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# Overview on research activities at TU Wien for the production of sustainable fuel-based energy carriers

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TU Wien: Institute of Chemical, Environmental and Bioscience Engineering

IEA Bioenergy Task 33 workshop „Valuable (by-)products of gasification”

Vienna, 19.10.2022

„Future-proof and sustainable technical solutions for people within an intact habitat“

Shaping a sustainable fuel-based energy system of the future by means of

- **Testing and analysis**
- **Modeling**
- **Experimental** investigation and **validation**
- **Scale-up** through advanced **digital methods**

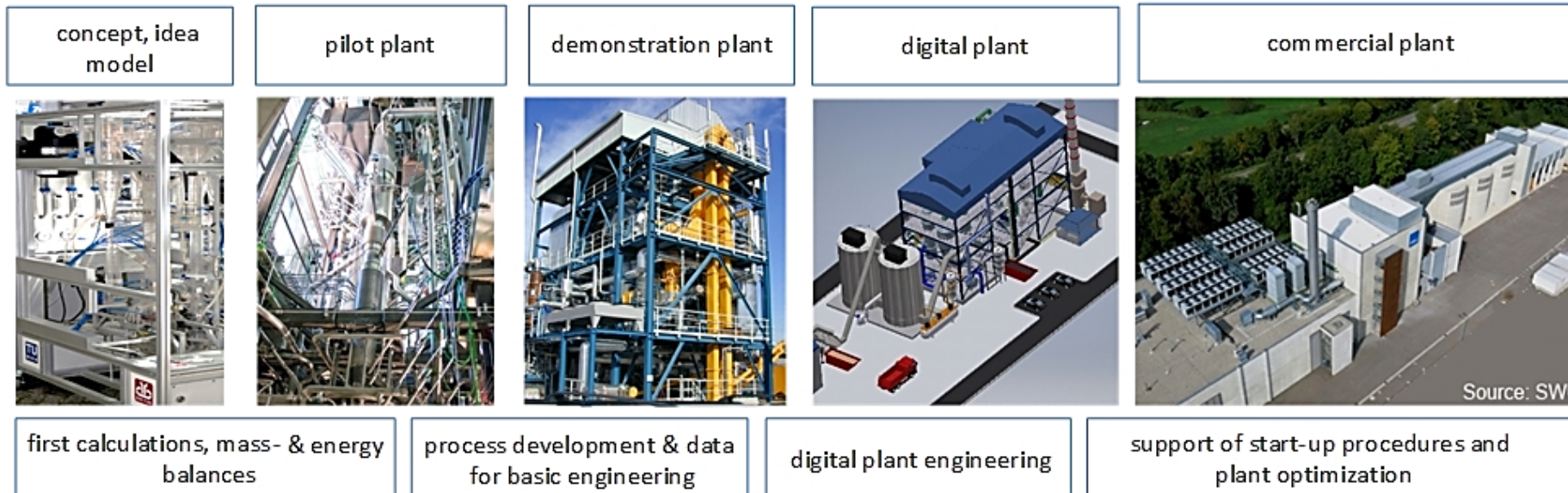
Accredited and Notified Testing  
Laboratory for Combustion Systems



Industrial Plant Engineering and  
Application of Digital Methods

Accompanying methodology in the research group  
Industrial Plant Engineering and Application of Digital Methods

## TECHNOLOGY DEVELOPMENT PHASE



## SUPPORTED BY MODELLING OF



*Conversion of biogenic, municipal and industrial raw and residual materials*



*wood chips*



*residues from agriculture*



*Industrial waste*



*urban residues*



*sewage sludge, digestate*



*CO<sub>2</sub> from industrial processes*



*H<sub>2</sub>O*



*heat*



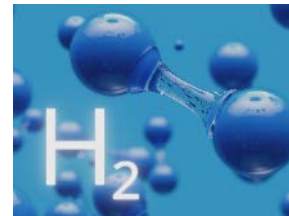
*electricity*



*biofuels*



*synthetic natural gas*



*hydrogen*



*platform chemicals*



*plant nutrients*

*into high-purity energy sources and valuable products*

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- Flexibility of the DFB gasification process



- Production of SNG

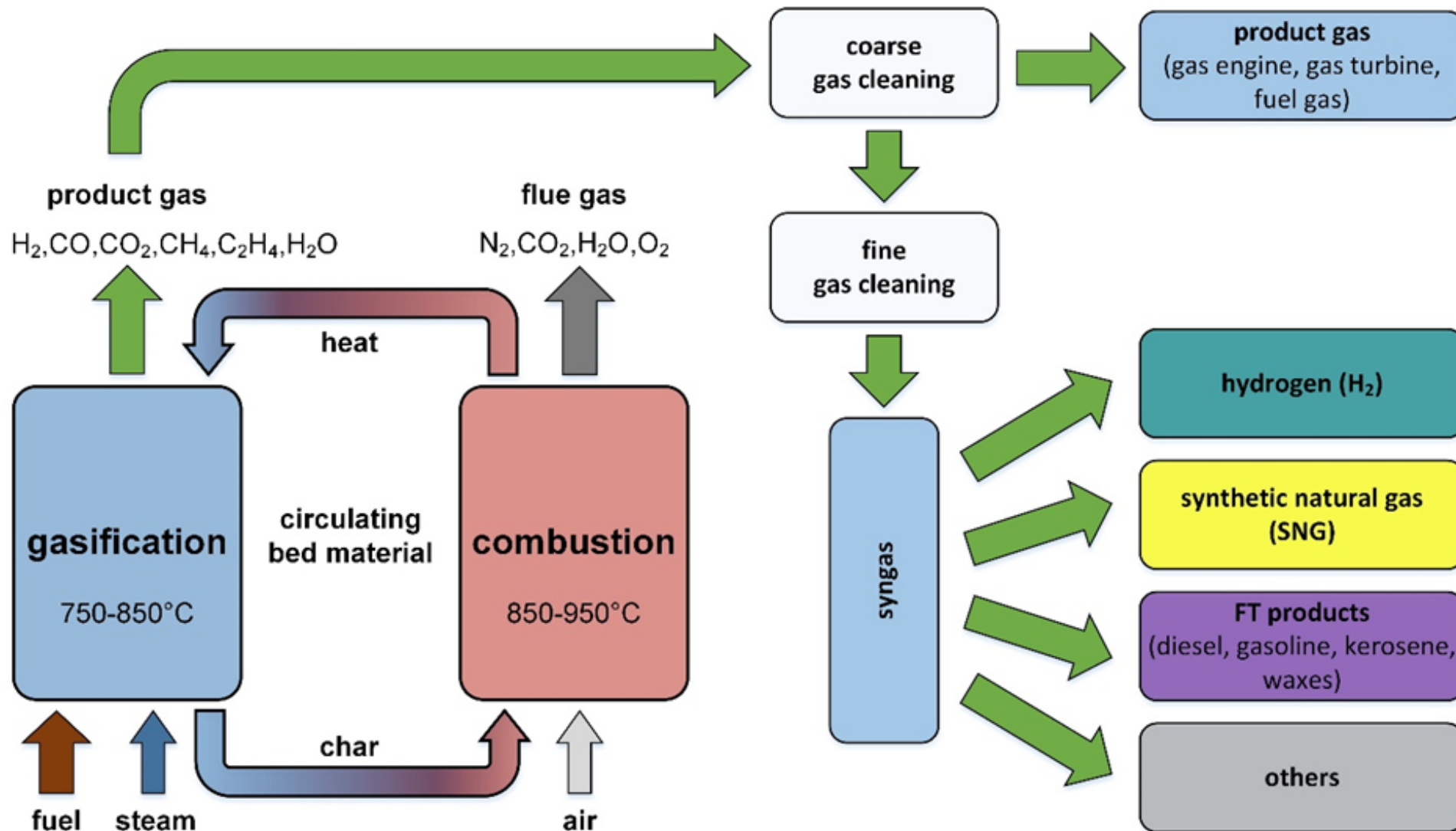


- Production of hydrogen



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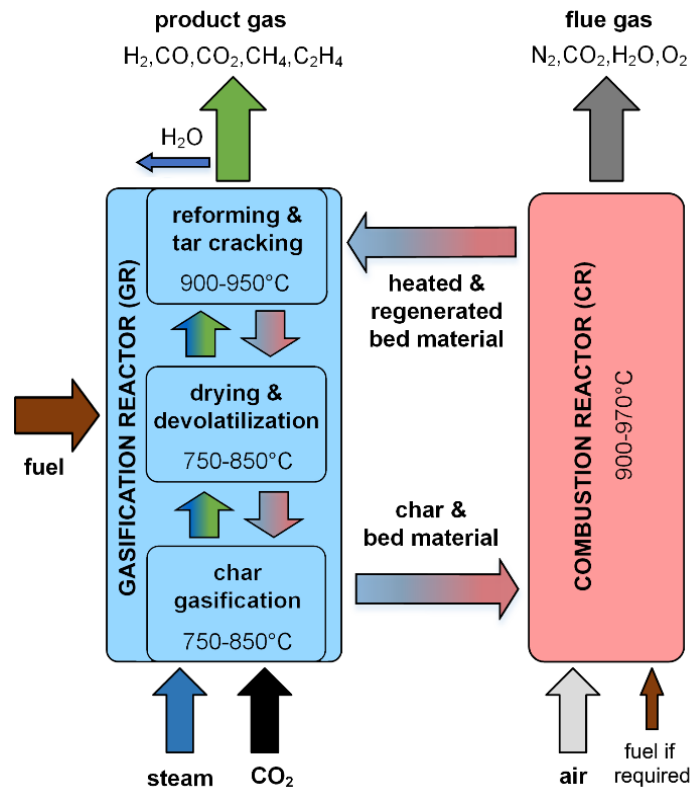
# Dual Fluidized Bed (DFB) Steam Gasification



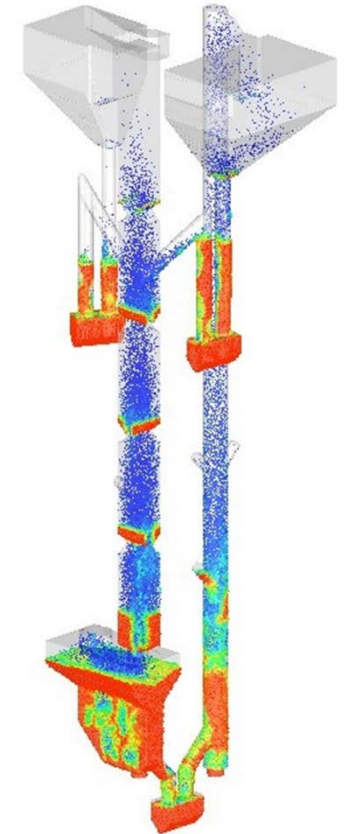
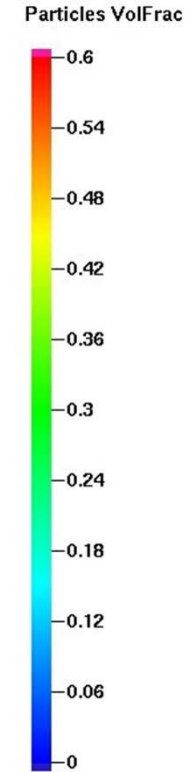
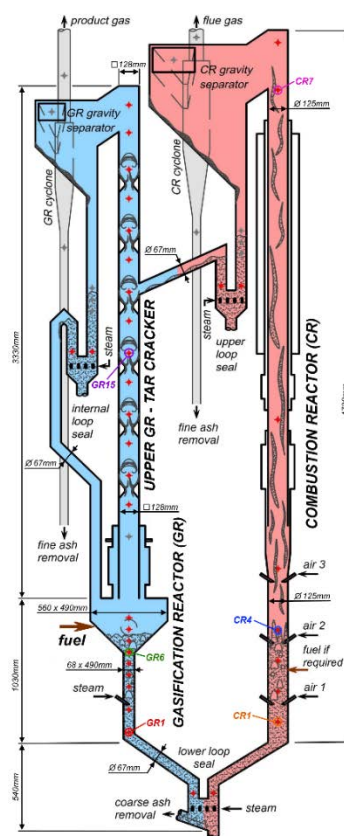
# Dual Fluidized Bed (DFB) Steam Gasification

## Advanced DFB steam/CO<sub>2</sub> gasification 100 kW pilot plant

### Basic principle



### Sketch & 3D model



J. C. Schmid, F. Benedikt, J. Fuchs, A. Mauerhofer, S. Müller, H. Hofbauer, 2021

„Syngas for biorefineries from thermochemical gasification of lignocellulosic fuels and residues—5 years’ experience with an advanced dual fluidized bed gasifier design“.

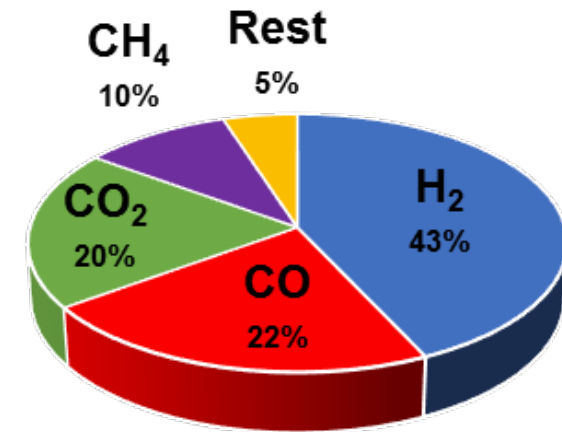
Biomass Conv. Bioref. 11, 2405–2442 (2021)

# Dual Fluidized Bed (DFB) Steam Gasification



≅ 20 kg/h softwood pellets  
daily operation for fuel testing

main product gas  
components



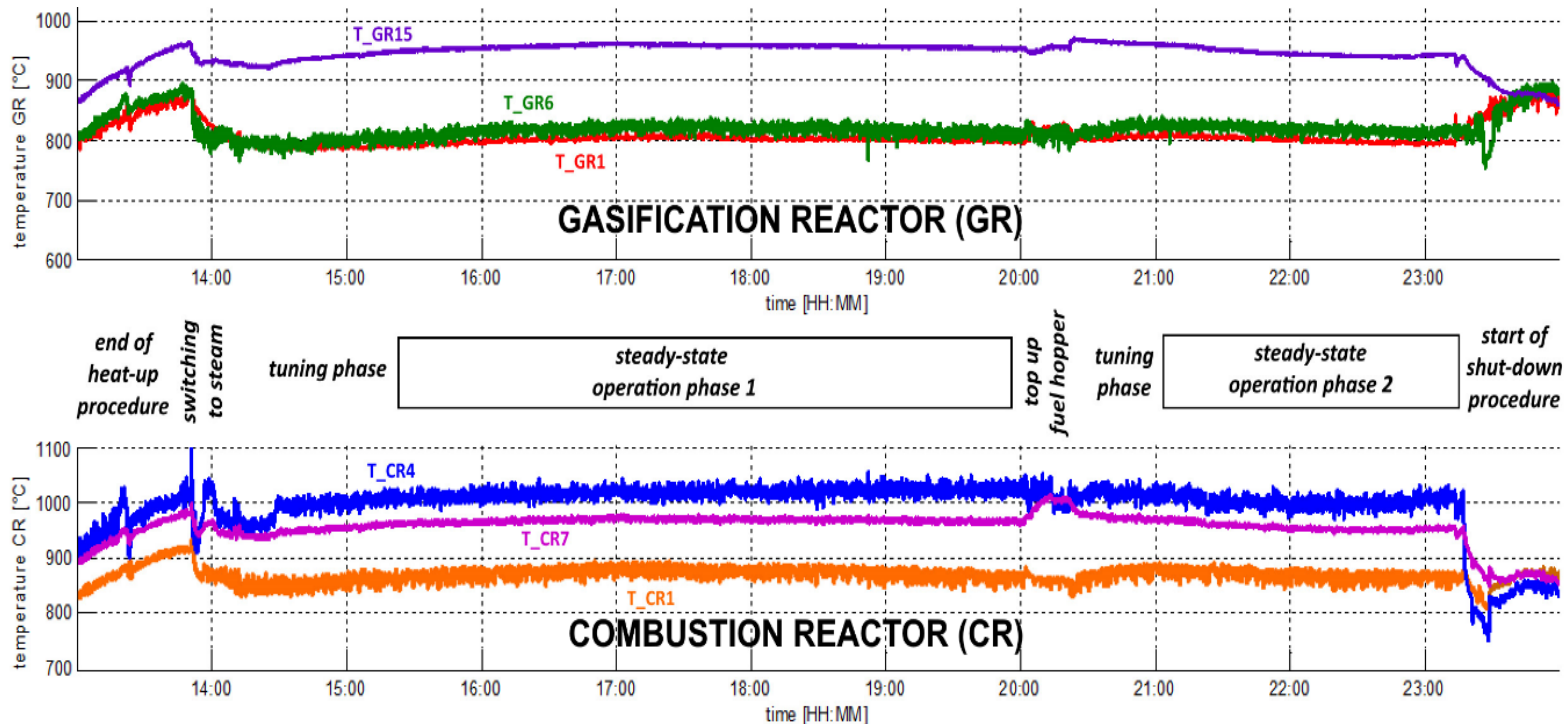
J. C. Schmid, F. Benedikt, J. Fuchs, A. Mauerhofer, S. Müller, H. Hofbauer, 2021

„Syngas for biorefineries from thermochemical gasification of lignocellulosic fuels and residues—5 years’ experience with an advanced dual fluidized bed gasifier design“.  
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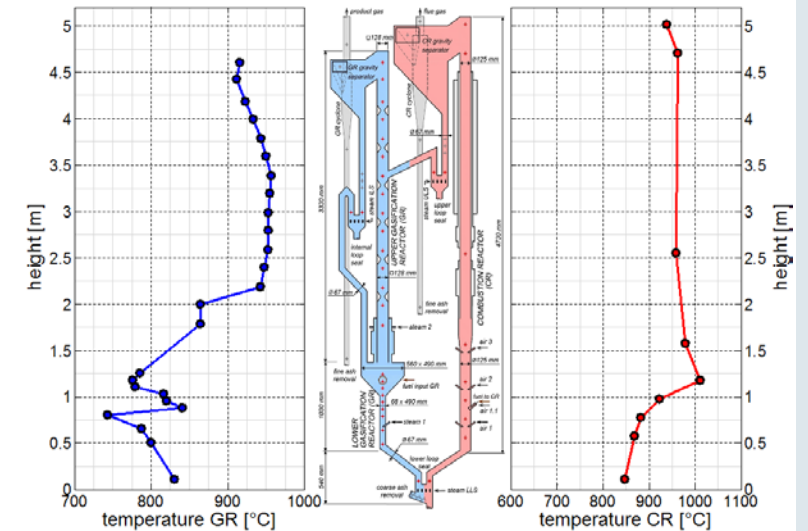
## Typical steady-state operation

### Temporal course of temperatures



### Temperature profiles of

### GR & CR



J. C. Schmid, F. Benedikt, J. Fuchs, A. Mauerhofer, S. Müller, H. Hofbauer, 2021

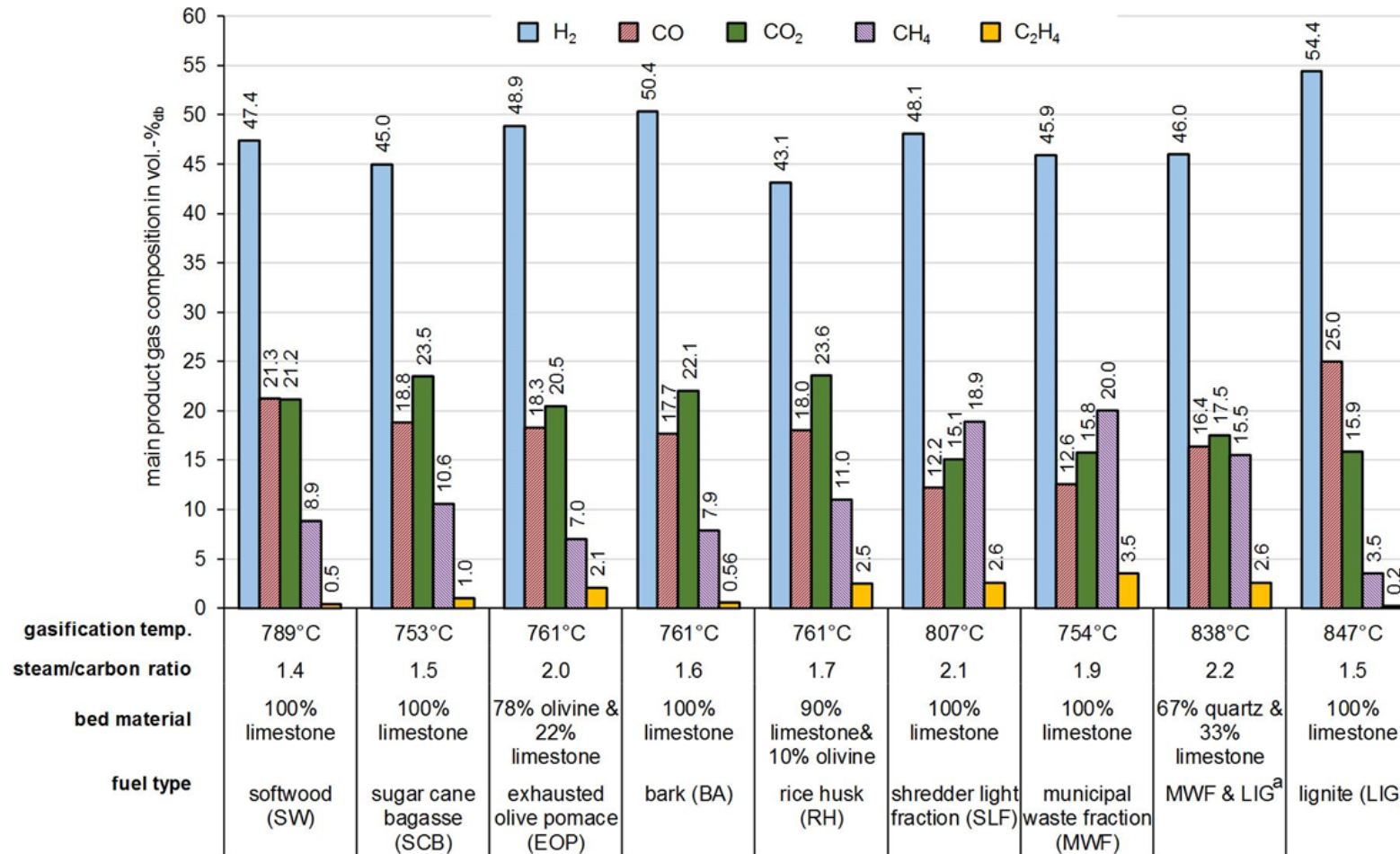
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Biomass Conv. Bioref. 11, 2405–2442 (2021)

## Gasification of different fuels at TU Wien

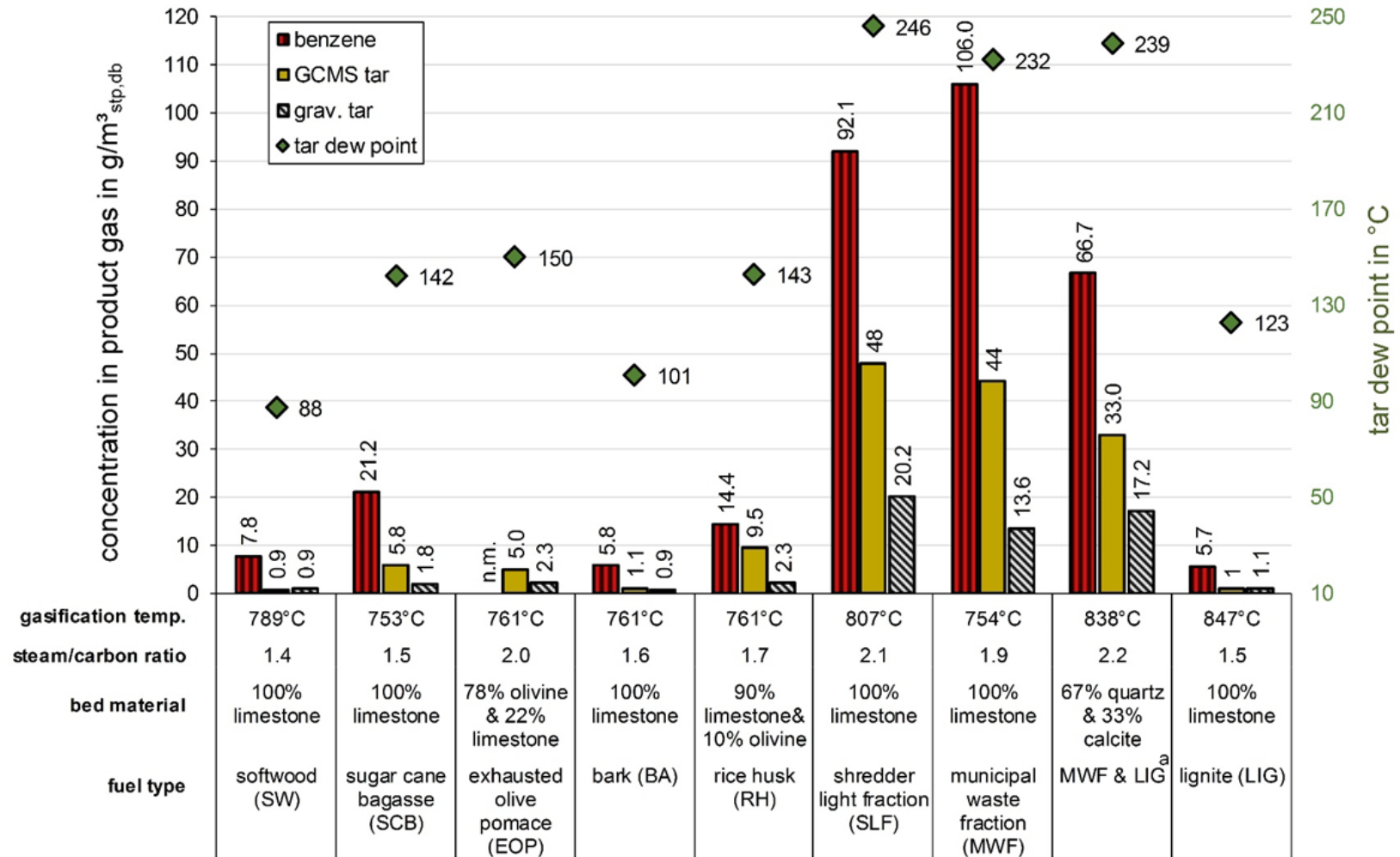


Benedikt, F., Schmid, J.C., Fuchs, J., Mauerhofer, A., Müller, S., Hofbauer, H., 2018, "Fuel Flexible Gasification with an Advanced 100 kW Dual Fluidized Bed Steam Gasification Pilot Plant", Energy, Vol.164, pp. 329-343



a: 75% municipal waste fraction and 25% lignite based on lower heating value

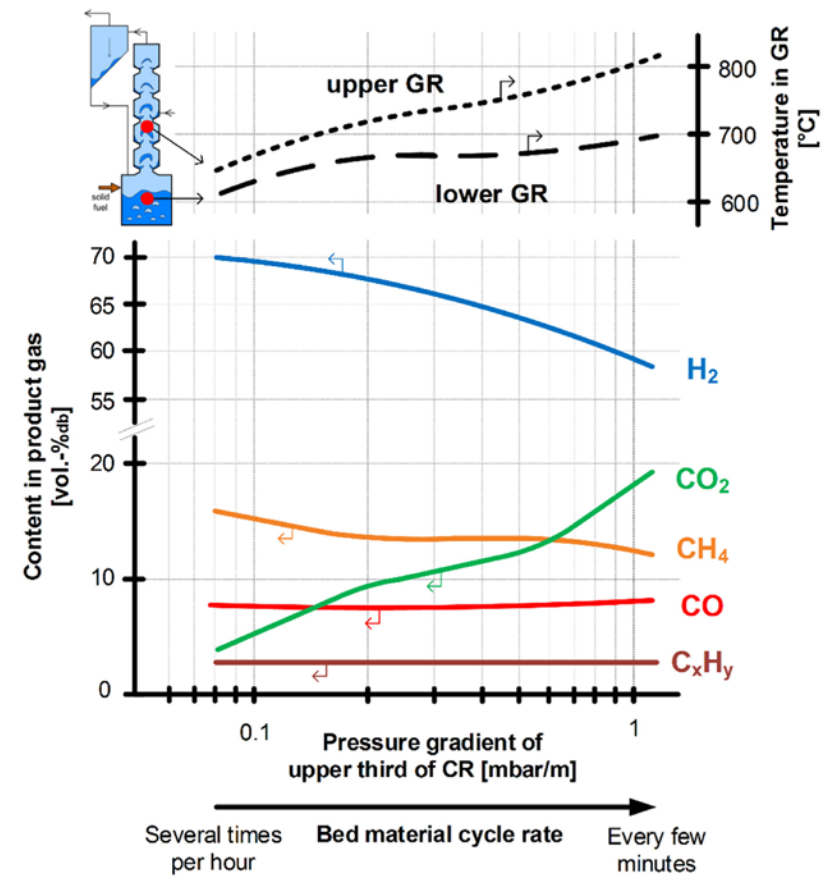
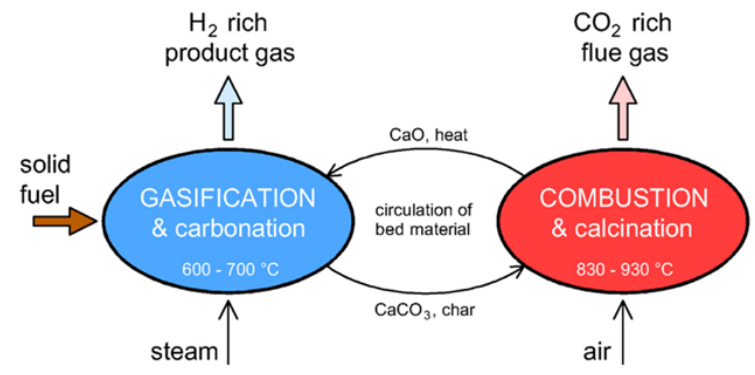
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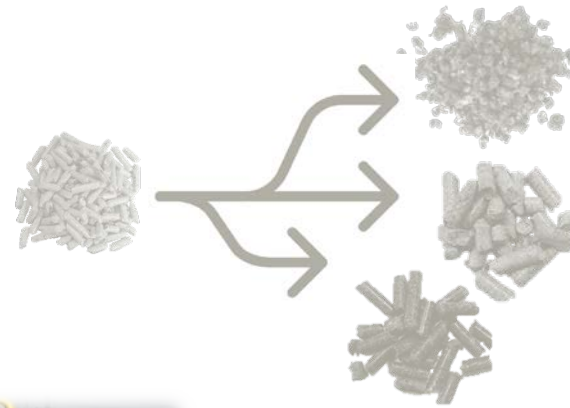
## Adjustment of H<sub>2</sub>/CO ratio for synthesis application



J. Fuchs, J. C. Schmid, S. Müller, H. Hofbauer, 2019

„Dual fluidized bed gasification of biomass with selective carbon dioxide removal and limestone as bed material: A review“  
 Renewable and Sustainable Energy Reviews, Volume 107,, Pages 212-231

- Flexibility of the DFB gasification process



- Production of SNG

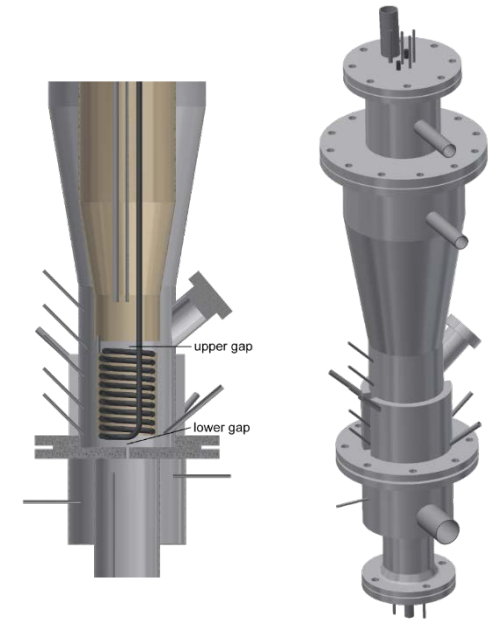
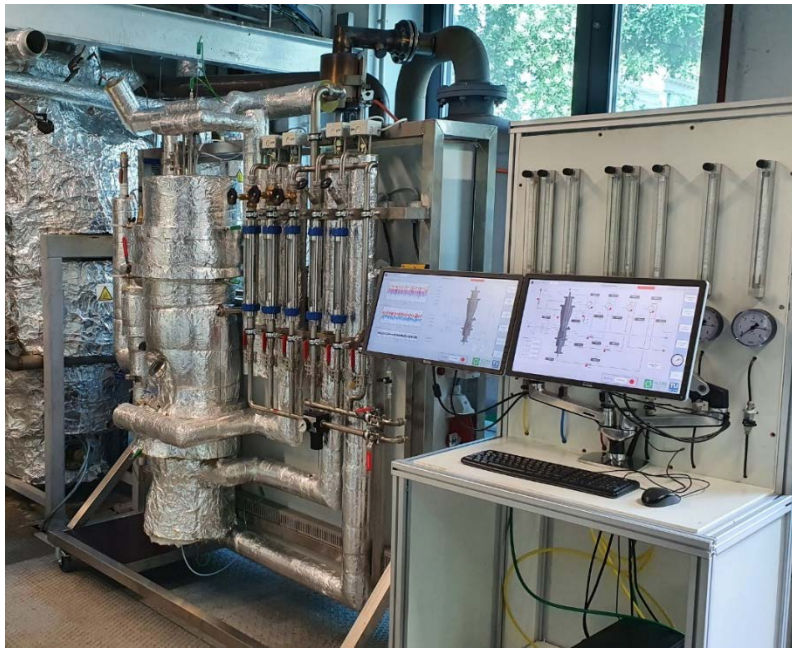
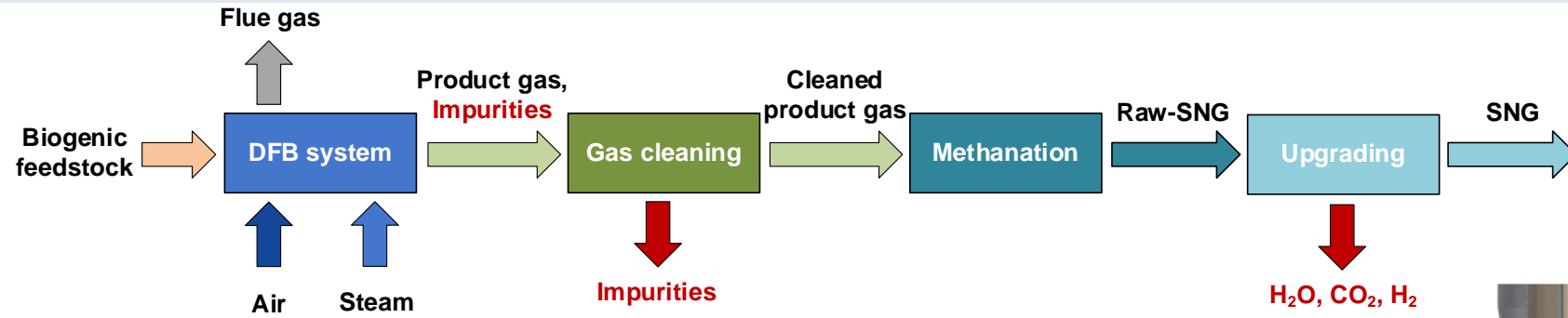


- Production of hydrogen



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# Fuel-based sustainable SNG production



➤ Full process chain for SNG production via fluidized bed methanation

A. Bartik, F. Benedikt, S. Müller, M. Gattringer, J. C. Schmid, H. Hofbauer, 2021

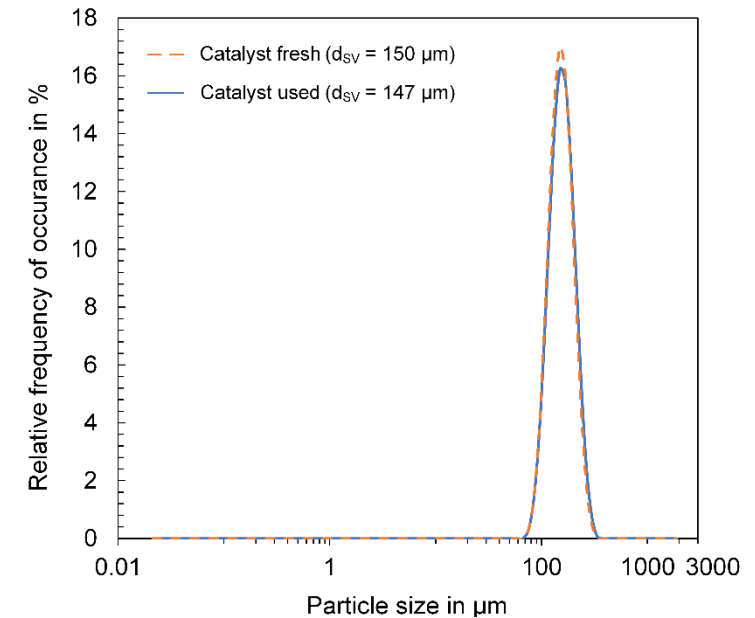
„Gase aus regenerativen Reststoffquellen für die Industrie“ Energieforschungsprogramm Klima- und Energiefonds, Projektkurztitel: ReGas4Industry, publizierbarer Endbericht

# Catalyst for fluidized bed methanation

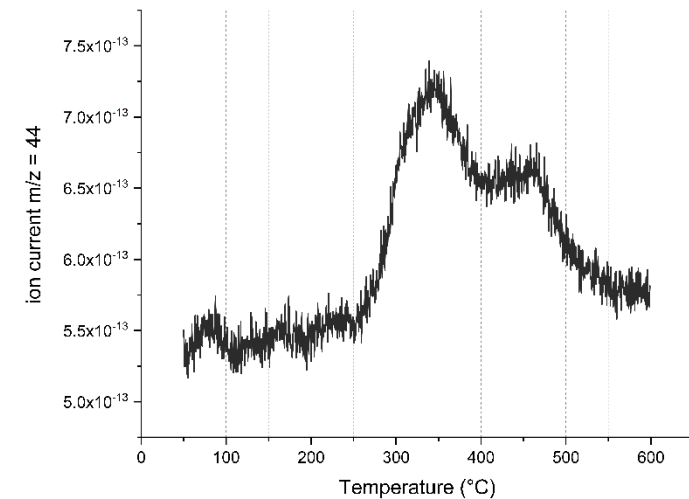
## Catalyst

- 20 wt.-% NiO/Al<sub>2</sub>O<sub>3</sub> with 2 wt.-% MgO through impregnation

Parameter	Unit	Value
$d_{SV}$	$\mu\text{m}$	150
$\rho_b$	$\text{kg}/\text{m}^3$	900
Amount	$g_{\text{cat}}$	1600
BET	$\text{m}^2/\text{g}$	142
Ni particle size	nm	37
Ni surface area	$\text{m}^2/\text{g}$	2.7



Mechanical stability after ~200h

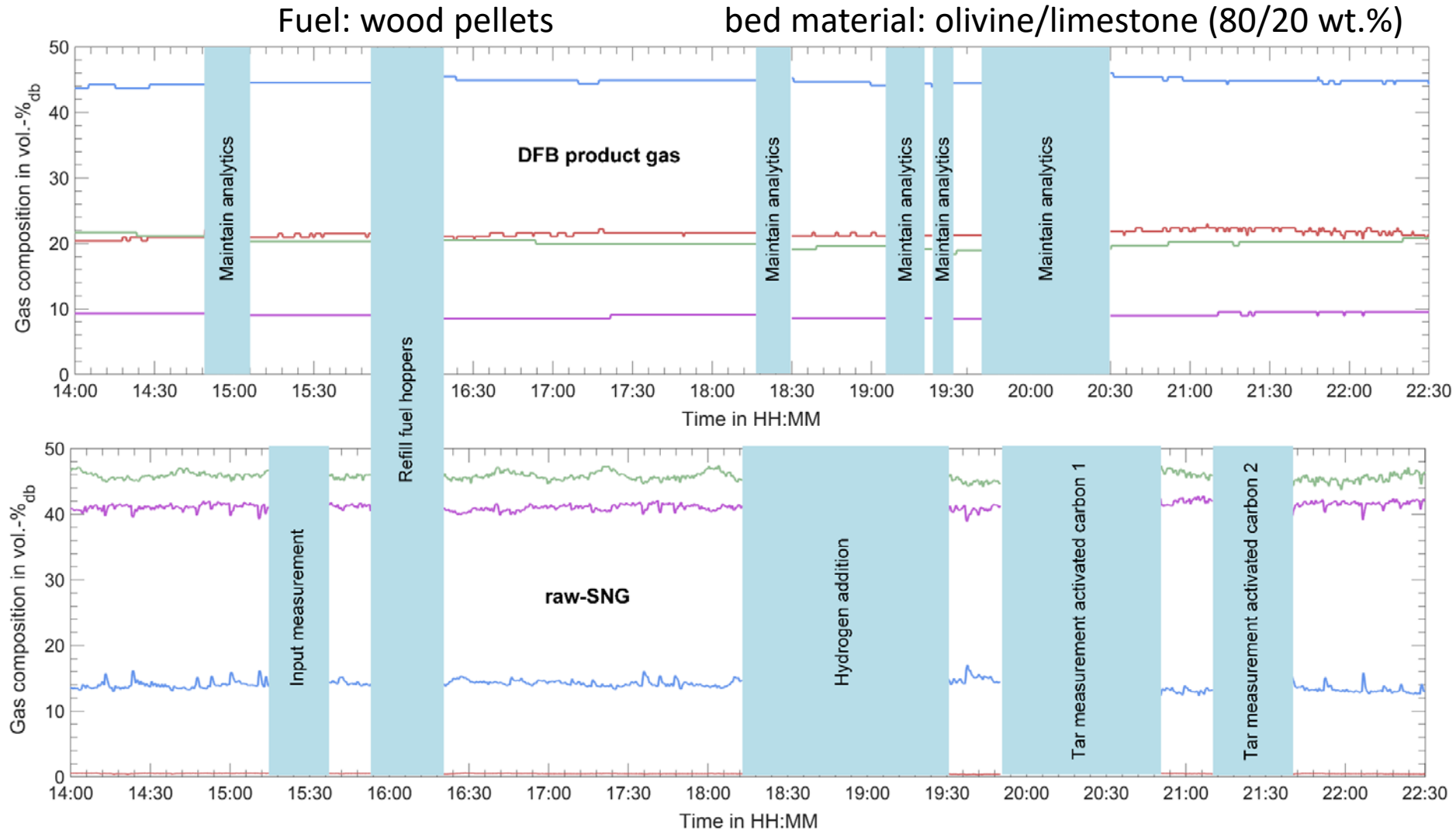


Chemical stability after ~100h

A. Bartik, J. Fuchs, G. Pacholik, K. Föttinger, H. Hofbauer, S. Müller, F. Benedikt, 2022  
 „Experimental investigation on the methanation of hydrogen-rich syngas in a bubbling fluidized bed reactor utilizing an optimized catalyst“,  
 Fuel Processing Technology, Volume 237



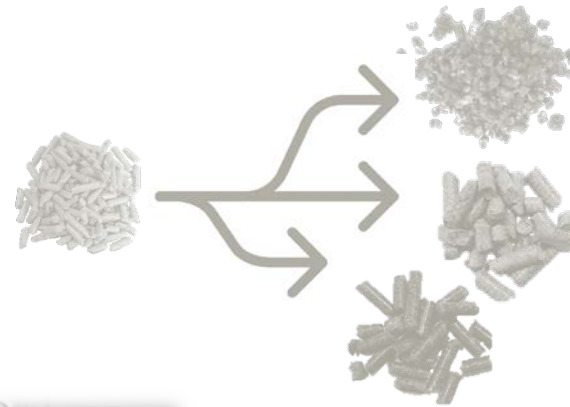
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- Production of SNG

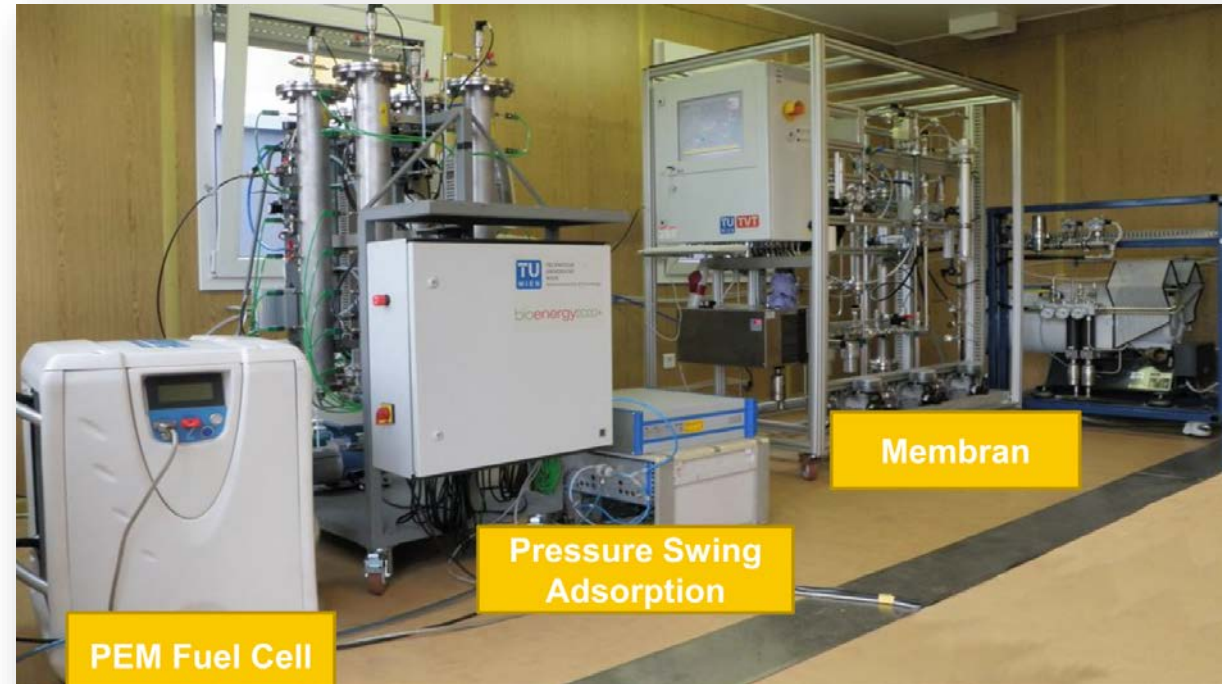


- Production of hydrogen



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## H<sub>2</sub> production in Oberwart 2014

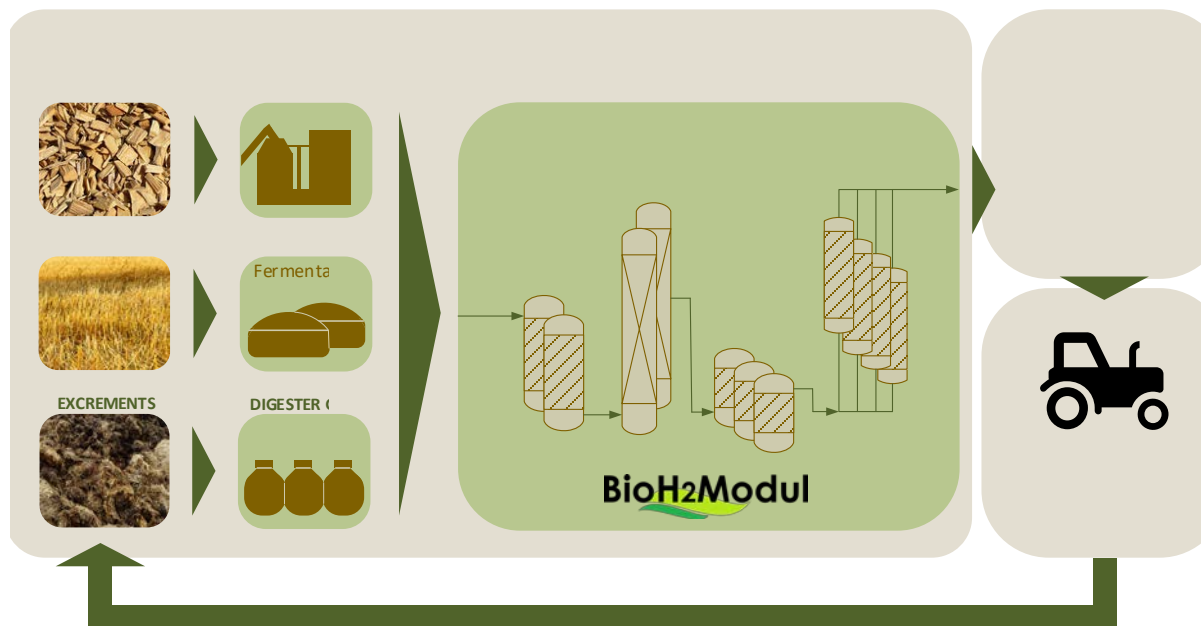


➤ Process chain for enrichment and purification of H<sub>2</sub> from fuel-based sources to fuel cell quality

S. Fail, N. Diaz, F. Benedikt, M. Kraussler, J. Hinteregger, K. Bosch, M. Hackel, R. Rauch, H. Hofbauer, 2014  
 „Wood Gas Processing To Generate Pure Hydrogen Suitable for PEM Fuel Cells”  
 ACS Sustainable Chem. Eng. 2, 12, 2690–2698

## Flagship project FCTRAC

- Production of **sustainable hydrogen** by **purifying product gas** from gasification of wood chips and utilization of the hydrogen produced in a **fuel cell tractor**.
- **Targets:**
  - Demonstration of an entire zero-emission value chain in the agricultural sector
  - Development of a stand-alone solution for decentralized hydrogen production based on biomass



Source and further information:

<https://www.klimafonds.gv.at/dossier/wasserstoff-dossier/projekte/fctrac/>

## Flexibility of the DFB gasification process

- Various feedstocks have been tested for use in thermo-chemical conversion in DFB steam gasification at pilot scale
  - Long-term behavior is currently being investigated on a 1 MW demonstration scale (Waste2Value, Research Competence Center BEST GmbH)
- The product gas can be optimally adjusted by suitable operating parameters for the respective synthesis ( $H_2/CO$  ratio)

## Production of SNG, $H_2$ und further products

- Production of SNG and hydrogen is currently investigated in full process chain pilot-scale experiments
- Optimization and scale-up considerations via case studies are ongoing subject to research efforts



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