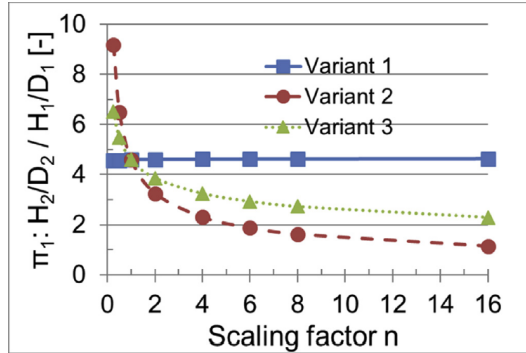
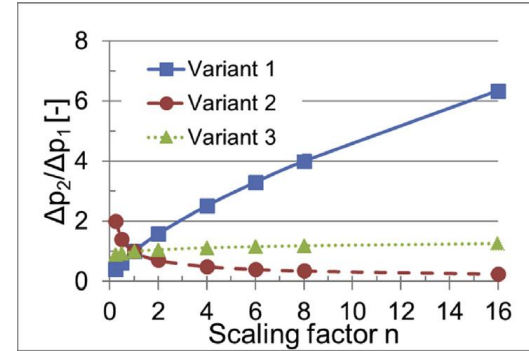
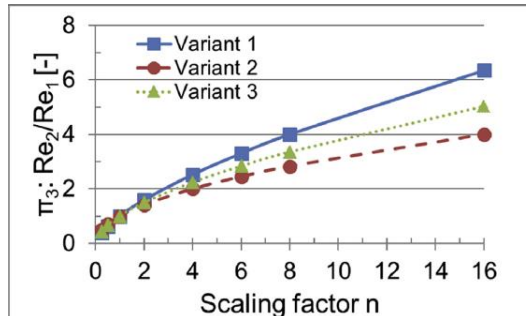
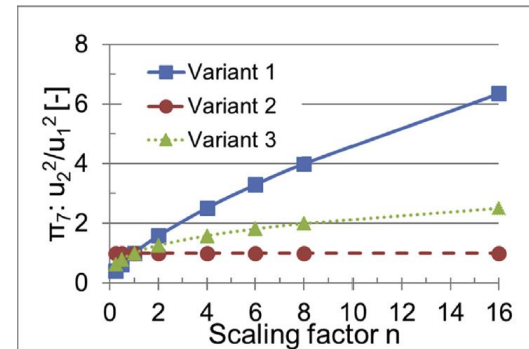
Evaluation via simulation shows good results regarding CO emissions!

Simulation validated with test at 35 kW appliance.



Results – Scale up

Influence of scaling factor





References

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Thank you for your attention.