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Hydrothermal carbonization as a pretreatment technology for upgrading wet biogenic feedstocks for thermochemical conversion

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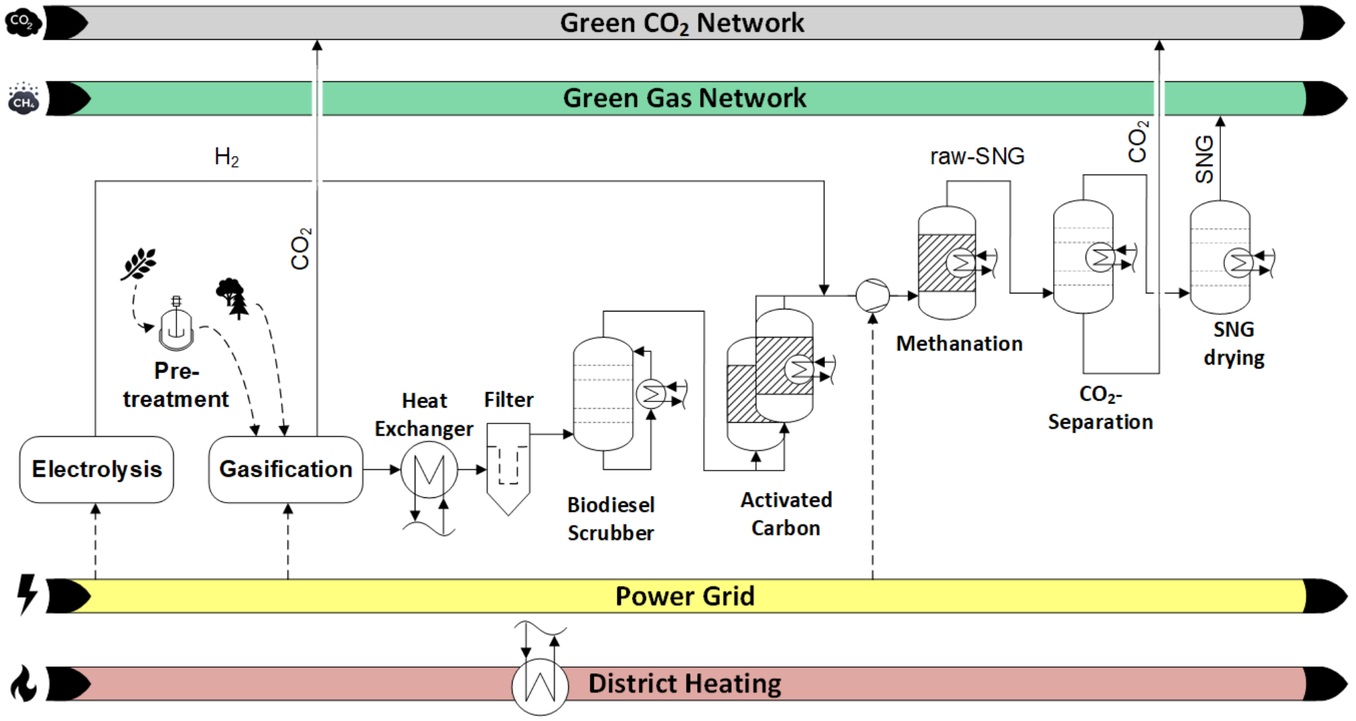
9. Österreichischer Biochar-Day, TU Wien



The I/O-Gas Project

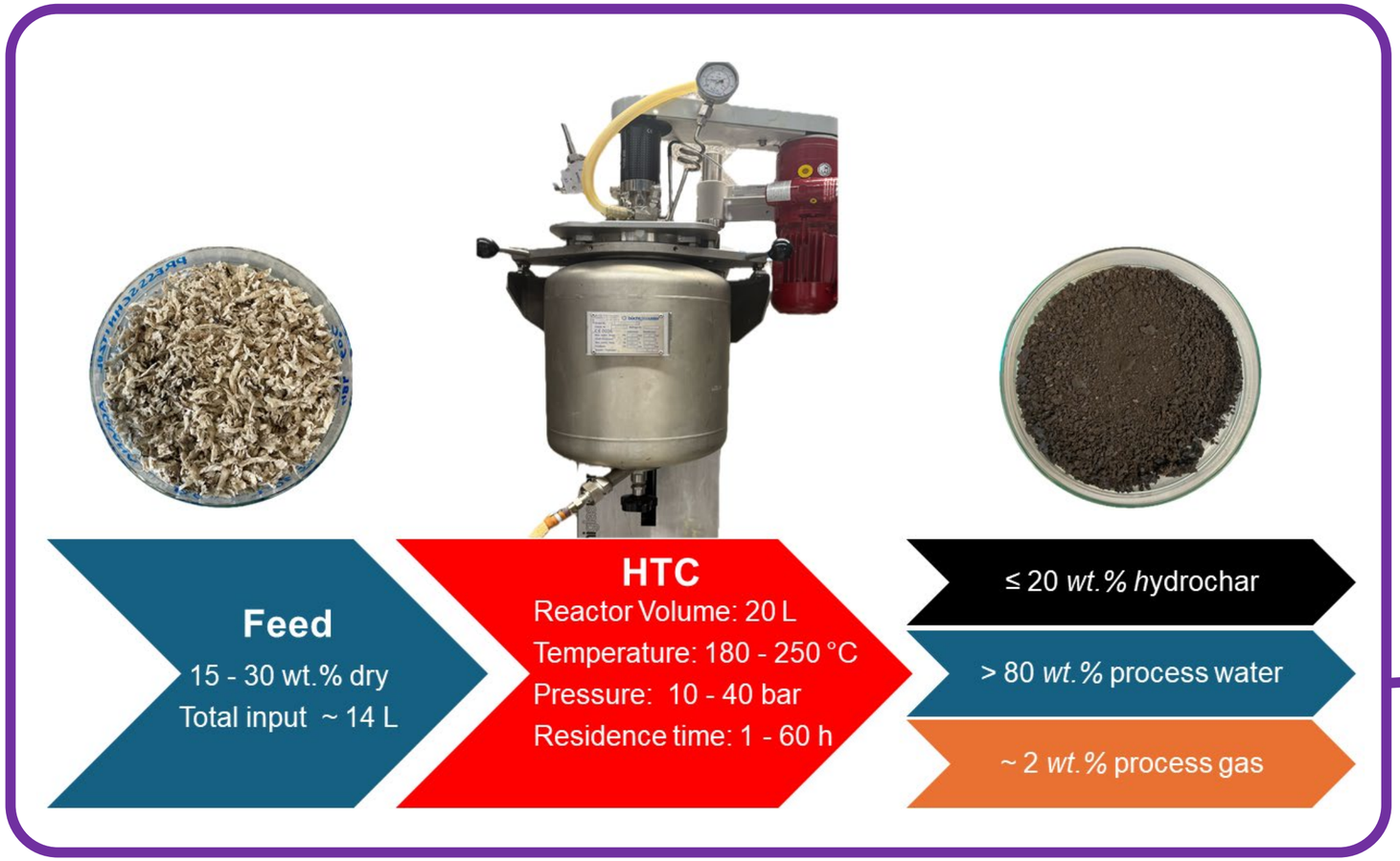
Biomass steam gasification

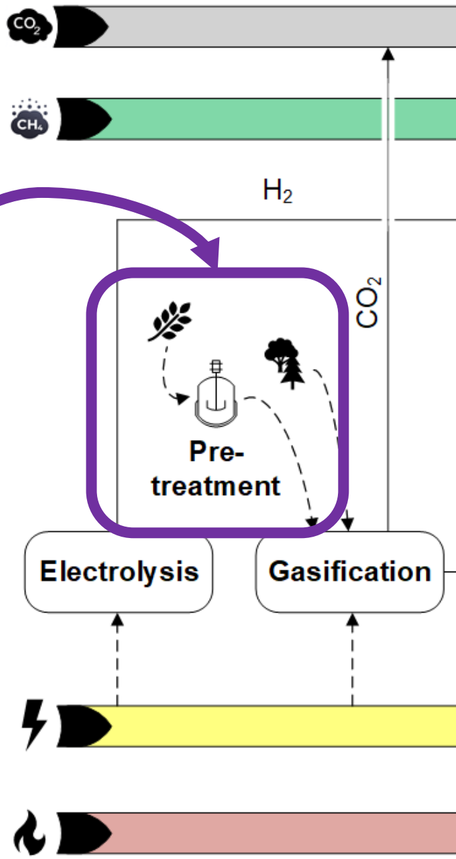
- Find suitable fuel pre-treatment for residues from agricultural sector and food processing industry (HTC and pyrolysis)
  → extend the fuel range/potential for:
- Dual Fluidized Bed (DFB) Steam Gasification
- Gas cleaning, upgrading and synthesis to synthetic natural gas (SNG)
- Process assessment (mass & energy balances)
- Sector coupling and investigation of integration scenarios including techno-economic assessment



https://short.boku.ac.at/io-Gas

Hydrothermal carbonization as pretreatment step





Hydrothermal carbonization (HTC): Thermochemical process converting wet biomass into coal-like or carbonized material “hydrochar” at 180–250 °C under pressure in a water-based environment.

Why hydrothermal carbonization for gasification?





Hydrochar

Increasing the potential for usable biogenic fuels

- Devolatilize the → lower tar content in product gas (gasification)
- Better ash melting behaviour (increase the feedstock range)
- Energetic benefit for wet fuels → mechanical dewatering before thermal drying
- Improved storage stability and beneficial transport properties for seasonal fuel supplies

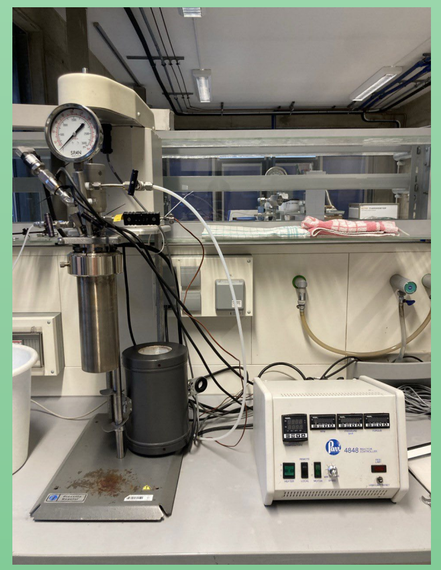
- Additional process step
- Wastewater treatment
- Possible carbon and energy loss in the fuel

Biogenic Residues – Design of Experiment Study

Temperature: 180, 215, 250 °C
Residence times: 120, 300, 480 min

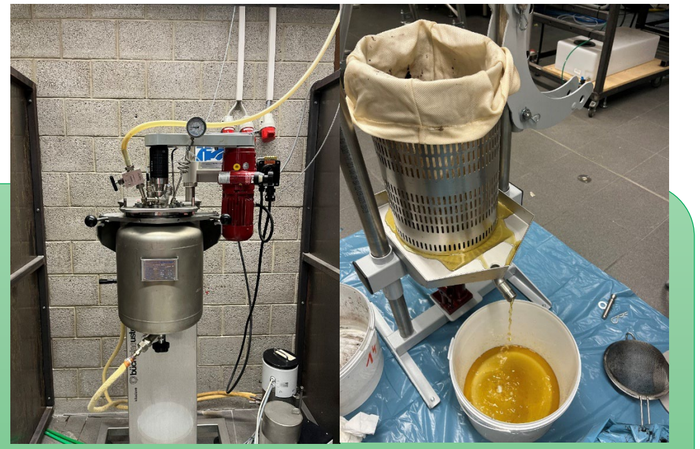
0.6 L Reactor

1. Corn cobs
2. Sugar beet pulp
3. Wheat bran pellets
4. Brewers grains
5. Sunflower husks
6. Reeds
7. Spelt husks
8. Grass with lime
9. Grass without lime
10. Spirulina algae
11. Macrophages of the Donau river



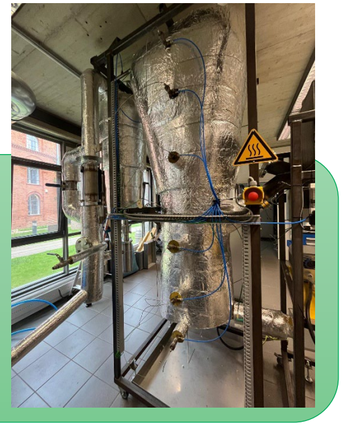
20 L Reactor

1. Sunflower husks
2. Sugar beet pulp



Gasification

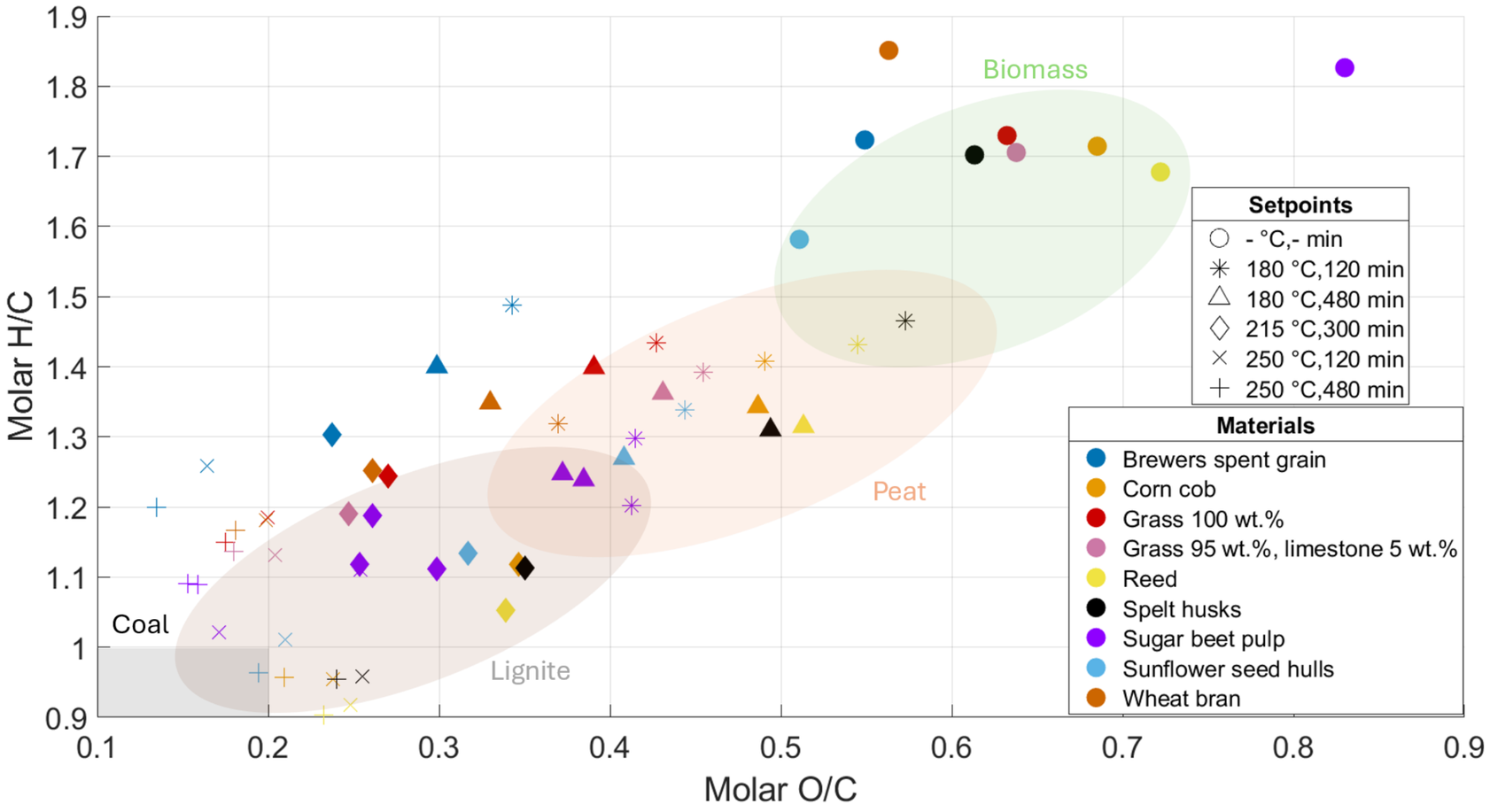
1. HTC - Sugar beet pulp



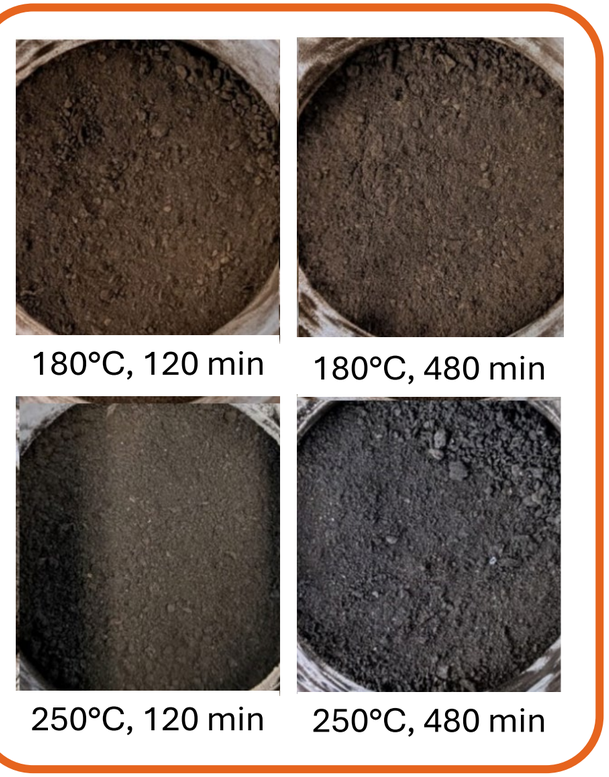
From Biomass to Hydrochar

Van-Krevelen-Diagramm

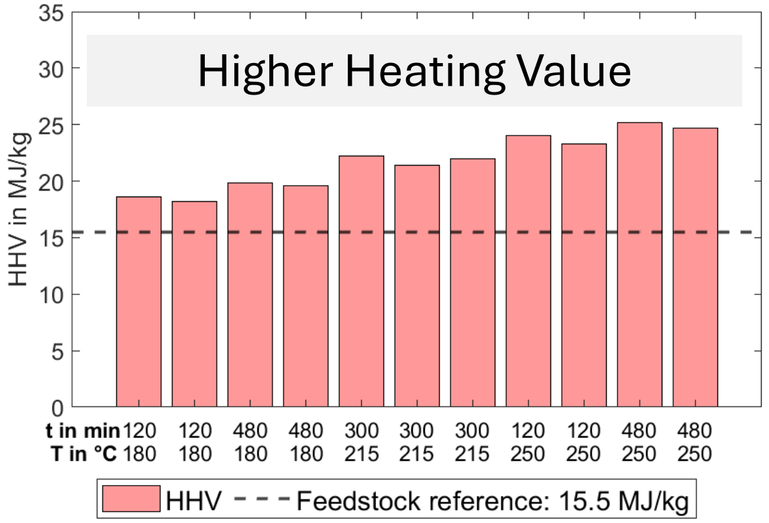
High residence time and temperature promote a higher degree of carbonization



sugar beet pulp



Results Fuel Analysis – Sugar Beat Pulp

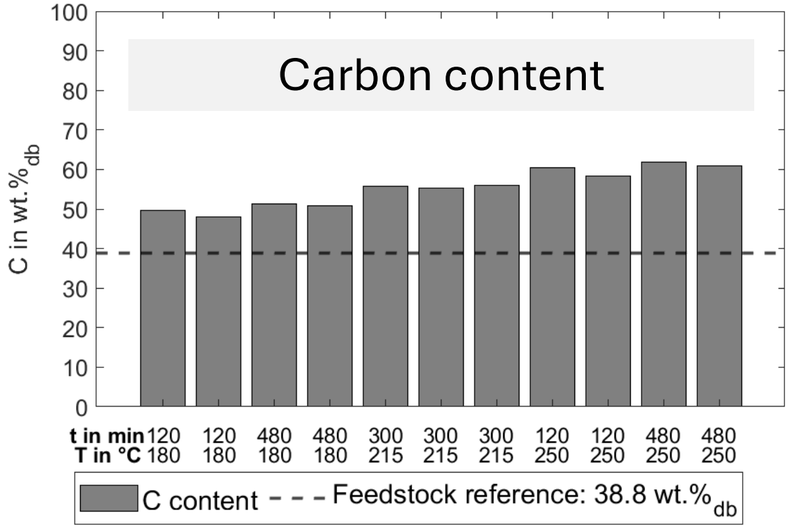


Ultimate Analysis (C,H,N)

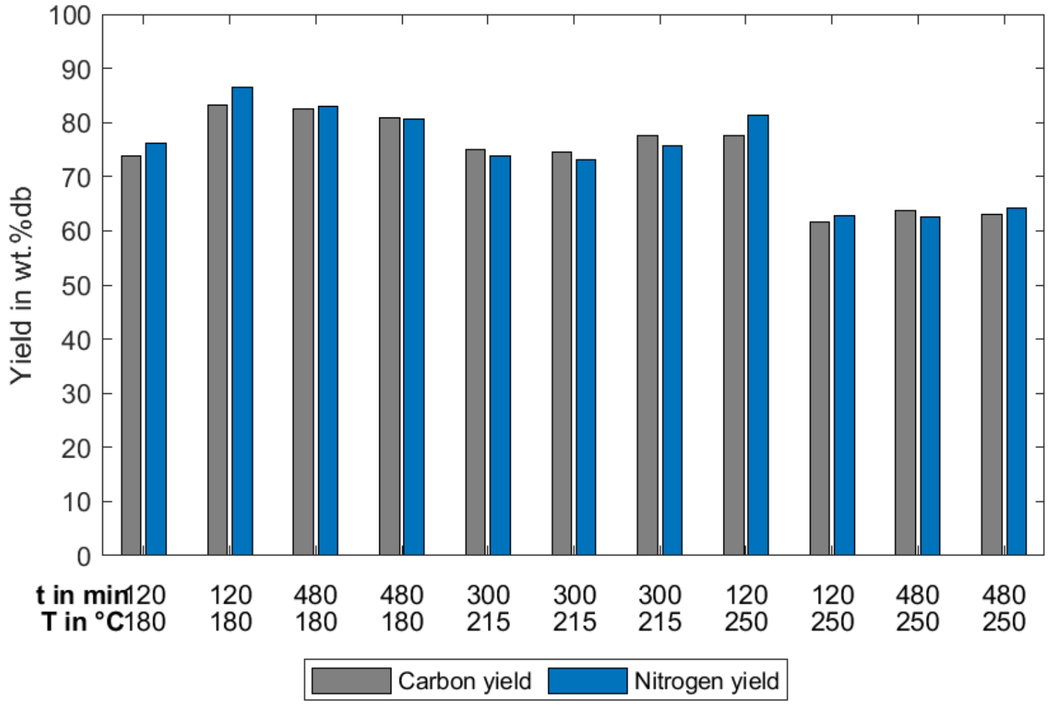
- Higher energy density: less fuel is needed for the same thermal fuel power input.
- Carbon is “lost” in the process water



TruSpec CHN from LECO



The carbon content increases, but not 100% of the total carbon is converted into hydrochar.



Results Fuel Analysis – Sugar Beat Pulp

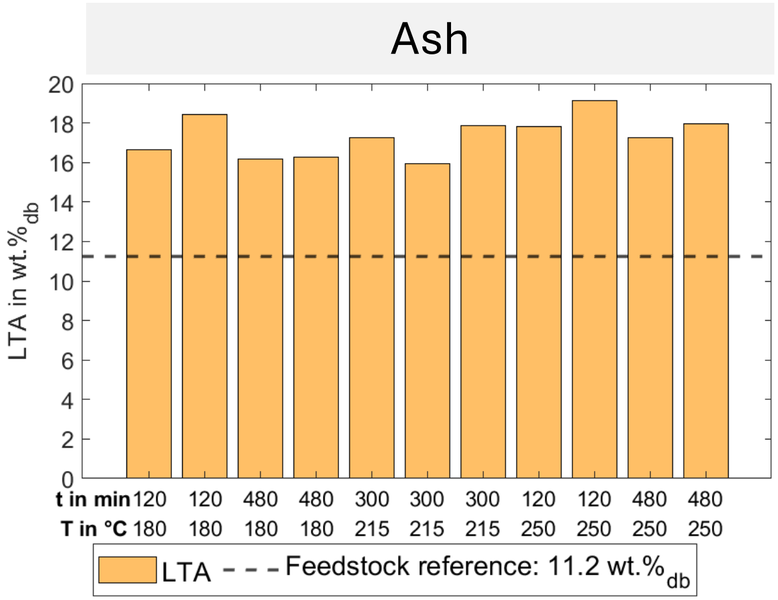


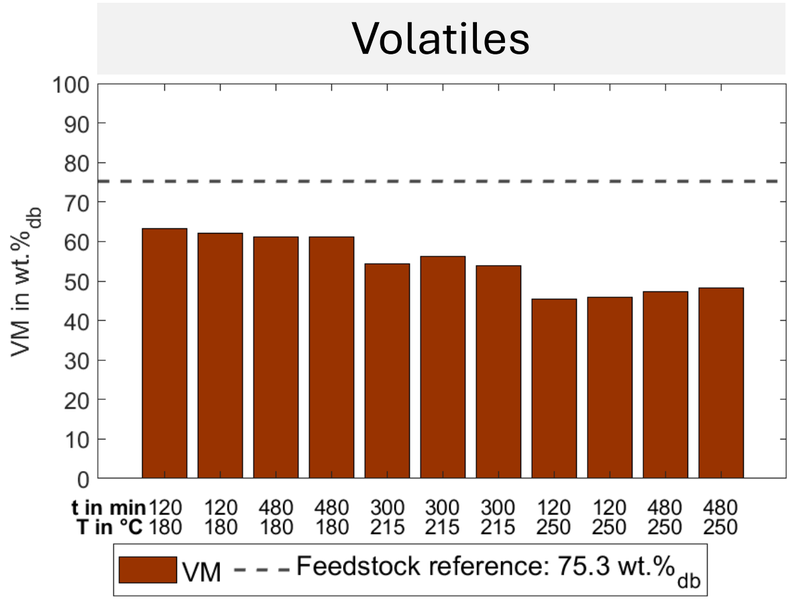


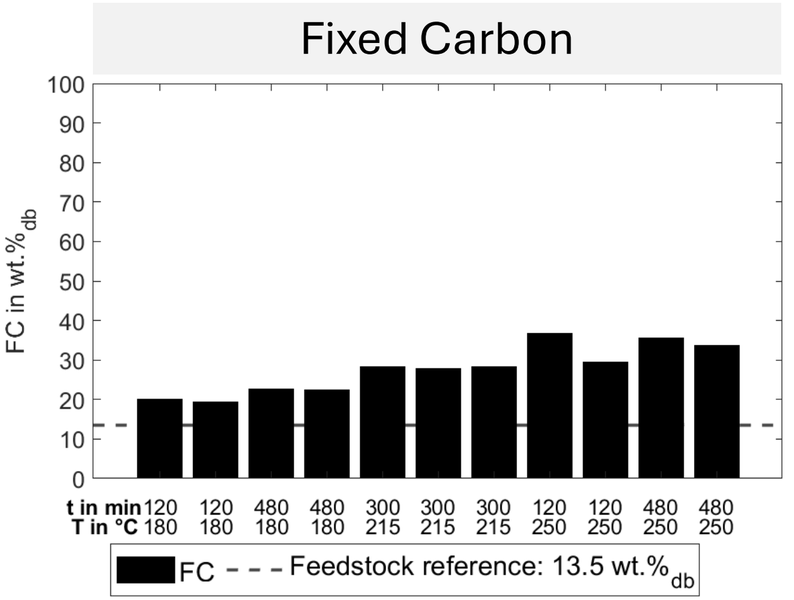
Thermogravimetric Analyzer from ELTRA

Proximate Analysis

- **Ash Content:** rises percentual, but less fuel is needed due to higher energy density, similar total amount in the system
- **Volatiles:** decrees percentual and total amount in the system
- **Fixed Carbon:** increases with the degree of carbonization



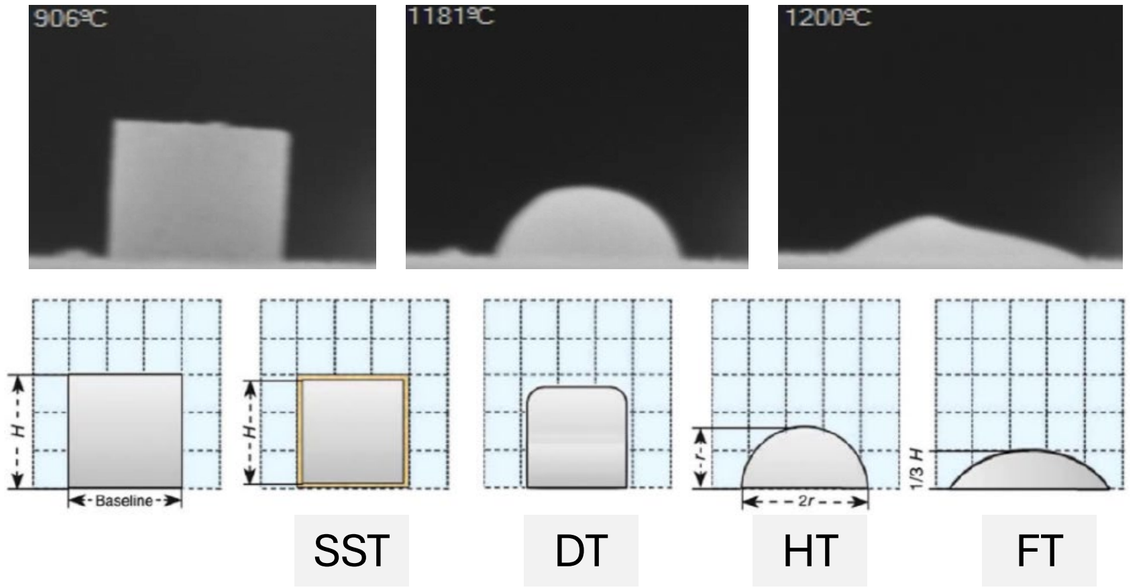


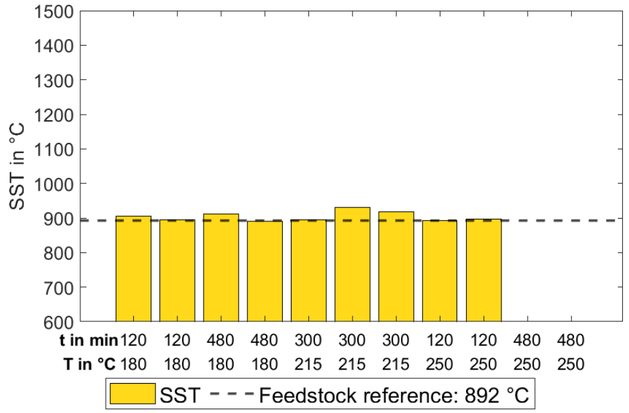


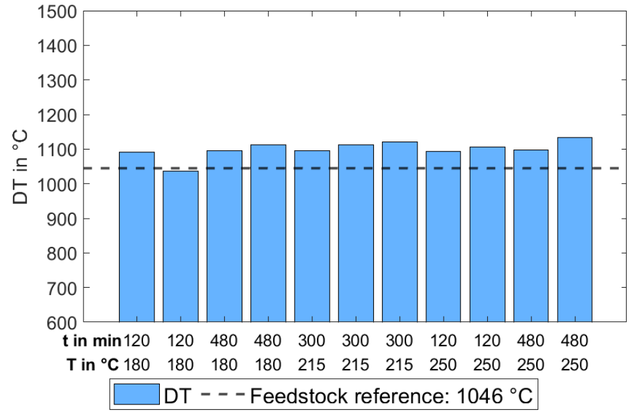
Results Ash Melting Behavior

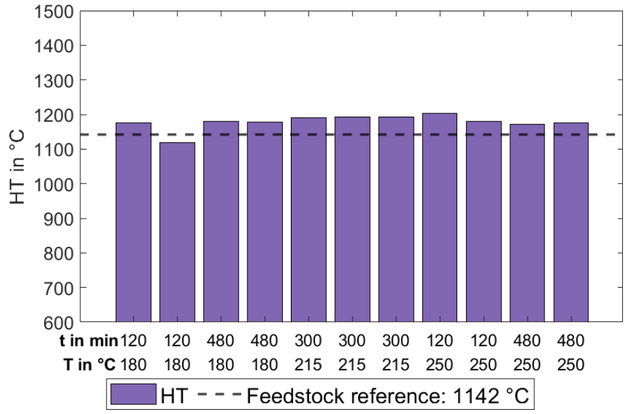
Low deformation temperature (DT):

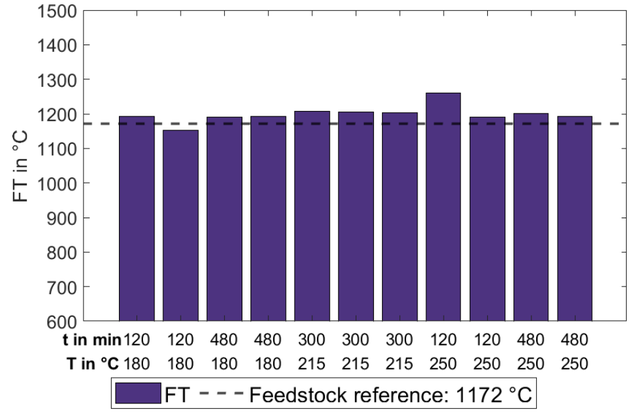
- Critical for gasification (DT < 1000 °C)
- Risk of agglomeration
  - Collapse of the fluidized bed











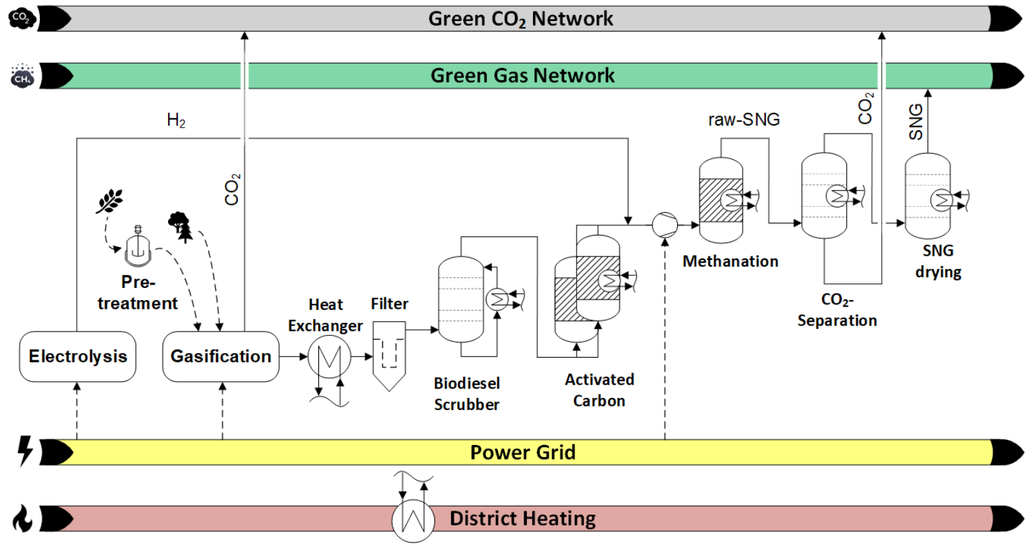
Slight improvement in the ash melting behaviour

SST	Shrinkage starting temperature	HT	Hemisperical temperature
DT	Deformation temperature	FT	Flow temperature

DIN EN ISO 21404:2020-06, Biogene Festbrennstoffe_- Bestimmung des Asche-Schmelzverhaltens (ISO_21404:2020); Deutsche Fassung EN_ISO_21404:2020. doi: 10.31030/3113641.

Conclusion & Outlook

- HTC could offer a good perspective for wet biogenic residues pre-treatment
- Experiments show improved fuel properties
- Smart process water integration in an overall process is investigated



Next Steps:

- Producing HTC pellets out of sugar beat pulp
- Experiments with Hydrochar
  out of sugar beat pulp (HTC SBP) and green waste (HTC GW) in BOKU steam gasifier
- Tar measurement → Gas chromatography–mass spectrometry (GC/MS)
- HTC GW 100 kW DFB pilot plant @TU Wien (www.tuwien.at/tch/icebe/ipe/projekte/i-o-gas)









[Merci BOKU]

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Integration und Optimierung der Produktion von erneuerbarem Gas aus biogenen Reststoffen (I/O GAS) , FO999915024
Dieses Projekt wird aus Mitteln des Klima- und Energiefonds gefördert und im Rahmen des Energieforschungsprogramms 2023 durchgeführt.