Results from the 100 kW dual fluidized bed gasifier at TU Wien

Florian Benedikt, Josef Fuchs, Anna Mauerhofer, Stefan Müller, Johannes Schmid, Hermann Hofbauer

IEA FBC and IEA Bioenergy Task 33 Gasification of Biomass and Waste

Joint workshop in Skive, Denmark:

Fluidized Bed Conversion of Biomass and Waste

24.10.2017

Vision for gasification technology at TU Wien

RESSOURCES

low grade wood chips

biogenic residues

industrial waste

homogenous municipal waste

sewage sludge manure

rising technological challenges with respect to gasification & gas cleaning

heat

PRODUCTS

electricity

hydrogen

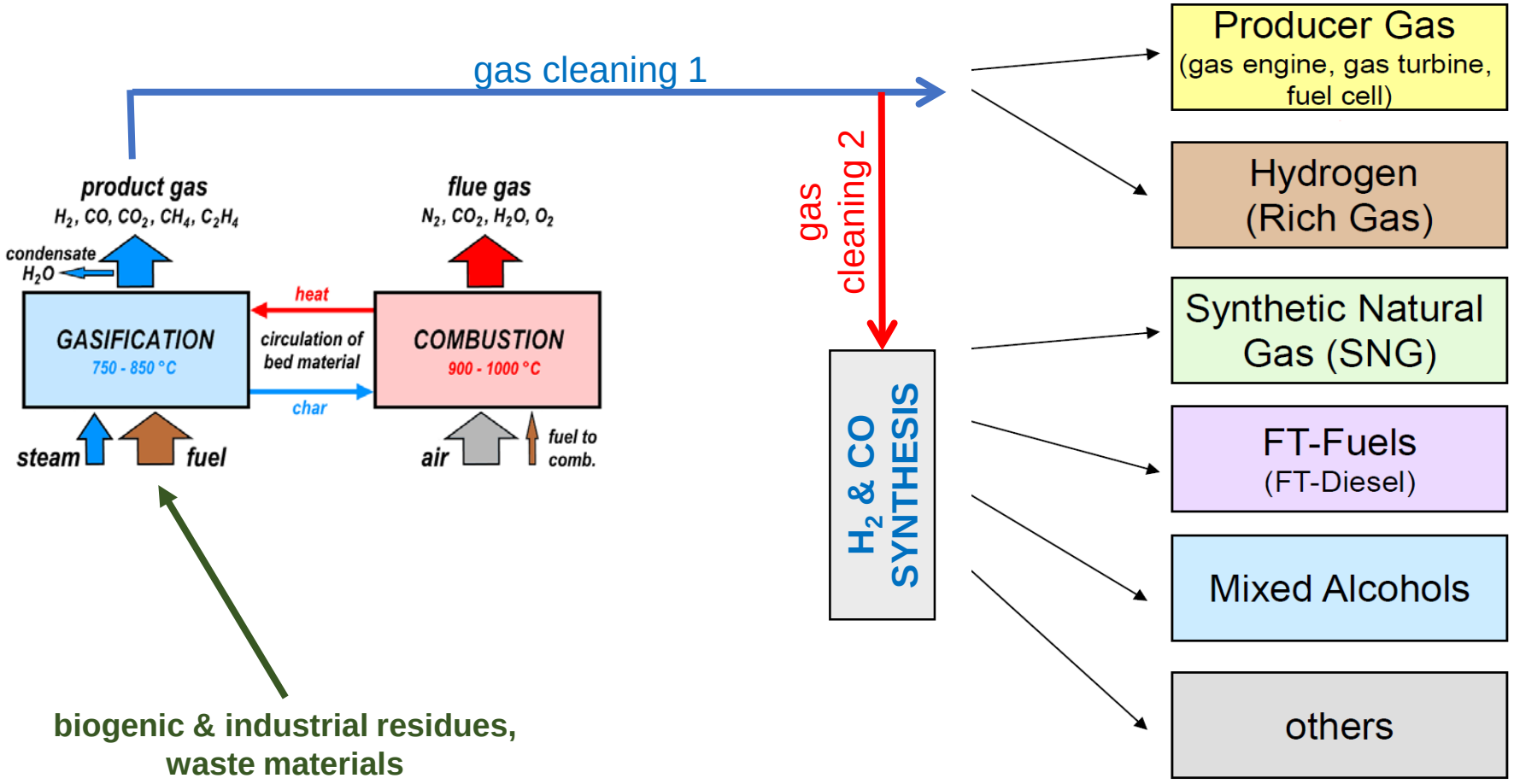
synthetic natural gas

transportation fuels & basic chemicals

Objectives:

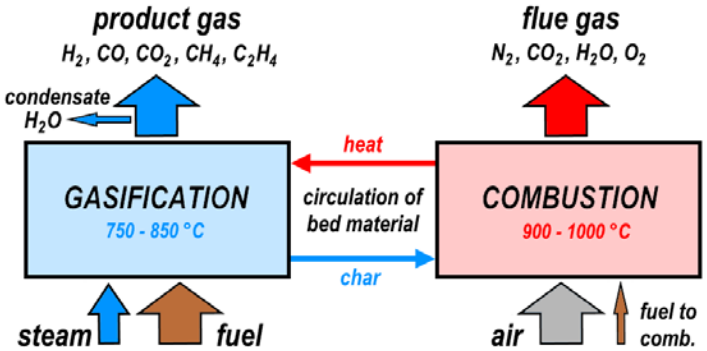
- Increasing the fuel flexibility
- Optimization of gasification (bed materials)

Dual fluidized bed steam gasification

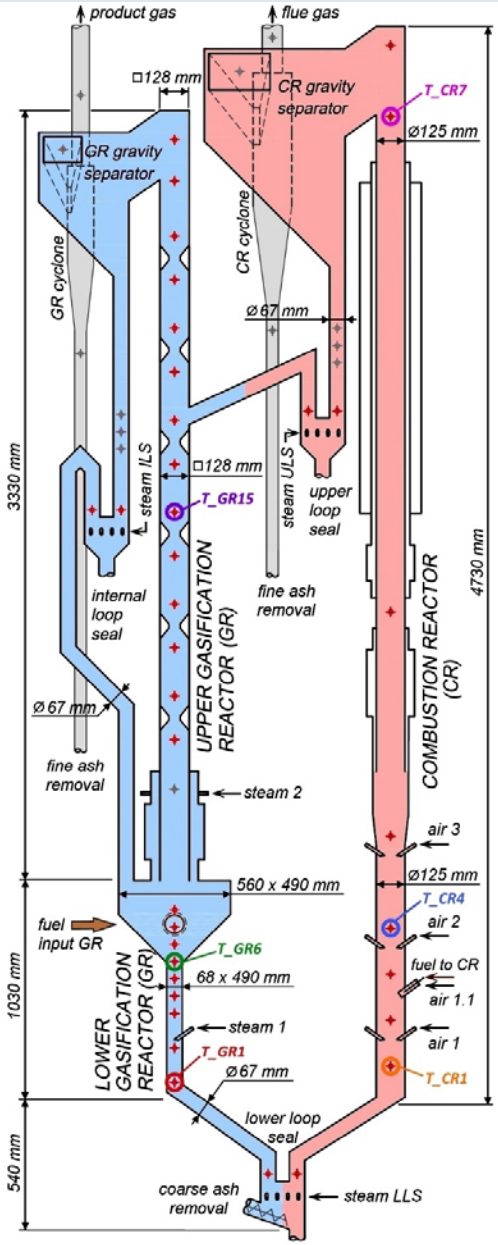


Source: Schmid J.C. 2014

Basic principle and Reactor system:



Dual fluidized bed steam gasification



Source: Schmid J.C. 2014

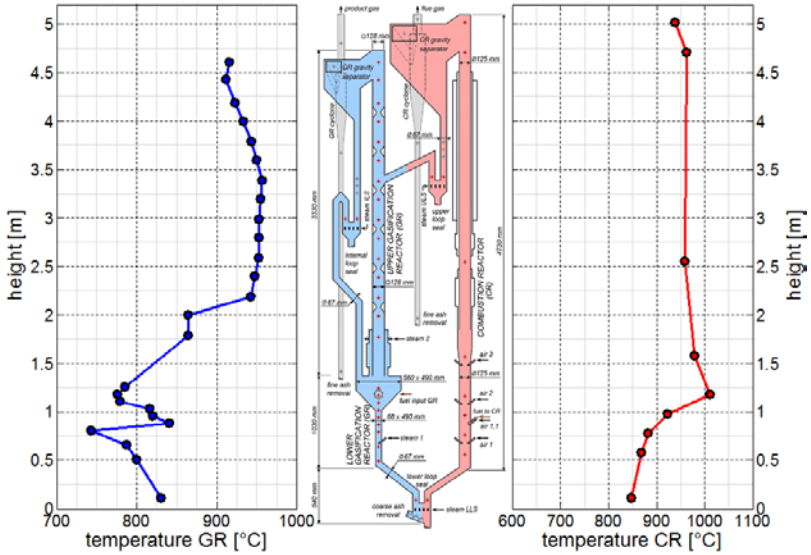
100 kW_{th} Gasification Pilot Plant at TU Wien

- Height: 7.5 m
- Base area: 35 m^2 per floor (2)
- 105 Temperatures
- 70 Pressures
- 13 Volume/mass flows
- 22 Values of gas analyses

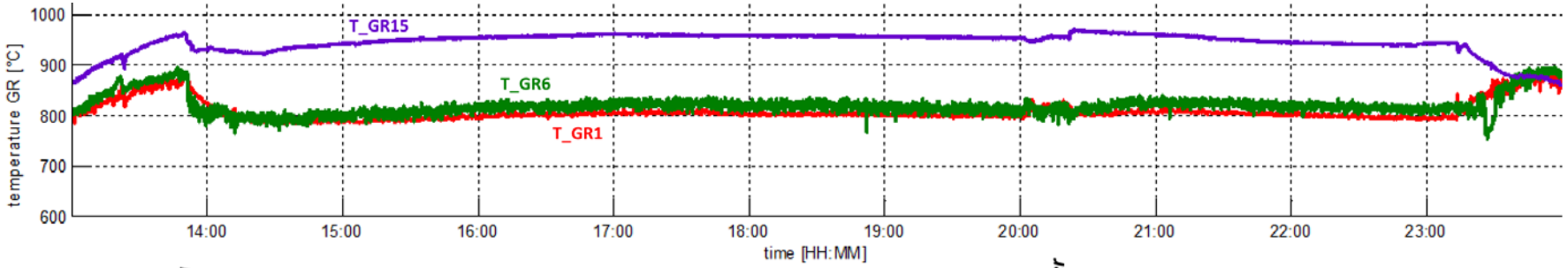
Source: Schmid J.C. 2014

Typical test run:

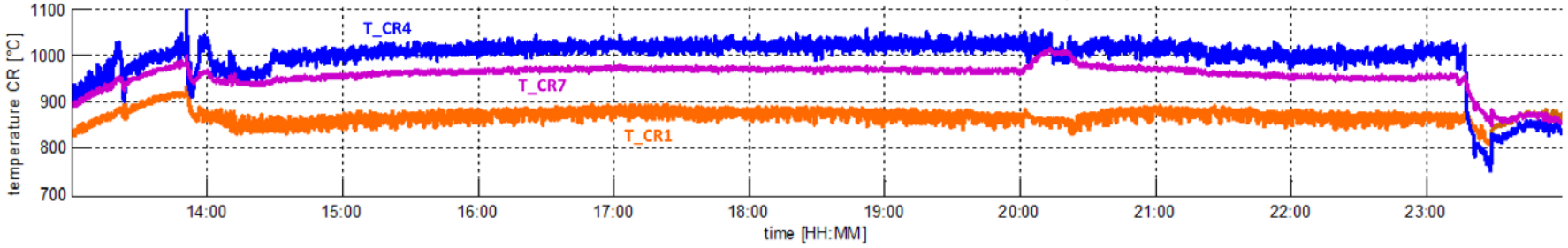
Temperature profiles



Temporal course of temperatures



end of heat-up procedure | *switching to steam* | *tuning phase* | *steady-state operation phase 1* | *top up fuel hopper* | *tuning phase* | *steady-state operation phase 2* | *start of shut-down procedure*



?? Fuels of the future ??

Wood chips

soft wood pellets

Fuels gasified at TU Wien

Coal

Wood chips

Bark pellets

Wheat bran pellets

Reed grass

Empty palm fruits

Palm leaves

Sugar cane bagasse

Sugar cane residues

waste wood A

waste wood B

waste wood C

soft wood pellets

saw dust

granulates

MSW-plastics

SLF-plastics

PE+PS

Sewage Sludge

Sources: Wilk V. 2013, Kitzler H. 2013, Kern S. 2013

“Steam gasification at high temperature” with different bed material

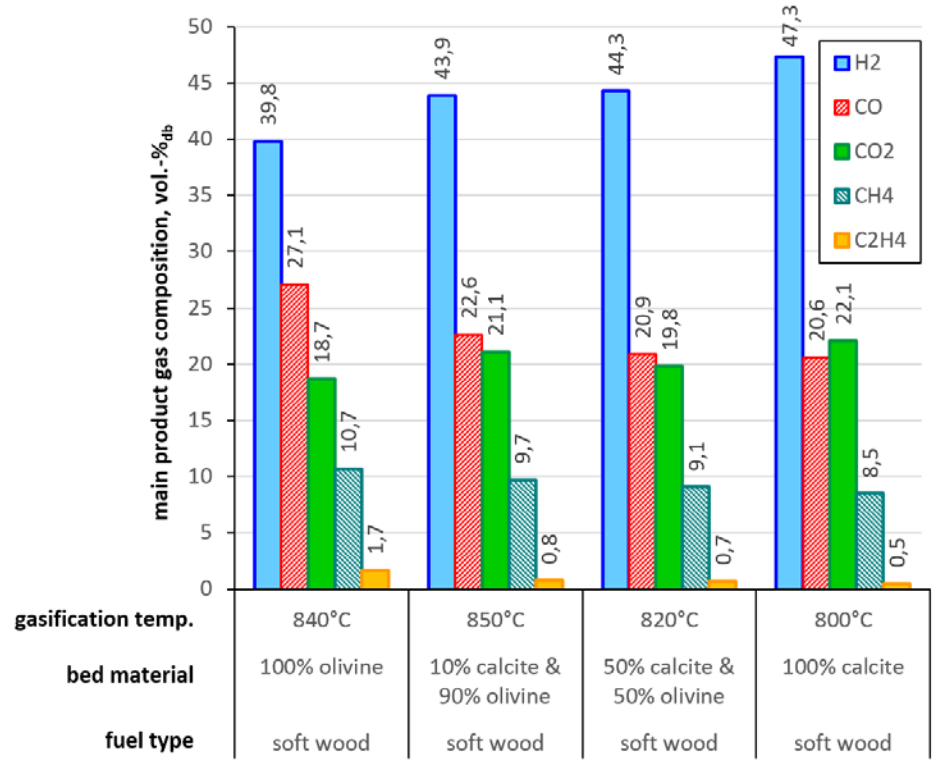
feldspar calcite olivine quarz

Source: Mauerhofer A.M. et al. 2017

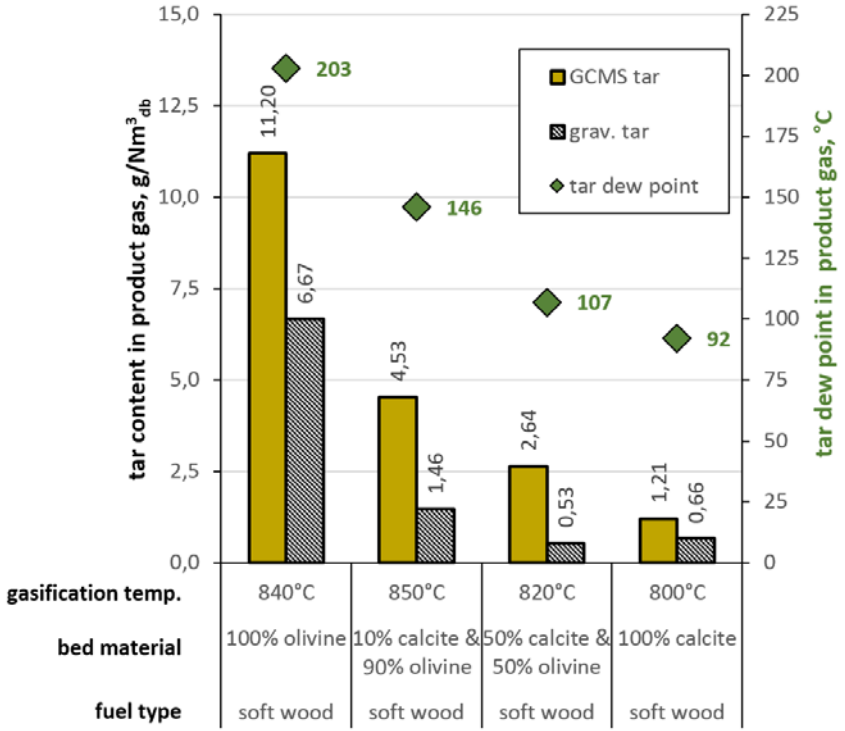
STEAM GASIFICATION

at temperatures >750°C

Influence of different bed material mixtures:



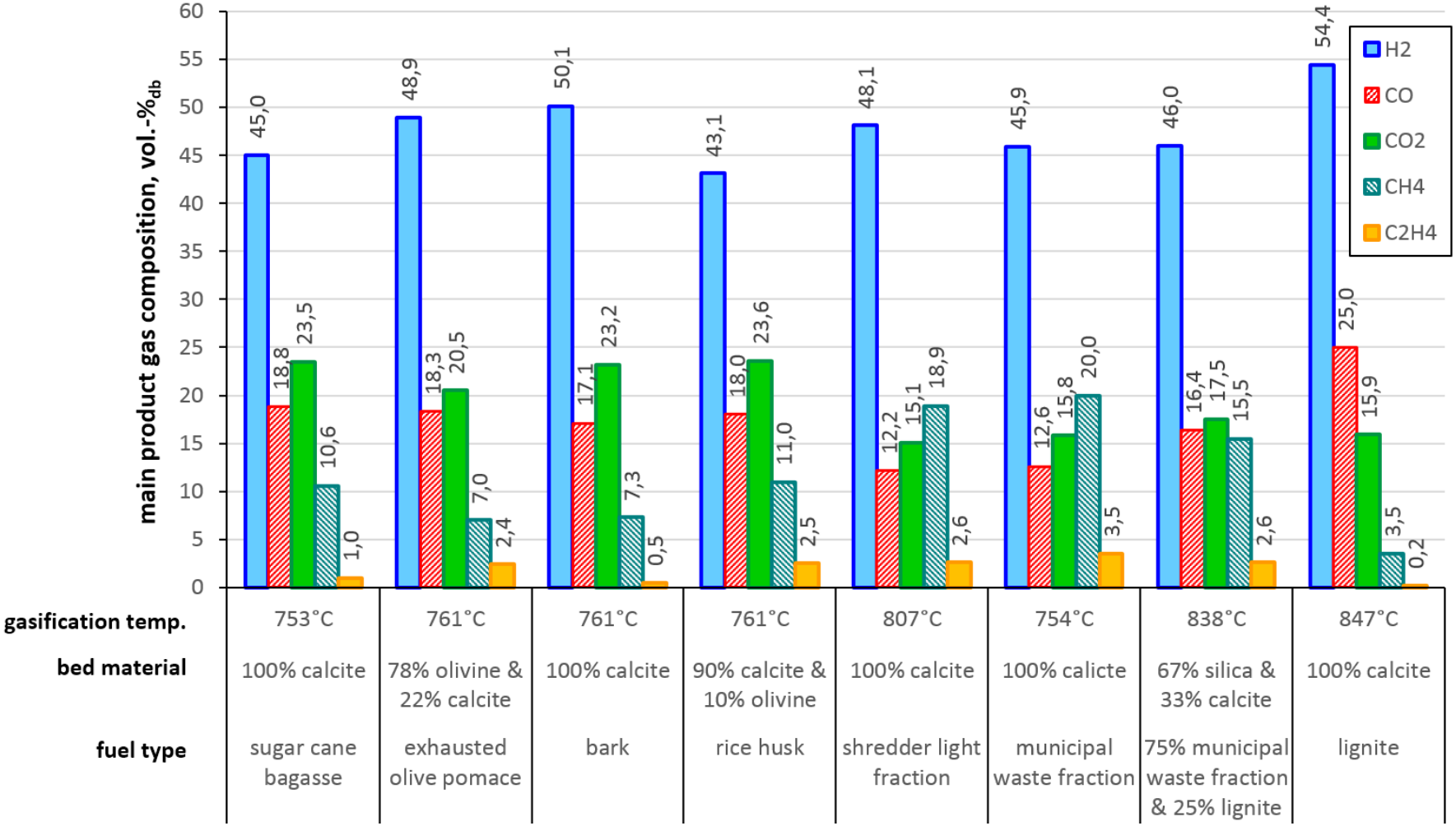
Main product gas components



Tar content and dew point

Source: Benedikt F. et al. 2017

Gasification of different fuels:



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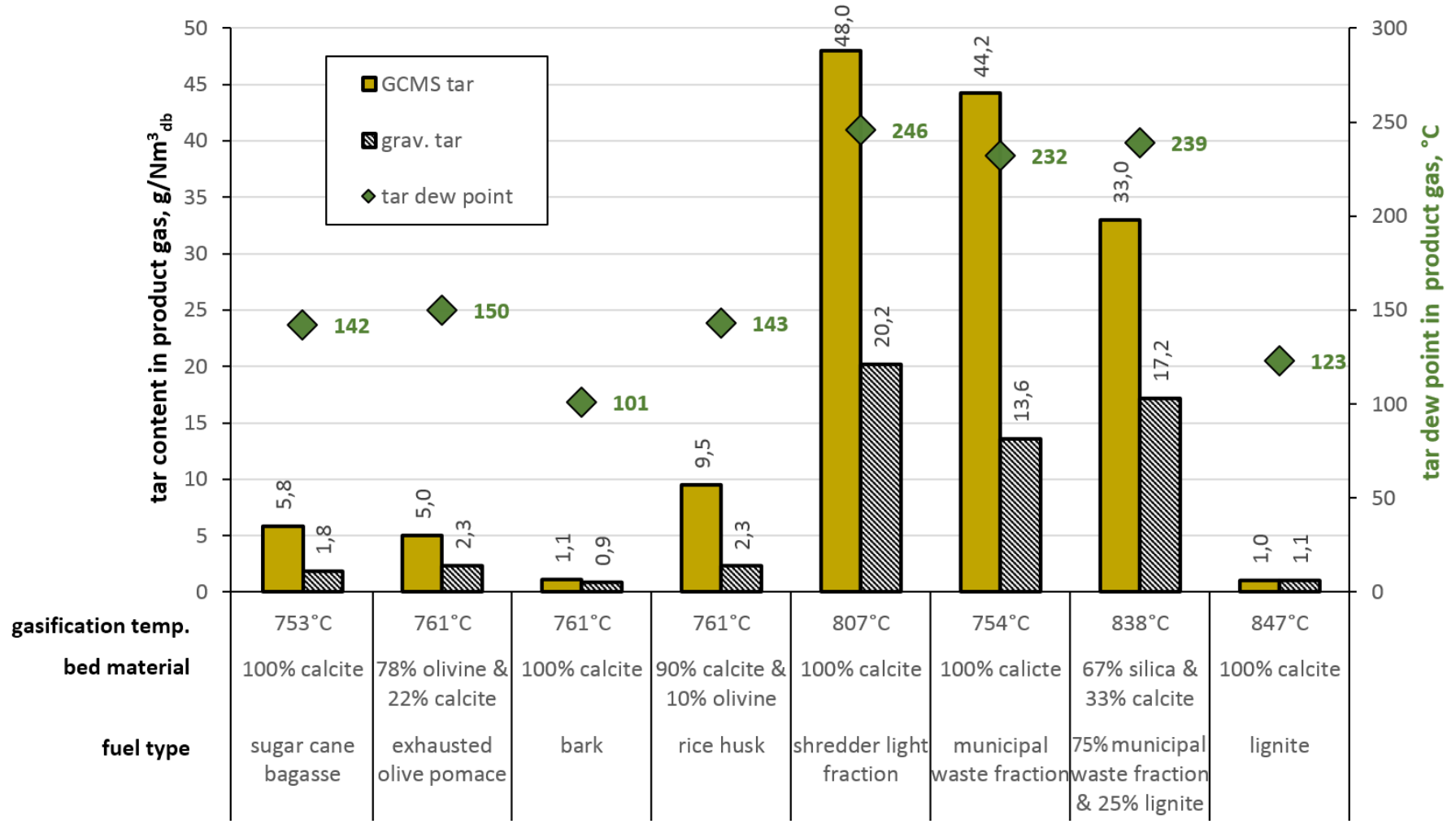


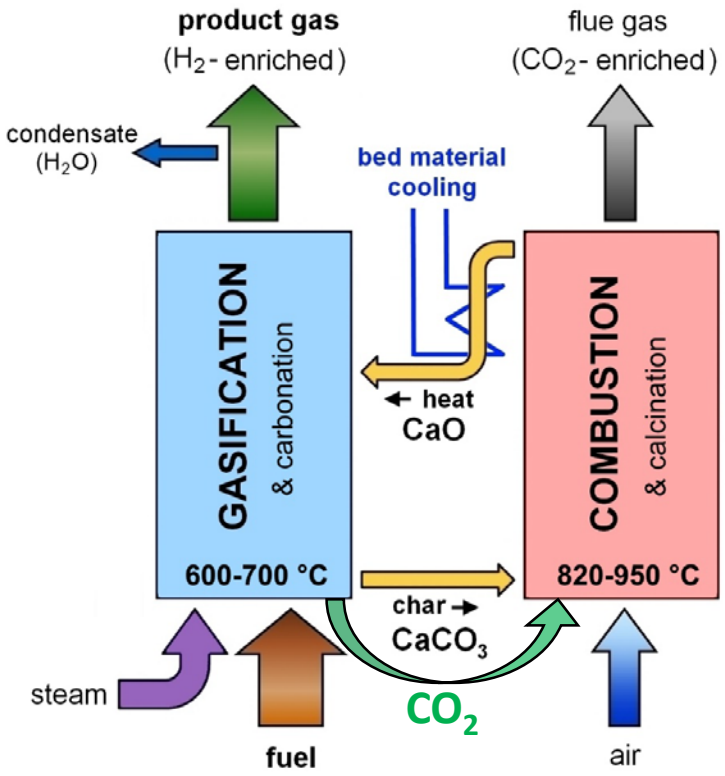
Tar content and dew point

Source: Benedikt F. et al. 2017

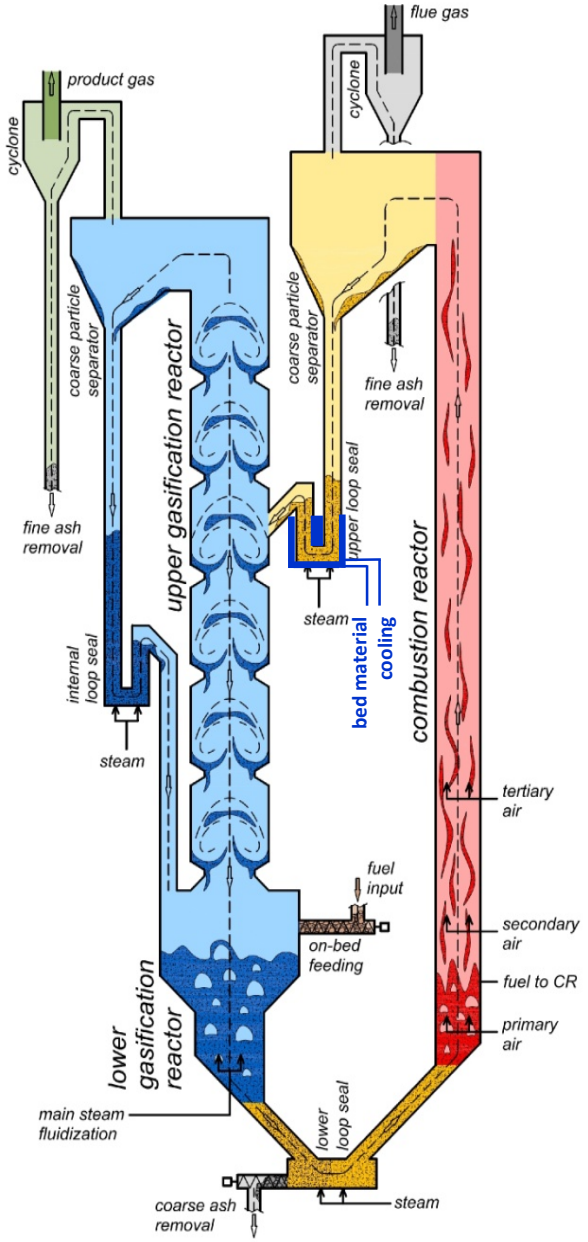
SORPTION ENHANCED REFORMING

at temperatures 620-680°C

„Sorption Enhanced Reforming (SER)“ with Limestone/Calcite as Bed Material



CaO / $CaCO_3$
as bed material:
heat <u>and</u> **CO_2 carrier**



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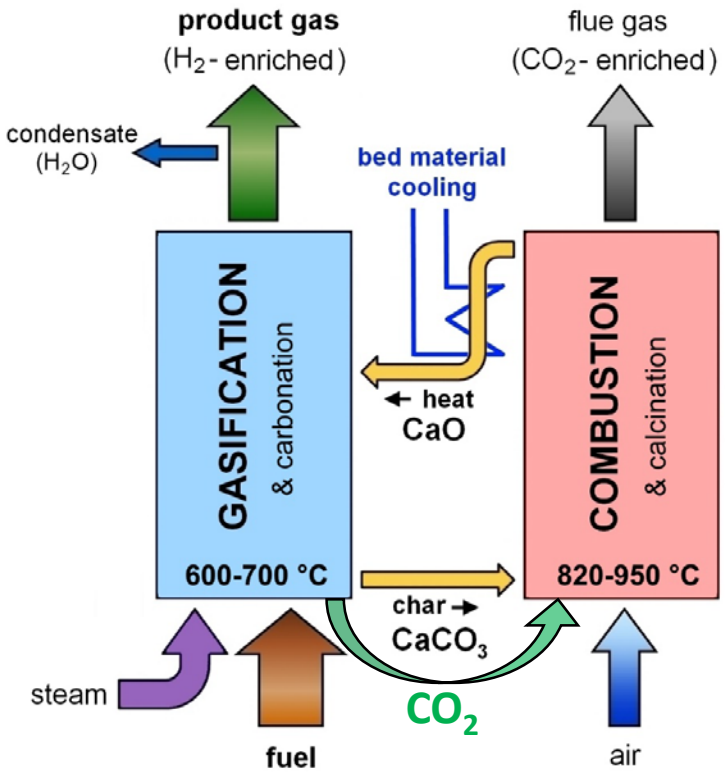

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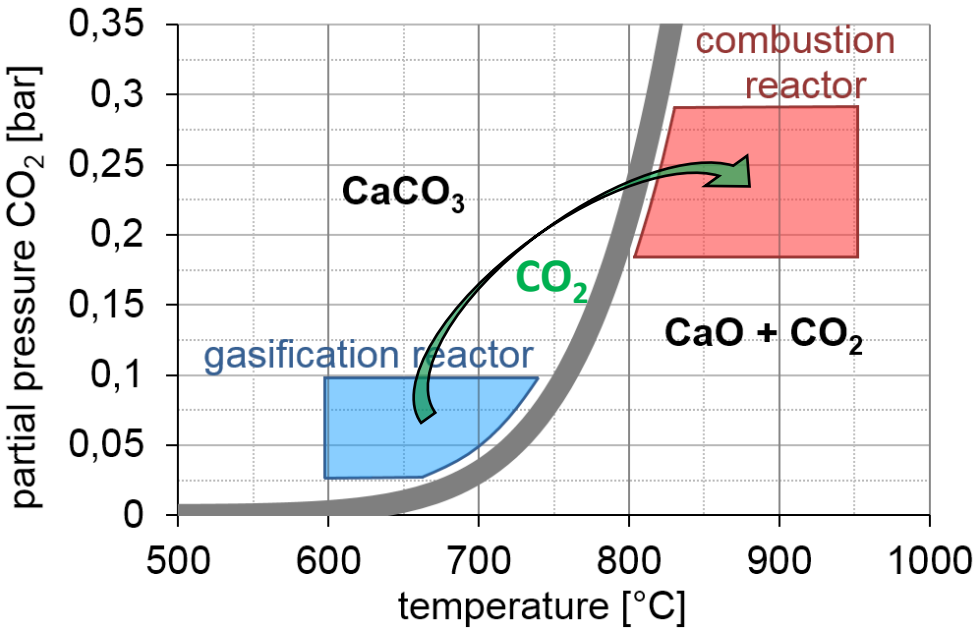
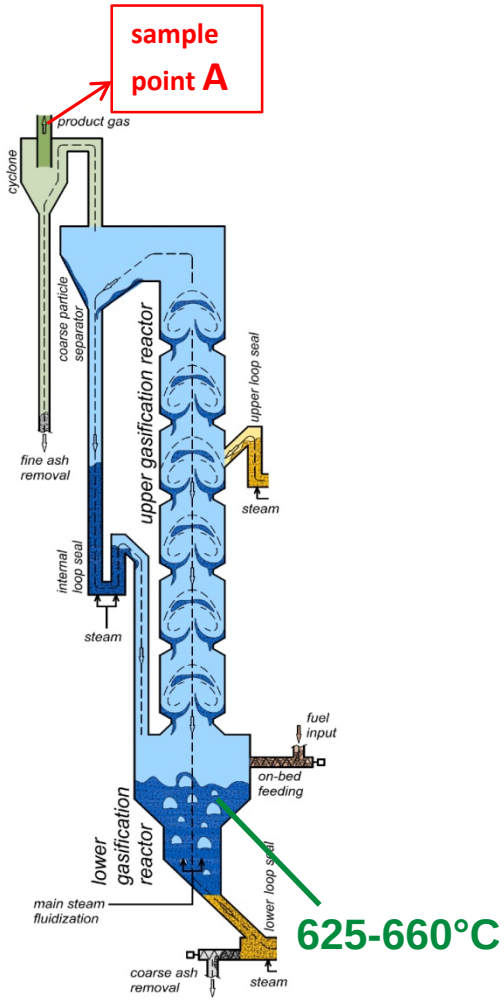


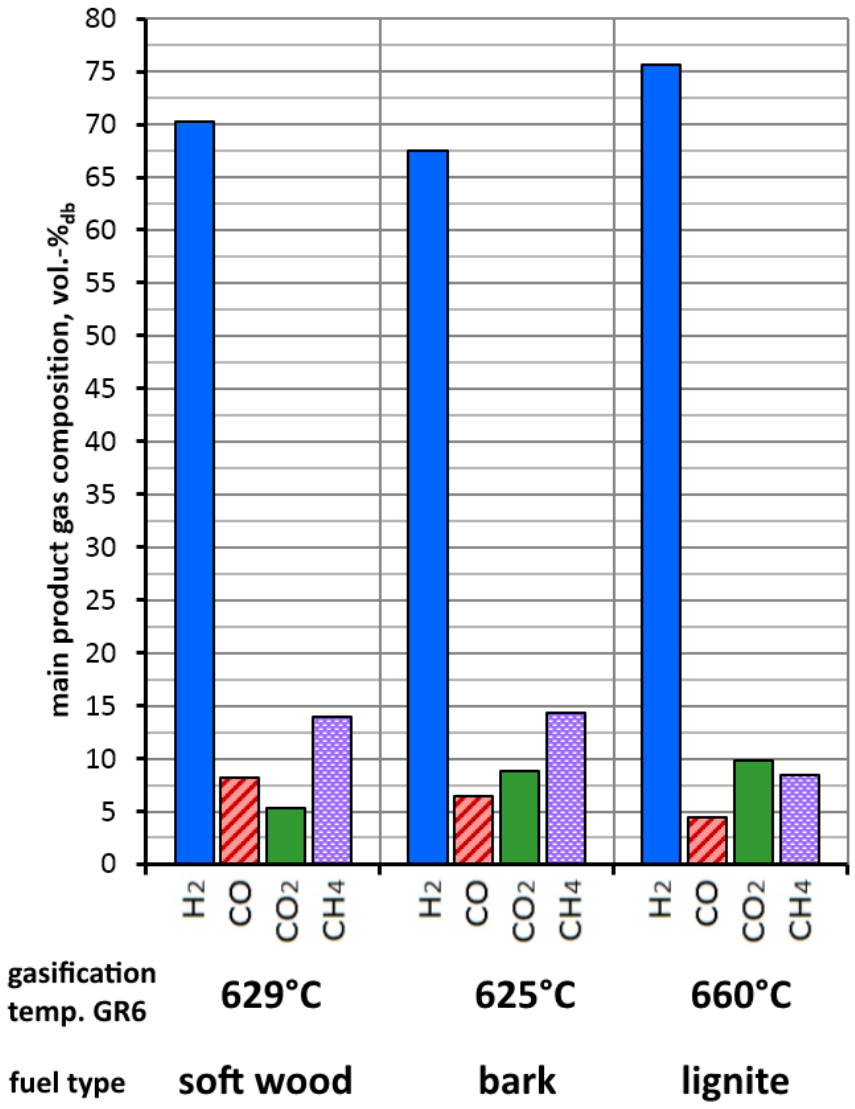
$$CaCO_3 \rightarrow CO_2 + CaO \qquad \Delta H_R^{850} = +167\ kJ/mol$$

$$CaO + CO_2 \rightarrow CaCO_3 \qquad \Delta H_R^{650} = -170\ kJ/mol$$

$$CO + H_2O \leftrightarrow CO_2 + H_2 \qquad \Delta H_R^{650} = -36\ kJ/mol$$

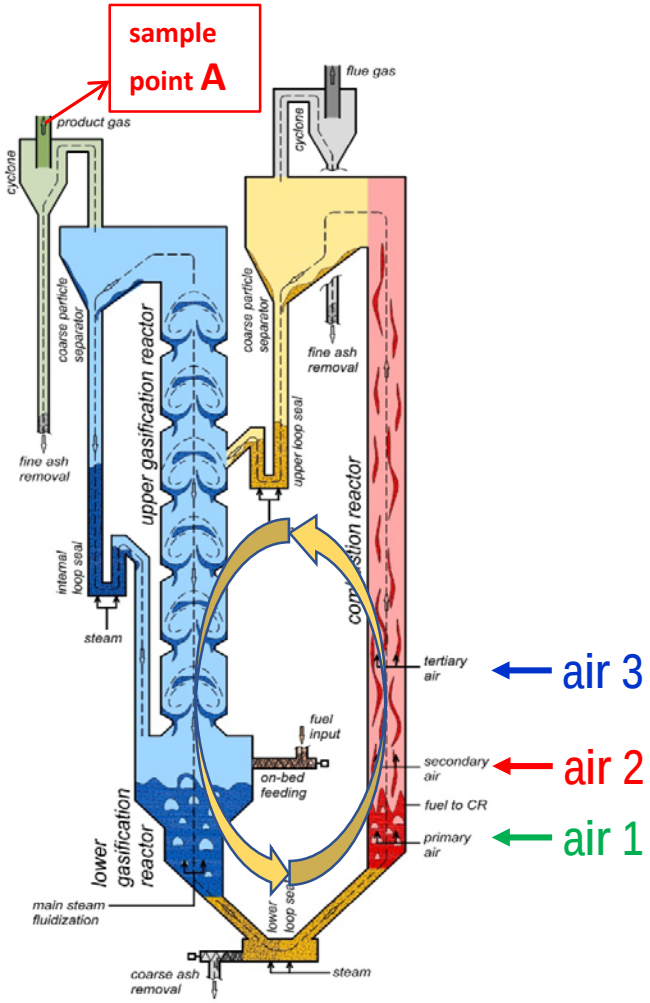
SER: Variation of Fuel Type

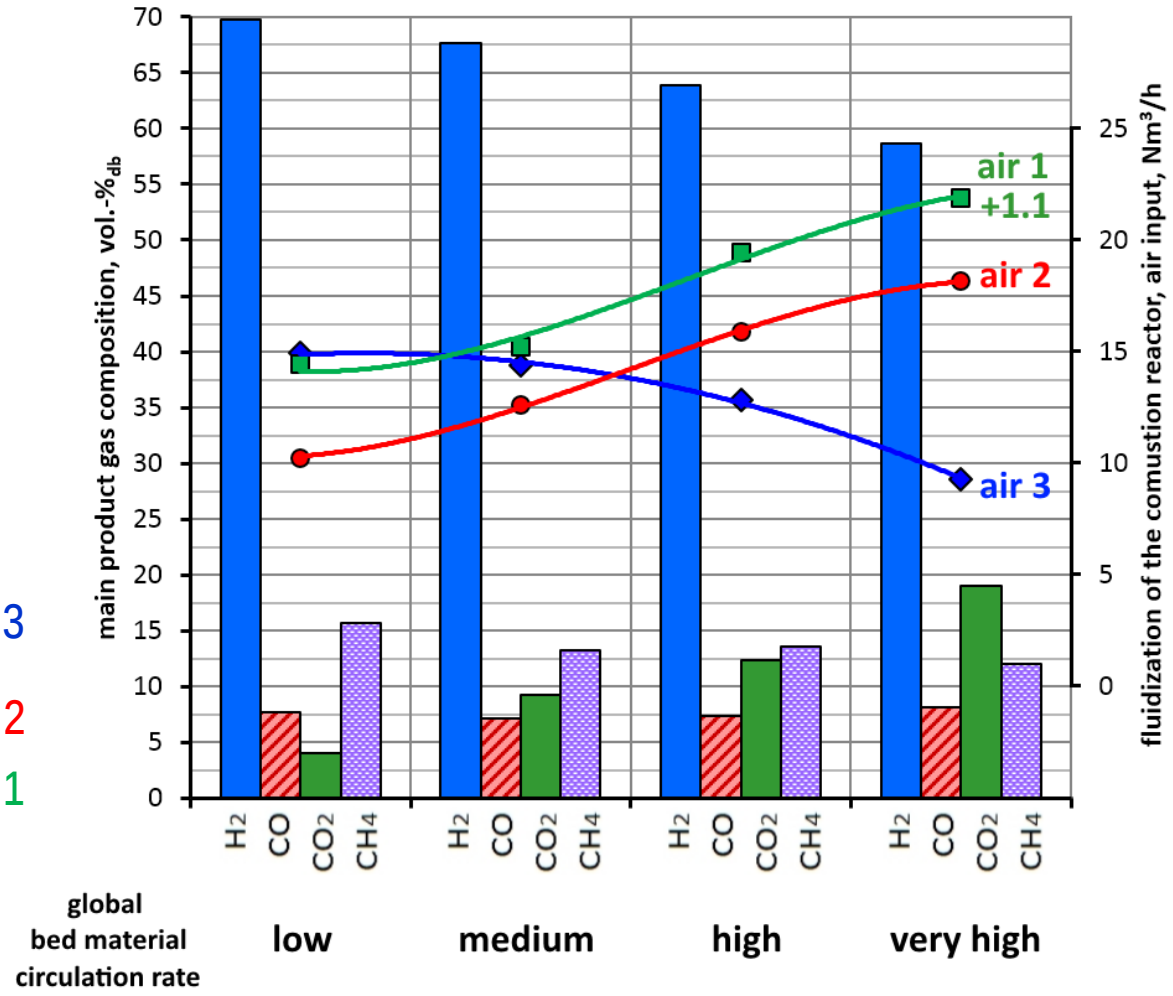




Source: Fuchs J. et al. 2017

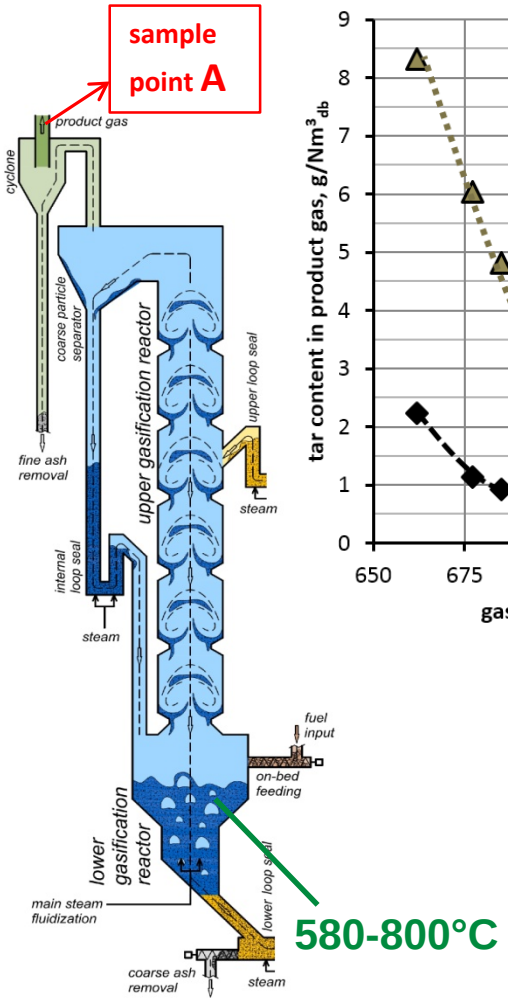
SER: Variation of Bed Material Circulation

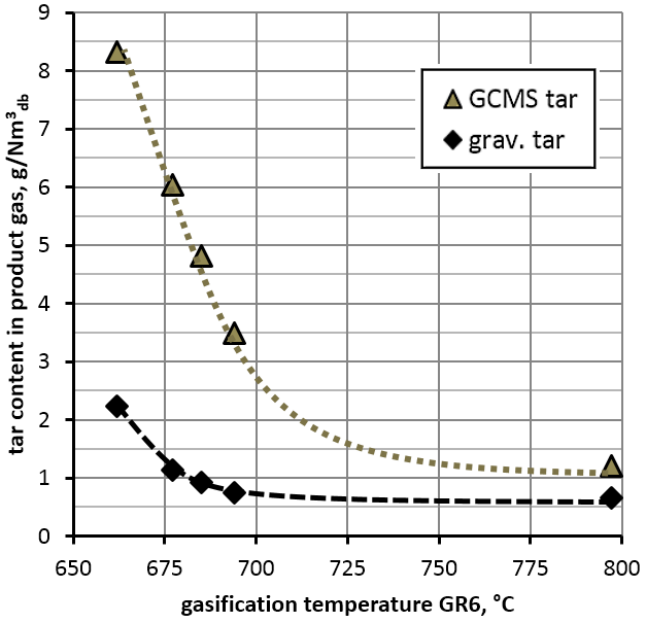


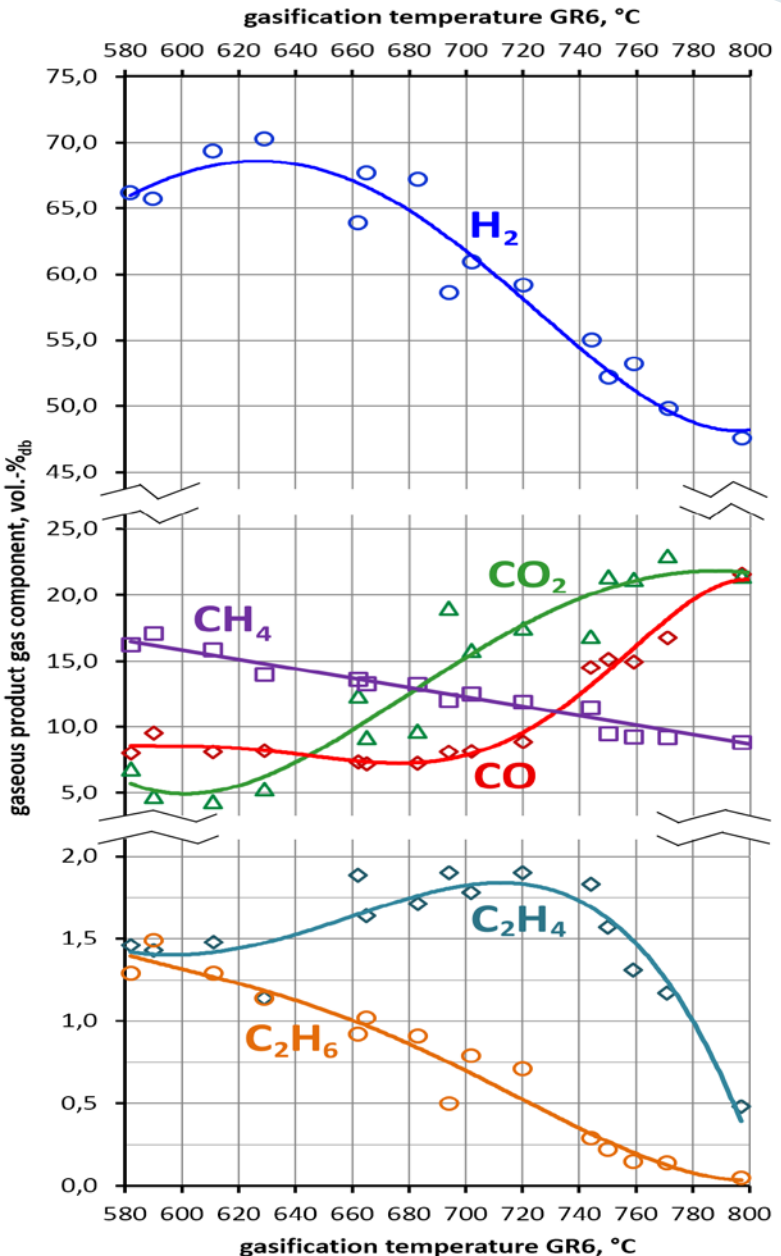


Source: Schmid J.C. et al. 2017

SER: Variation of temperat

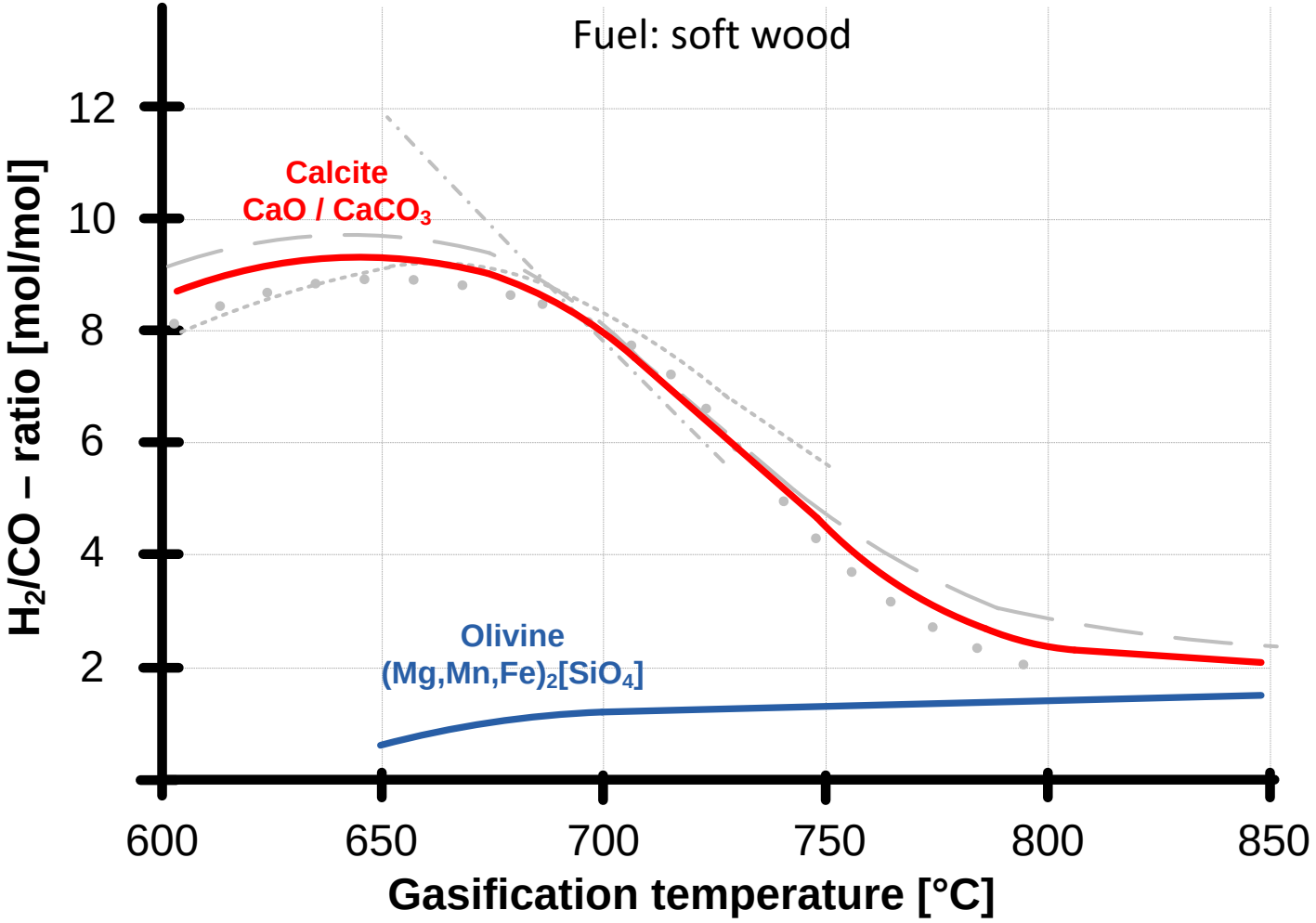






Source: Schmid J.C. et al. 2017

Variation of the gasification temperature

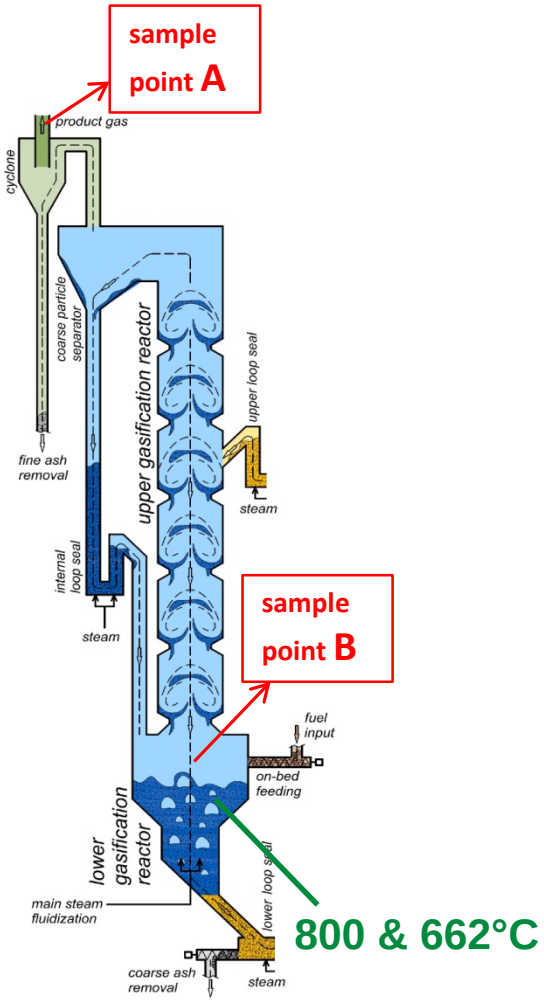


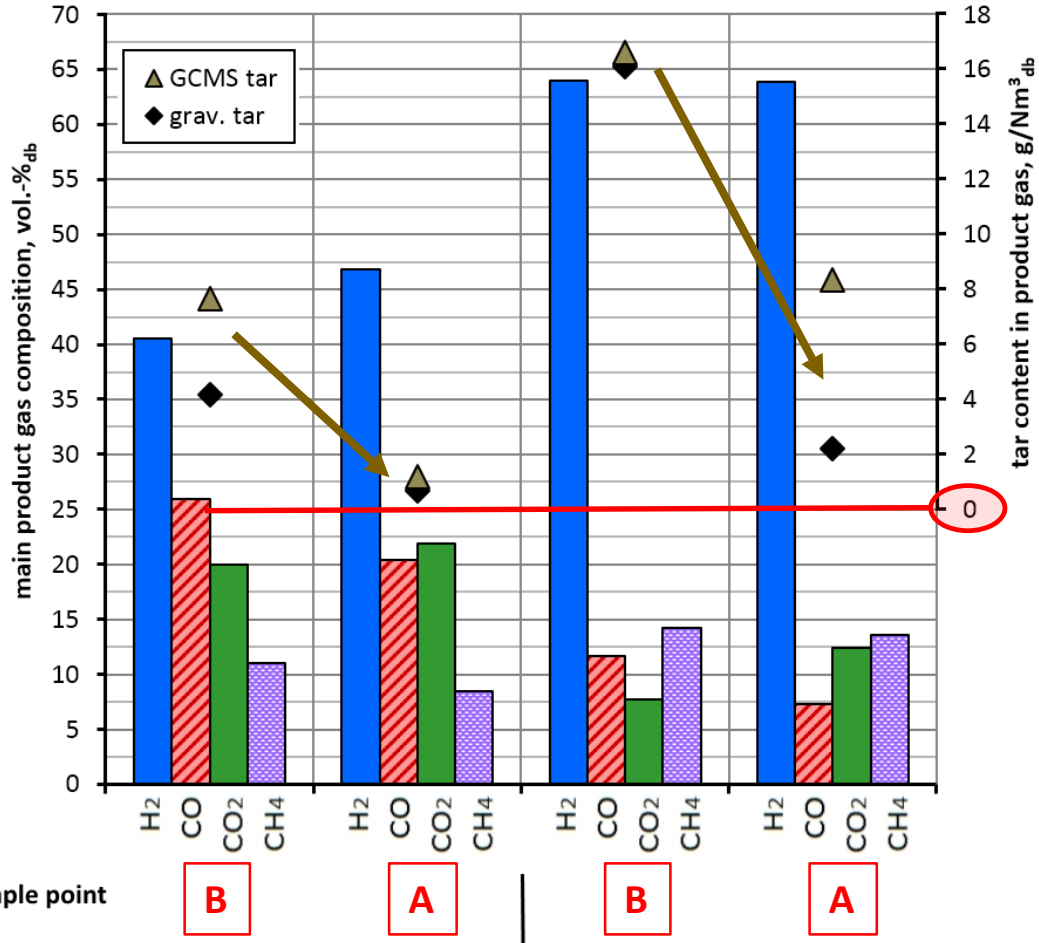
Source: Müller S. et al. 2017

H2/CO ratio for gasification with calcite, Average of different facilities

H2/CO ratio for gasification with olivine, Advanced 100 kWth DFB gasifier, TU Wien

Impact of Upper Gasification Reactor





Conclusion:

- Novel design: fuel and bed material flexible
- Low-cost fuels can be gasified
- Alternative, residual fuels increase requirements on the gas cleaning system significantly
- Hydrogen rich gas can be produced (SER)
- H_2/CO adjustment with the gasification process
- Novel separation system for soft bed materials

Outlook:

Research questions for the future:

- Impurities or valuable substances of different fuel types
- Where are the substances (product gas, fine ash, coarse ash, fly ash,...)
- Suitable gas cleaning processes

Thank you for your attention

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