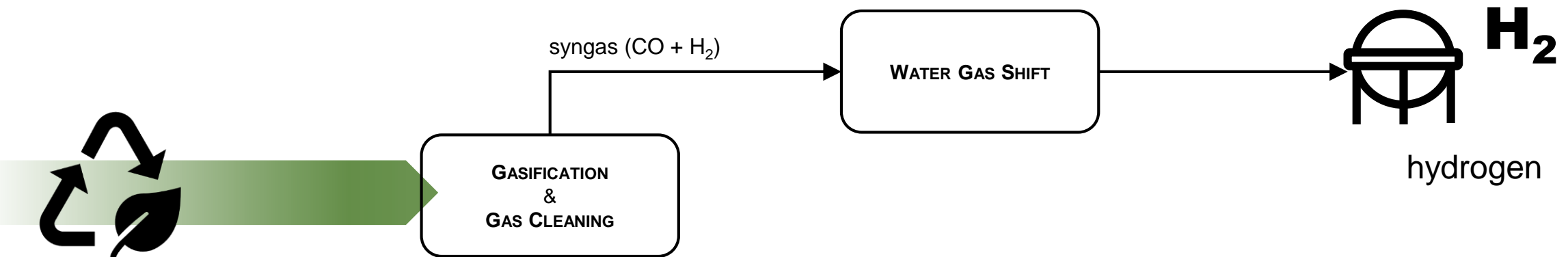


## IMPULSVORTRAG

# **Gasifizierung von biogenen Reststoffen zur Herstellung eines H<sub>2</sub>-reichen Synthesegases**

Prof. Dr.-Ing. Bernd Epple  
TU Darmstadt, Institute for Energy Systems & Technology

## Integration of gasification into the hydrogen and carbon cycle

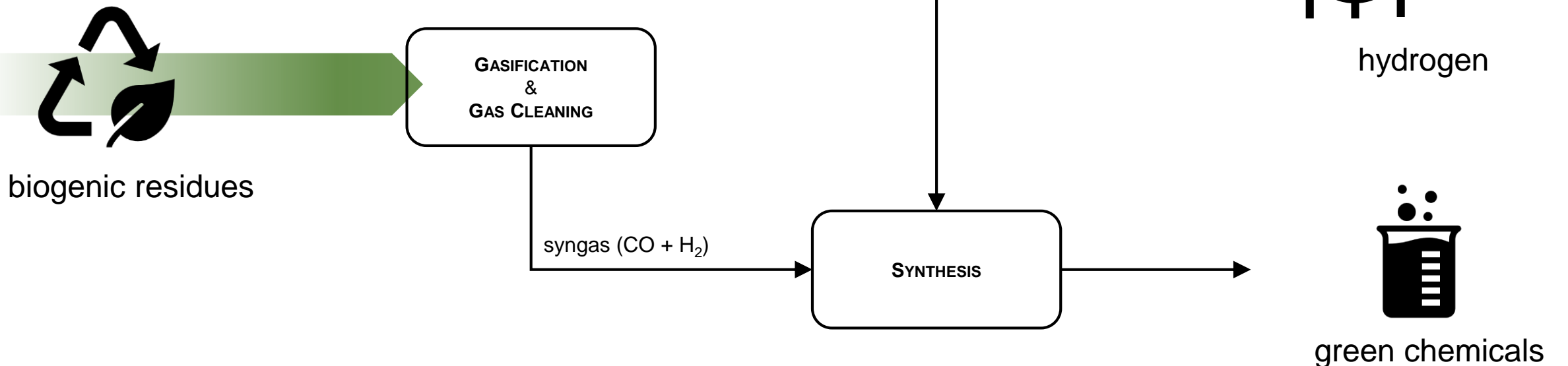


biogenic residues

- > Biogenic residues are converted to sustainable hydrogen.
- > The production costs are only influenced to a small extent by the electricity price.

## Integration of gasification into the hydrogen and carbon cycle

- > The gasification technology can utilize hydrogen to maximize the output of green chemicals.
- > These chemicals can substitute fossil fuels within the carbon cycle.





# VERENA

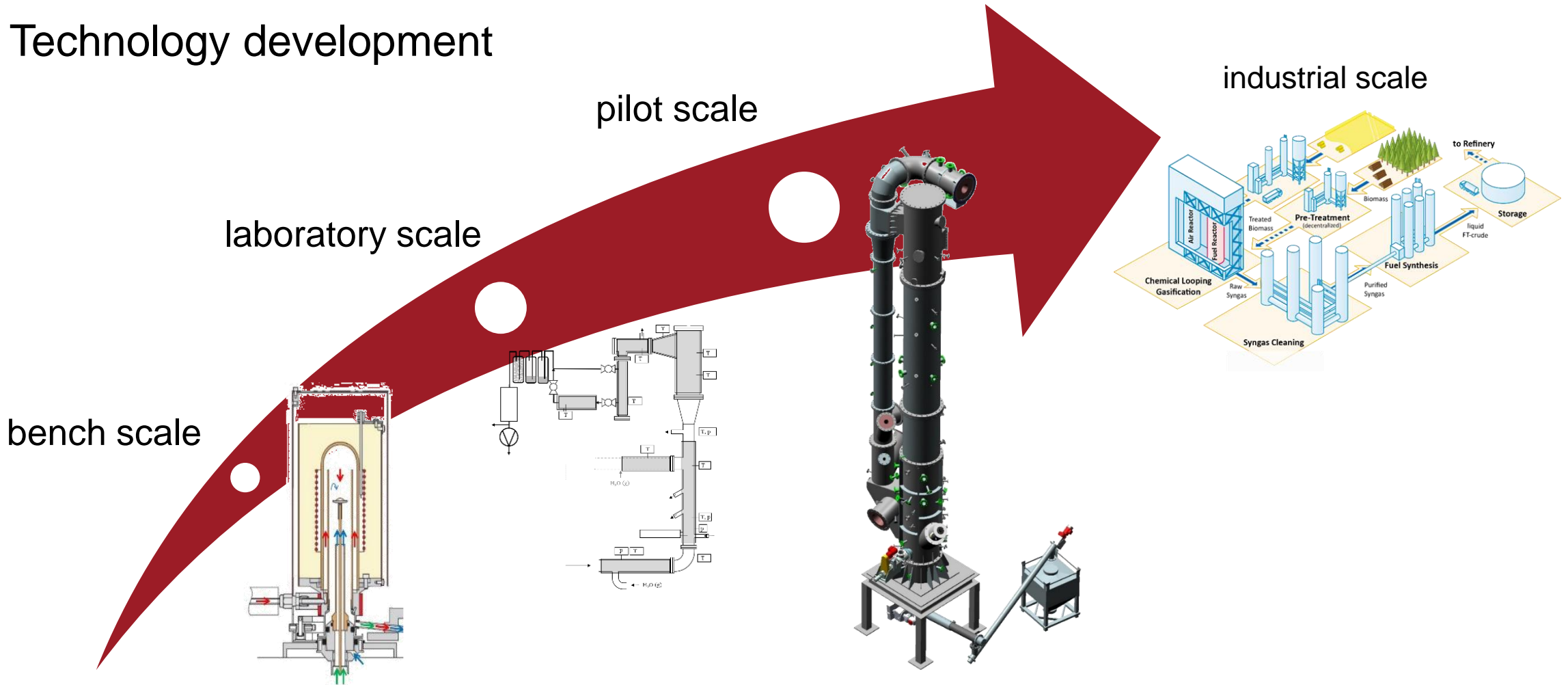
FKZ: 03EE5044A



Federal Ministry  
for Economic Affairs  
and Climate Action

- > Lead: TU Darmstadt
- > 10/2020 - 09/2024
- > Budget: 11.1 M€
- > Development and evaluation of technologies for the flexible production (polygeneration) of electricity and synthetic energy sources from residual materials

# Technology development





**high temperature  
process facility**

**gas cleaning plant**

**synthesis test rig**

**laboratory**



## Erection of the pilot plant in 2009

February



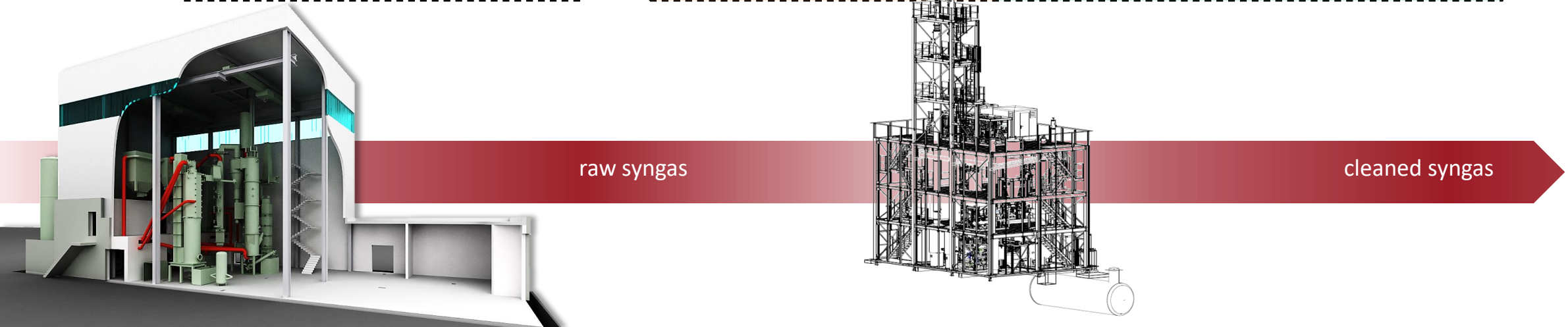
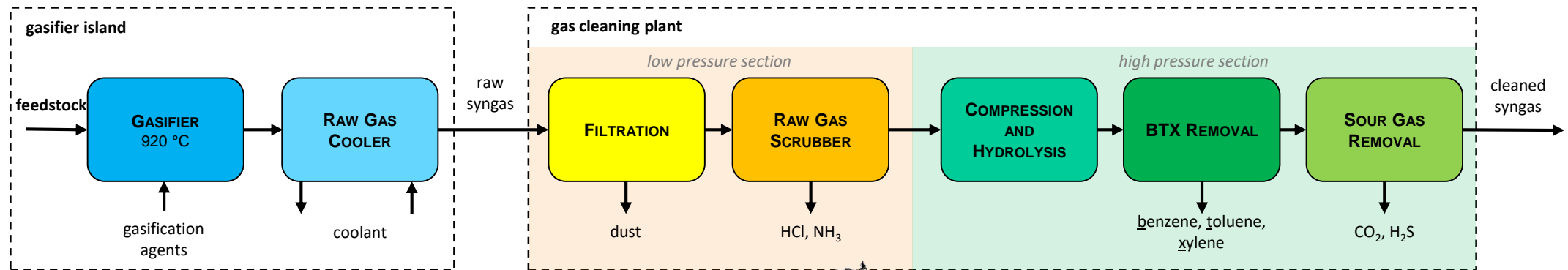
May

July



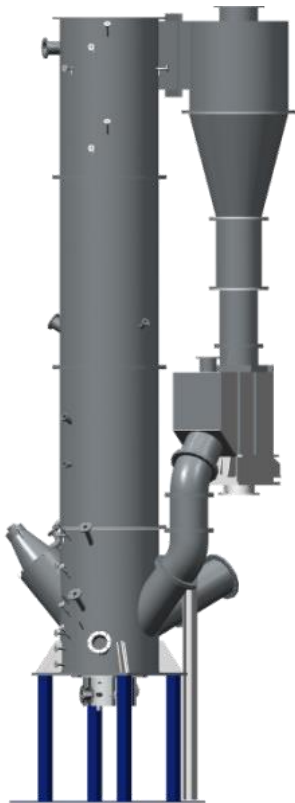
September

# Waste-to-value





## 1 MW modular pilot plant



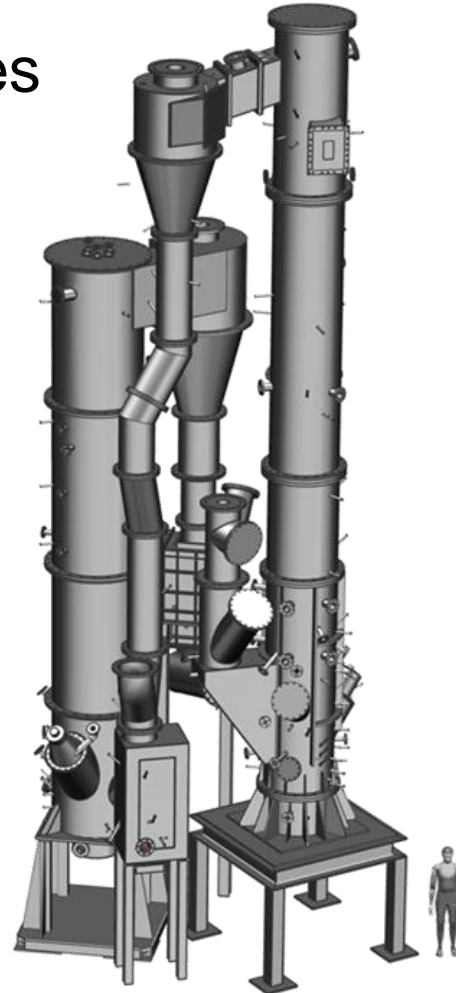
circulating fluidized bed reactors		
CFB 600		CFB 400
<b>dimensions</b>		
600 mm	inner diameter	400 mm
1300 mm	outer diameter	1000 mm
8 m	height	11 m
<b>process parameters</b>		
650 ... 1050 °C	temperature	850 ... 1000 °C
atmospheric	pressure	atmospheric
3 ... 6 m/s	velocity	0.5 ... 6 m/s



## Gasification of residues

### coupled reactors

- > Dual fluidized bed gasification (DFB)
- > Chemical looping gasification (CLG)

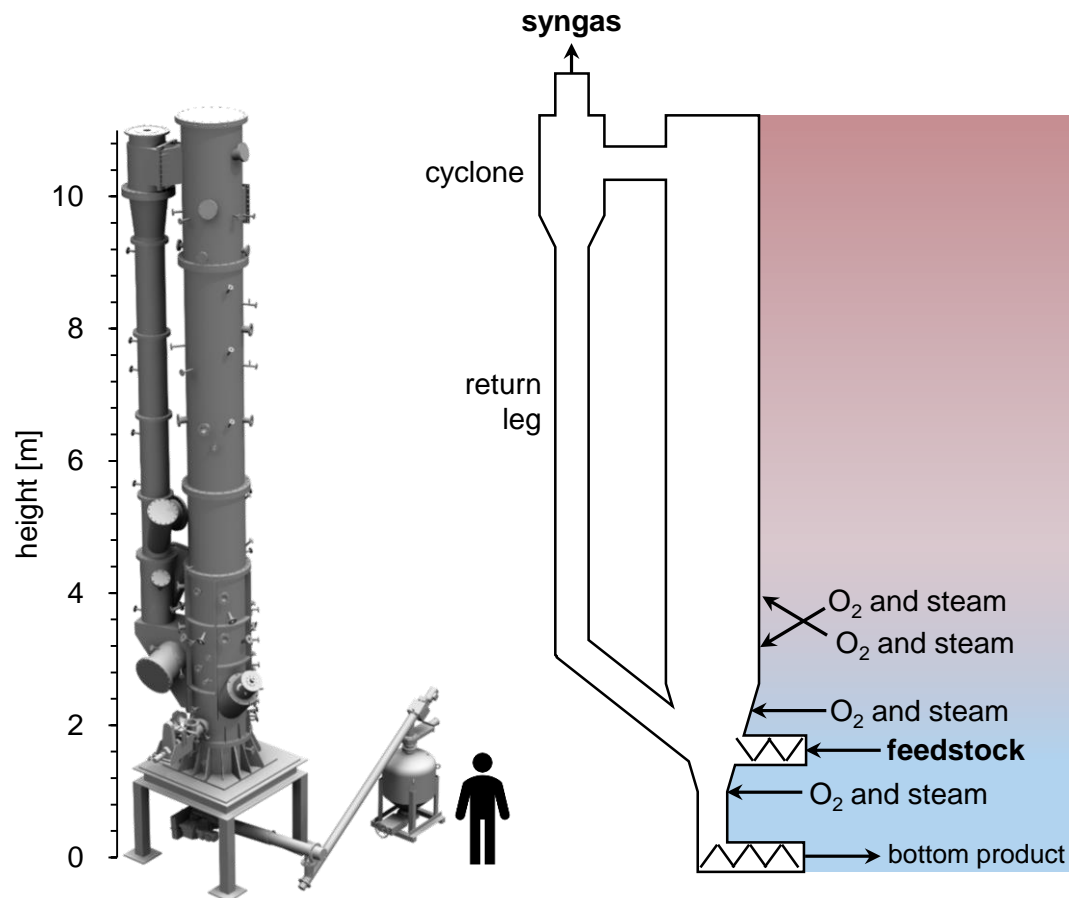


### single reactor

- > High-Temperature-Winkler gasification (HTW)
- > Circulating Fluidized Bed gasification (CFB)



## Bubbling bed gasifier



### post gasification zone (PGZ) – 800 to 1100 °C

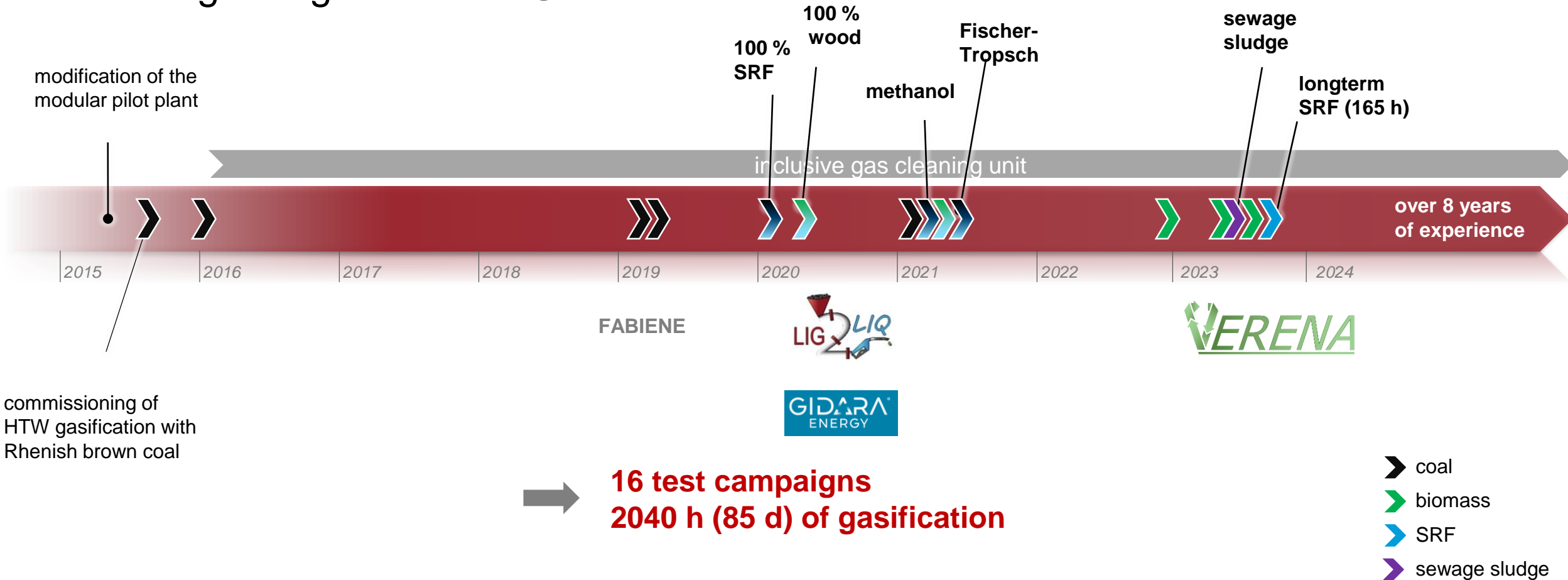
- freeboard
- conversion of hydrocarbons
- conversion of fixed carbon (entrained dust)
- temperature below ash softening point

### bubbling bed – 650 to 750 °C

- homogeneous temperature profile
- release of volatiles & conversion of fixed carbon
- bed inventory: ash and char



## Bubbling bed gasification @EST



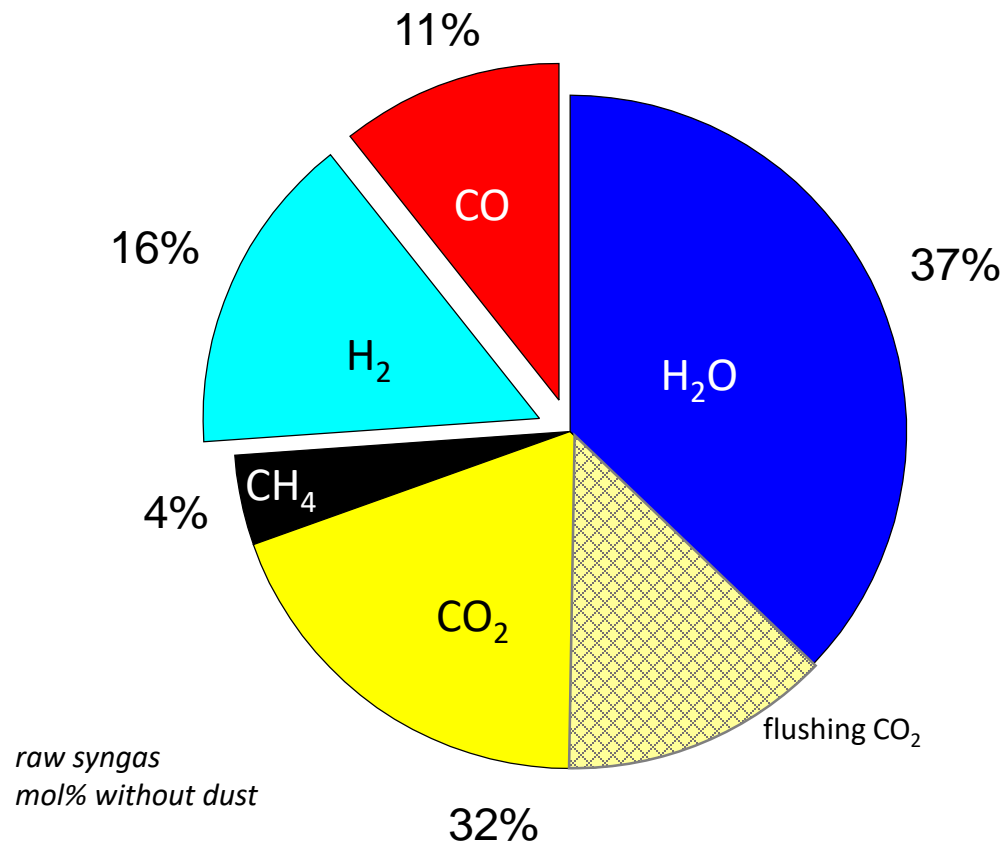


## Experience



type of feedstock	lignite	pine forest residue	sewage sludge	SRF (solid recovered fuel)
pre-treatment	grained	pelletized	dried	pelletized
operation mode	full-chain	full-chain	stand-alone	stand-alone
thermal load	350-500 kW	340-460 kW	400 kW	400-440 kW
netto syngas operation time	> 1,000 h	138 h	72 h	171 h
product	FT and methanol	methanol	syngas	syngas

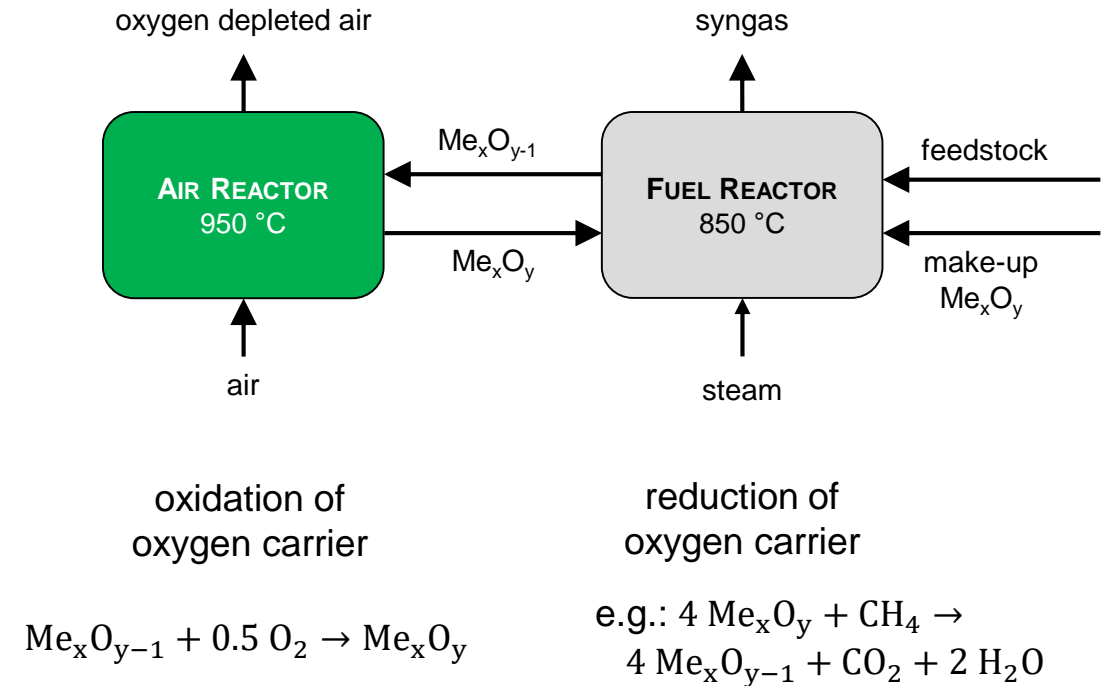
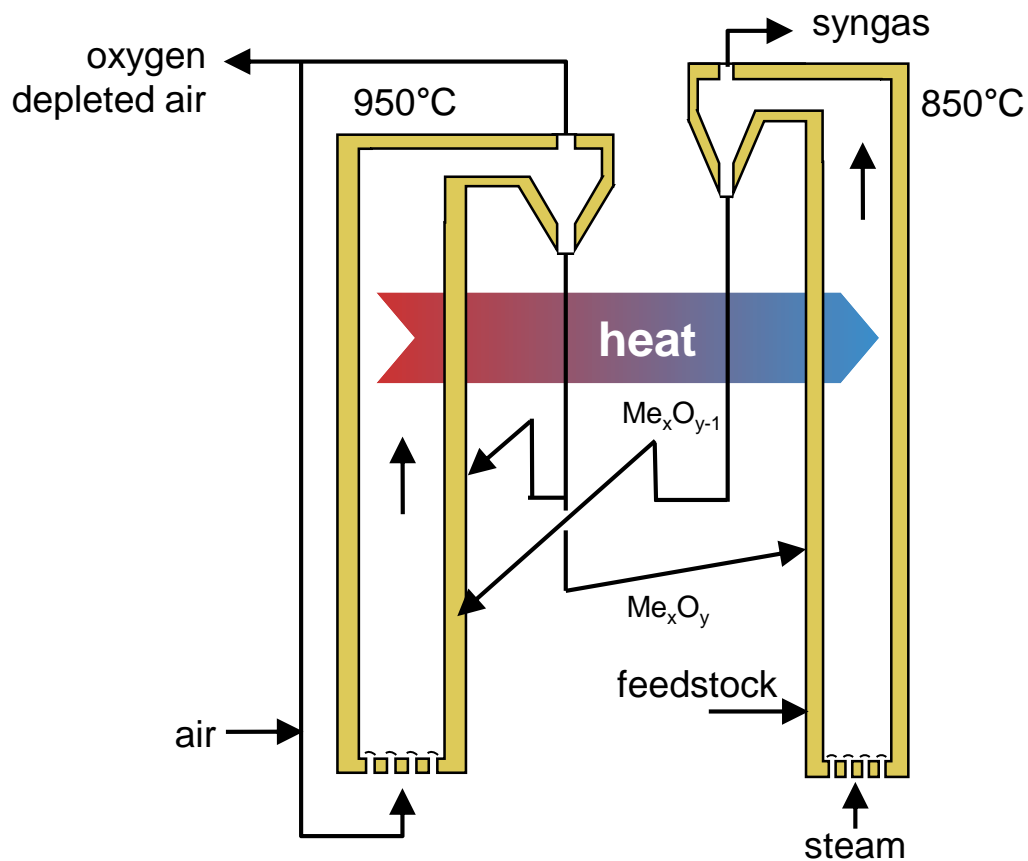
## Results



feedstock	pine forest residue
mass load	83 kg/h
thermal power	425 kW <sub>th</sub>
efficiency*	64 %
lambda	0.33
syngas	200 Nm <sup>3</sup> /h

- > CO<sub>2</sub> is used as a purge for measuring devices and feed supply
- > validation of models through test data
- > \*cold gas efficiency: chemical energy syngas/ thermal input
  - pilot scale: 64%
  - industrial scale: 81% (upscaled models)

## Chemical looping gasification



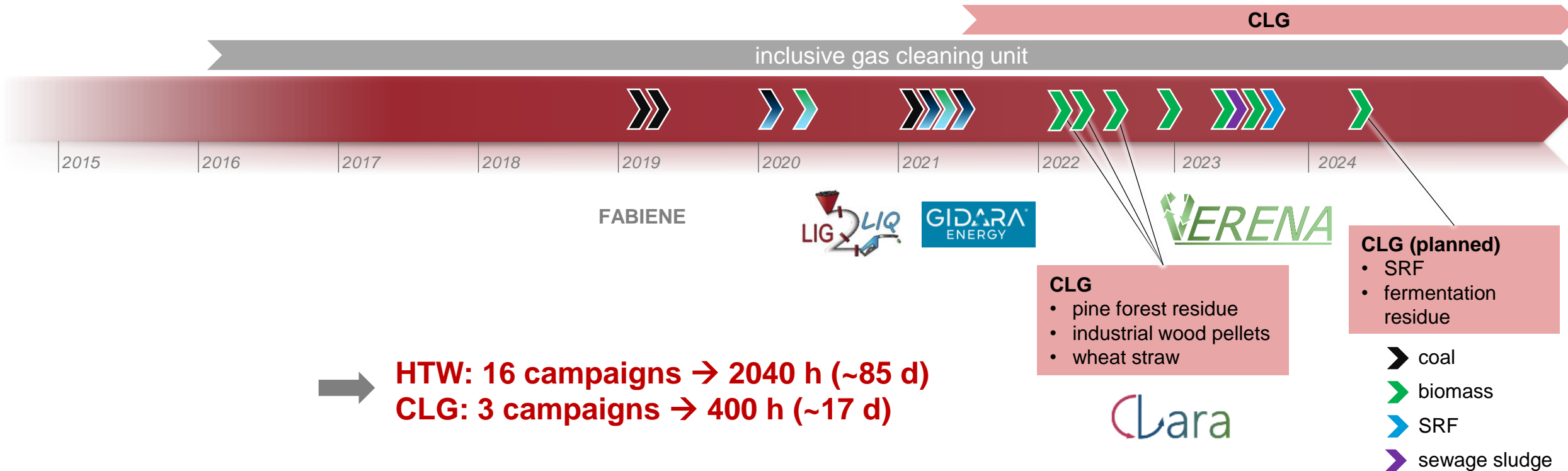
# Chemical looping gasification @EST


**CSIC**  
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

1.5 kW<sub>th</sub> and 50 kW<sub>th</sub>

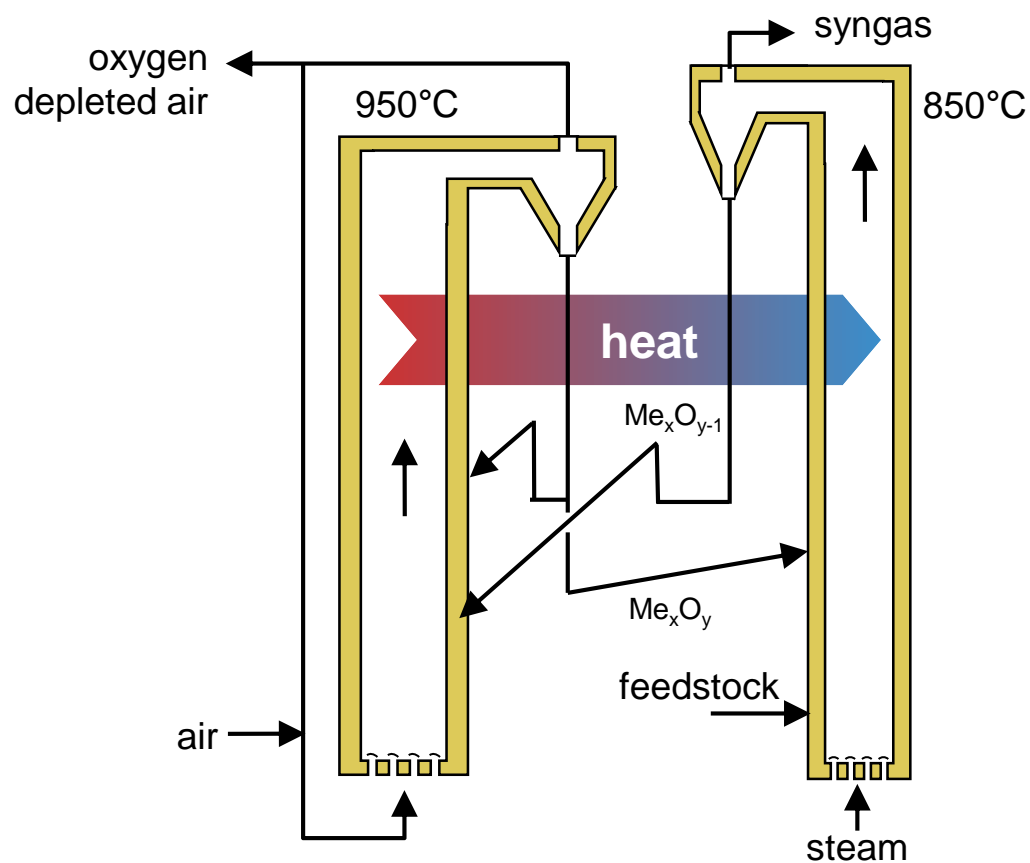

**CHALMERS**  
UNIVERSITY OF TECHNOLOGY

10 kW<sub>th</sub> and 100 kW<sub>th</sub>





## Results



industrial wood pellets



pine forest residue pellets



wheat straw pellets

- > 100 t of biomass converted to syngas
- > 150 h of operation with sub-stoichiometric process control
- 800 Nm<sup>3</sup>/h of syngas
- ~40% of hydrogen and carbon monoxide
- 8-12% of C1 and C2

## Outlook

### ✓ **Bubbling bed gasification:**

longterm experience with a wide range of feedstock including

- several types of biomass
- and SRF

### ✓ **Chemical looping gasification**

- Proof of Concept with biomass at pilot scale
- April 2024: test campaign using 100 % SRF and fermentation residues
- more operational experience to be gained

### ⌘ **Techno Economic Assessment of Industrial Scale**

- scale up of validated models to industrial scale
- techno-economical assessment and life cycle assessment

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Energy Systems and Technology

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