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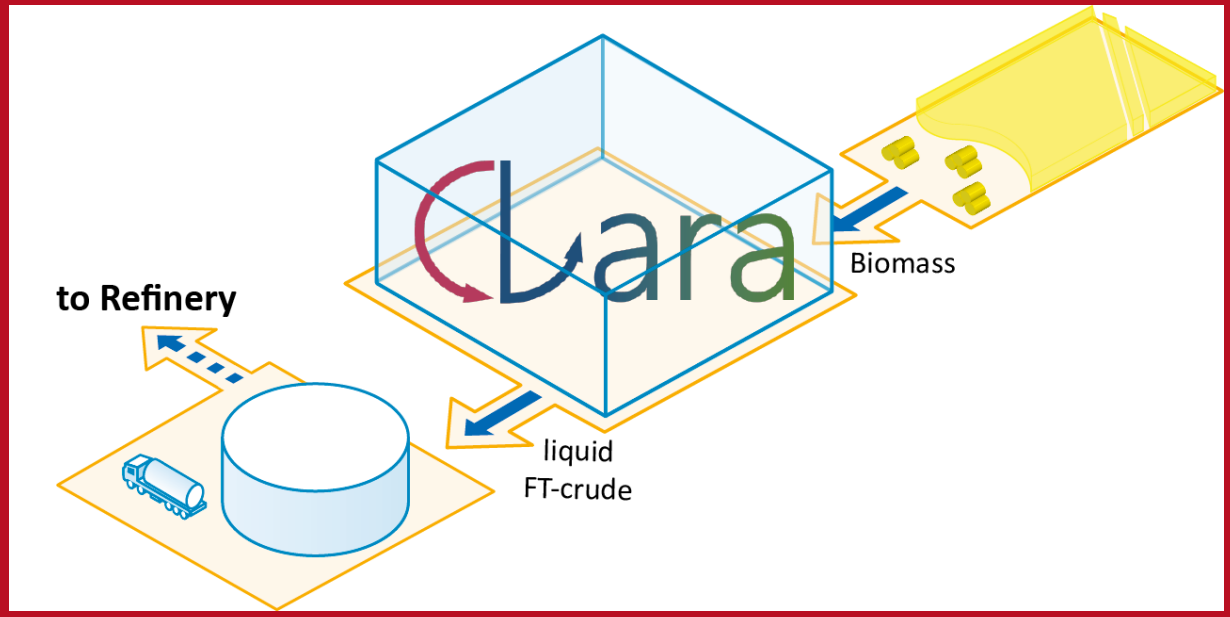
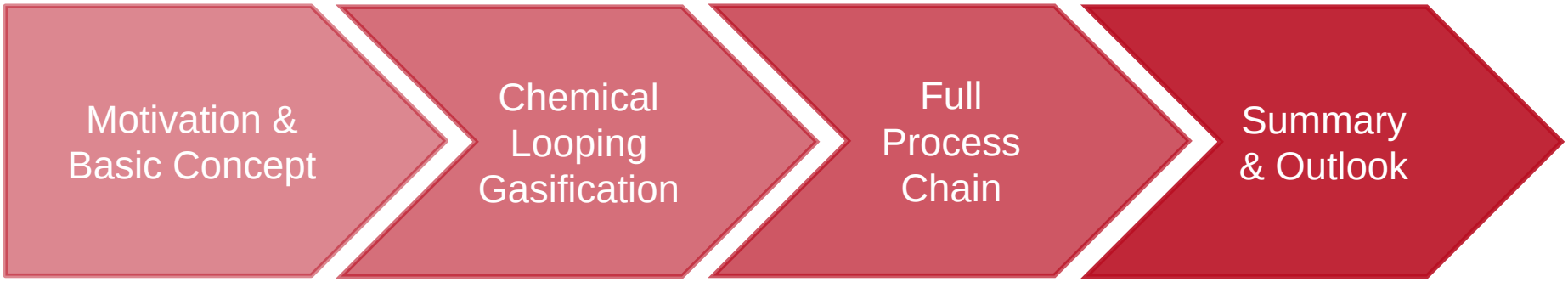
Chemical Looping Gasification – A Novel Process for the Sustainable Production of Biofuels

6. Central European Biomass Conference
Graz, 22.1 - 24.01.2020



Outline

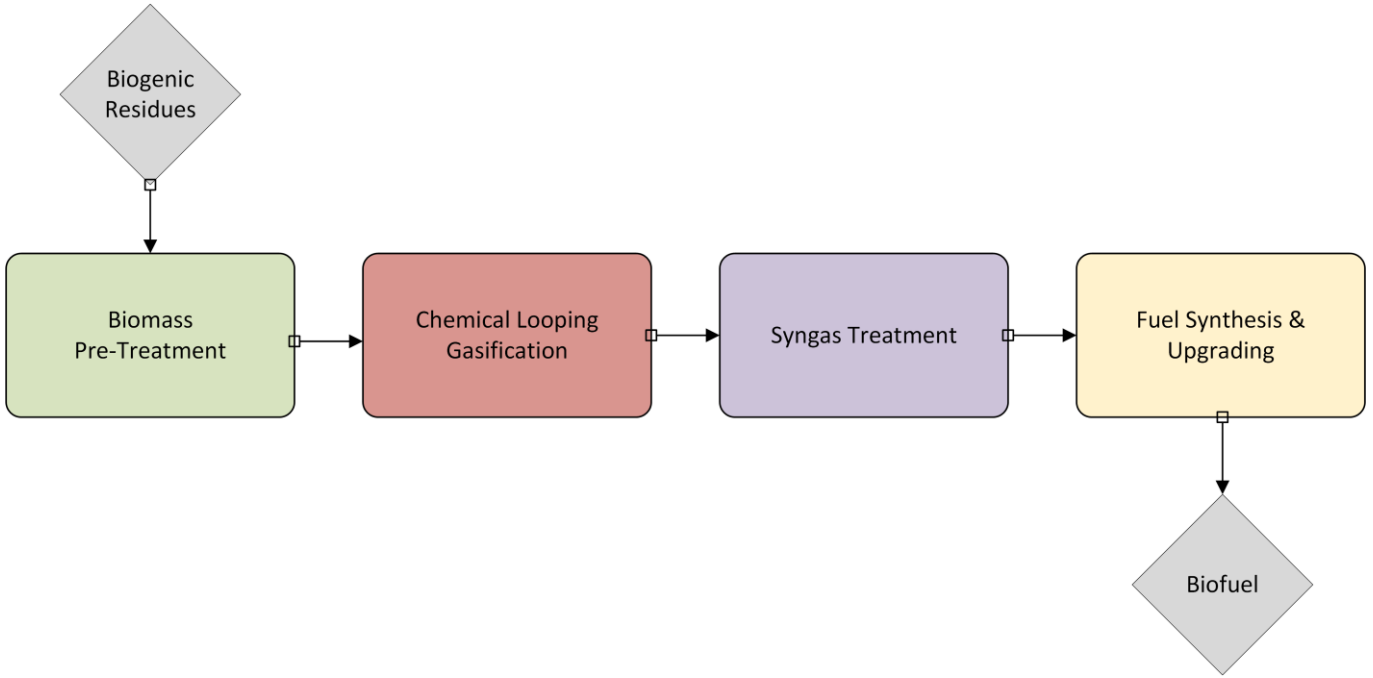

Motivation & Basic Concept
Chemical Looping Gasification
Full Process Chain
Summary & Outlook

Motivation & Concept (I)

- 25 % of European GHGE stem from the transport sector[1]

➢ Profound changes required to reach climate targets

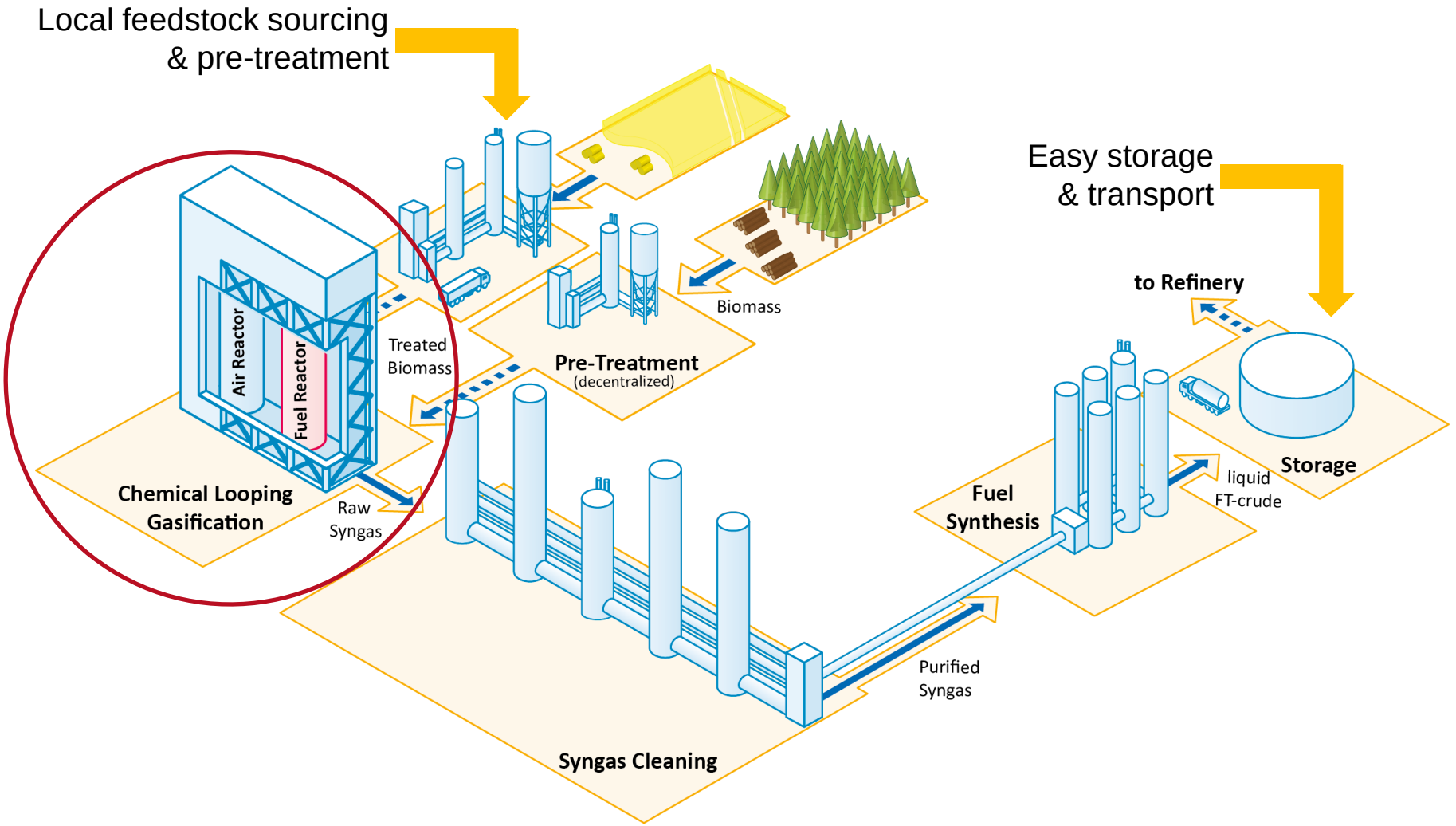
- Novel biomass-to-biofuel process chain for the production of 2nd generation biofuels



- Innovative biomass pre-treatment, gasification and syngas treatment concepts

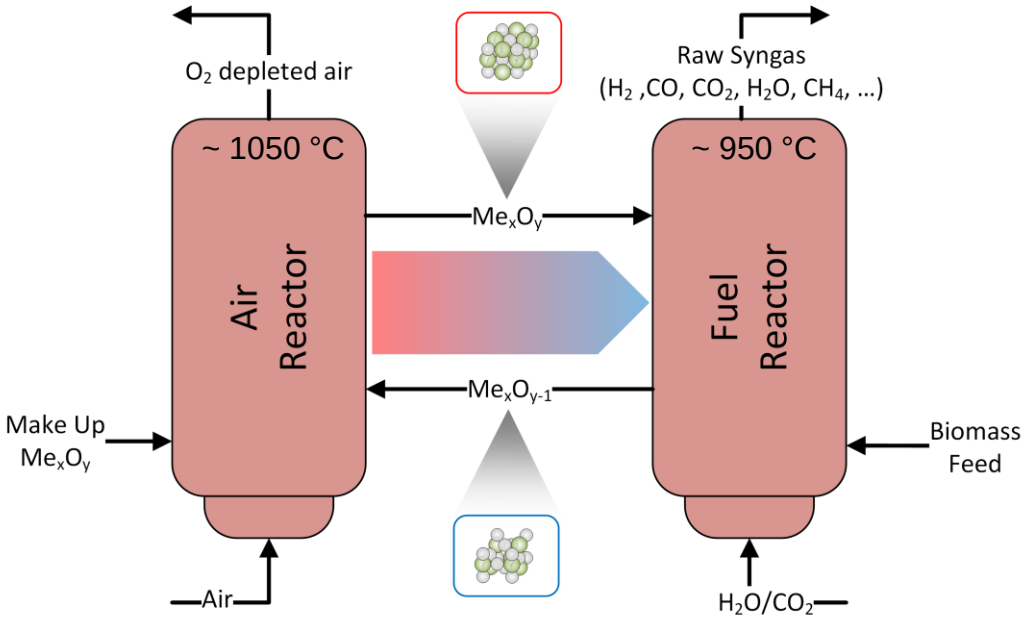
[1]Transport emissions - A European Strategy for low-emission mobility, https://ec.europa.eu/clima/policies/transport_en.

Motivation & Concept (I)



➢ Cost competitive and environmentally compatible fuels for road transport

Chemical Looping Gasification (CLG) - Overview



- Feedstock gasification with H_2O/CO_2 assisted by solid phase oxygen
- Circulation of Me_xO_y for oxygen & heat transport between reactors
  - No air separation required → cost-efficient
  - CO_2 concentrated in syngas → facilitation of net negative CO_2 emissions
  - Tar cracking on Me_xO_y surface
- Oxygen carriers: Fe_2O_3/Fe_3O_4, $Fe_2TiO_5/FeTiO_3$
- Low λ (~0.3 - 0.5) to achieve partial fuel oxidation → formation of synthesis gas

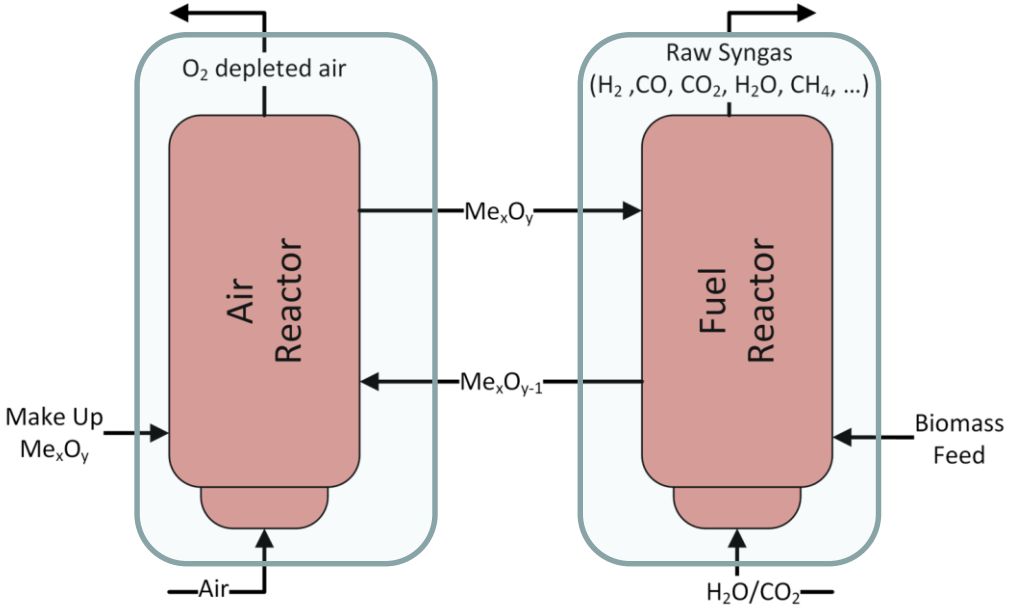
Chemical Looping Gasification (CLG) - Reactions

- **AR** (T~ 1050 °C)
  - re-oxidation of oxygen carrier

$$Me_xO_{y-1} + 0.5\ O_2 \rightarrow Me_xO_y$$

  - Combustion of unconverted char

$$C + O_2 \rightarrow CO_2$$



- **FR** (T~ 950 °C)
  - Gasification of biomass

$$C + CO_2 \rightarrow 2\ CO$$

$$C + H_2O \rightarrow\ CO + H_2$$

  - Heterogeneous Me_xO_y – gas reactions

$$4\ Me_xO_y + CH_4 \rightarrow 4\ Me_xO_{y-1} + 2\ H_2O + CO_2$$

$$Me_xO_y + CH_4 \rightarrow Me_xO_{y-1} + 2\ H_2 + CO$$

$$Me_xO_y + CO \rightarrow Me_xO_{y-1} + CO_2$$

$$Me_xO_y + H_2 \rightarrow Me_xO_{y-1} + H_2O$$

  - Tar cracking

e.g. $C_8H_{18} \rightarrow C_3H_6 + C_5H_{12}$

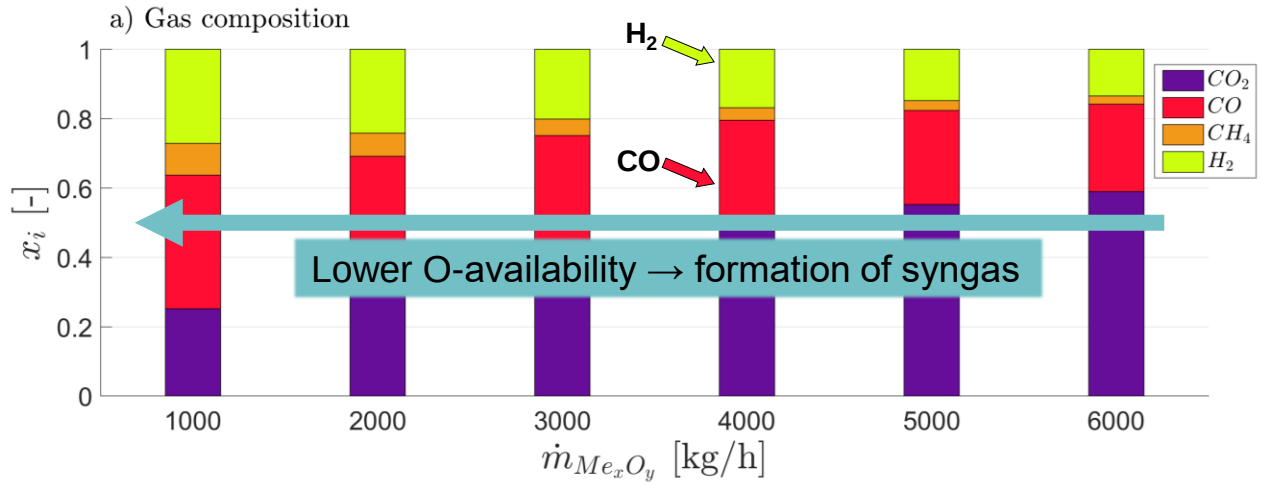
  - Water gas shift reaction

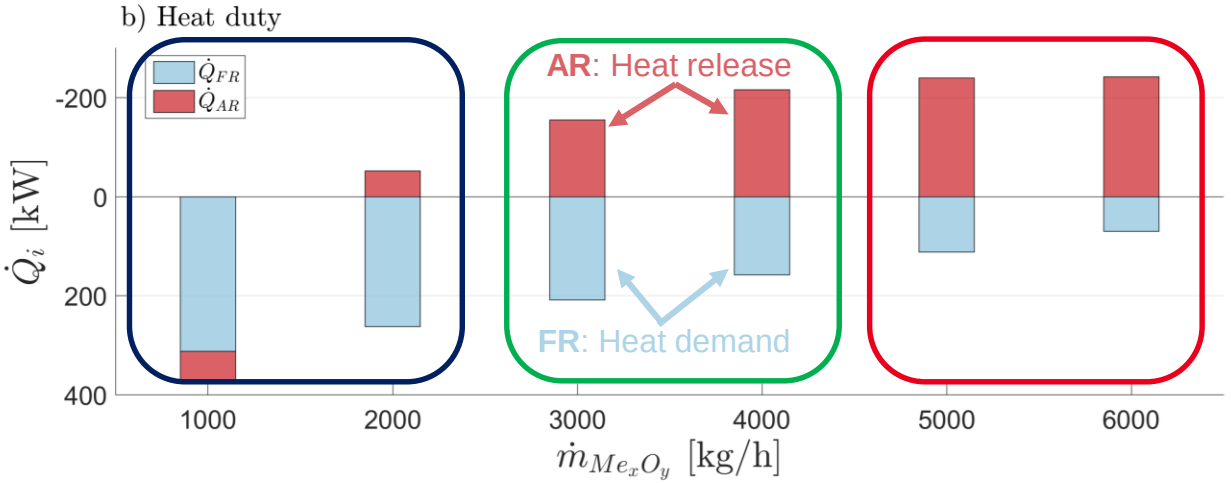
$$CO + H_2O \leftrightarrow H_2 + CO_2$$

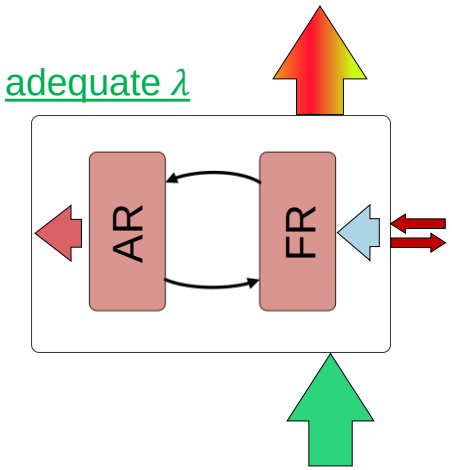
➢ Continuous conversion of feedstock to syngas without N_2-dilution

Chemical Looping Gasification (CLG) – Mode of Operation (I)

- Control of heat & oxygen transport through circulation rate of Me_xO_y







➢ Reactors **not** in heat balance!

➢ Challenge: achieving adequate λ **and** sufficient heat transport

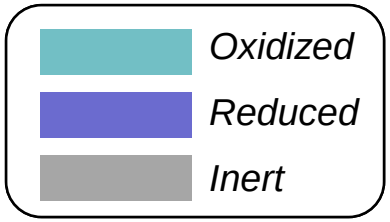
Chemical Looping Gasification (CLG) – Mode of Operation (II)

- Challenge: achieving adequate λ, while guaranteeing sufficient heat transport

a. Adjustment of reactor temperature gradient

- Decrease T_{FR} to **increase** specific **sensible heat transport**

FR:  AR: 



b. Selection of alternative oxygen carrier materials

- Me_xO_y exhibiting **low O-transport capacity & high c_p**

FR:  AR: 

c. Decoupling of heat and oxygen transfer

- I: **Dilution** of Me_xO_y **with inert solid** (e.g. Olivine)

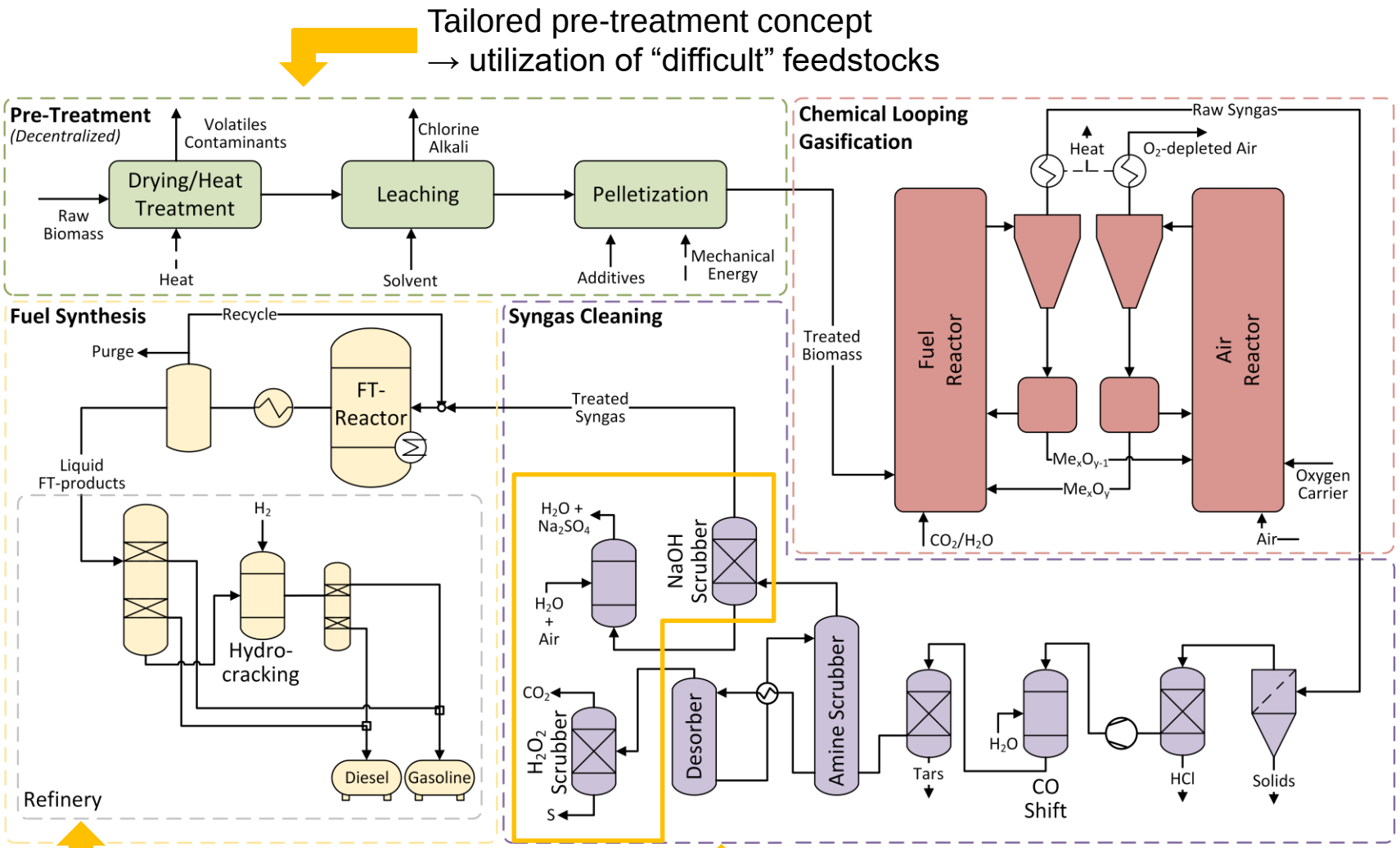
FR:  AR: 

- II: Operation of **AR in O_2 deficient atmosphere**

FR:  AR: 

➢ Different approaches are currently being investigated

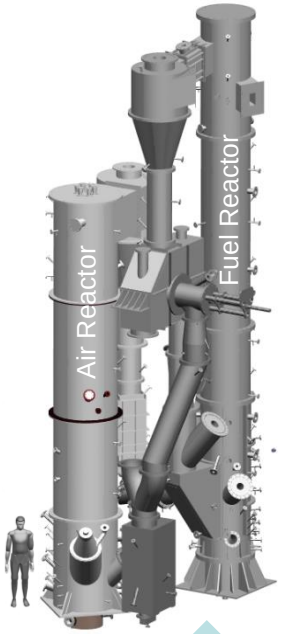
Full Process Chain



Summary & Outlook

- Novel biomass-to-biofuel process chain for second generation biofuels
- Innovative pre-treatment, gasification and syngas treatment concepts
- Investigation of full process in 1 MW_{th} pilot scale

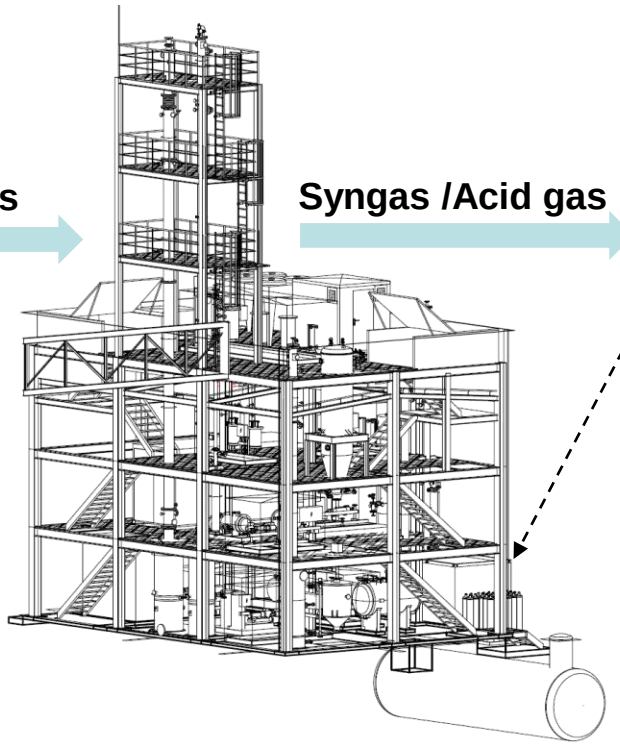
CLG plant (TUDA)



Feedstock pellets

Raw gas

Gas treatment plant (TUDA)



Syngas /Acid gas

Gas cleaning test rig (RWE)

Syngas

FT-synthesis test rig (RWE)

liquid FT-products

Consortium & Funding

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Thank you for your attention!