

Pilot Testing Demonstrates Chemical Looping Gasification Biomass to Liquid Process Chain

Falko Marx, Paul Dieringer, Jochen Ströhle, Bernd Epple



Energy Systems &
Technology
Prof. Dr.-Ing. B. Epple
www.est.tu-darmstadt.de

2nd Public
Workshop



1 Process Chain

2 Technology Advancement

3 Pilot Testing

4 Summary

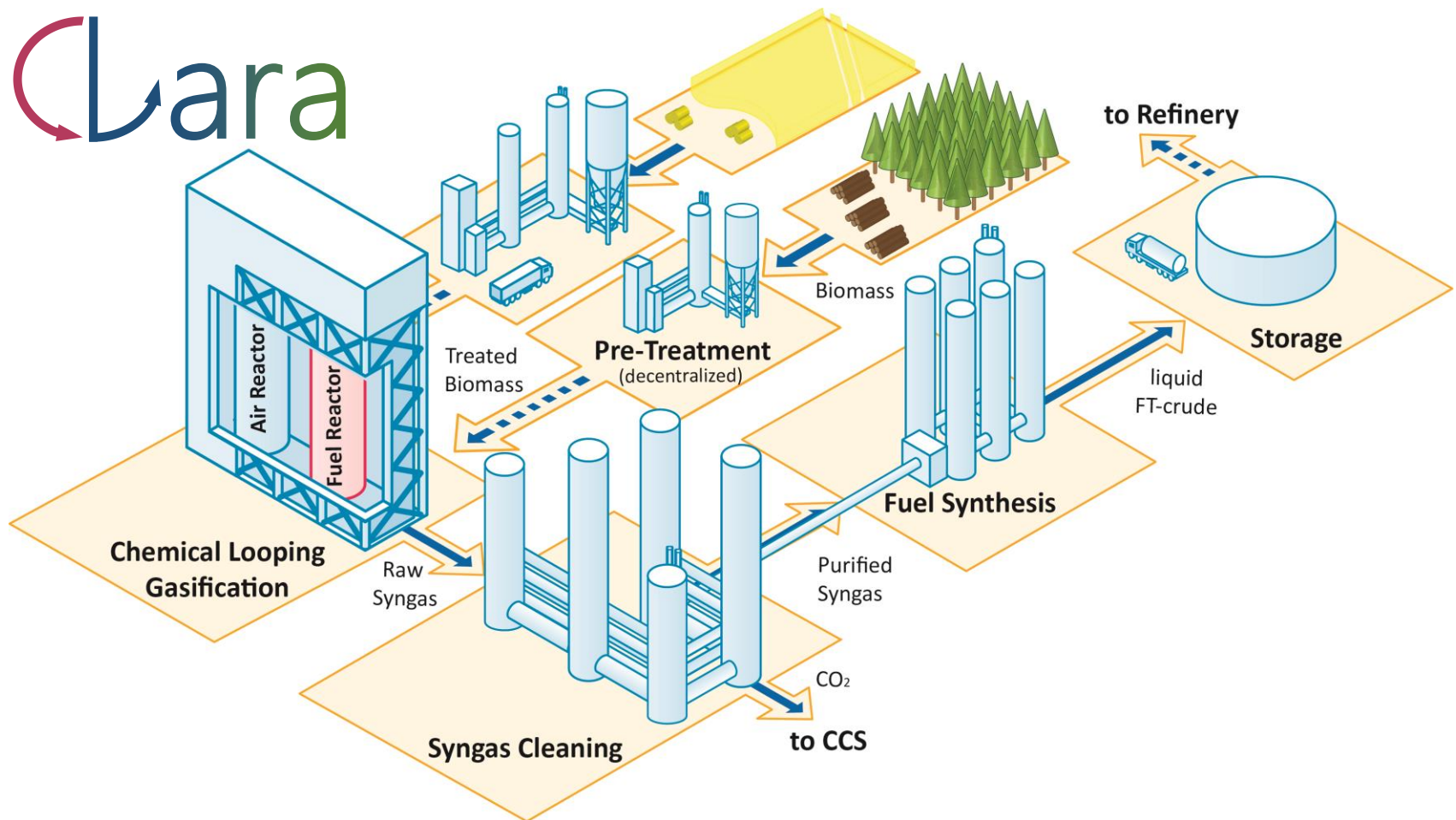
1

The Complete CLARA Process Chain is Carbon-Neutral or Carbon-Negative



TECHNISCHE
UNIVERSITÄT
DARMSTADT

CLara

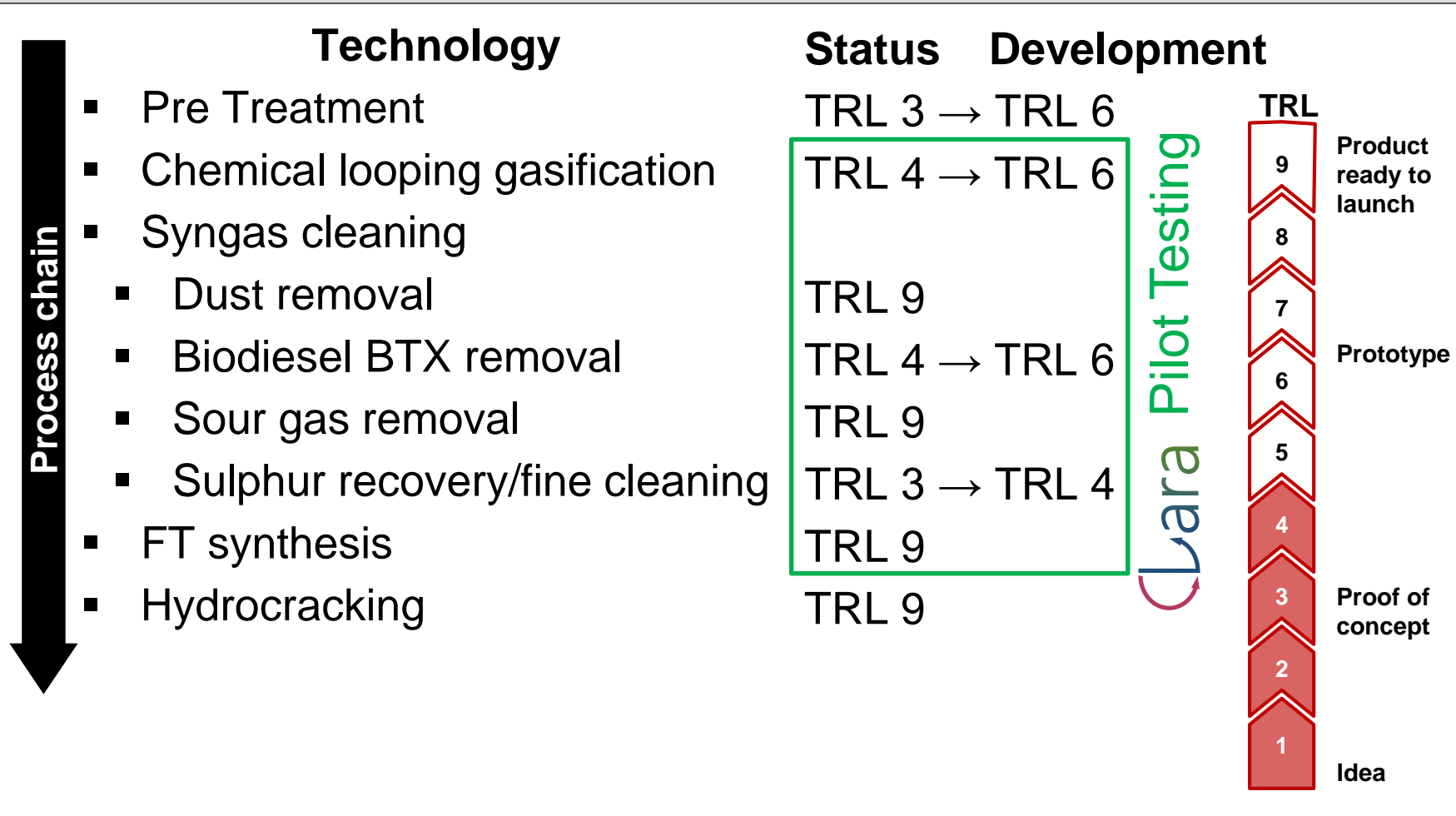


2

All Process Chain Technologies are State of the Art or have been Proven to Work in Lab Scale



TECHNISCHE UNIVERSITÄT DARMSTADT



Lab Scale

Individual Processes

- General proof of concept
- Parameter studies

CLG

- Process control?
- Parameter studies
- External heating

Gas Cleaning

- General application
- Parameter studies



Pilot testing
advances the TRL

Clara

Large Scale

Process Chain

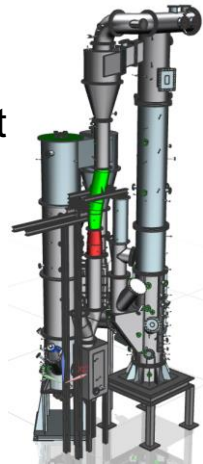
- Efficiency
- Process flow
- Demonstration of full process chain
- Data for assessment of Economic Feasibility generated

CLG

- New process control
- Parameter interdependent
- Autothermal operation

Gas Cleaning

- Efficiency
- Operation experience
- Usability of produced syngas

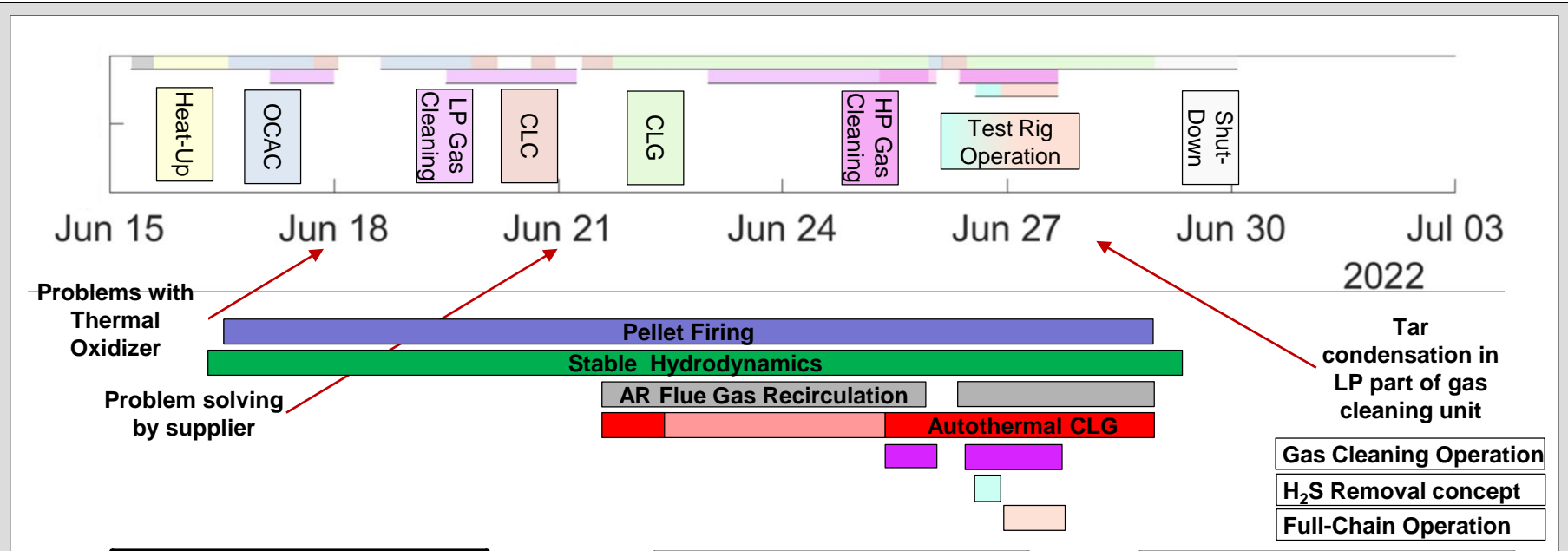


3

Feasibility of the CLG-BtL Process Chain has been Demonstrated Autothermal



TECHNISCHE UNIVERSITÄT DARMSTADT



Process Chain

- Demonstration of full CLG-BtL process chain
- Data for assessment of Economic Feasibility generated

CLG

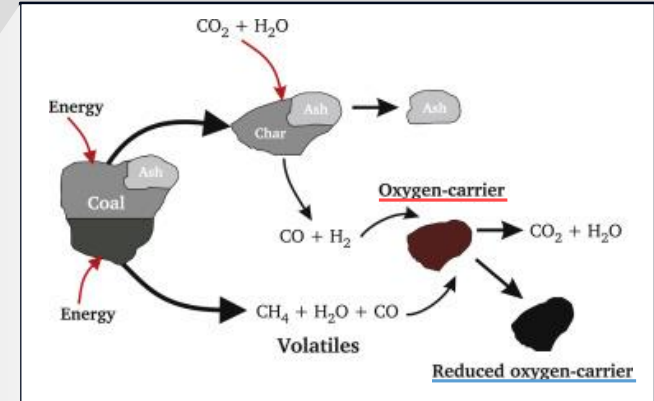
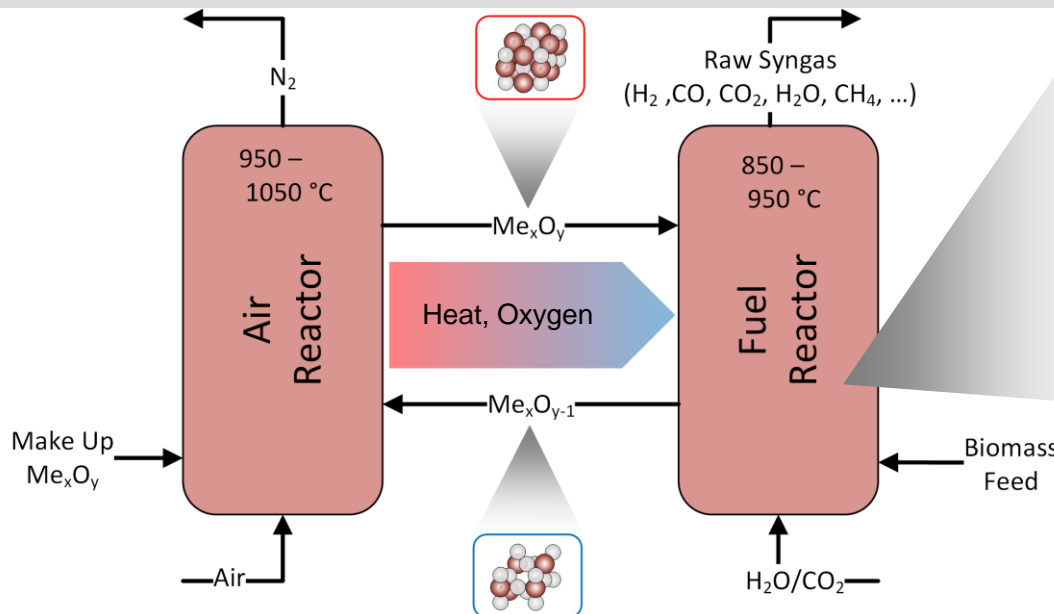
- New process control
- Parameter interdependent
- Autothermal operation

Gas Cleaning

- Efficiency
- Operation experience
- Usability of produced syngas

3

CLG is an Oxygen Assisted Gasification Technology



[1] Alobaid et al., Energy (2015)

- No direct contact between air and feedstock
 - FR: Conversion of feedstock into syngas, reduction of oxygen carrier (OC) material
 - AR: Oxidation of OC
 - OC: Transport of oxygen and sensible heat (← important in CLG operation)
- Goal:
 - High syngas generation = high H₂ and CO content in FR off gas
 - High conversion of feedstock in FR = low CO₂ content in AR flue gas

3

CLG Produces Low Tar Syngas From Biogenic Residues



TECHNISCHE
UNIVERSITÄT
DARMSTADT



Industrial Wood Pellets Pine Forest Residue Pellets Wheat Straw Pellets

- 3 different residual biomasses tested in pilot scale
- > 100 t of biomass converted to syngas
- Over 150 h of operation with sub-stoichiometric process control

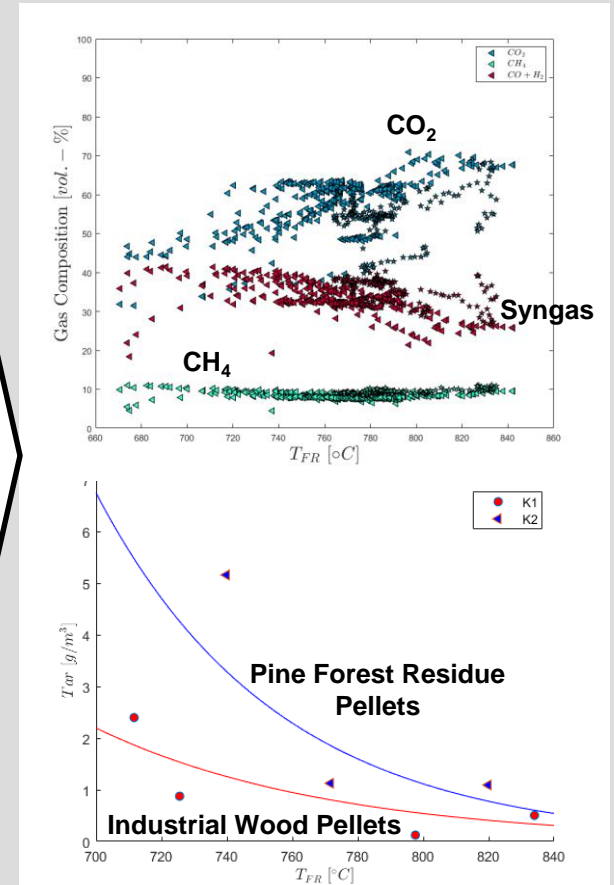
Oxygen Carrier:
Ilmenite



CLG Pilot Testing

- Pilot Scale
- High percentage of CO₂ from LS fluidization and purge gas ~ 20 %
- High relative heat losses
- Higher temperatures require higher λ
- Syngas ↓
- Methane production ~10 %

Generated Syngas

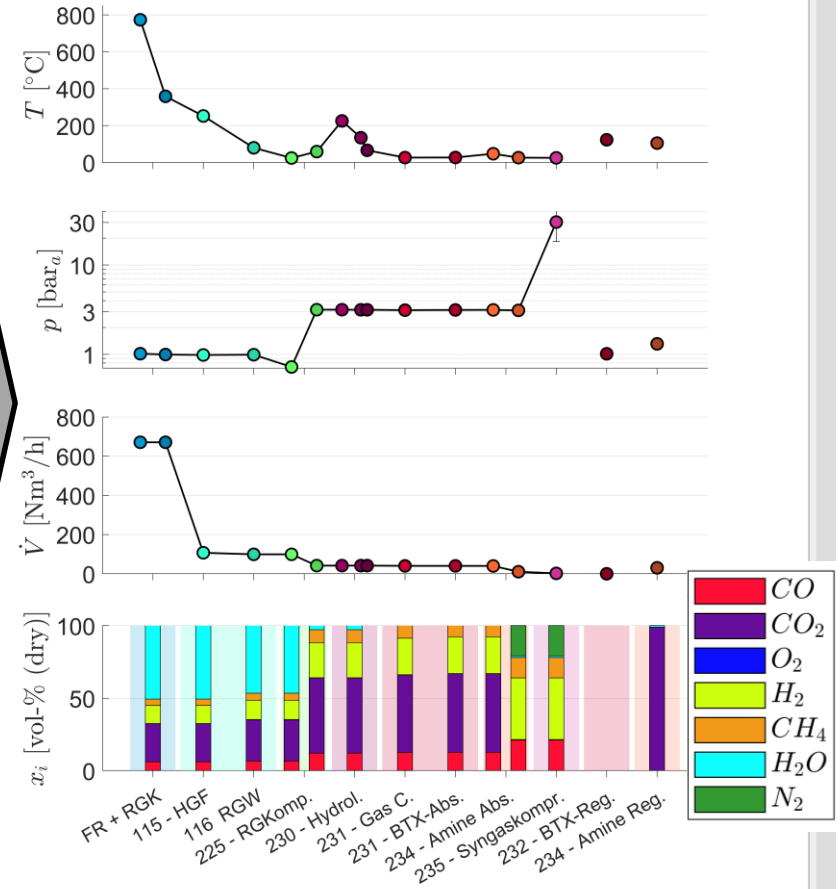
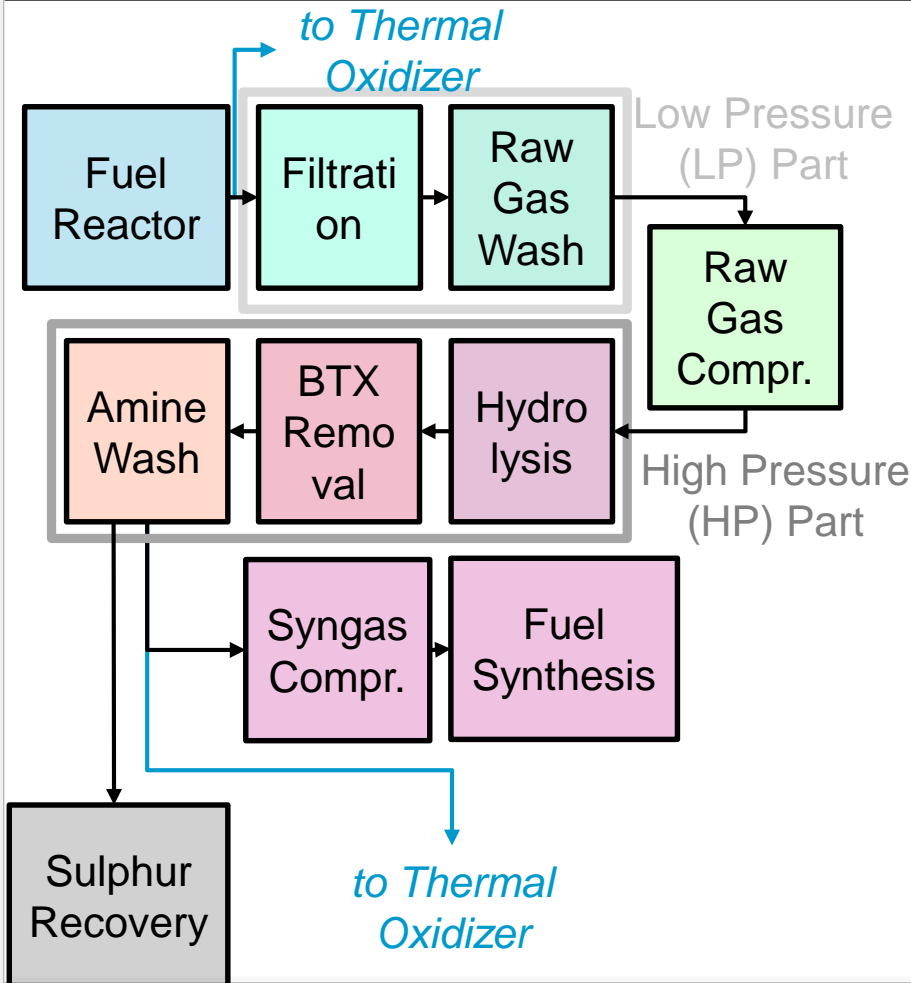


3

Syngas Cleaning Pilot Plant shows Successful Cleaning



TECHNISCHE
UNIVERSITÄT
DARMSTADT



3

Sour Gas Cleaning Test Rig Shows Sulphur Capturing

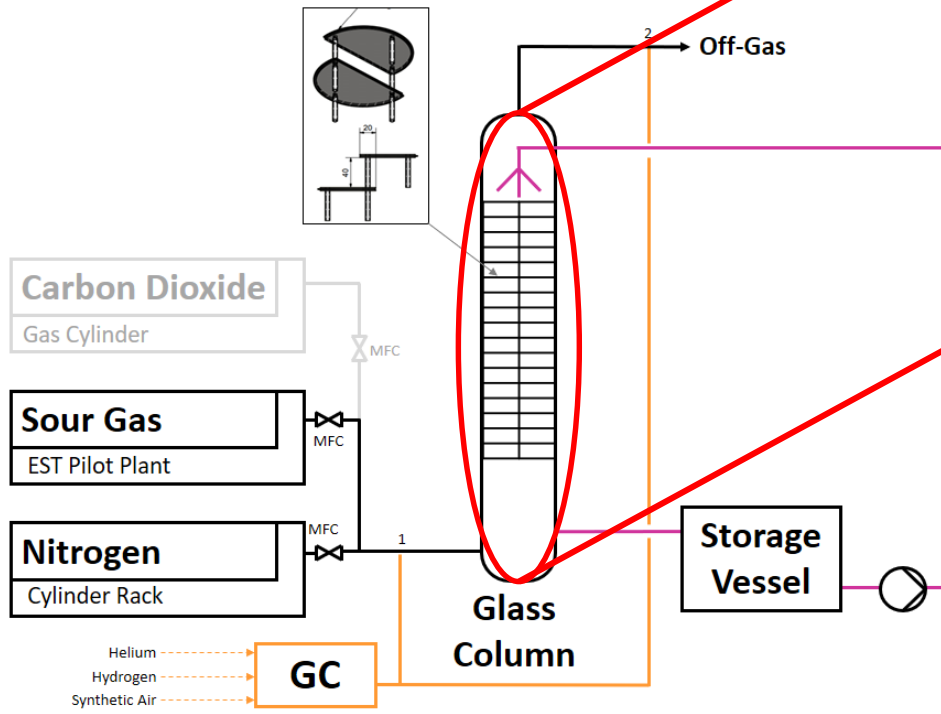


TECHNISCHE
UNIVERSITÄT
DARMSTADT

- Stable operation of the Amine system required
- Demonstration ended after 12 h and conversion of KMnO_4 was achieved



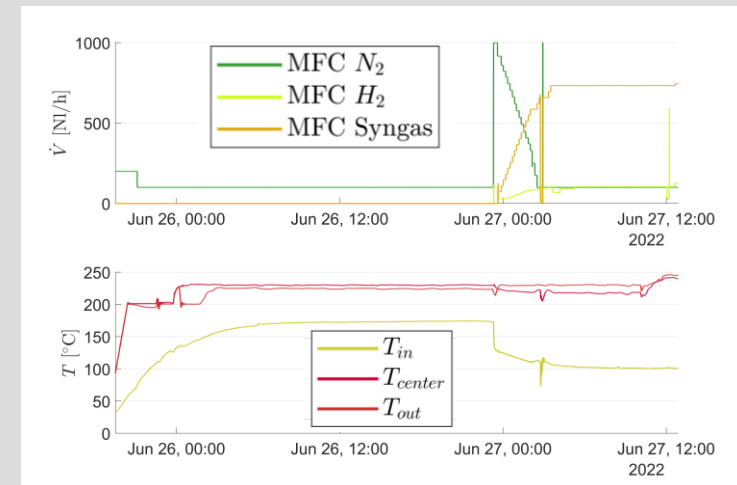
Conversion of KMnO_4
--
Capturing of H_2S



MFC = Mass Flow Controller
GC = Gaschromatograph

FT Synthesis

- Cobalt-based Catalyst from UNICRE
- Operation with cleaned syngas
- 30 bar system pressure
- 230 – 245 °C system temperature



4

Pilot Testing has been a Team Effort



TECHNISCHE
UNIVERSITÄT
DARMSTADT

Direct Contribution

- Pilot plant modification & investigation



- HAZOP



- Feedstocks



- Washing & synthesis test rigs



- Catalyst



- Hydrocracking



Indirect/Information Contribution

- Feedstock pre-treatment



CENER

- Feedstock OC interaction



UNIVERSITÀ
DEGLI STUDI
DE L'AQUILA

- Ash melting behavior



- OC screening & lab scale testing



- Lab scale testing



- Assessment



Thank You for Your Attention!



TECHNISCHE
UNIVERSITÄT
DARMSTADT



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817841: Chemical Looping gAsification for sustainAble production of biofuels (CLARA).

 Clara Homepage



 EST Homepage



Falko Marx

Energy Systems and Technology

Mail: falko.marx@est.tu-darmstadt.de

Phone: +49 6151 16 22677

Otto-Berndt-Straße 2, 64287 Darmstadt / Germany

www.est.tu-darmstadt.de