

Experimental Investigation of Combustion Characteristics During Co-Combustion of Solid Recovered Fuel and Coal in a 1 MW_{th} Circulating Fluidized Bed Reactor

A. Kuhn; E. Langner; D. Hülsbruch; E. Kallio; A. Soderholm,
V. Barišić; J. Ströhle; B. Eppe

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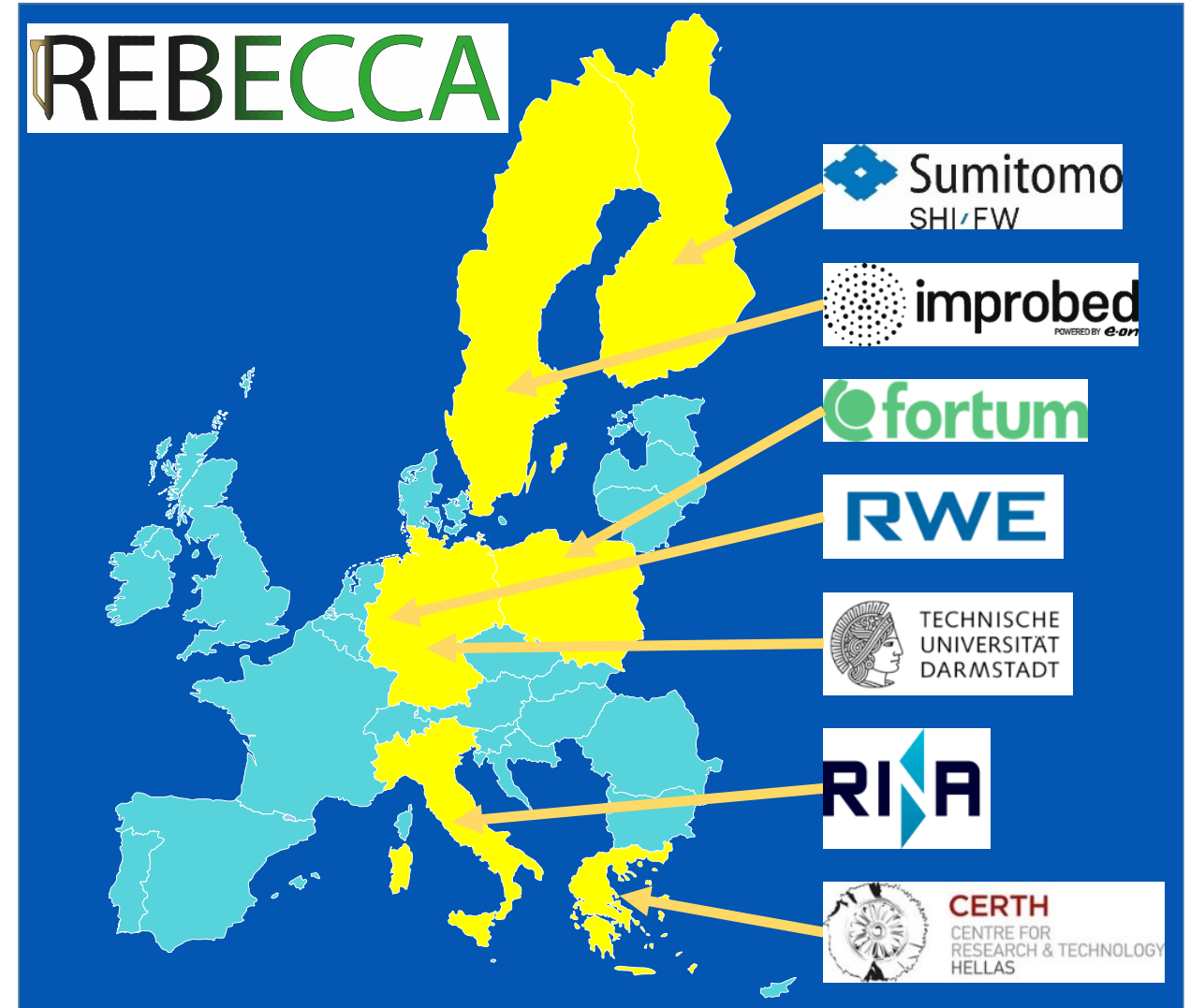


REBECCA PROJECT

- Start date: 01/07/2021
- End date: 21/12/2024
- Budget: 2.72 M€
- **Retrofitting Fluidized Bed Power Plants for Waste-Derived Fuels and CO₂ Capture**



Grant Agreement Number:
101034024





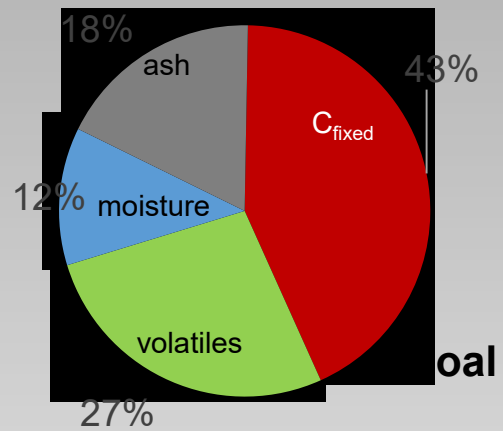
[1]



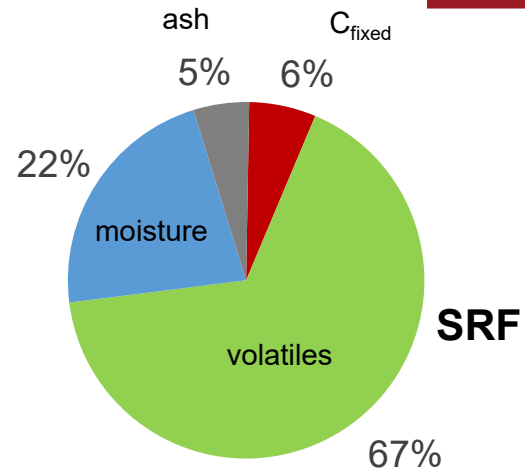
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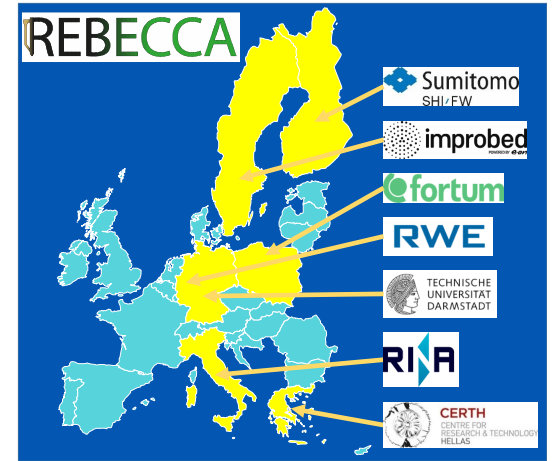
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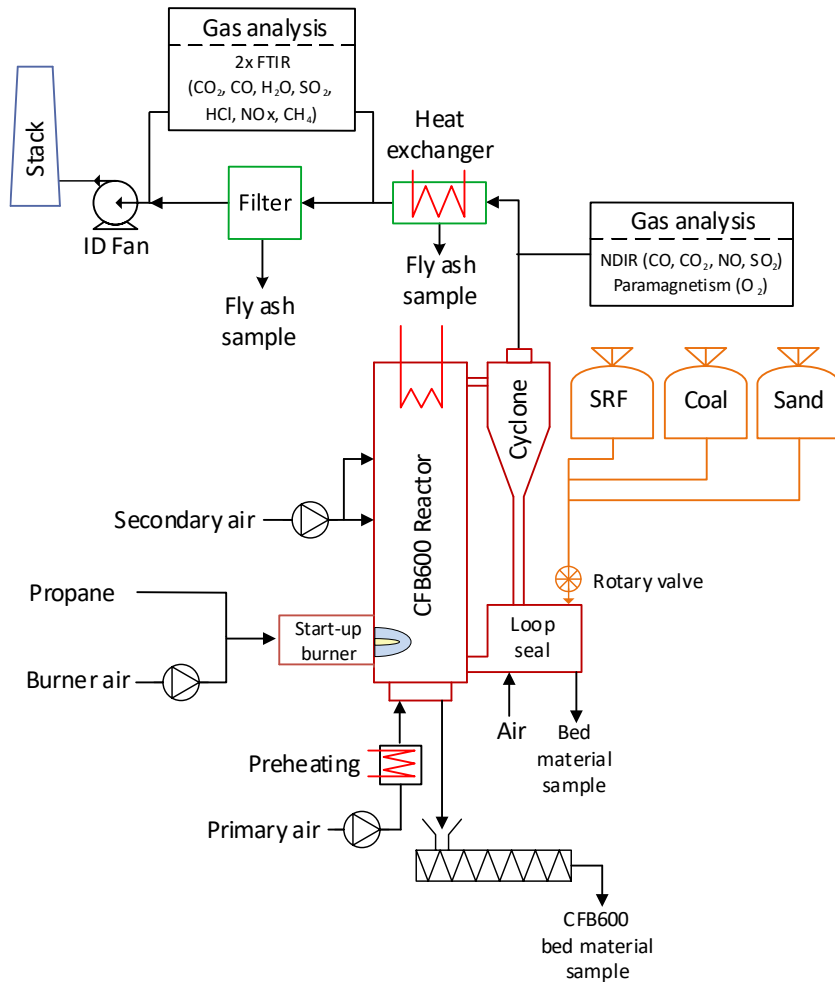
coal



SRF



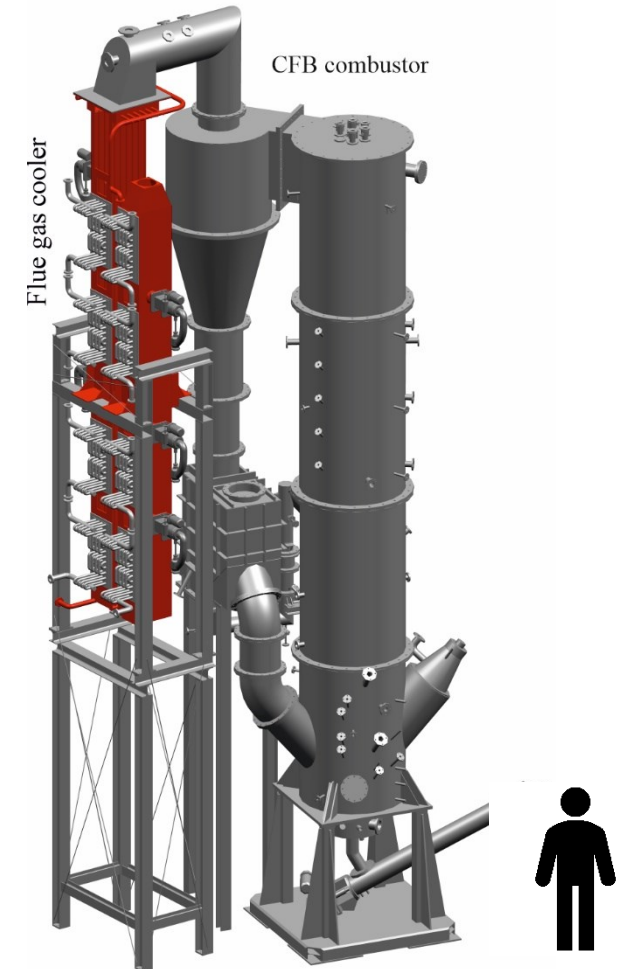
PROCESS SCHEME



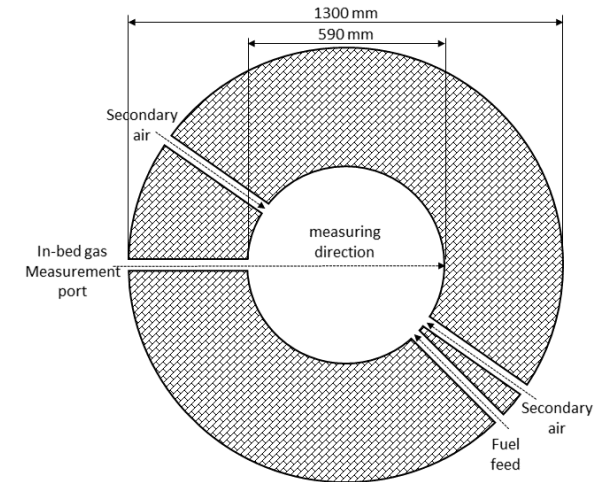
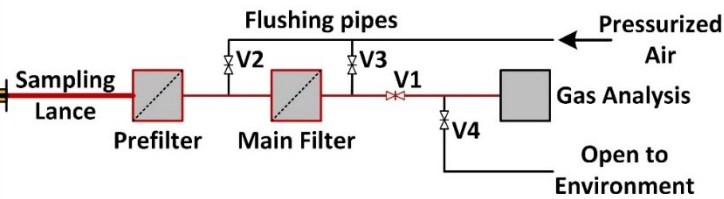
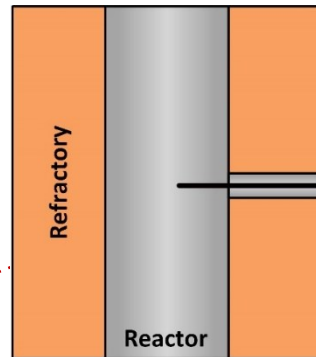
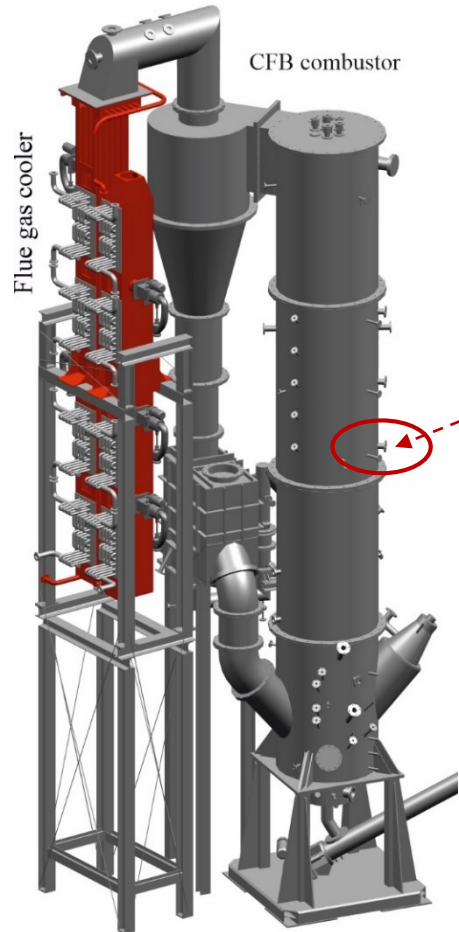
1 MW_{th} Combustion Reactor

- Inner diameter: 600 mm
- Outer diameter: 1300 mm
- Height: 8600 mm

- Fuel feed: up to 1 MW_{th}
- Solid inventory: ~ 130 kg
- Superficial velocity: 3 – 7 m/s



SET-UP IN-BED GAS MEASUREMENTS



- $h_{\text{measurement}}$: 4200 mm
- T_{heating} : 200 °C
- # positions: 12 - 28

- $h_{\text{measurement}}$: 4200 mm
- $h_{\text{secondary air}}$: 2740 mm
- $h_{\text{fuel feed}}$: 480 mm



EXPERIMENTAL BOUNDARY CONDITIONS

- 10 day test campaign
 - 24 h combustion of 100% coal
 - 90 h combustion of fuel mixture
 - 36 h combustion of 100% SRF

		SRF	Coal
Moisture	[wt-% a.r.]	22.0	11.8
Ash	[wt-% dry]	6.6	20.4
Volatiles	[wt-% dry]	85.2	30.8
Fixed Carbon	[wt-% dry]	8.3	48.8
LHV	[MJ/kg a.r.]	20.9	21.9
Maximum particle size	[mm]	10.0	10.0
Bulk density	[kg/m ³]	96	704



SRF
 $\bar{d}_p = \sim 10 \text{ mm}$



Coal
 $\bar{d}_p = \sim 5.2 \text{ mm}$



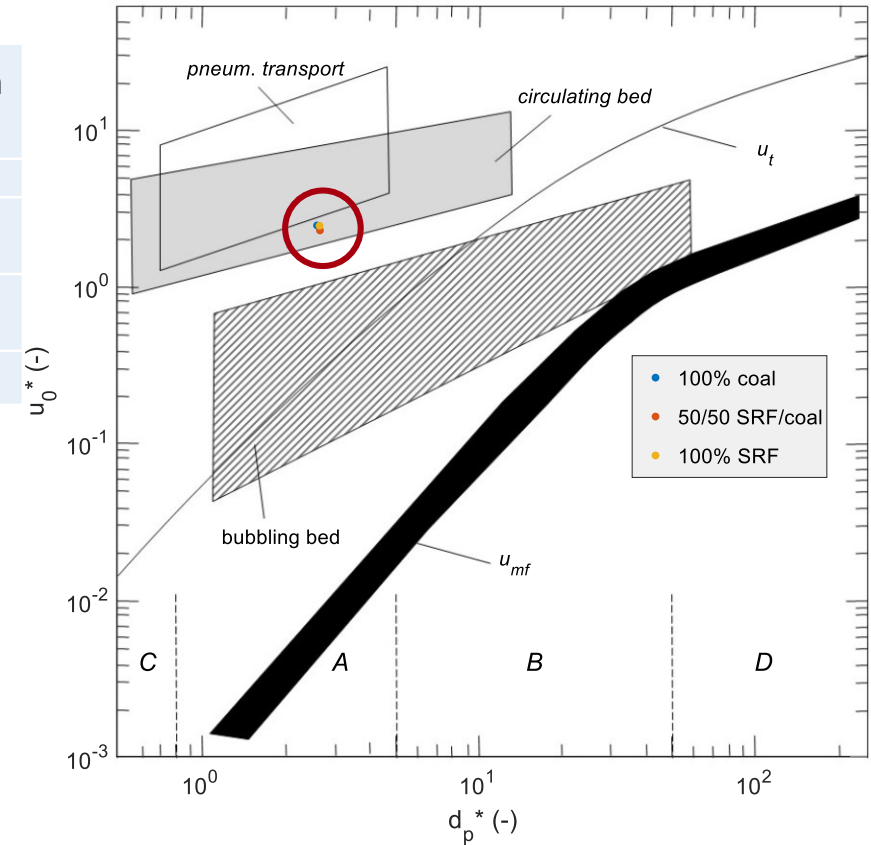
Sand
 $\bar{d}_p = 191 \mu\text{m}$

SELECTED TEST PERIODS

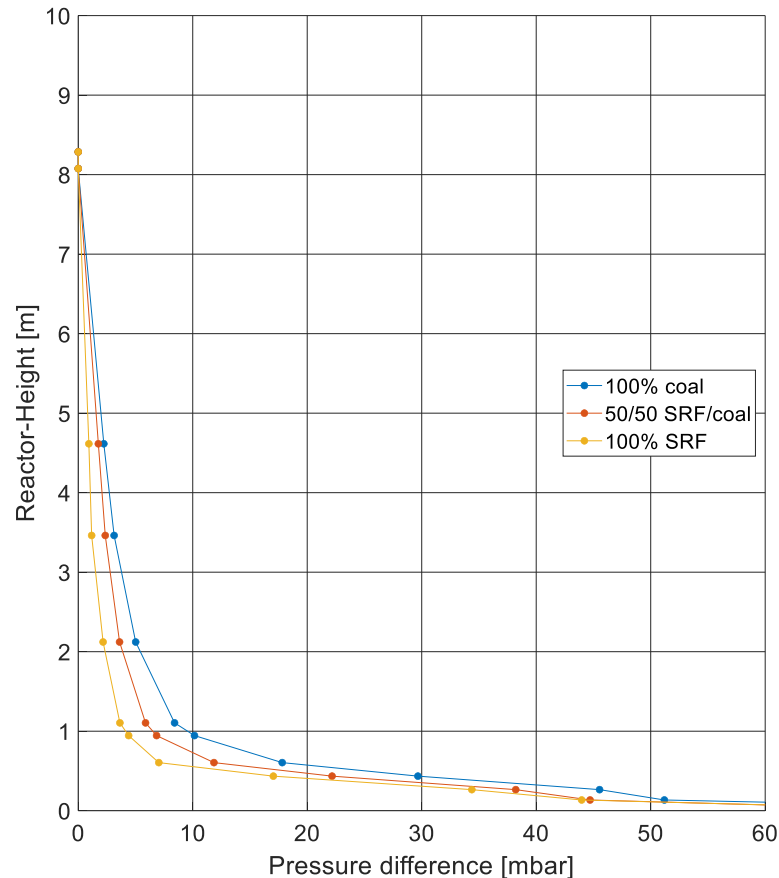
Operation point	Load [kW _{th}]	Load share [%]		Primary air share [%]	Secondary air share [%]	Velocity [m/s]	Duration [h]
		SRF	Coal				
I: 100% coal	705	0	100	64	36	4.2	4.5
II: fuel mixture tests	698	50	50	56	44	3.8	3.5
III: fuel mixture tests	788	72	28	54	46	4.0	2.0
IV: 100% SRF	674	100	0	50	50	4.1	3.5

Assignment of test periods

- Reaktor: I, II, IV
- Gas profile: I, III, IV



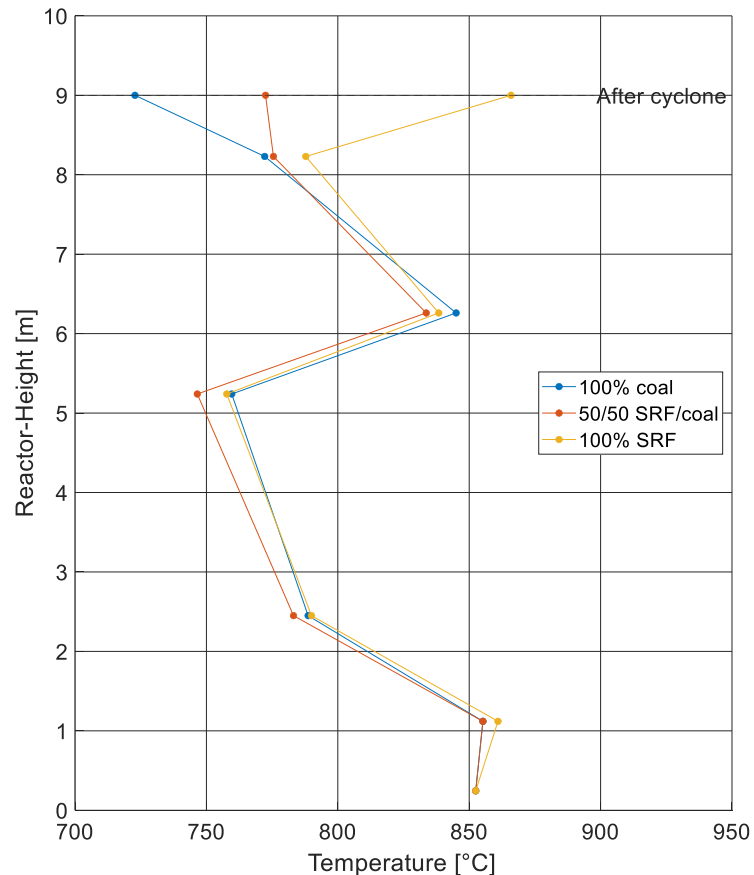
HYDRODYNAMIC INVESTIGATION



- Typical pressure profile for CFB-Combustion
- Higher particle density for coal-combustion
 - ➔ Higher ash content in coal
 - ➔ Higher Bulk density of coal

Operation point	Load [kW _{th}]	Load share [%]		Primary air share [%]	Secondary air share [%]	Velocity [m/s]	Duration [h]
		SRF	Coal				
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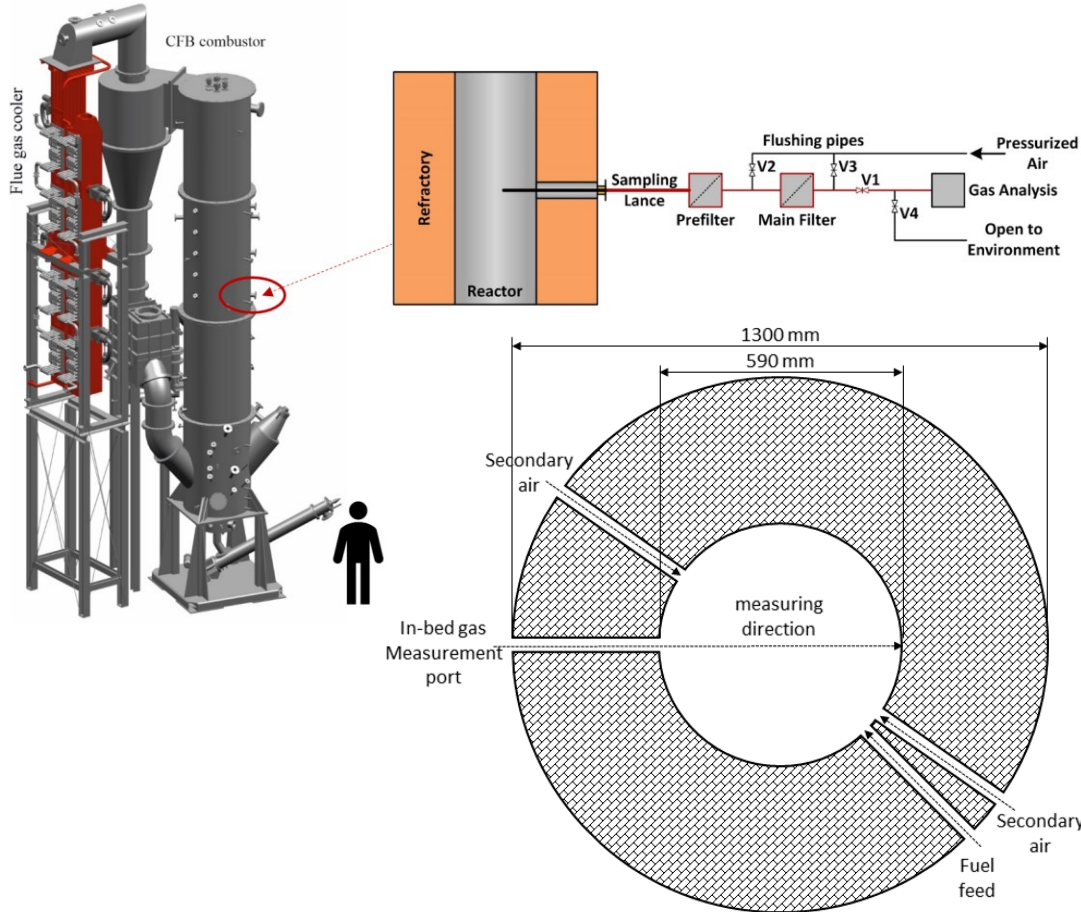
THERMODYNAMIC INVESTIGATION



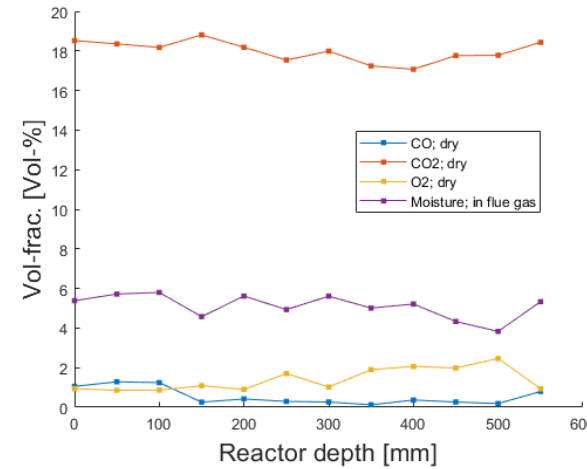
- Typical temperature profile of CFB-Combustion
- Varying number of cooling lances inserted
→ Higher Temperatures for coal-combustion
- Temperature increase in upper reactor area
→ increases with higher SRF-shares

Operation point	Load [kW _{th}]	Load share [%]		Primary air share [%]	Second- ary air share [%]	Velocity [m/s]	Duration [h]
		SRF	Coal				
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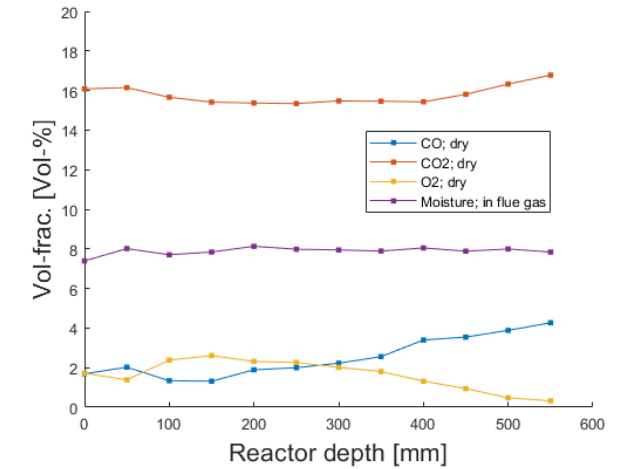
IN-BED GAS MEASUREMENTS



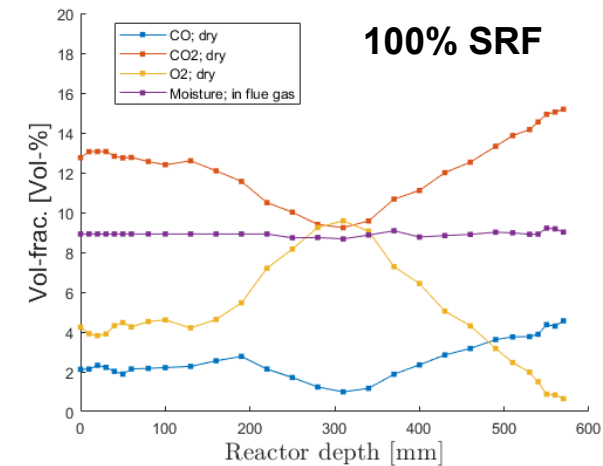
100% coal



72/28 SRF/coal



100% SRF



SUMMARY/OUTLOOK



✓ Summary

- Operation with 100 % SRF proved
- Shift of combustion to higher reactor areas seen
→ Countermeasures outcome of Rebecca-Project
- Measures for stable reactor inventory desirable

✓ Outlook

- Upscaling of test results to commercial systems
- Implementation of retrofit concepts to industrial plants

SOURCES



- [1] <https://umweltinstitut.org/energie-und-klima/kohle/>
- [2] <https://de.vecteezy.com/foto/13104259-grosser-haufen-steinkohle-steinkohle-isoliert-auf-weissem-hintergrund>
- [3] <https://www.nationalgeographic.de/umwelt/kohle-wie-lange-noch>
- [4] <https://www.fortum.com/energy-production/chp-combined-heat-and-power/plants/zabrze>

M.Sc Alexander Kuhn

Energy Systems and Technology

Mail: Alexander.Kuhn@est.tu-darmstadt.de

Phone: +49 6151 16 23006

Otto-Berndt-Straße 2, 64287 Darmstadt / Germany

www.est.tu-darmstadt.de

REBECCA

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**THANK YOU VERY MUCH FOR
YOUR ATTENTION**

