



**Energy Systems
and Technology**
Prof. Dr.-Ing. B. Epple

Otto-Berndt-Str. 2
64206 Darmstadt / Germany
Phone: +49 6151 16 23002
www.est.tu-darmstadt.de



TECHNISCHE
UNIVERSITÄT
DARMSTADT

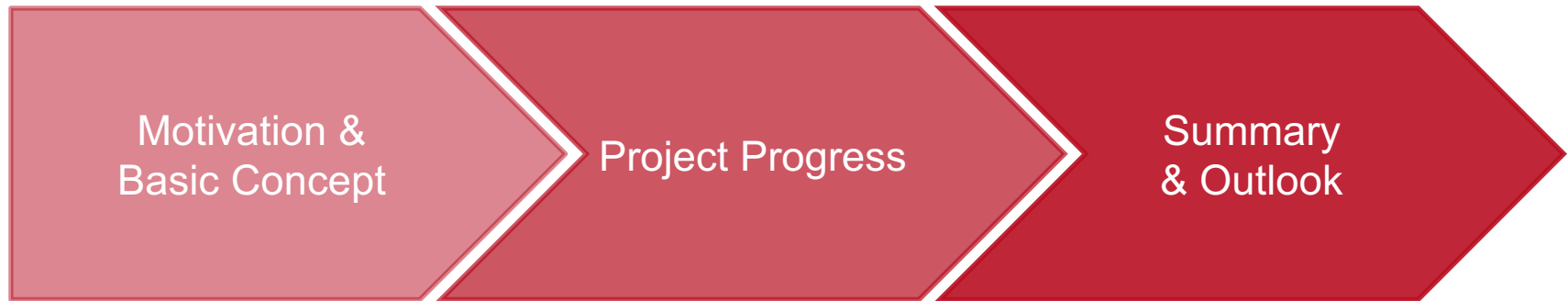
CLARA - Chemical looping gasification for sustainable production of biofuels



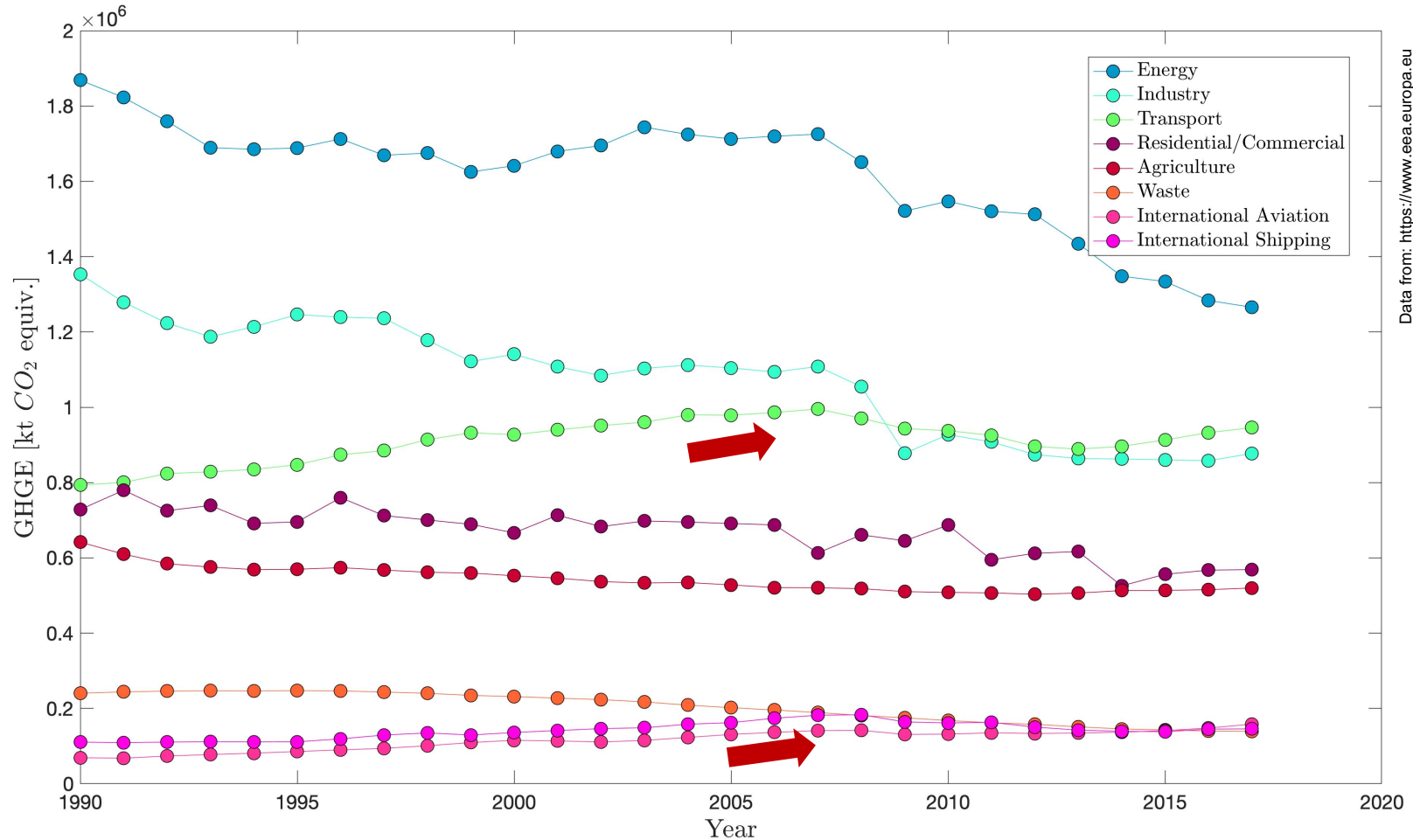
**Gasification - a key technology in the energy transition and for the circular
economy - Workshop**

2nd Dec. 2021





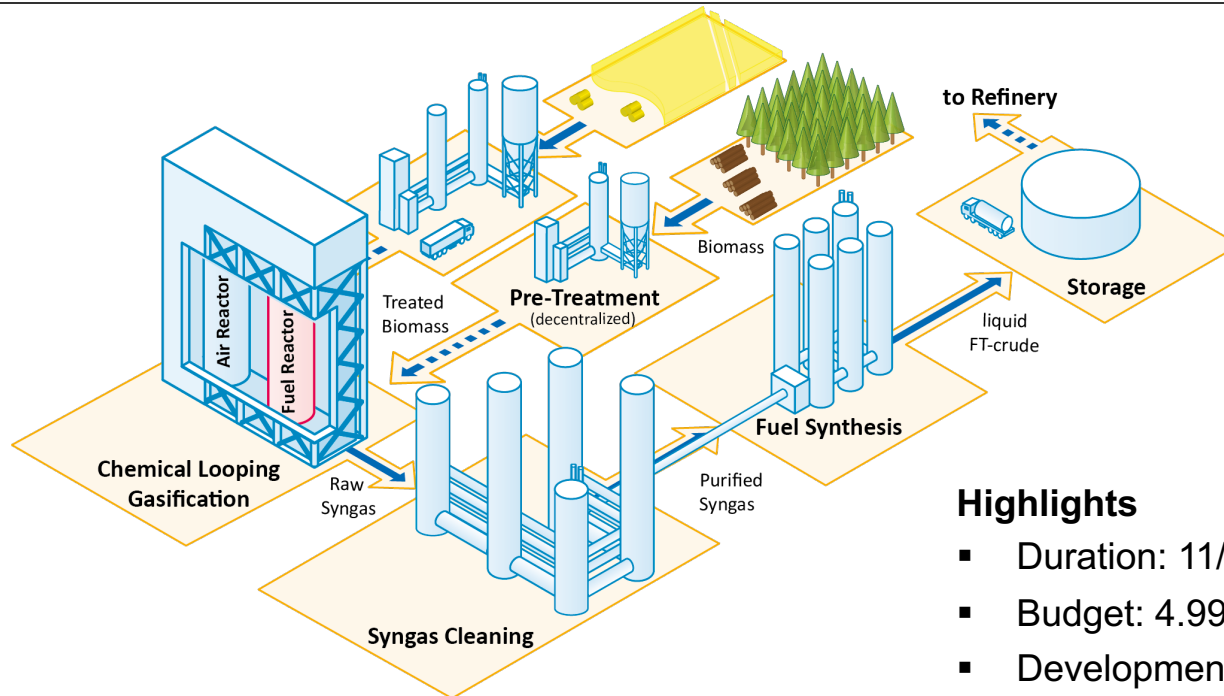
Motivation – GHG in Transport



Data from: <https://www.eea.europa.eu>

- Transport/shipping sectors is a “problem child” in terms of GHGE in the EU

Motivation - Project Overview

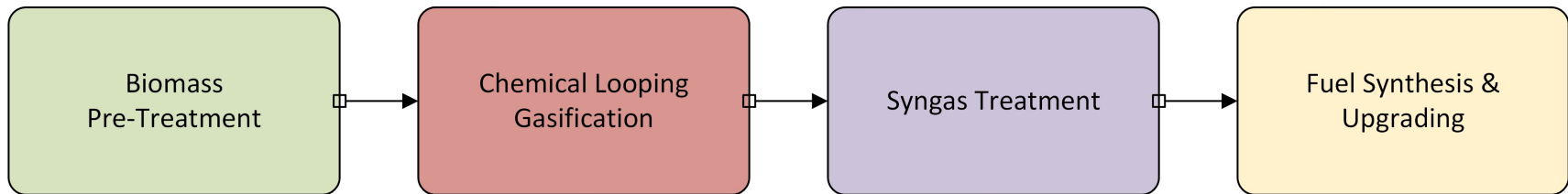


Highlights

- Duration: 11/2018 – 03/2023
- Budget: 4.99 M€
- Development of concept for production of 2nd generation biofuels based on chemical looping gasification of biogenic residues
- Advancement of novel gasification, pre-treatment and gas cleaning technologies
- Scale-up of all associated technologies to 200 MW_{th}
- Technical, socio-economic, and environmental investigation of full process chain, allowing for net-negative CO₂ emissions

Key Performance Indicators	Target
Carbon utilization	> 33 %
Energetic fuel efficiency	> 55 %
Fuel cost	< 0.7 €/l
CO ₂ emissions	< 0
Cold gas efficiency	> 82 %
Carbon conversion	> 98 %

Optimization based on requirements of down-stream unit

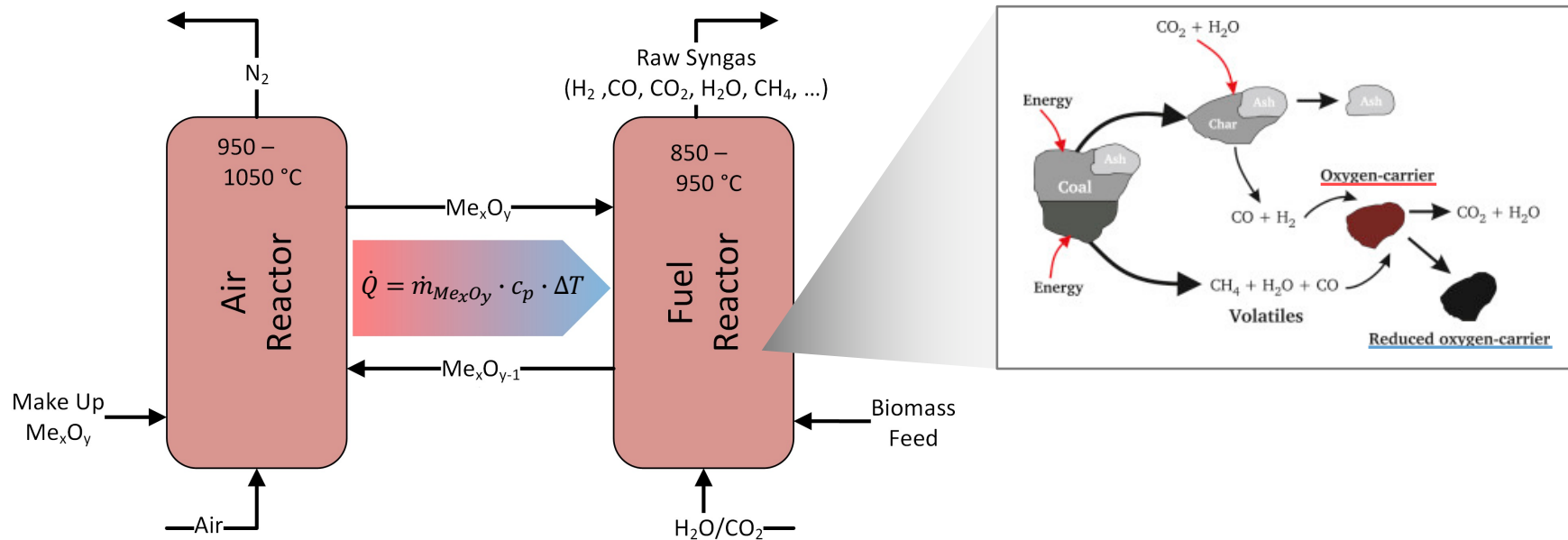


Optimization based on overall process requirements



Efficient and cheap production on 2nd generation biofuels.

Concept – Chemical Looping Gasification



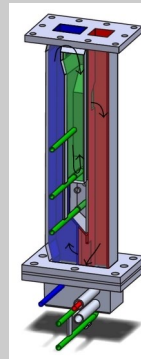
- Feedstock gasification with H₂O/CO₂ assisted by solid phase oxygen
- Circulation of Me_xO_y for oxygen & heat transport between reactors
 - No air separation required → cost-efficient
 - CO₂ concentrated in syngas → facilitation of net negative CO₂ emissions
 - Tar cracking/conversion on Me_xO_y surface
- Oxygen carriers: Fe₂O₃/Fe₃O₄, Fe₂TiO₅/FeTiO₃
- Low λ (~0.3 - 0.5) to achieve partial biomass oxidation → formation of synthesis gas

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

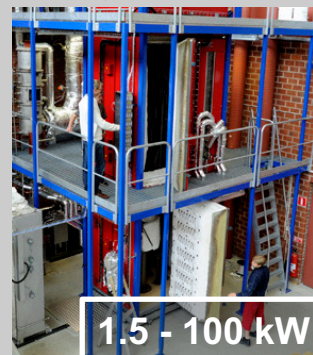
Biomass Pre-Treatment



Chemical Looping Gasification

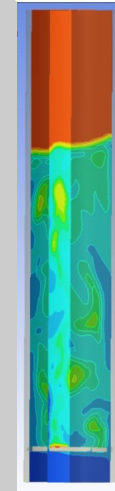


300 W



Gas Cleaning

Concept



Lab-Tests



Demonstration

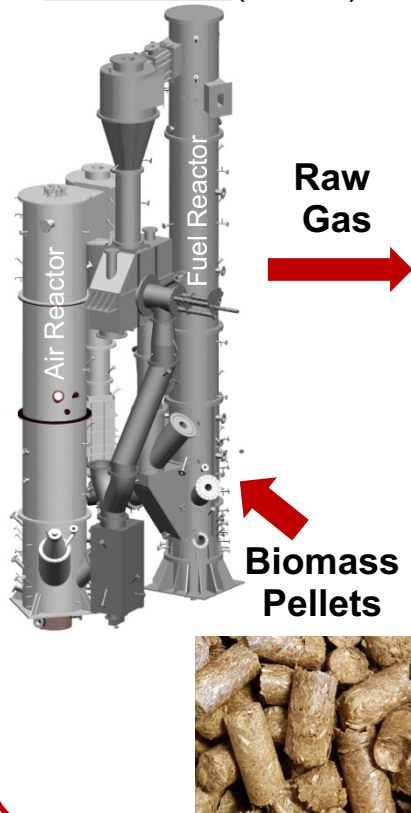


Project Progress - 1 MW Full-Chain Tests

- Investigation of full process in 1 MW_{th} pilot scale at TUDA
- Industry-like conditions for pre-treatment, gasification & gas cleaning concepts

TUDA Site

CLG Plant (TUDA)



Gas Treatment Plant (TUDA)



Sour Gas



Gas Cleaning Test Rig (RWE)



FT-Synthesis Rig (RWE)

Syngas

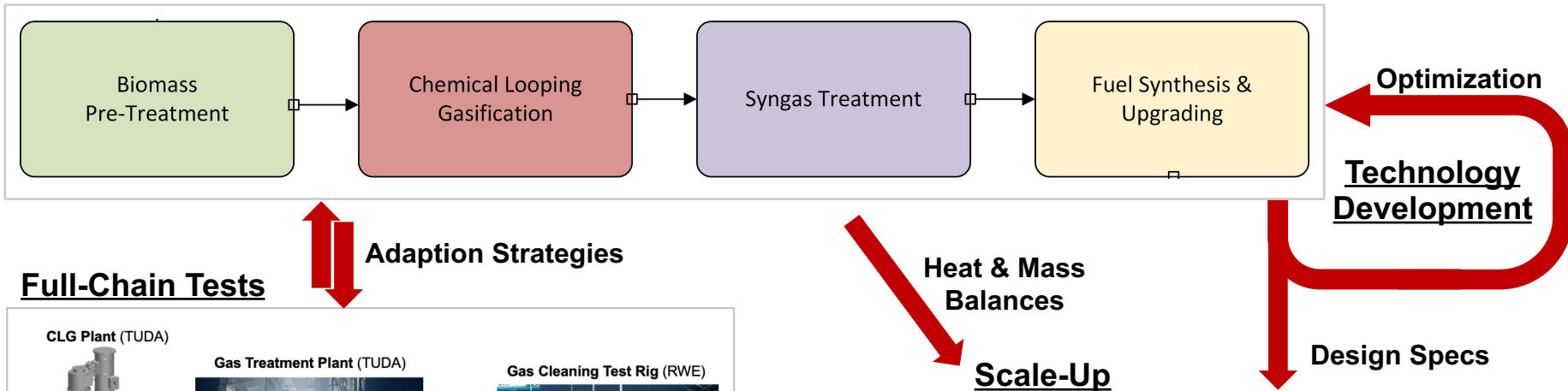


liquid FT-products



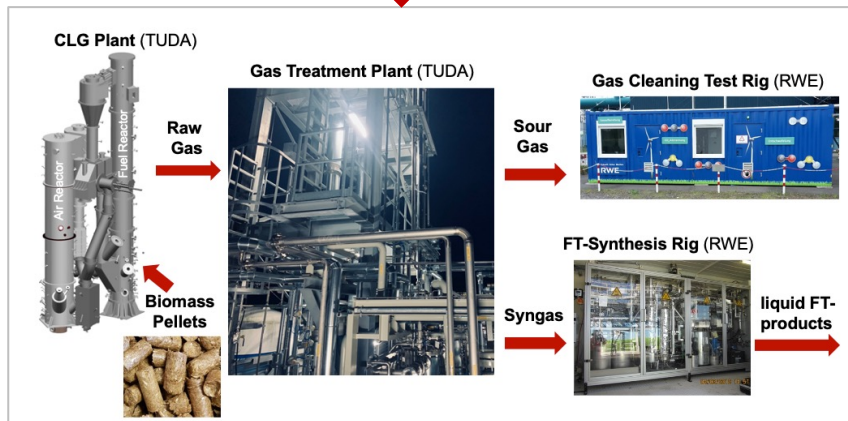
Project Progress - Process Design, Optimization & Scale-Up

Process Design

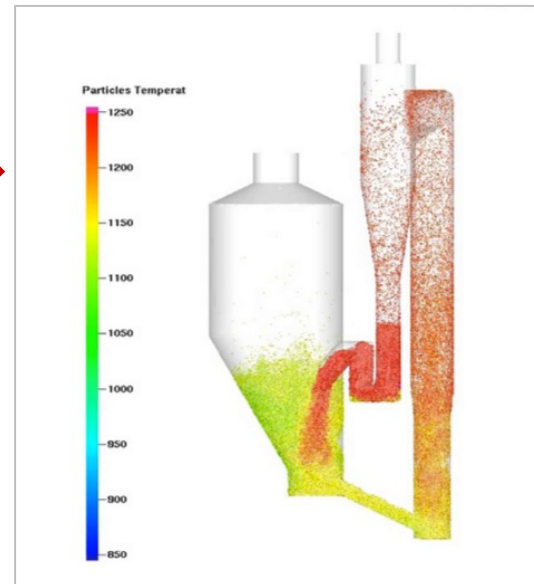


Adaption Strategies

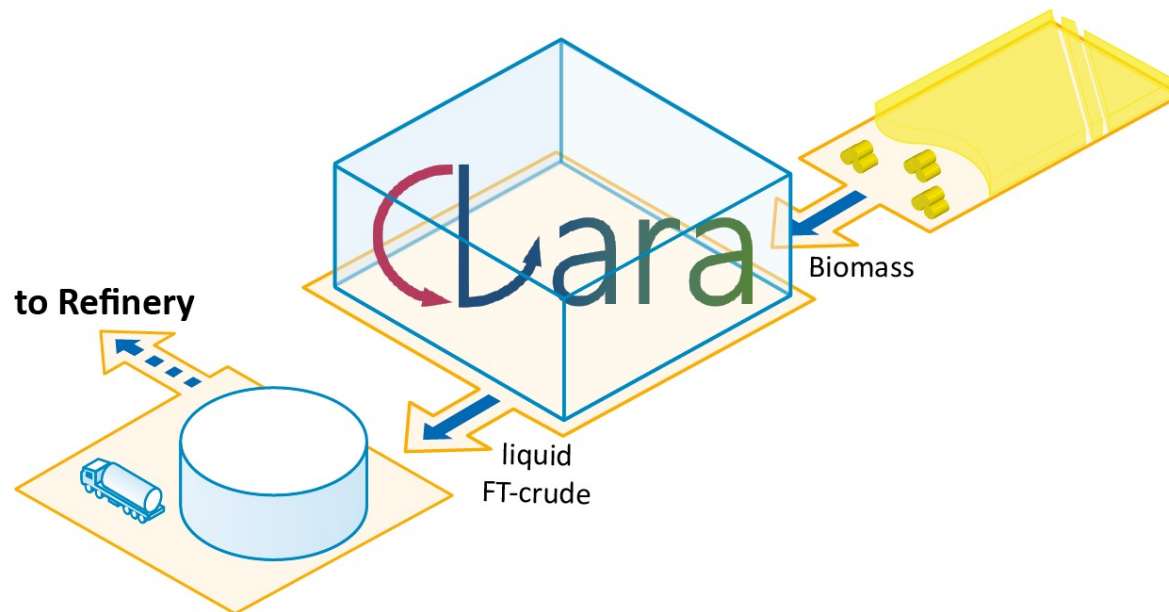
Full-Chain Tests



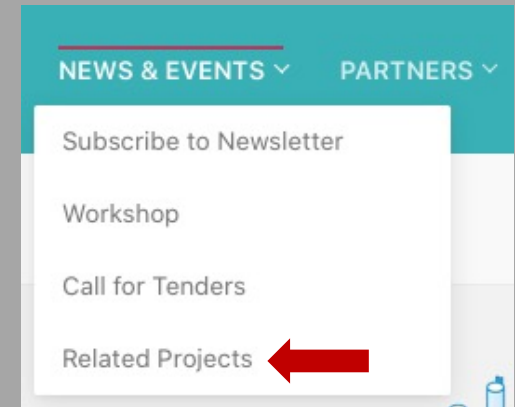
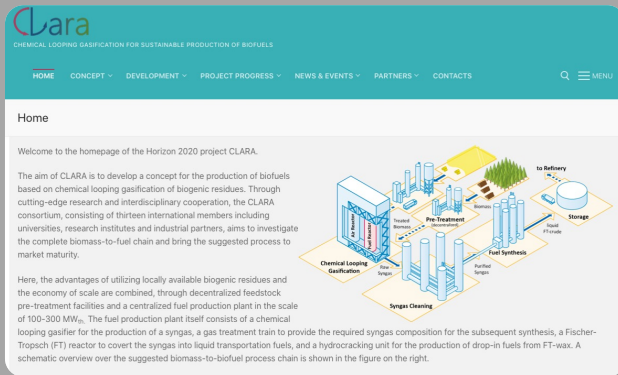
- Scale up of all technologies to 200 MW_{th}
- Technical, socio-economic, and environmental investigation of full process chain incl. risk analysis



- Novel Biomass-to-Liquid (BtL) process chain based on chemical looping gasification
- Individual technologies have been analyzed in lab & pilot scale
- First 1 MW_{th} full-chain test pending (Q1 2022)
- Upscaling of all relevant technologies by Q4 2022
- Techno-economic assessment of entire BtL chain by Q1 2023
- Techno-socio-economic risk evaluation of all technologies by Q1 2023



Website



➤ Visit website!

➤ Cross-link your project

Social Media



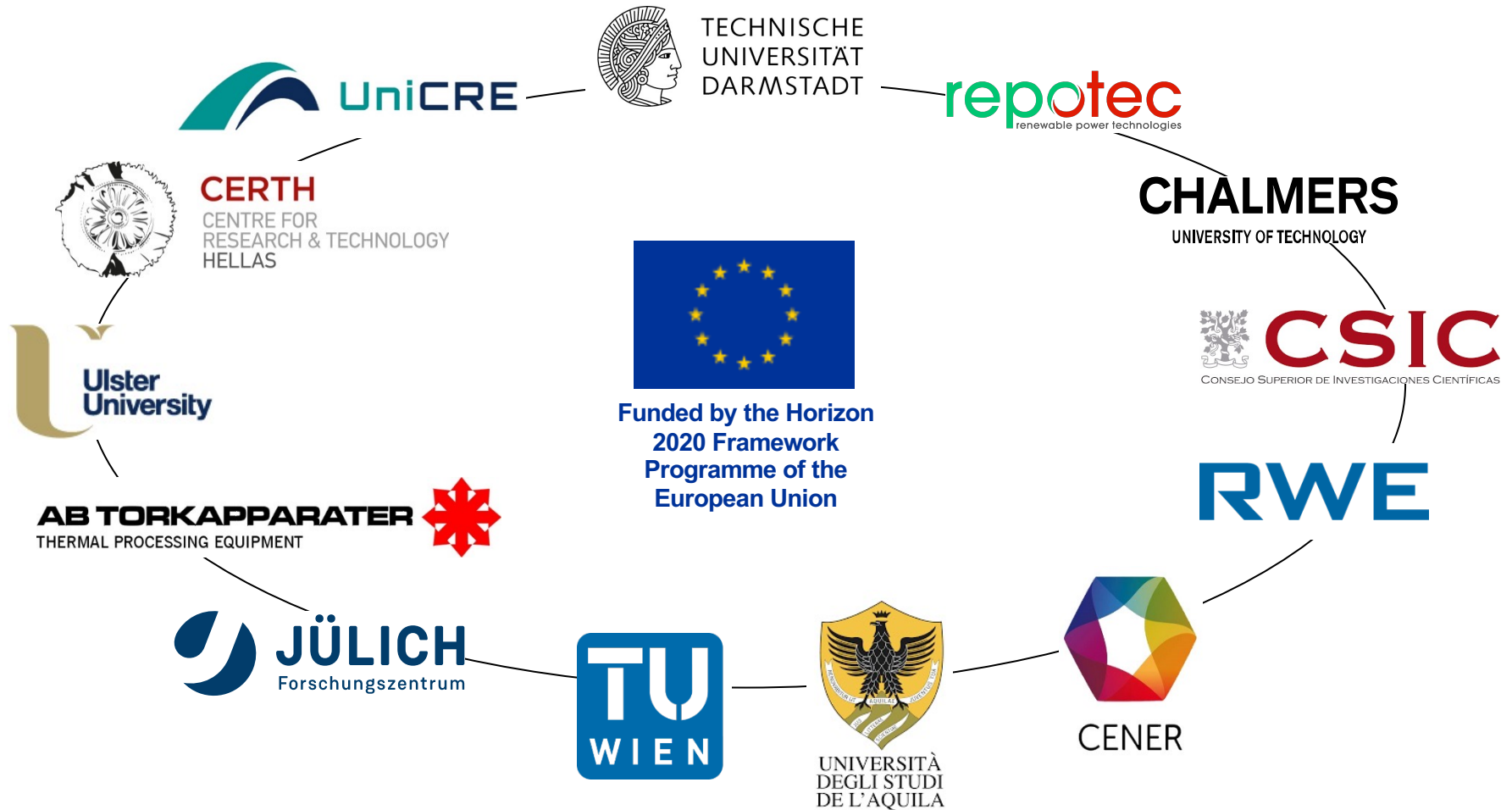
➤ Receive updates on social media!

Newsletters



➤ Read our biannual newsletters

Consortium & Funding



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817841

Thank you for your attention!

