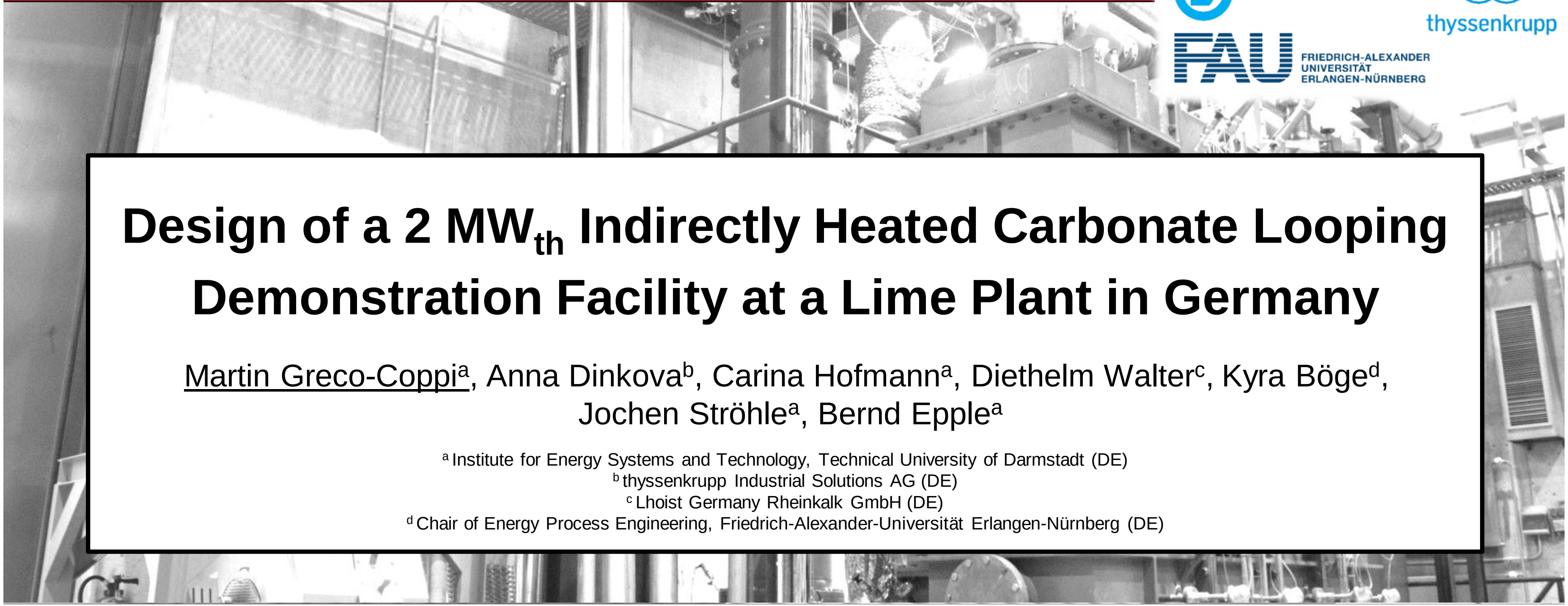
7th Post Combustion Capture Conference

Pittsburgh, PA, USA

September 25 - 27, 2023



Design of a 2 MW_{th} Indirectly Heated Carbonate Looping Demonstration Facility at a Lime Plant in Germany

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The EST Institute
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300 kW_{th} IHCaL **CO_2 capture** pilot plant (2014) and corrosion testing facility

Laboratory and mechanic workshop

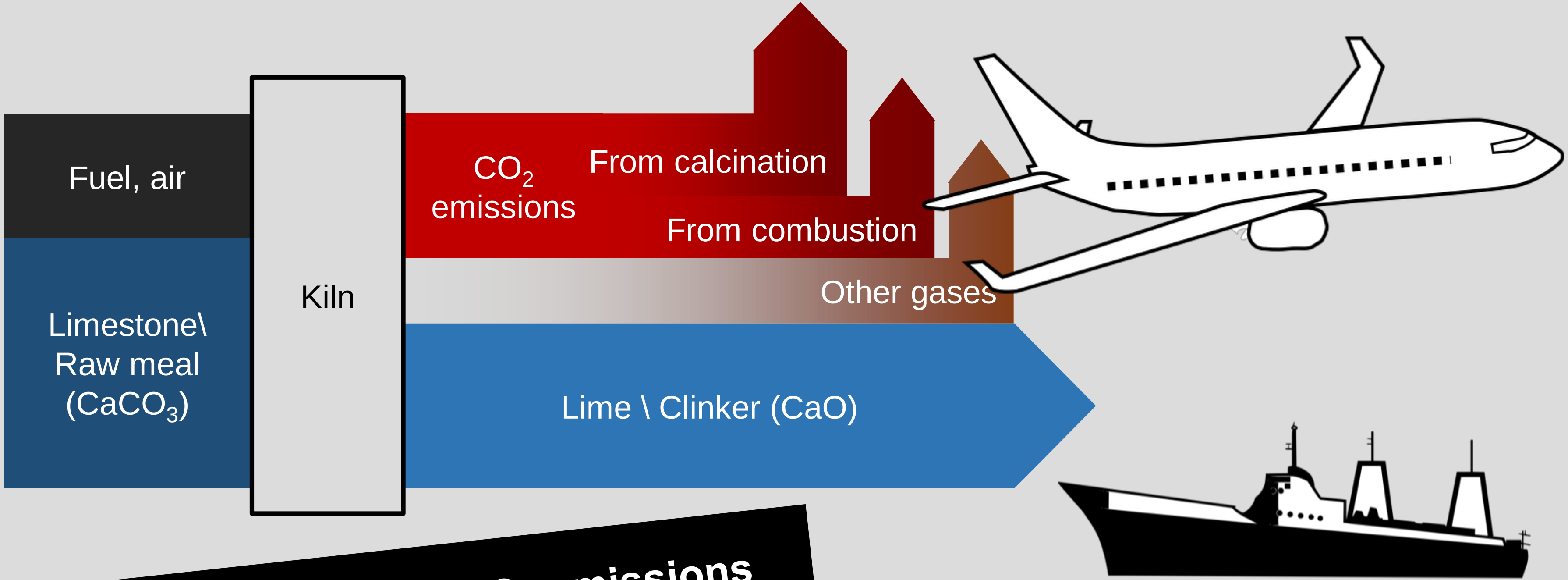
1 MW_{th} pilot plant for **CO_2 capture** and gasification (2010)

Gas cleaning pilot plant with amine scrubbing (2021)

Fuel and chemicals synthesis facility (2021)

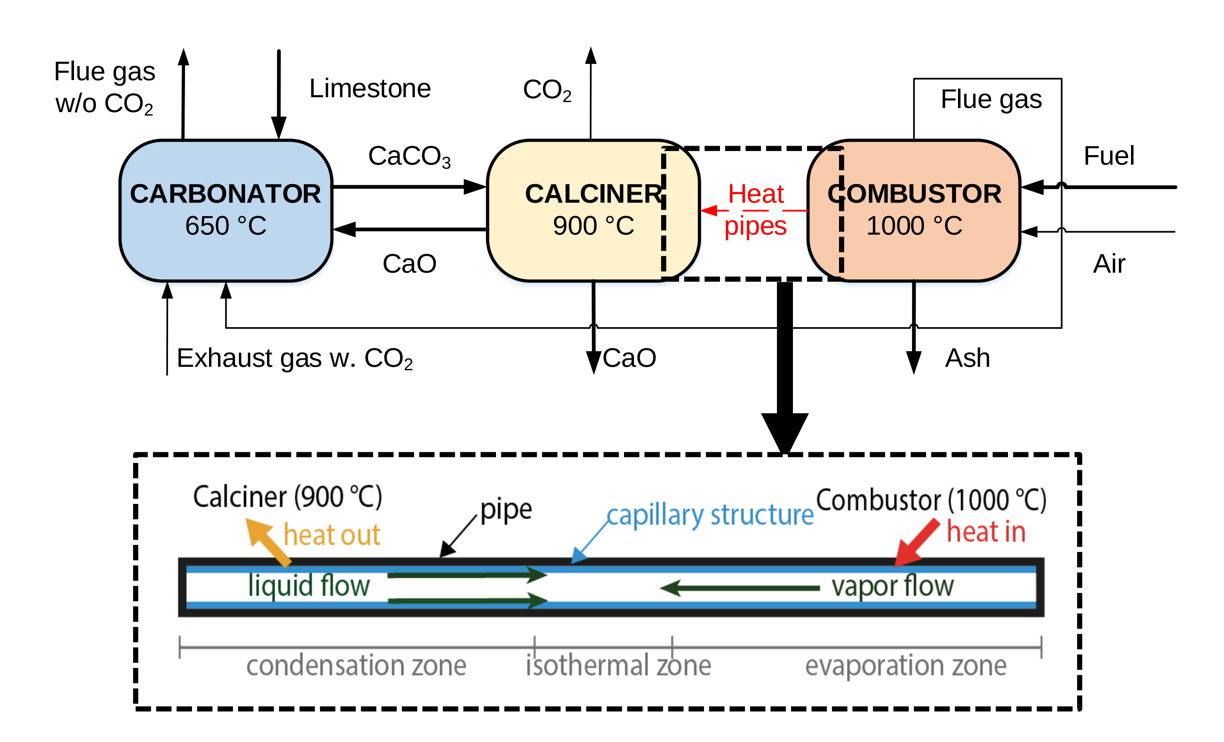
Layout

1 Motivation
The Lime and Cement Industry



8% of global fossil CO_2 emissions

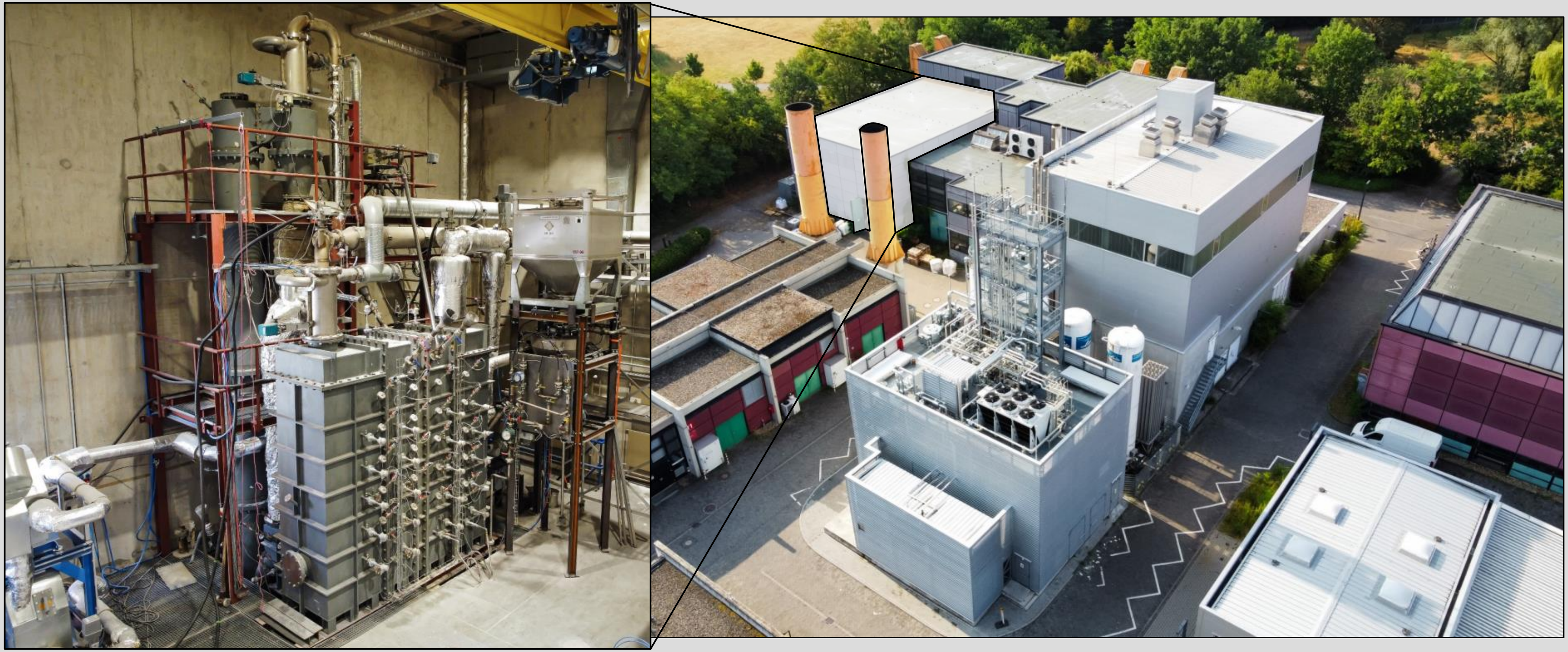
2 Indirectly Heated Carbonate Looping



Indirectly heated Carbonate Looping

- **No air separation unit** is necessary
- **Few impurities** (sulfur, ash, O_2)
- **Synergies** with cement & lime
- **Validated** in the pilot scale: 300 kW_{th}

3 The ANICA Project
Pilot Testing (300 kW_{th})



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Pilot Testing (300 kW_{th})

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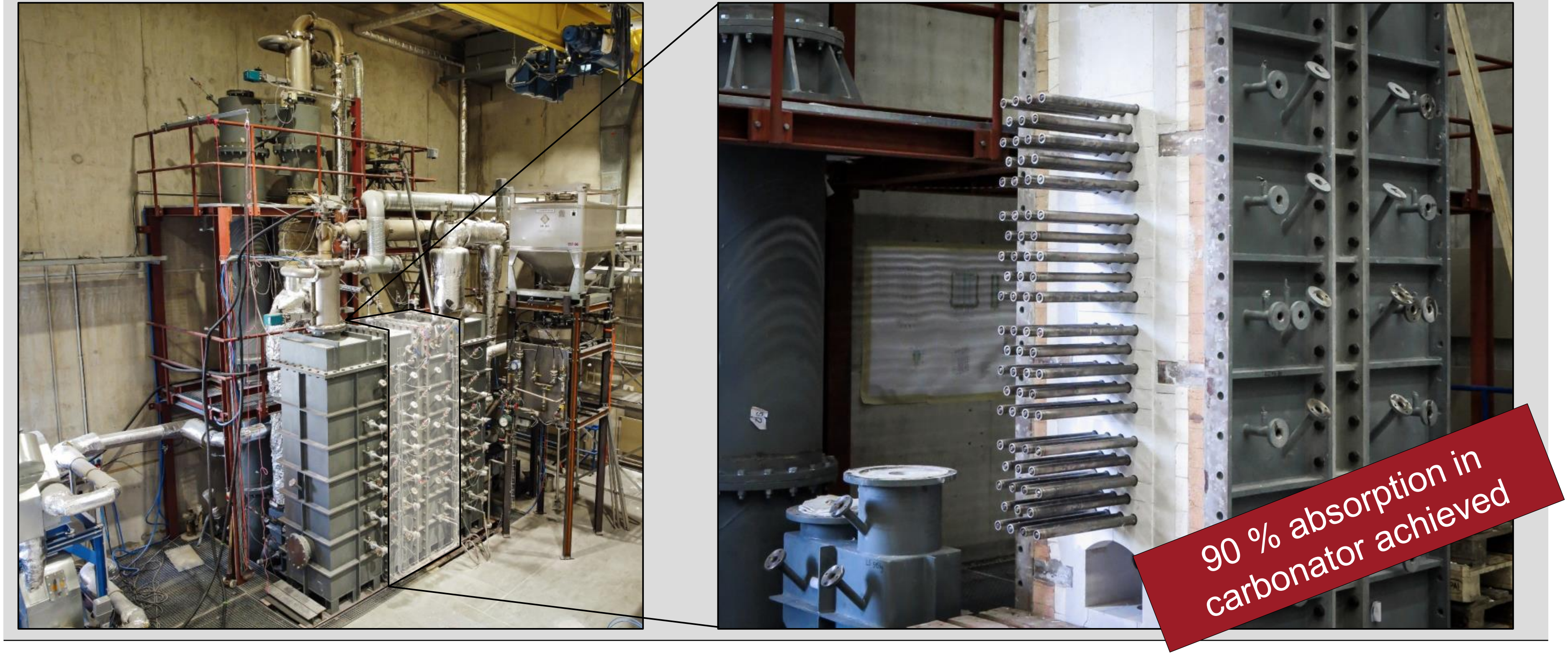
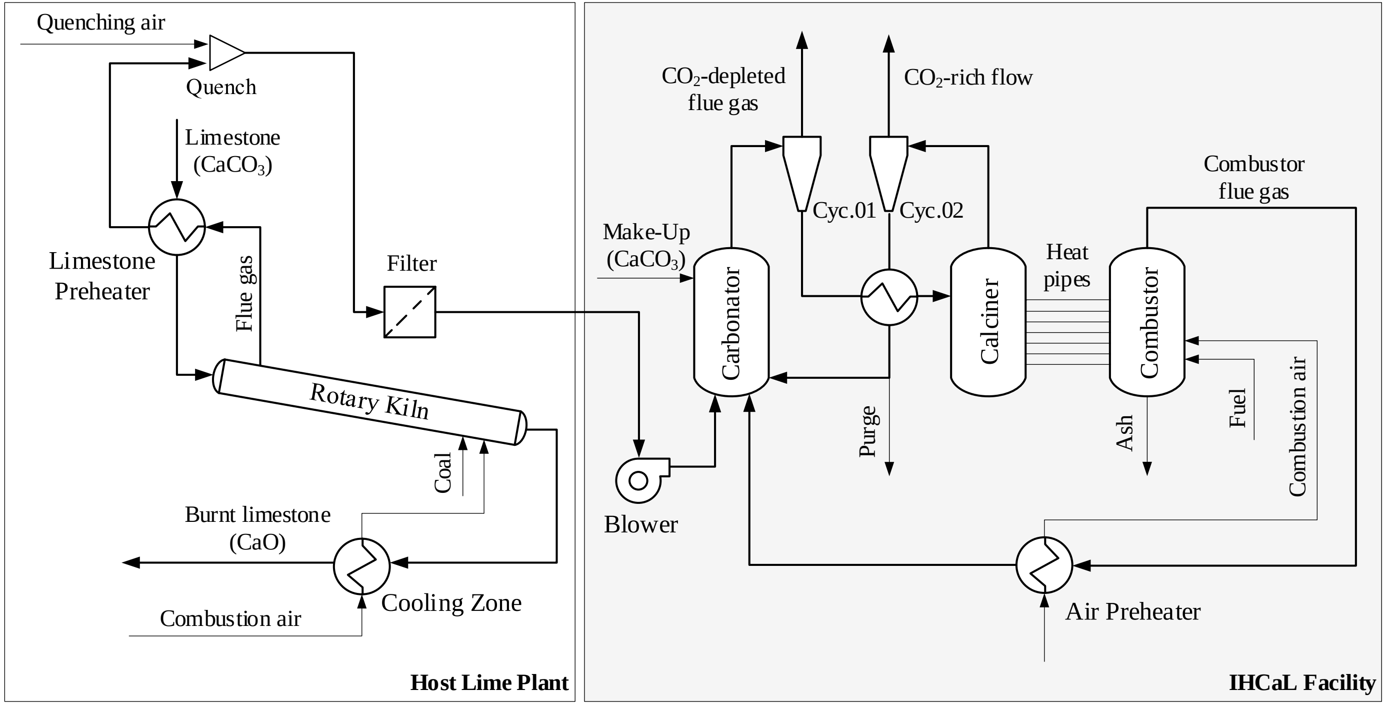


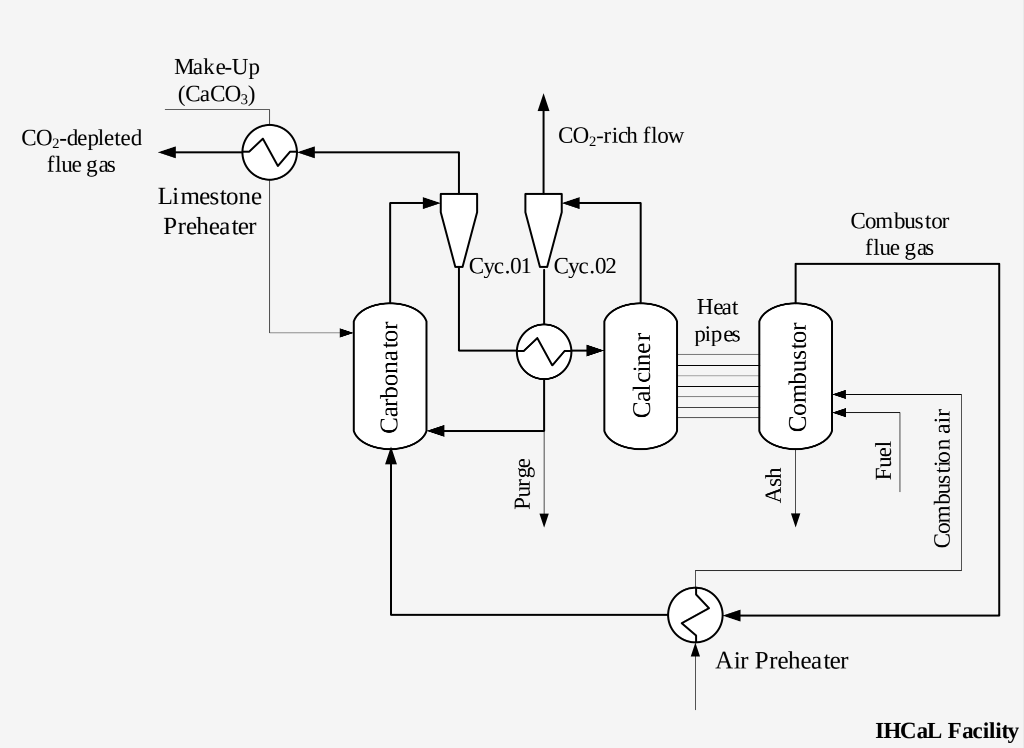
The ANICA Project
IHCaL in the Lime Production: Tail-End



Dried lignite
21.5 MJ/kg

Solid Recovered Fuel
21.5 MJ/kg

The ANICA Project
IHCaL in the Lime Production: Integrated

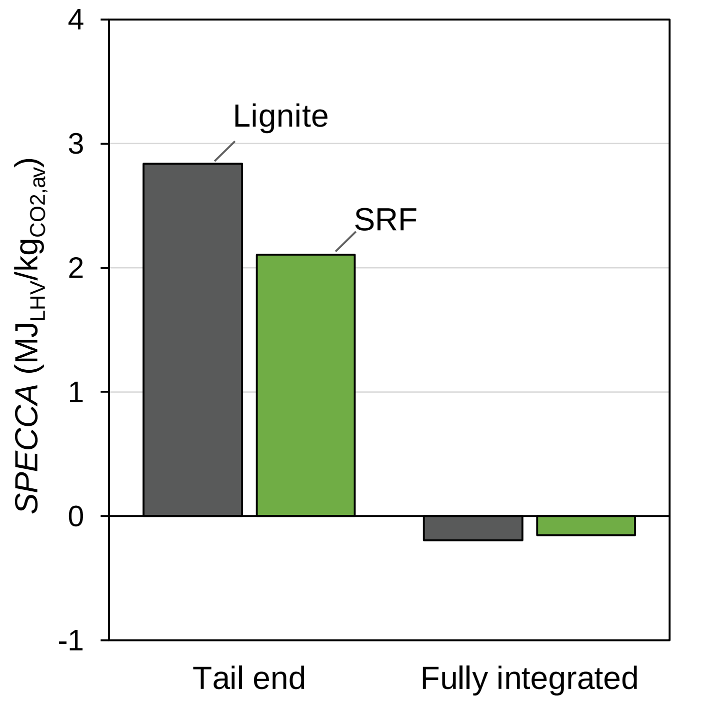


Dried lignite
21.5 MJ/kg

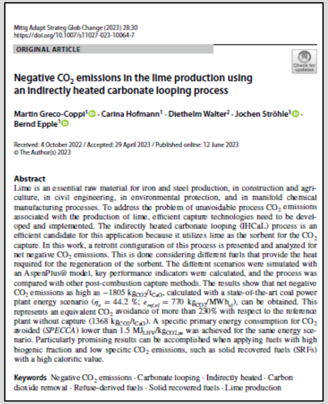
Solid Recovered Fuel
21.5 MJ/kg

4 The ANICA Project

IHCaL in the Lime Production: Energy



- KPI: *<u>S</u>pecific <u>P</u>rimary <u>E</u>nergy <u>C</u>onsumption per <u>C</u>O_2 <u>a</u>voided*
- Low values compared to benchmark technologies
- Efficient heat utilization
- Best SPECCA for fully integrated solutions



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ORIGINAL ARTICLE

Negative CO_2 emissions in the lime production using an indirectly heated carbonate looping process

Martin Greco-Coppi[1] · Carina Hofmann[1] · Diethelm Walter[2] · Jochen Ströhle[1] · Bernd Epple[1]

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Abstract
Lime is an essential raw material for iron and steel production, in construction and agriculture, in civil engineering, in environmental protection, and in manifold chemical manufacturing processes. To address the problem of unavoidable process CO_2 emissions associated with the production of lime, efficient capture technologies need to be developed and implemented. The indirectly heated carbonate looping (IHCaL) process is an efficient candidate for this application because it utilizes lime as the sorbent for the CO_2 capture. In this work, a retrofit configuration of this process is presented and analyzed for net negative CO_2 emissions. This is done considering different fuels that provide the heat required for the regeneration of the sorbent. The different scenarios were simulated with an AspenPlus® model, key performance indicators were calculated, and the process was compared with other post-combustion capture methods. The results show that net negative CO_2 emissions as high as $-1805\ kg_{CO2}/t_{CaO}$, calculated with a state-of-the-art coal power plant energy scenario ($\eta_e = 44.2$ %; $e_{ref,el} = 770\ kg_{CO2}/MWh_{el}$), can be obtained. This represents an equivalent CO_2 avoidance of more than 230% with respect to the reference plant without capture ($1368\ kg_{CO2}/t_{CaO}$). A specific primary energy consumption for CO_2 avoided (*SPECCA*) lower than $1.5\ MJ_{LHV}/kg_{CO2,av}$ was achieved for the same energy scenario. Particularly promising results can be accomplished when applying fuels with high biogenic fraction and low specific CO_2 emissions, such as solid recovered fuels (SRFs) with a high calorific value.

Keywords Negative CO_2 emissions · Carbonate looping · Indirectly heated · Carbon dioxide removal · Refuse-derived fuels · Solid recovered fuels · Lime production

4

The ANICA Project
IHCaL in the Lime Production: Cost

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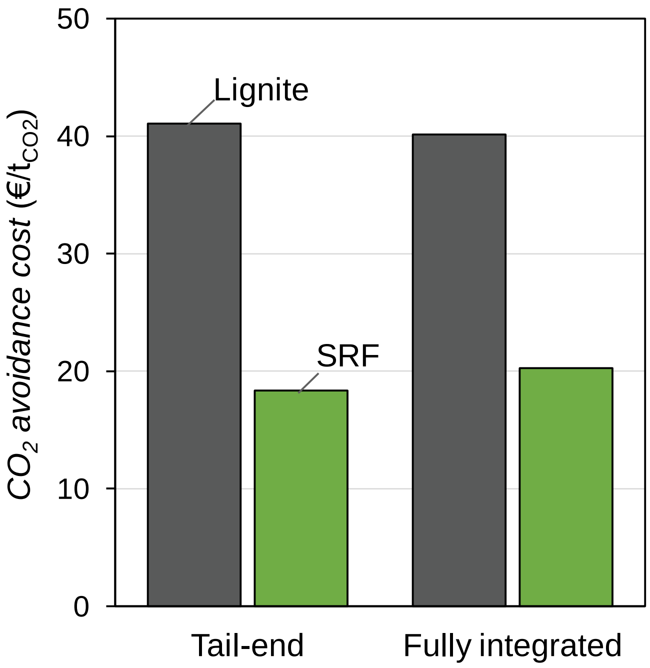


- **Alternative fuels** are key to reduce costs
- **Low operation costs**
- Tail-end and fully integrated have **similar specific costs**, but tail-end requires higher investment
- Low values compared to **benchmark** technologies

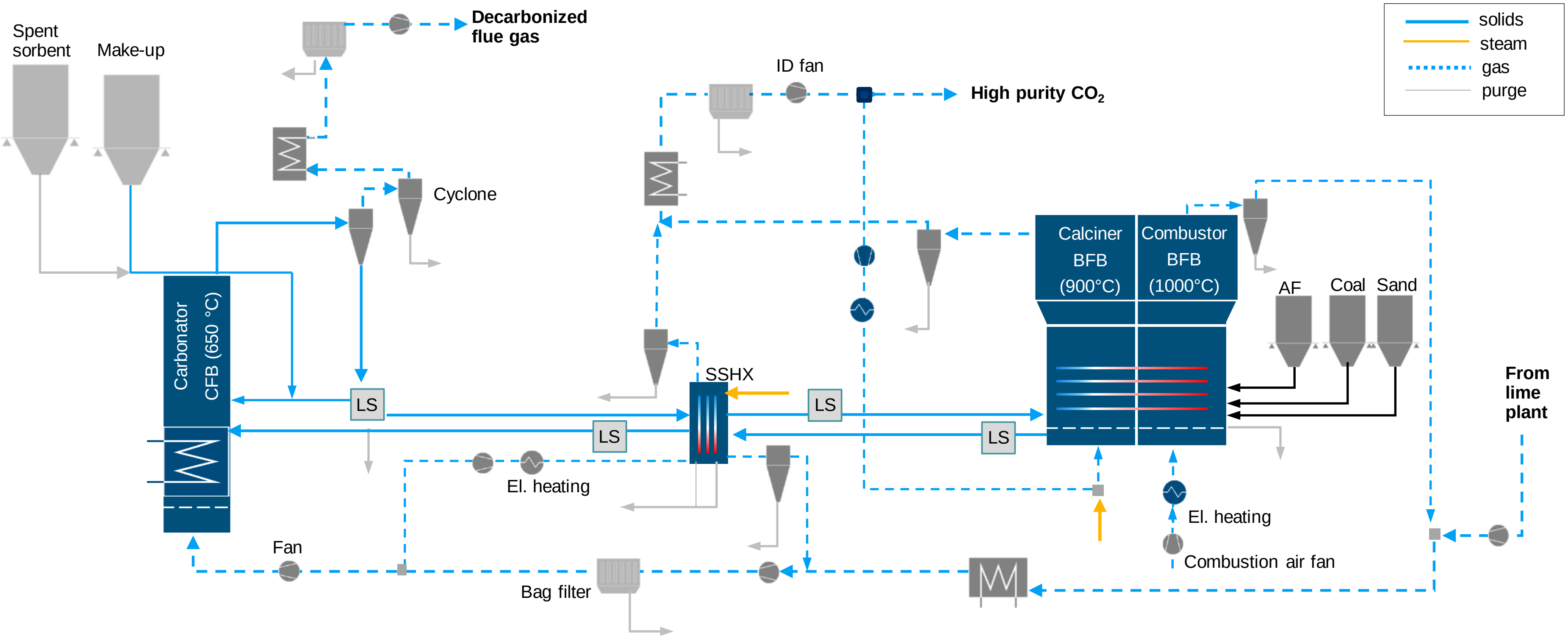
4 Demonstration Plant
Overview

- Industrially-relevant operation
- Real flue gas from lime plant
- Post-combustion capture
- 2 MW_{th} combustor heating power

Host lime plant:

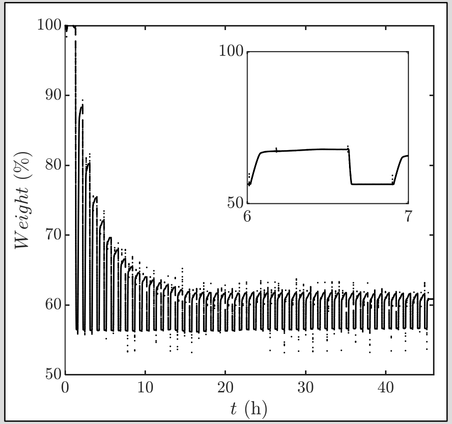
- Preheated rotary kiln
- 600 tonne of lime per day

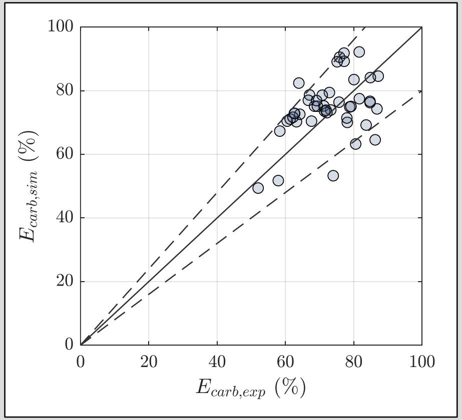
4 Demonstration Plant
Flowsheet

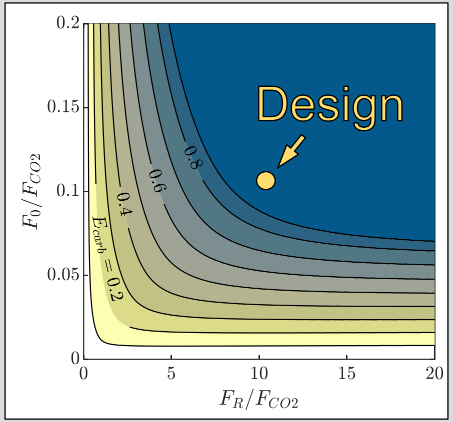


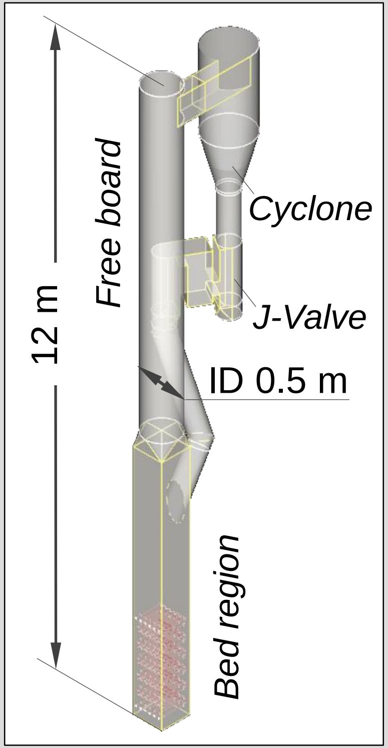
4 Demonstration Plant

Carbonator









- Cooling duty: 540 kW_{th}
- Circulation rate: 8.0 t/h
- Make-up rate: 260 kg/h

Expected absorption in carbonator:

90%+

4 Demonstration Plant
Calciner

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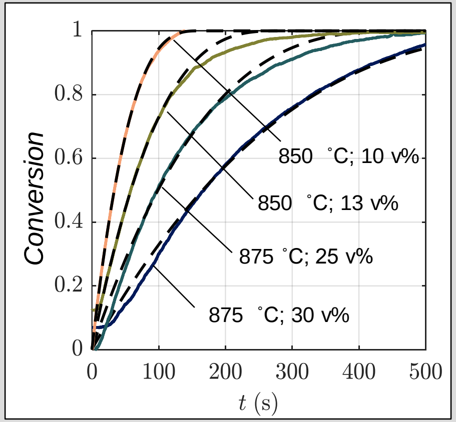
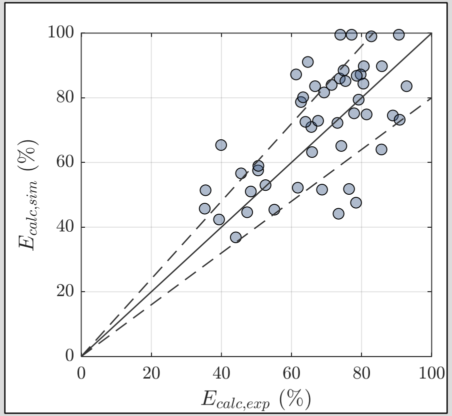
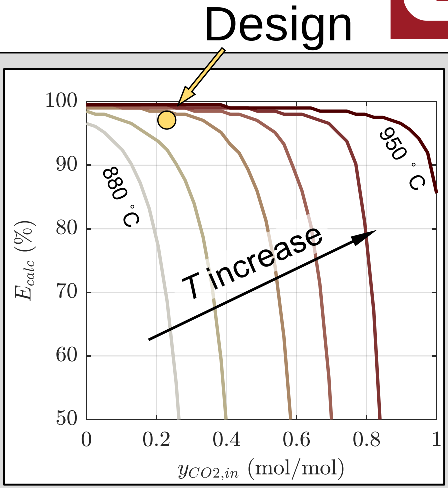
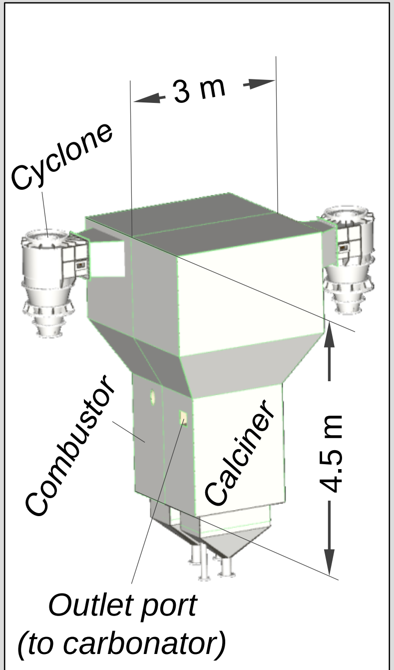








- Operating temperature: 900°C
- Steam fluidization: 380 kg/h
- Heat pipes duty: 1.4 MW_{th}

Expected calcination in reactor:

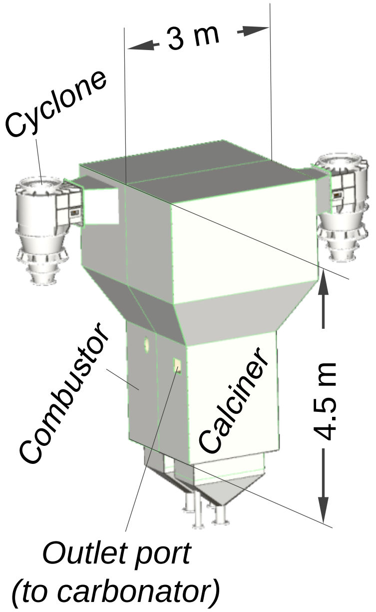
90 – 100%

4 Demonstration Plant
Combustor

- Air preheating: 800°C
- Air flow rate: 4200 m^3/h
- Nominal load: 2 MW_{th}
- Circulation of flue gas to carbonator

Dried lignite
21.5 MJ/kg

Solid Recovered Fuel
19.6 MJ/kg



Expected outcomes

- Long term heat-pipe behaviour
- Sensitivity to fuel variation
- Sorbent deactivation

5 Conclusion

The IHCaL Technology

- Energy efficiency
- Low CO_2 avoidance costs (<20 EUR/t_{CO2})
- Lime and cement plants
- Demonstration plant is key for validation

The ANICA Project

- Publications available (more coming up)
- Project completion: September 2023

Acknowledgments

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Thank you for your attention

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