Heat to Fuel

CO_2 gasification of dry biomass in combination with e-fuel synthesis

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Research topics selected for this presentation:

1) Tackling the problem of ash agglomeration
2) Determining the influence of replacing H_2O with CO_2
3) Determining the influence of total pressure

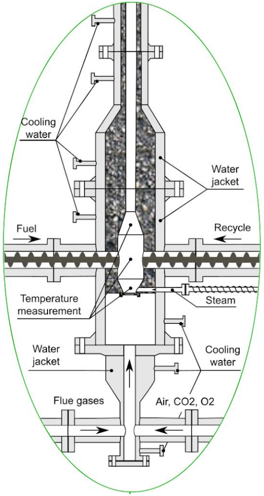
Production of e-fuels from biomass

Biomass

Pretreatment

Fuel

Gasification → Syngas



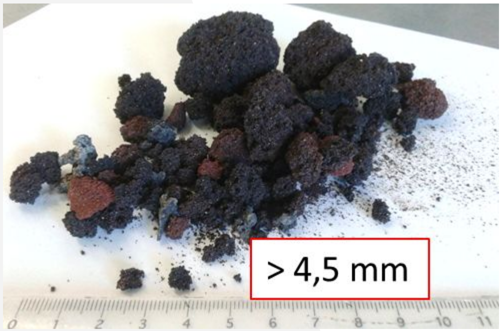
CO_2 + H_2O + O_2
+
↑↓ Total pressure

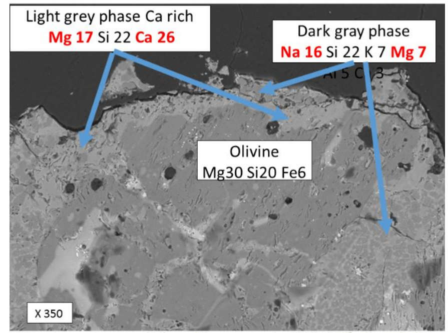
Gas cleaning
+
Syntesis

FT fuels

The challenge posed by feedstocks originating from biomasses

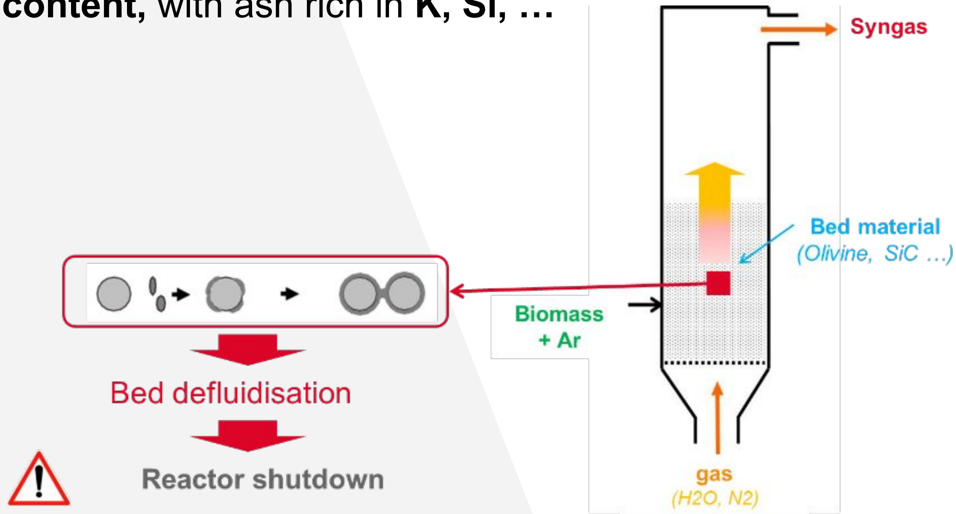
FB agglomeration and defluidization



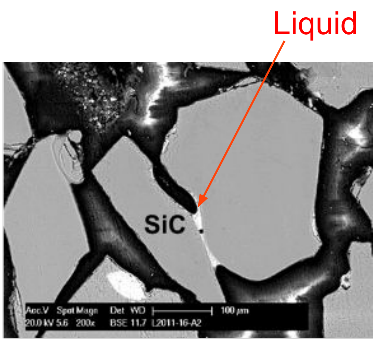


The challenge posed by feedstocks originating from biomasses

Initial and critical step in agglomeration: formation of **low temperature melting phase** (silicates, carbonates, salts) in gasification of biomass with **high ash content,** with ash rich in **K, Si, …**



Simplified Fluidized bed

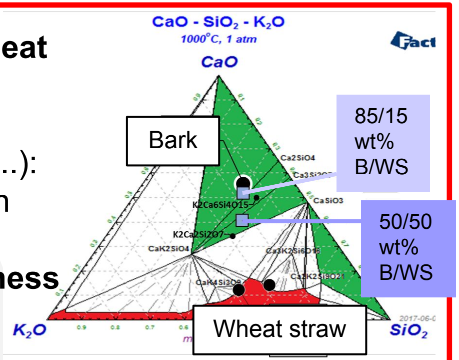


Wheat straw/SiC

Solution: to blend biomass in such a way to react their ashes into products of higher melting temperatures.

A 3 steps-methodology

1) **Definition of blends (wheat straw-bark)** according to inorganic content of each biomass (Ca, K, Si, P, Al, ..):
-> thermodynamic simulation calculations
-> assumption of **completeness of reactions**



Compaction as necessary pretreatment step

Heat to Fuel

A 3 steps-methodology

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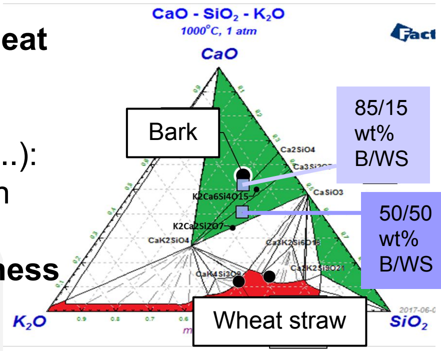
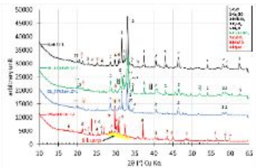
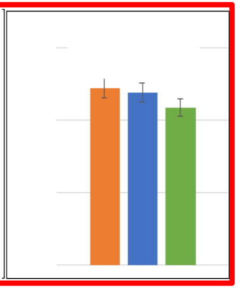


2) Lab scale assessment of the method
heat treatments 0-1000°C, oxid. and half-red. atm., SEM, XRD characterisation



3) Pilot scale tests – FB treatment of the blends (pellets)
- Investigation of agglomeration: Agglomeration rate (agglomerates in bed) + online measurement of T heterogeneity in bed (sign of defluidisation)
- Gasification efficiency (gas yield-composition)



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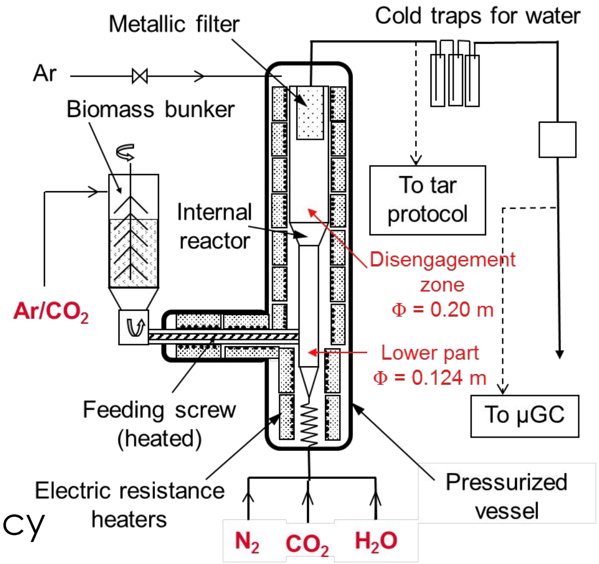
A 3 steps-methodology to simulate DFB conditions

1. **steam gasification at 850°C**
2. cooling down of the reactor – opening – weighing of bed+ash, observation, screening, sampling, and back into the reactor
3. **air combustion at 950°C**

Tmax	1000°C
P_{abs}	1.5 to 12 bars
Biomass feeding rate	0.3-5 kg/h
Product analysis/quantification	Dry gas: µGC Water: condensation Tar protocol (isopropanol) + GC-FID quantification

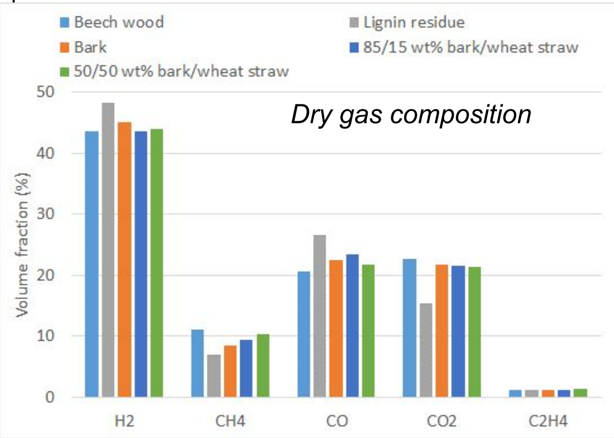


Objective of the experiments:

- Measurement of gasification efficiency
- Checking for no agglomeration

Results of the blending method

	Lignin	Bark	Bark / straw (85/15 wt%)	Bark / straw (50/50 wt%)
Cold gas efficiency (all gas species)	**0.71**	0.81	0.80	0.77
Product gas LHV (MJ/Nm^3)	12.9	12.2	12.4	12.9
Product gas yield (Nm^3/kg daf)	1.21	1.22	1.19	1.09
Condensable tar (g/Nm^3)	**9.1**	2.3	0.9	2.2
BTX (g/Nm^3)	**12.9**	7.3	6.5	9.6

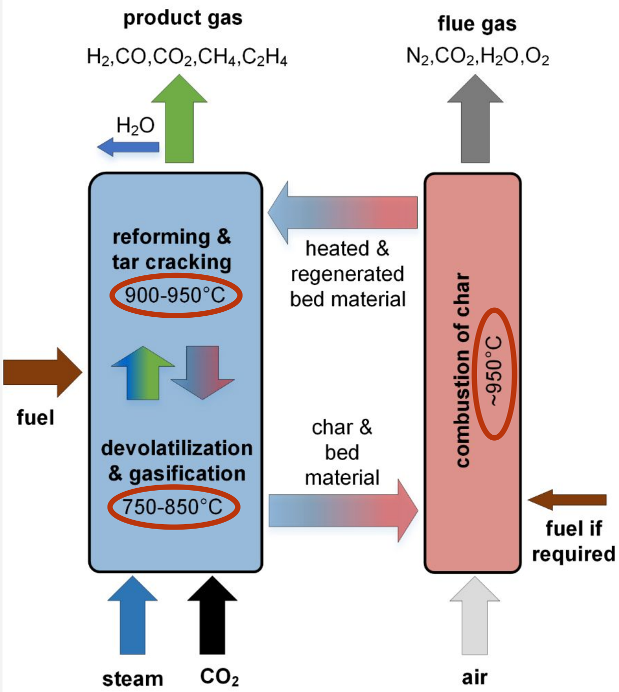


Efficiency of the blending method proved for the 85/15 wt % blend

- Gasification efficiency comparable to that of bark
- Limited agglomeration propensity

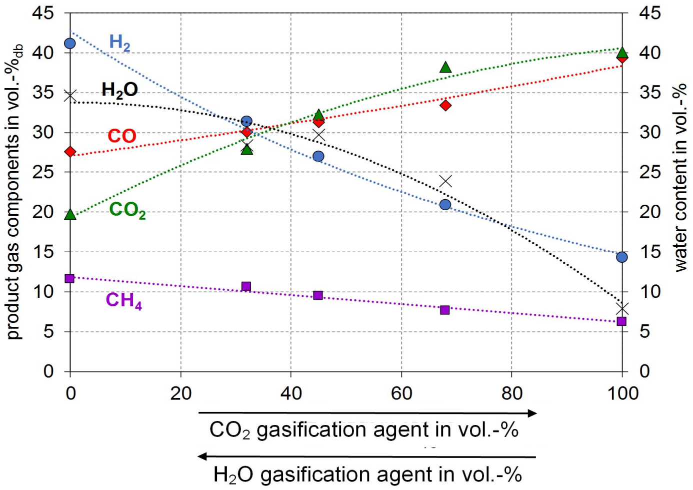
- Limited efficiency for the 50/50 wt % blend
- Good gasification efficiency for all feedstock

H_2/CO „turn-down ratio" – DFB



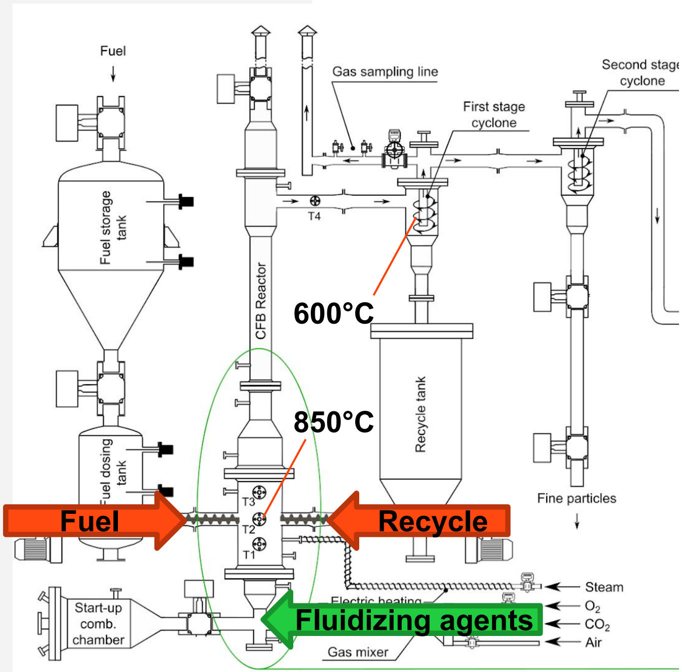
softwood

olivine



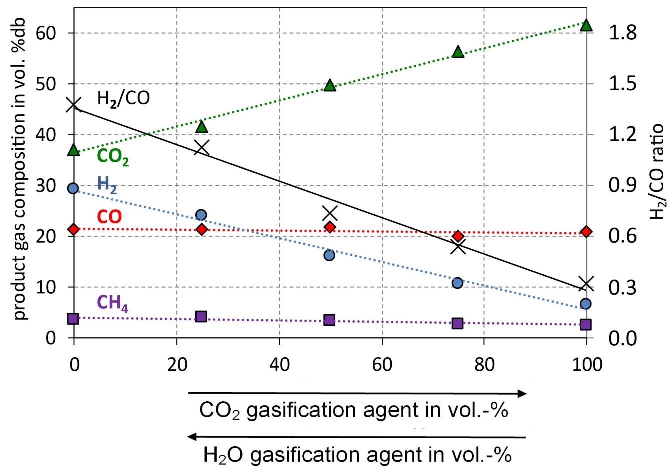
Gas free of combustion products
Reactor needs a certain ΔT

H_2/CO „turn-down ratio" – DFB



bark

olivine

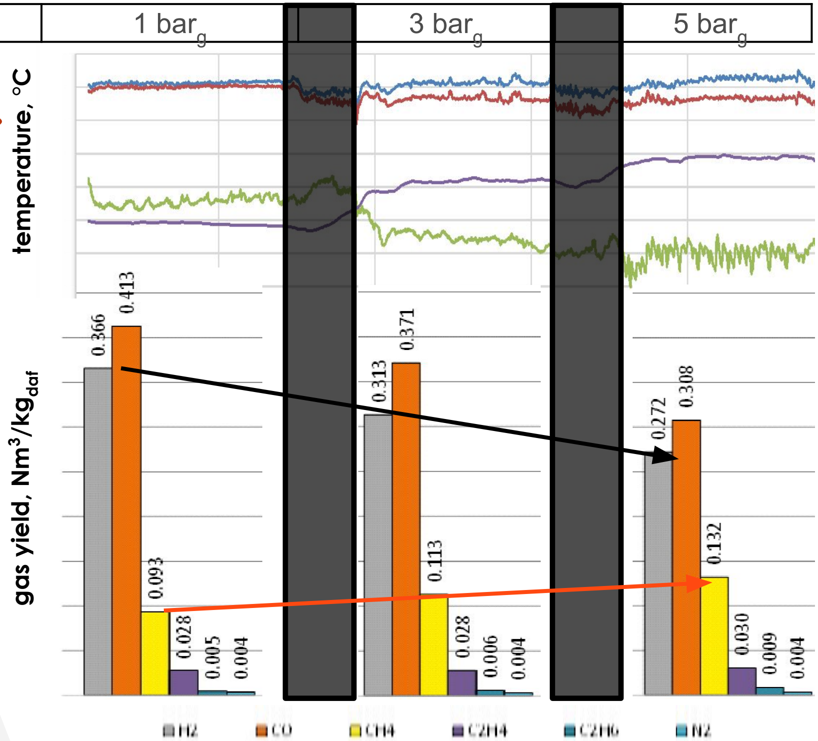


Gas additionally reach in CO_2 due to autothermicity of the gasifier

Results of the influence of pressure and CO_2

Blend 85/15

Temp. in FB top, [°C]	(green line)
Temp. in FB mid, [°C]	(red line)
Temp. in FB bot, [°C]	(blue line)
Temp. bef. cyclone, [°C]	(purple line)



- **Gasification with CO_2** leads to ↑**CO and** ↓**H_2** productivity.

- From a technological standpoint, gasification under pressure **increases the output and efficiency of the process**, thus, is attractive in the case of SNG or FT (10 – 30 barg).
- However, in the near perspective, swift development of such units will be **hurdled by higher complexity and CAPEX**.

HtF open access gasification research

Tackling the problem of ash agglomeration:
S. Valin, et al., Energies, 13 (2020). 10.3390/en13143706
F. Defoort et al., Energy Fuels 33 (2019) 10.1021/acs.energyfuels.8b04169

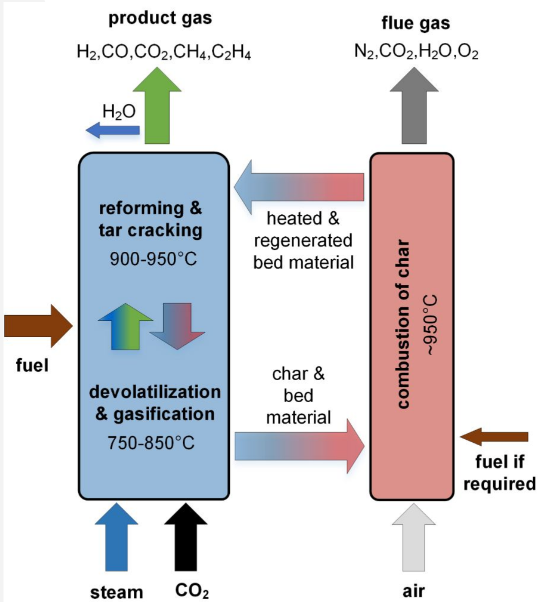
Determining the influence of replacing H2O with CO2 in DFB:
A. M. Mauerhofer el al., Energy 173, (2019) 10.1016/j.energy.2019.02.025
Biom. Conv. & Bioref. (2019) 10.1007/s13399-019-00493-3
Fuel 253, (2019) 10.1016/j.fuel.2019.04.168
Biomass Conv. Bioref. 11, (2021) 10.1007/s13399-020-00822-x

Determining the influence of total pressure and CO2 on gasification in CFB:
M. Szul, et al., Energies 2022, 15(4), 1395; 10.3390/en15041395

Also find more open access research performed within HtF on:

https://zenodo.org/communities/heattofuel/

100 kW$_{th}$ DFB gasification pilot plant at TU Wien



Please see the installations by yourselves. Enjoy the excursion, while in the future, we would be happy also to welcome you at our sites.

Heat to Fuel

THANK YOU