2nd International Conference on Negative CO_2 Emissions

Chalmers University of Technology, Gothenburg, Sweden

June 14-17, 2022

Negative CO_2 Emissions in the Lime Production Using an Indirectly Heated Carbonate Looping Process

Martin N. Greco-Coppi, Carina Hofmann, Jochen Ströhle, Bernd Epple

Technical University of Darmstadt, Institute for Energy Systems & Technology, Otto-Berndt-Str. 2, 64287, Germany

The EST Institute
Darmstadt, Germany

TECHNISCHE UNIVERSITÄT DARMSTADT

- 300 kW_{th} IHCaL pilot plant and corrosion testing facility
- Laboratory and mechanic workshop
- 1 MW_{th} Pilot plant for testing of CO_2-capture und gasification
- Gas cleaning pilot plant
- Fuel and chemicals synthesis facility

Agenda

TECHNISCHE UNIVERSITÄT DARMSTADT

1 Motivation

2 Indirectly Heated Carbonate Looping

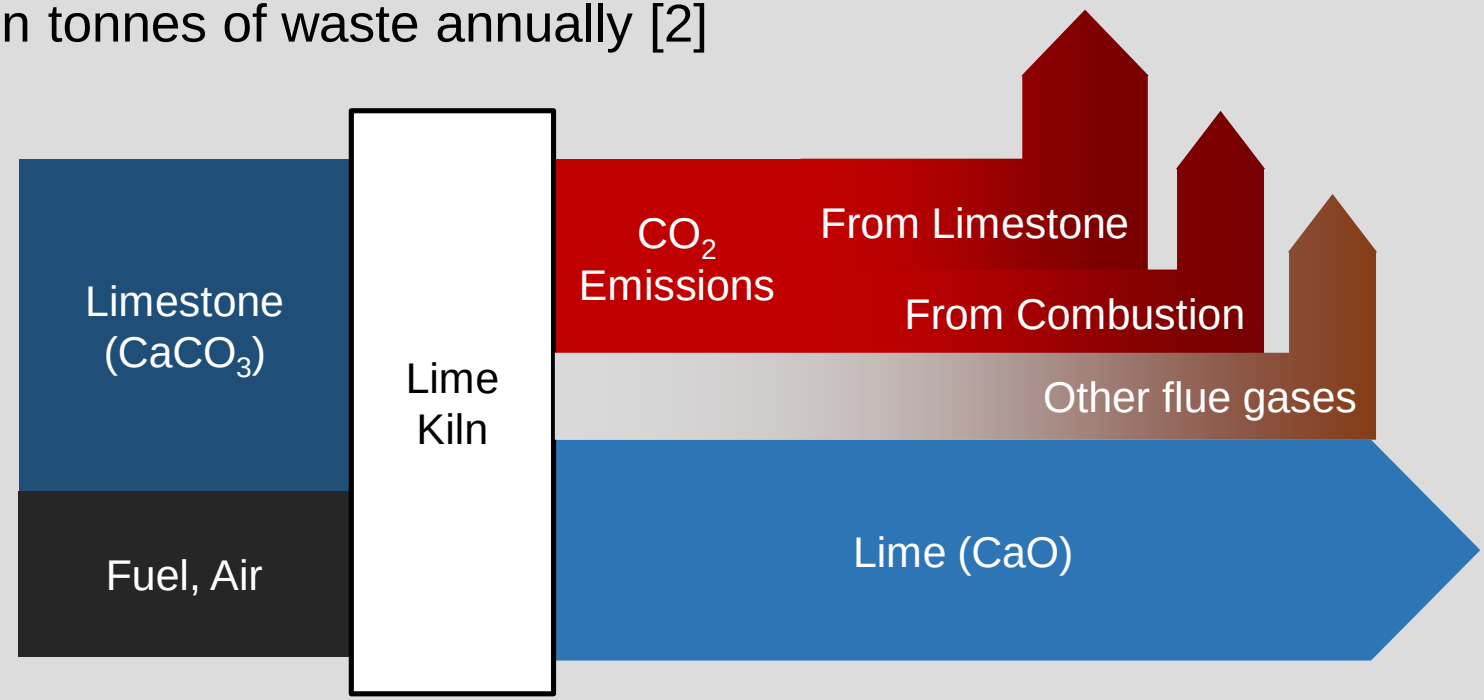
3 Methodology

4 Results

5 Summary and Outlook

1 Motivation

- 50 million tonnes CO_2 annually [1]
- 2 billion tonnes of waste annually [2]

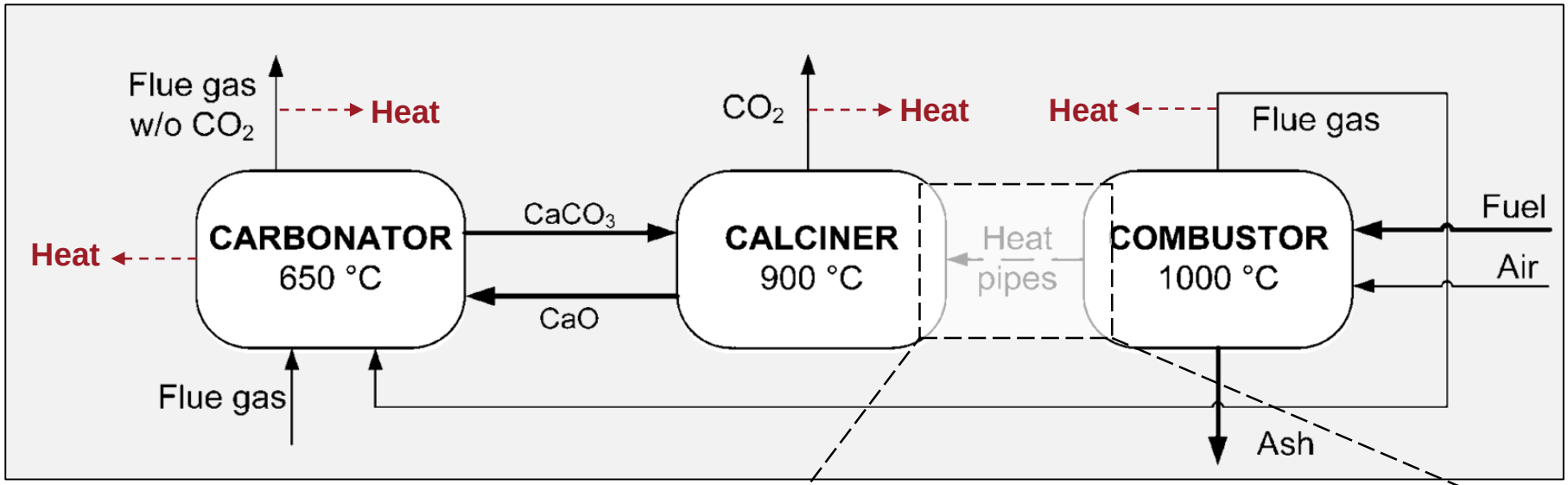


*Mass flow diagram with data form [1]

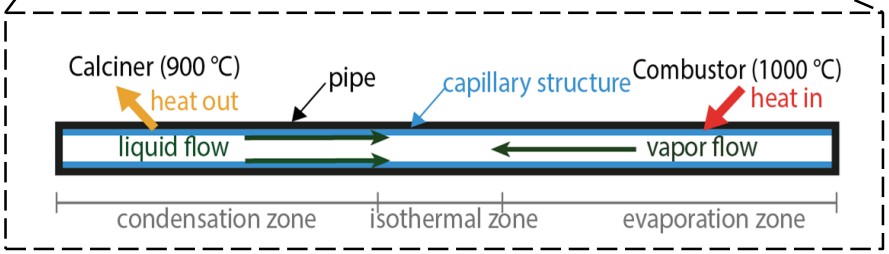
[1] Schorcht et al. *BAT Reference Document for the Production of Cement, Lime and Magnesium Oxide* (2016)
[2] Kaza et al. *What a waste 2.0.* (2018)

2 The IHCaL Process

Indirectly Heated Carbonate Looping



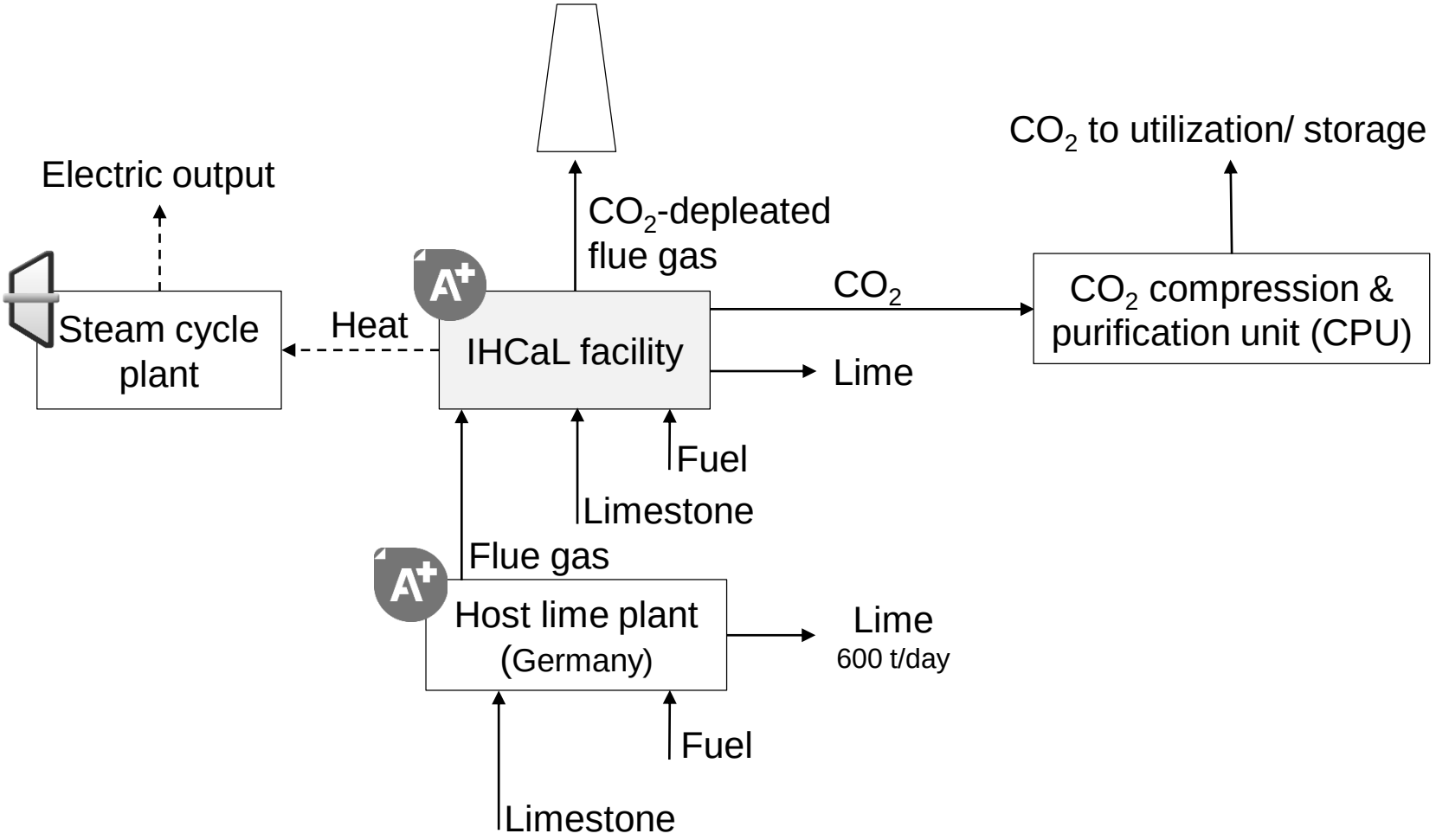
- Technology validated up to 0.3 MW_{th}
- Longer sorbent life
- High efficiency
- Reduced cost - no need of pure O_2
  - Oxy-fired CaL: 26.8 €/t CO_2 [3]
  - Indirectly heated CaL: 22.6 €/t CO_2 [4]



[3] Lyngfelt and Leckner, A 1000 MW_{th} Chemical-Looping Combustor for solid fuels – discussion of design and costs (2014)

[4] Junk et al., *Technical and economical assessment of the indirectly heated carbonate looping process* (2015)

3 Methodology
System Overview



3 Methodology
Fuels

Dried Lignite

- LHV_{wet} = 21.5 MJ/kg
- 96.7 gCO_2/MJ_{LHV}; x_{bio} = 0%

Refuse-Derived Fuel (RDF) Pellets

- LHV_{wet} = 19.6 MJ/kg
- 92.8 gCO_2/MJ_{LHV}; x_{bio} = 51%
- Pilot testing

Solid Recovered Fuel (SRF)

- LHV_{wet} = 15.7 MJ/kg; x_{bio} = 65%
- 88.7 gCO_2/MJ_{LHV}

Municipal Solid Waste (MSW)

- LHV_{wet} = 10.0 MJ/kg; x_{bio} = 65%
- 106.0 gCO_2/MJ_{LHV}

3 Methodology
Key Performance Indicators

TECHNISCHE UNIVERSITÄT DARMSTADT

IHCaL Key Performance Indicator

- Carbon capture efficiency:

$$E = \frac{F_{CO_2}^{captured}}{F_{CO_2}^{total}} = 90\%$$

Thermodynamic Key Performance Indicators

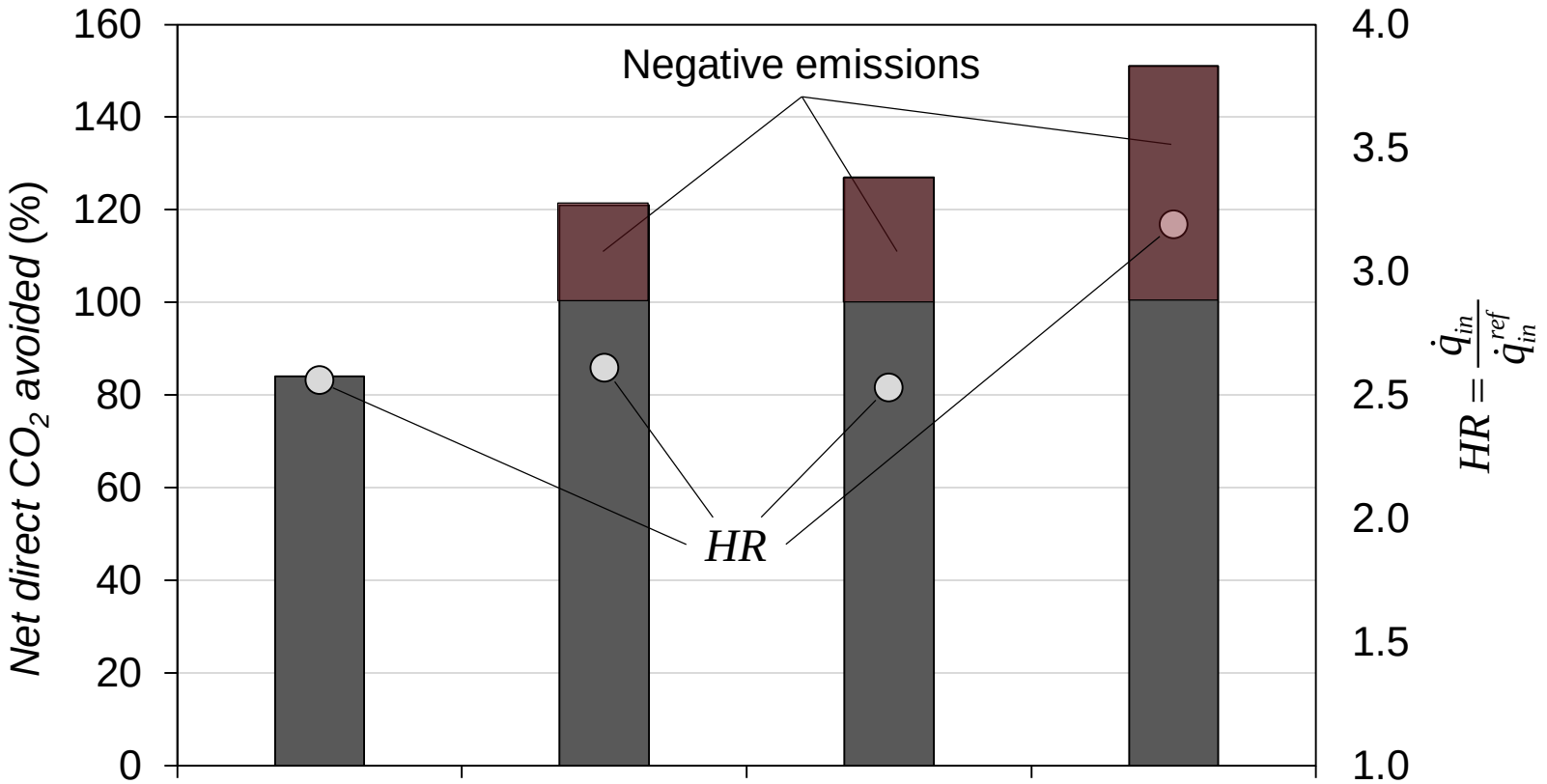
- Net direct CO2 avoided: (influence of biogenic fraction)

$$AC_{net} = 1 - \frac{e_{CO_2} - e_{CO_2,capt,bio}}{e_{CO_2,ref}}$$

- Specific primary energy consumption per kg of CO_2 avoided (SPECCA)

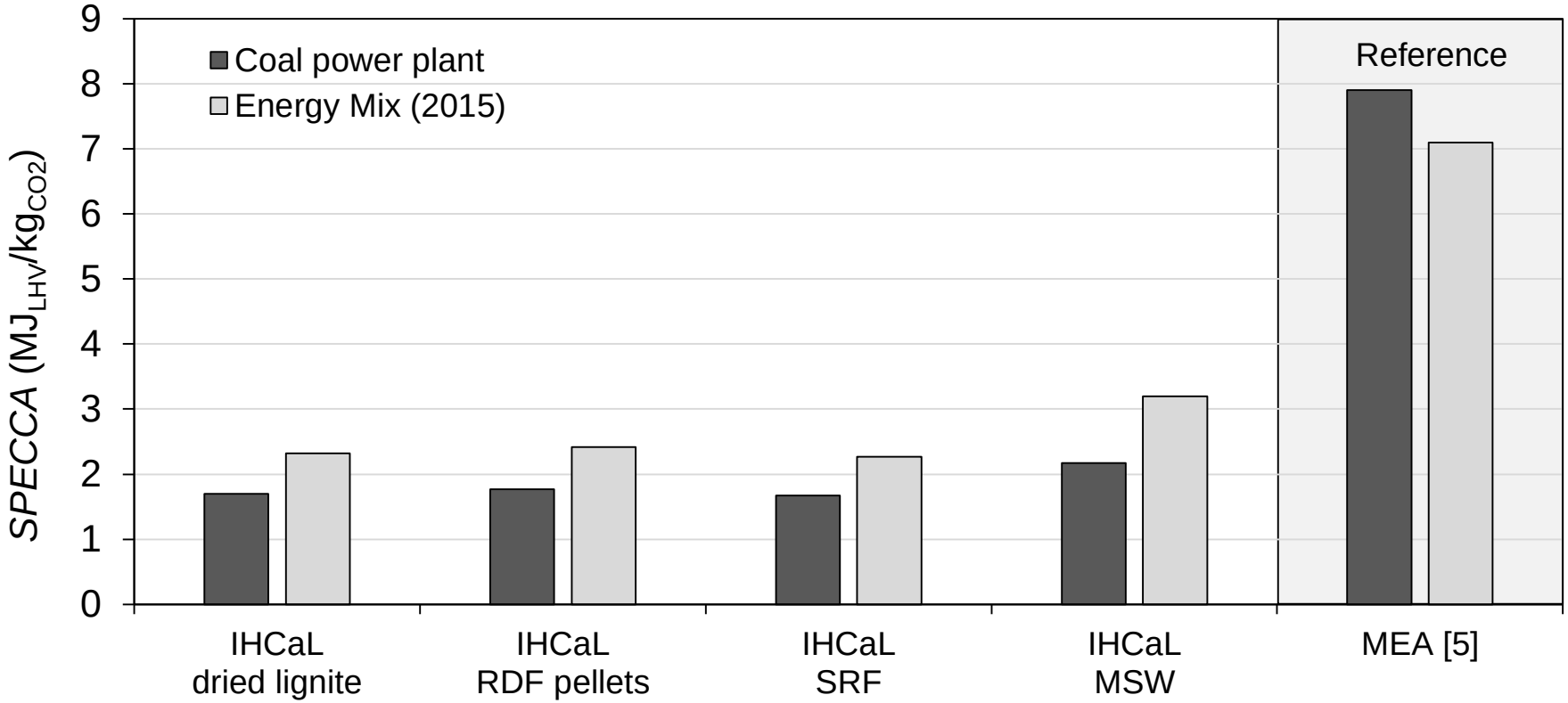
$$SPECCA = \frac{q_{eq} - q_{eq,ref}}{e_{CO_2,ref} - e_{CO_2}}$$

4 Results
Direct Fossil CO_2



No influence of P_{el}

4 Results *SPECCA*



Influenced by P_{el}

[5] M. Voldsund et al. *D4.6 CEMCAP comparative techno-economic analysis of CO2 capture in cement plants* (2019)

5 Summary and Outlook

- Potential for IHCaL
  - Negative emissions
  - Low SPECCA
  - Sorbent integration

Samples from the pilot testing at 300 kW_{th} scale. ® EST Institute, TU Darmstadt.

- Pilot-testing ongoing [6]
  - Pilot (300 kW_{th}) & Long-term (≈ 15 days)
  - Real flue gas and circulation conditions
  - Different sorbents and fuels (SRF)

- Outlook
  - Plant size
  - CAPEX

300 kW_{th} IHCaL pilot testing facility scale. ® EST Institute, TU Darmstadt.

[6] C. Hofmann et al. *Adaption of a 300kWth Pilot Plant for Testing the Indirectly Heated Carbonate Looping Process for CO2 Capture from Lime and Cement Industry* (2022)

Acknowledgements

ANICA

ADVANCED INDIRECTLY HEATED CARBONATE LOOPING PROCESS

https://act-anica.eu/

The work leading to these results has received funding through the ACT program (Accelerating CCS Technologies, Horizon2020 Project No. 294766) within the ANICA project. Financial contributions made from the German Federal Ministry of Economic Affairs and Energy based on a resolution of the German Parliament under grant N°03EE5025, are gratefully acknowledged.

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

Acknowledgements

Thank you for your attention!

Martin N. Greco-Coppi

Institute for Energy Systems and Technology
Technical University of Darmstadt

martin.greco@est.tu-darmstadt.de