9th High Temperature Solid Looping Cycles Network Meeting (IEA-HTSLCN)

Piacenza, Italy

14th-15th March 2023

Pilot Testing of the Indirectly Heated Carbonate Looping Process for Lime Plants

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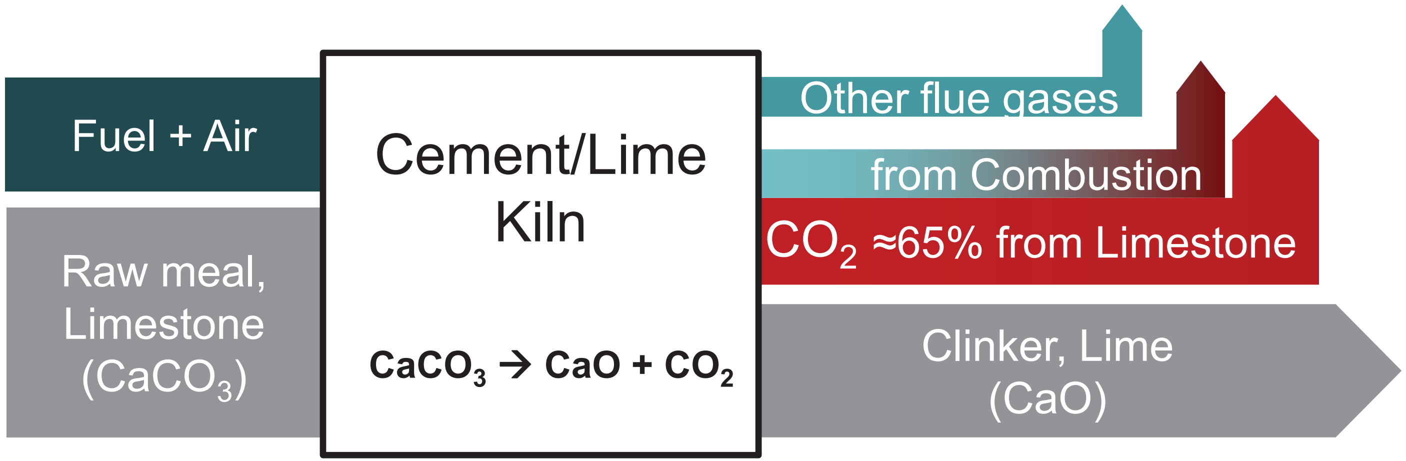
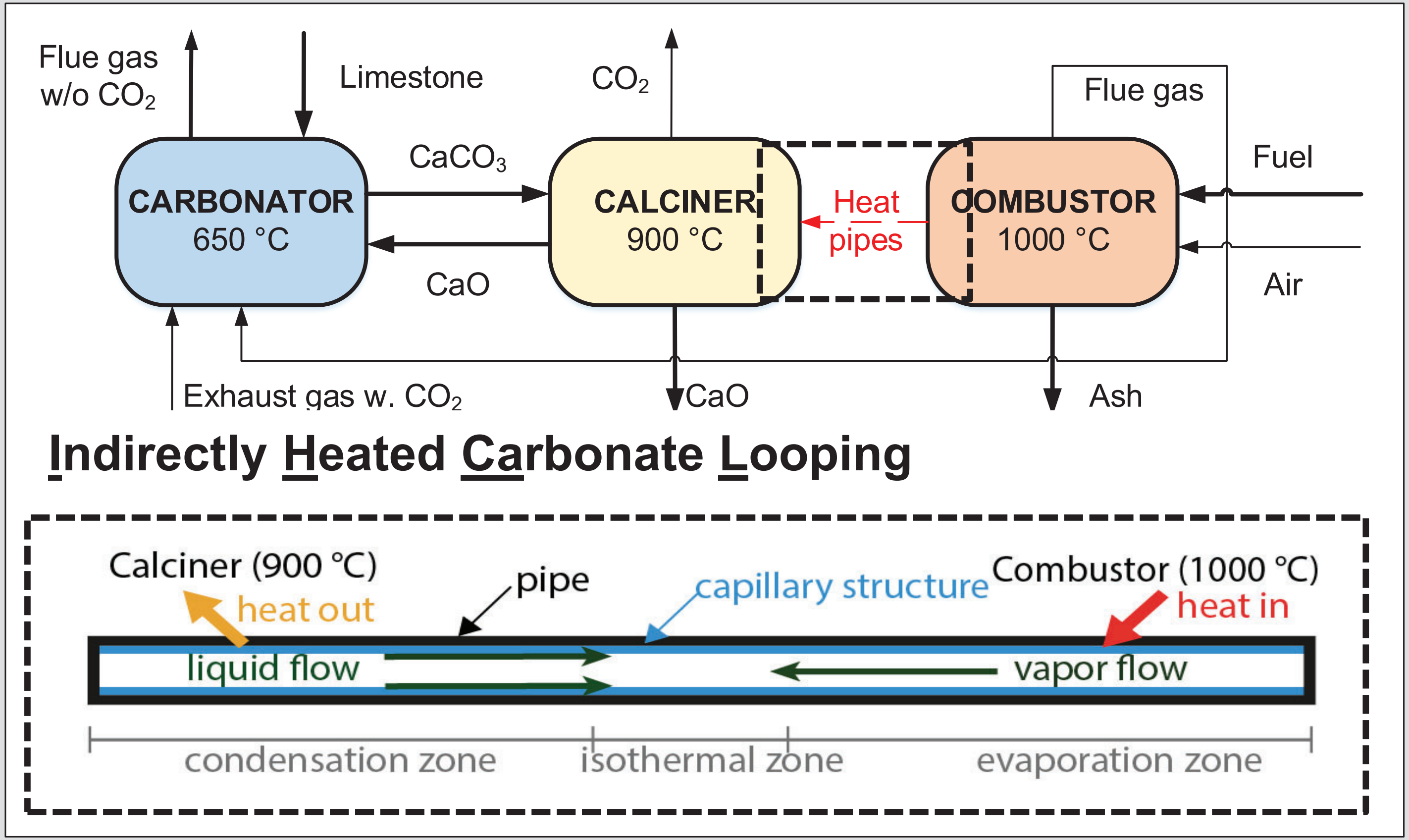
1 Motivation

- Lime and cement industries contribute to ~8 % of worldwide CO_2 emissions [1]
- $^2/_3$ are process CO_2 emissions (unavoidable): → **CO_2 capture required**
- Efficient, economic CO_2 capture technologies → **Indirectly Heated Carbonate Looping Process**



[1] European Commission (JRC), Trends in global CO_2 emissions, 2016

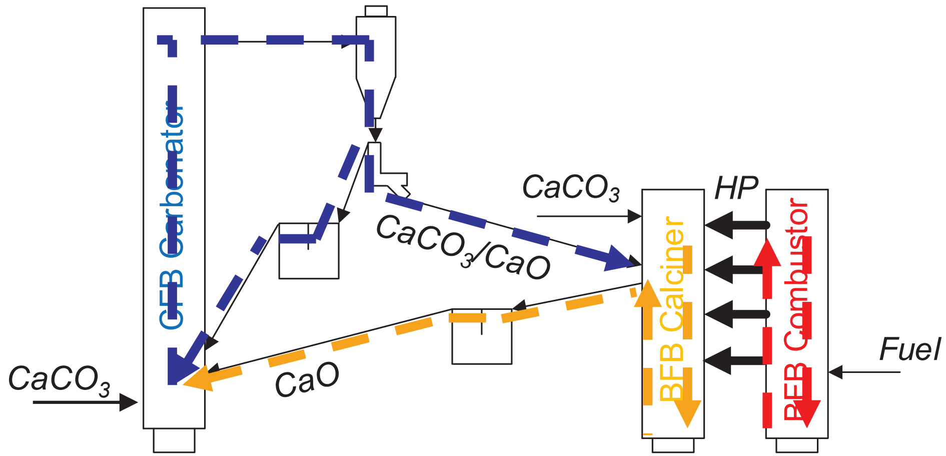
Introduction, Process Scheme IHCaL

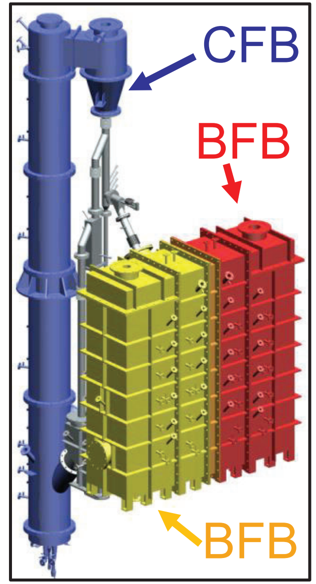


- **No air separation unit** is necessary
- **Few impurities** (sulfur, ash)
- **Synergies** with cement & lime
- Technology validated in **pilot scale** for power plants

Experimental
300 kW_{th} IHCaL Pilot Plant

Solid flow

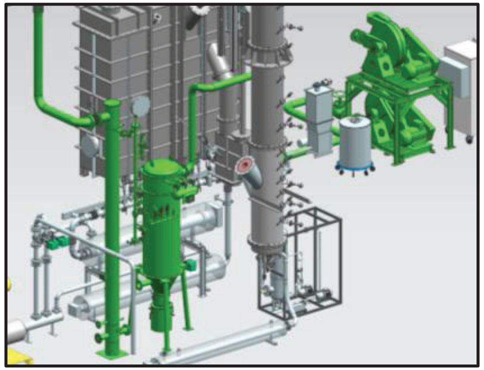


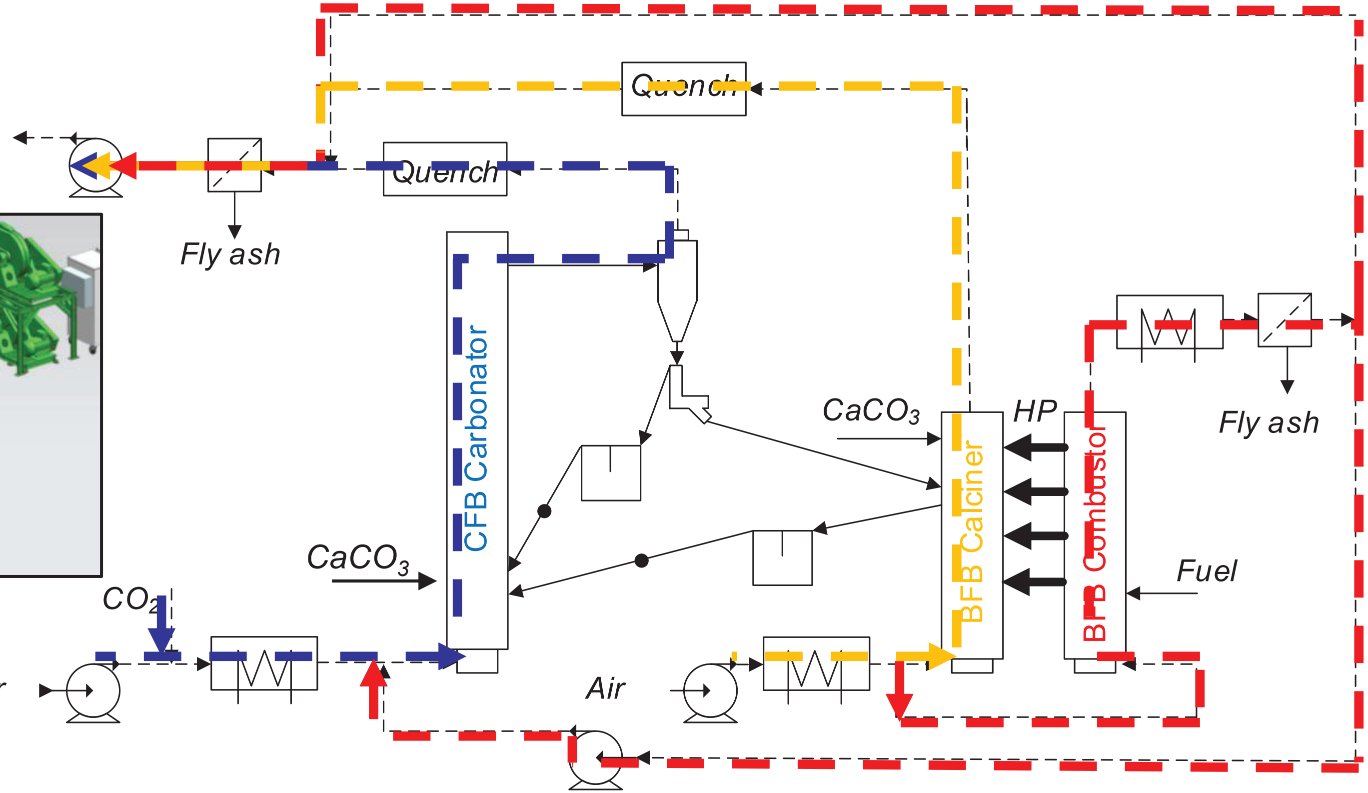


	Carbonator	Calciner	Combustor
Solid inventory	30 – 60 kg ($CaO/CaCO_3$)	400 kg ($CaO/CaCO_3$)	600 kg (silica sand)
Superficial velocity (u_o)	2.5 – 7.0 m/s	0.2 – 0.4 m/s	0.4 – 1.6 m/s

Experimental
IHCaL Configuration (I)

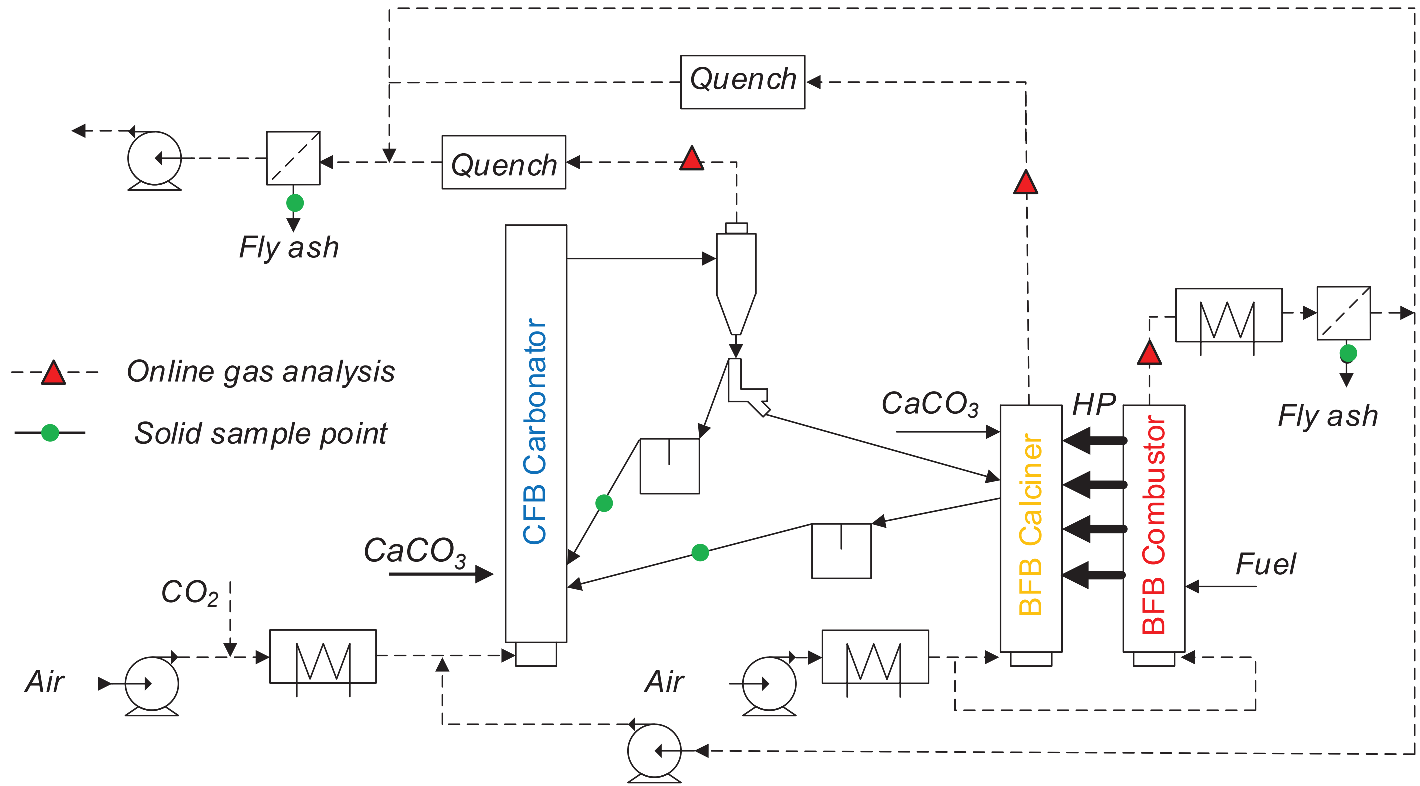
Gas flow





2 Experimental
IHCaL Configuration (II)

Overview



Experimental Boundary Conditions

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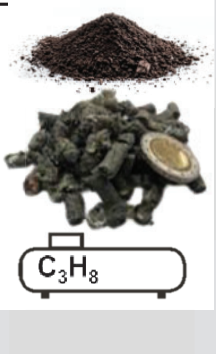
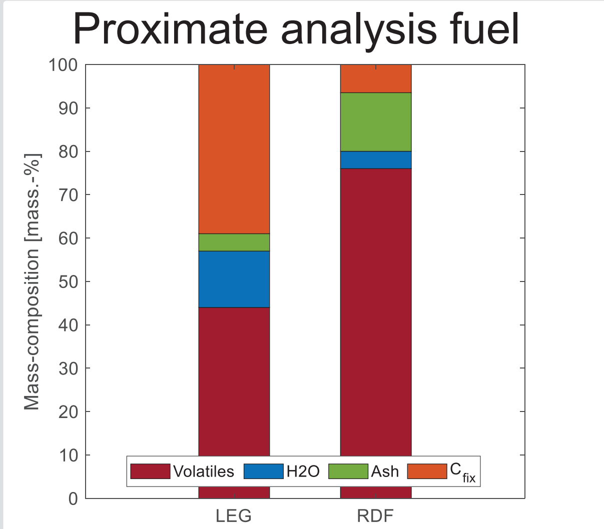
	LHV [MJ/kg]
Lignite (LEG)	21.5
Waste derived fuel (RDF)	19.6
Propane	46.5





- 300 h of operation in CO_2-capture mode
  - ➢ 24 h with co-firing lignite
  - ➢ 24 h with co-firing waste derived fuels
- Decarbonization of real flue gas

Variable	Unit	SP1	SP2.2	SP2.3	SP3.1
T_{Calc}	°C	820	-	-	↓
MUR	mol_{CaCO3}/mol_{CO2}	0.75	-	↓	↓
LR	mol_{CaO}/mol_{CO2}	15	↓	↓	↓
$Ws_{,Carb}$	kg/m²	600	↑	-	↓
T_{Comb}	°C	950	-	↓	↓
$Q_{th,Comb}$	kW_{th}	280	↑	↑	↓
x_{H2O}	kg/kg	0	↑	↑	↑

Results (I), Performance Carbonator

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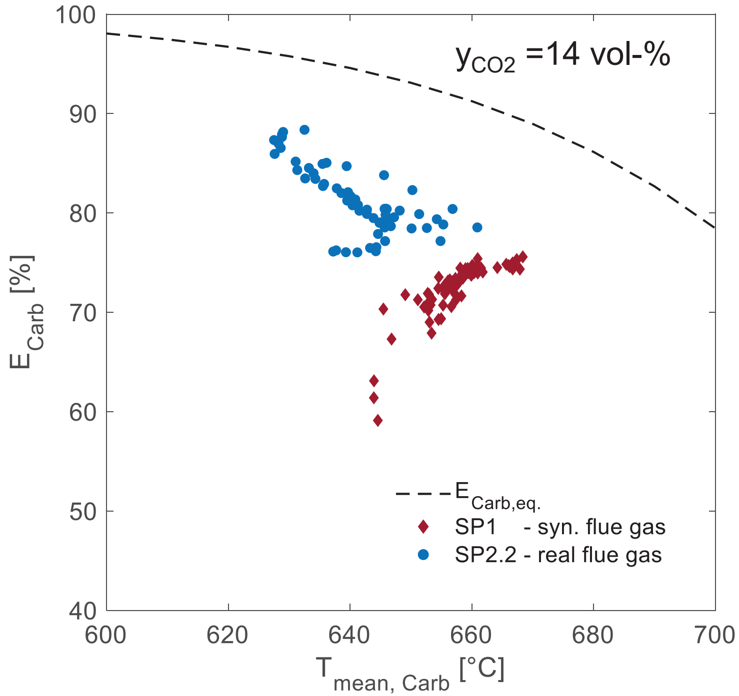

$$E_{carb} = \frac{\dot{N}_{CO2,Carb,in} - \dot{N}_{CO2,Carb,out}}{\dot{N}_{CO2,Carb,in}}$$

Variable	Unit	SP1	SP2.2
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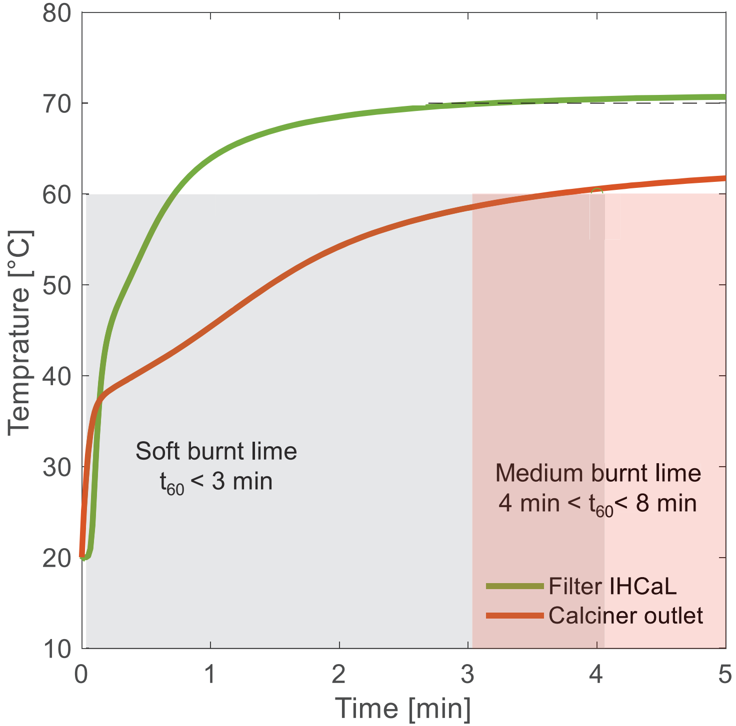
x_{H2O}	kg/kg	0	↑

- Each set point state of at least 3 hours
- Positive effect of moisture in flue gas
- Influence of active material in carbonator

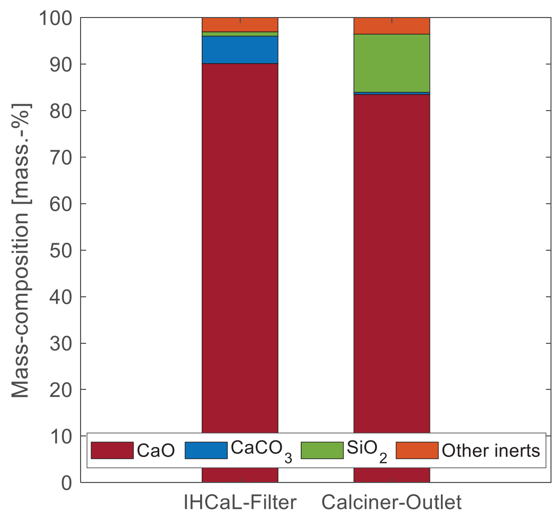
➢ Carbonator efficiency > 85% achieved

Results (II)
Slaking reactivity – t_{60} Test

Reactivity test for burnt lime with defined particle size



According to DIN EN 459-2: Building Lime - Part 2: Test Methods



- The higher T_{max}, the higher slaked CaO content
- SiO_2 content negative impact on slaking reactivity

➢ Filter material similar to **soft burnt lime**

➢ Bed material similar to **medium burnt lime**

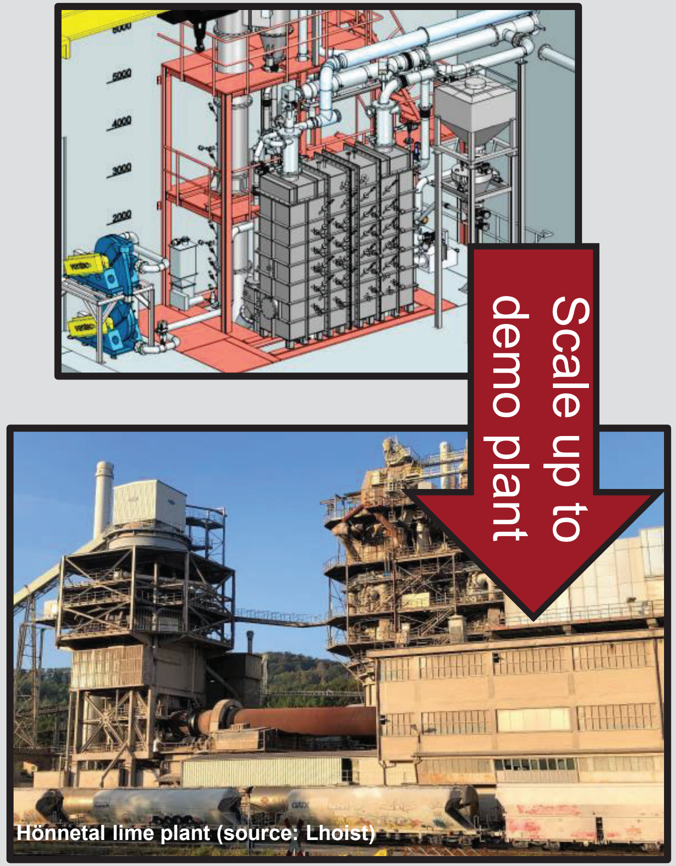
➢ According to results of t_{60}-test reactivity of purged material can be used for various applications

4 Summary

- First operation of IHCaL test facility with decarbonisation of real flue gas and co-firing of solid fuels
- Carbonator CO_2 absorption rate > 85% (with propane)
- Use of spent sorbent is possible for production of lime

Outlook

- Verification of results with different CaL-models
- Assessment of operational behavior while using different fuels
- Evaluation of data set and operational experience for scale up



Hönnetal lime plant (source: Lhoist)

Acknowledgement

This project ANICA is funded through the ACT programme (Accelerating CCS Technologies, Horizon2020 Project No 294766). Financial contributions made from; the German Federal Ministry of Economic Affairs and Climate Action based on a resolution of the German Parliament under grant no. 03EE5025, are gratefully acknowledged.

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

Accelerating CCS Technologies

Thank you for your Attention

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