ANICA

Adva**n**ced **I**ndirectly Heated
Carbonate Looping Process

Accelerating CCS Technologies

ANICA Project

Jochen Ströhle, TU Darmstadt

ACT Knowledge Sharing Workshop
9 June 2022

Federal Ministry for Economic Affairs and Energy

Department for Business, Energy & Industrial Strategy

GSRT
GENERAL SECRETARIAT FOR RESEARCH AND TECHNOLOGY

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 Energy, the Department for Business, Energy and Industrial Strategy of the United Kingdom and the Greek General Secretariat for Research and Technology.

ANICA Objectives

Overall aim:

Develop concepts of indirectly heated carbonate looping (IHCaL) process for ***CO_2 capture*** *from* ***lime*** *and* ***cement*** *plants*.

Specific Project Objectives

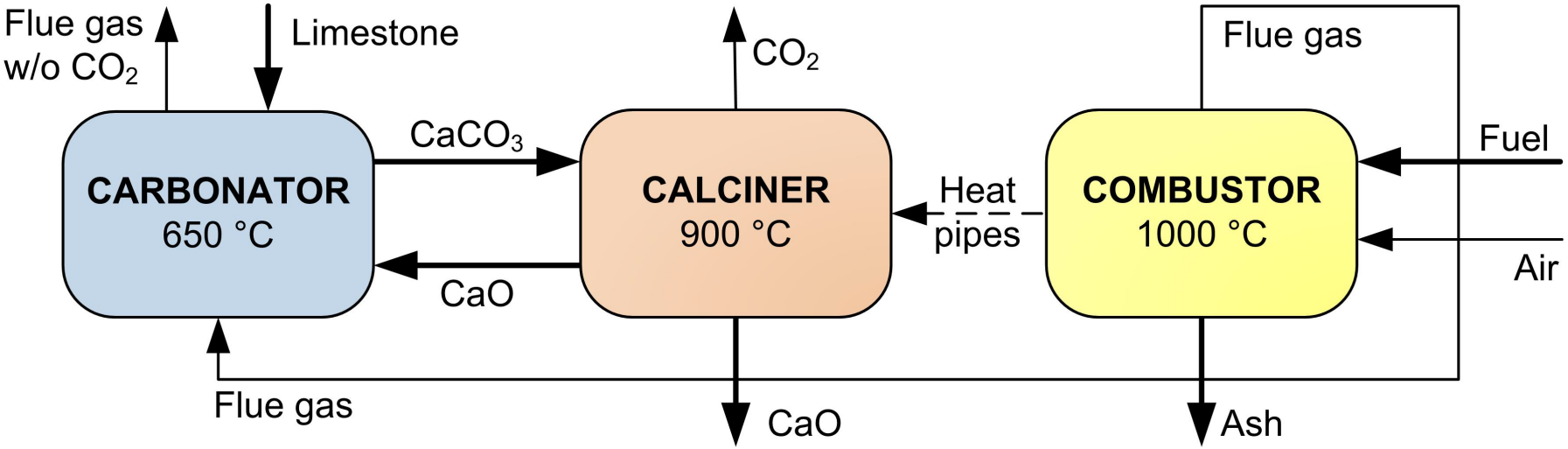
- Test at 300 kW_{th} **pilot plant**
- Prove feasibility of **utilizing of spent sorbent**
- Develop **novel concepts** of IHCaL reactors
- Assess **risks**, **economics**, **environmental** impact
- Design a 20 MW_{th} **demonstration** plant


Source: Lhoist

Consortium

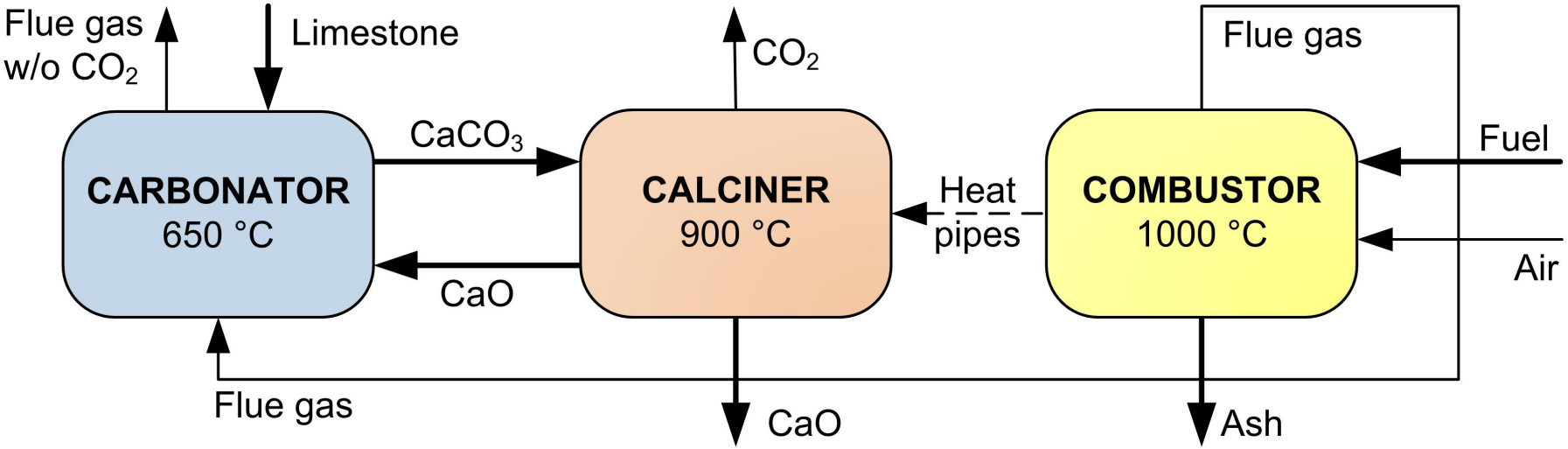

TECHNISCHE UNIVERSITÄT DARMSTADT
FAU FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG
CaO HELLAS Natural Chemicals
CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS
vdz.
Accelerating CCS Technologies
calix
thyssenkrupp
Ulster University
BUZZI Dyckerhoff
ESTRA
suez
Lhoist

Indirectly Heated Carbonate Looping (IHCaL)



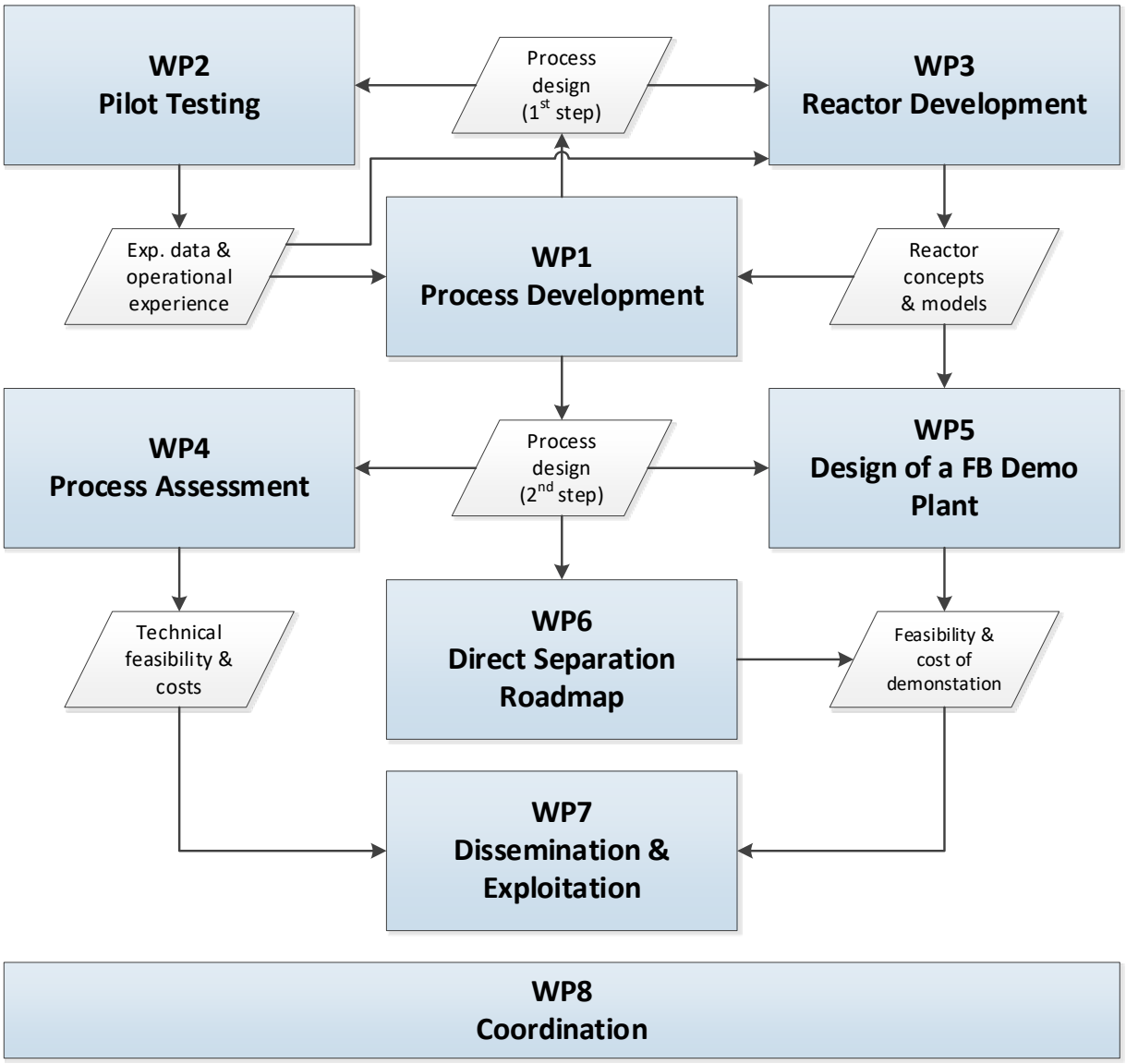
- Sorbent (limestone): cheap, abundant, non-toxic, environmentally friendly
- Spent sorbent (CaO): utilization in lime/cement production
- Utilization of heat at high temperature (→ highly efficient steam cycle)
- No oxygen for calciner → No ASU, **high efficiency**
- No fuel in calciner → **few impurities** (sulfur, ash), **low deactivation**
- Almost **pure CO_2** stream at calciner exit

KPIs for Lime/Cement Plants



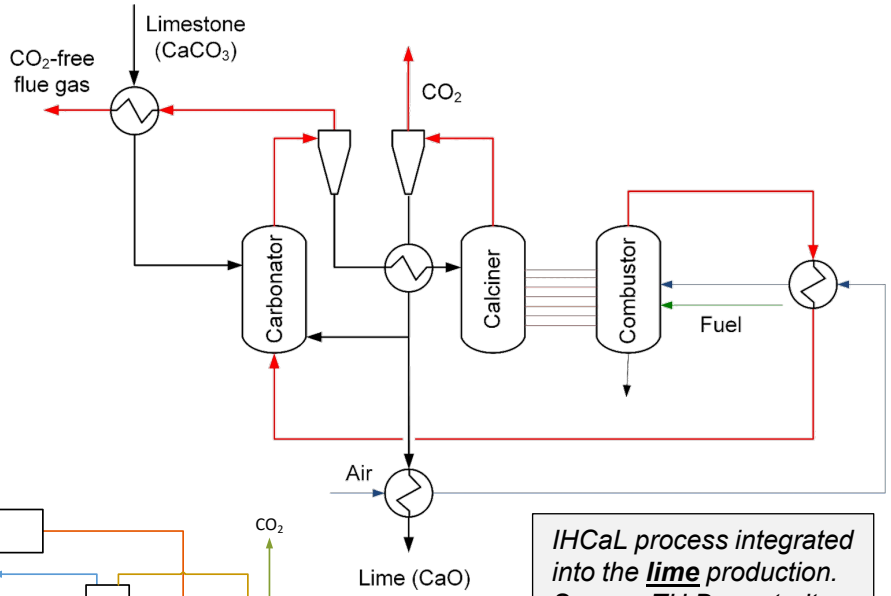
Key Performance Indicator (KPI)	Target
CO_2 capture efficiency	> 90 %
CO_2 purity	> 95 %
Net efficiency for power co-generation	> 45 %
Sorbent utilization	> 90 %
CO_2 avoidance costs	< 25 €/t
Net CO_2 emissions	< 0

Work Packages

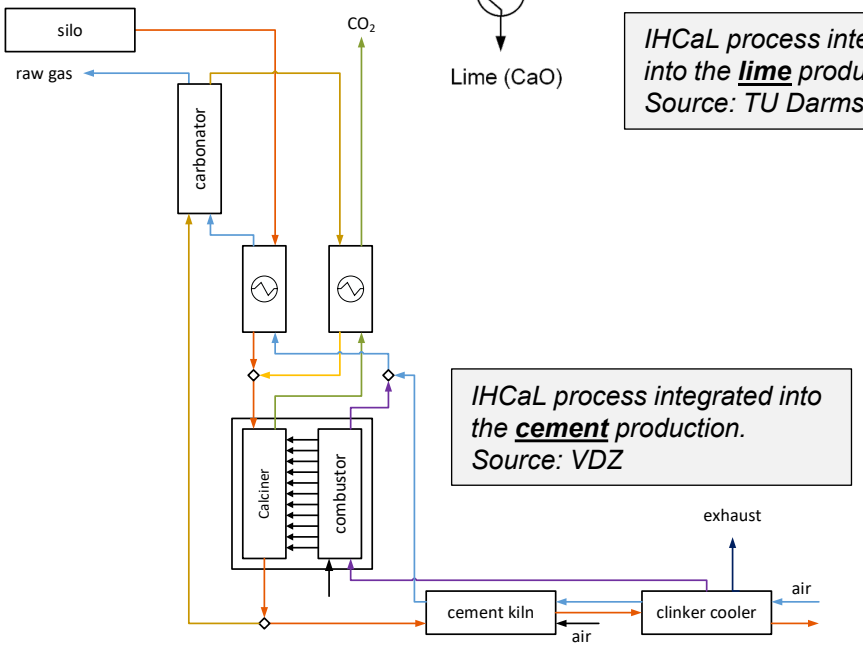


WP 1 – Process Development

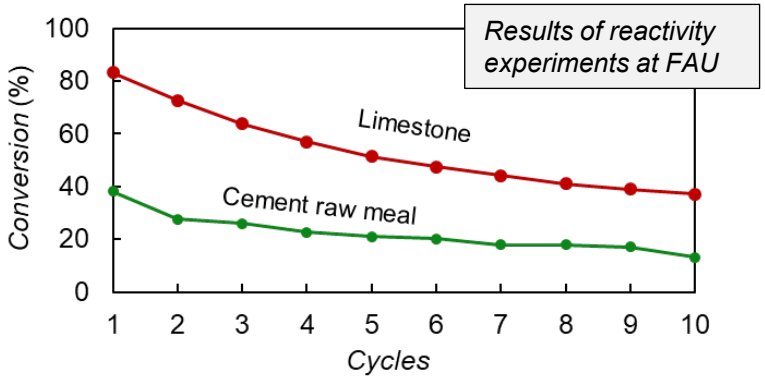
- Process design and simulation completed
  - Integration into lime and cement plants
  - High potential for power recovery: > 30%
  - Over 85% CO_2 avoidance
- Challenges:
  - Reactivity/PSD of cement raw meal
  - Heat integration and operation set-point
  - Component development



*IHCaL process integrated into the **lime** production. Source: TU Darmstadt*



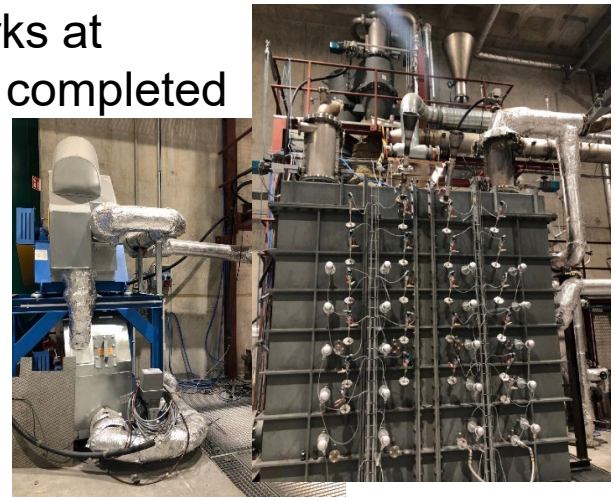
*IHCaL process integrated into the **cement** production. Source: VDZ*

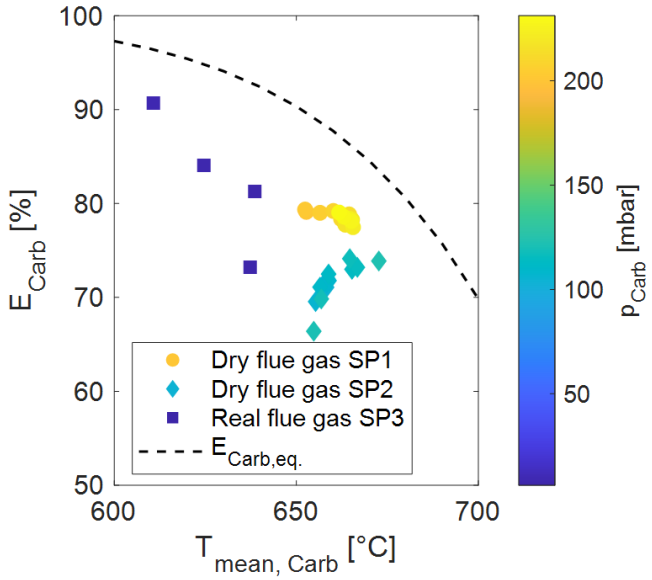


Results of reactivity experiments at FAU

WP 2 – Pilot Testing

- All construction works at 300 kW_{th} pilot plant completed





- Successful completion of first pilot test with real flue gas

- Solid samples generated for assessment of usability in lime and cement


Material from calciner


Entrained material from calciner

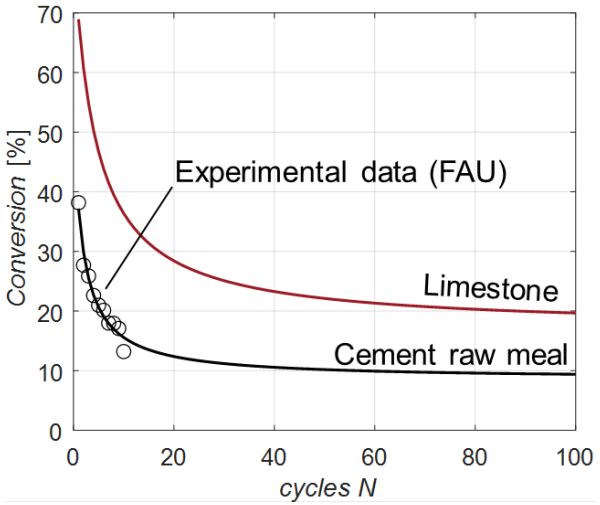

Cement raw meal (Fine)


RDF

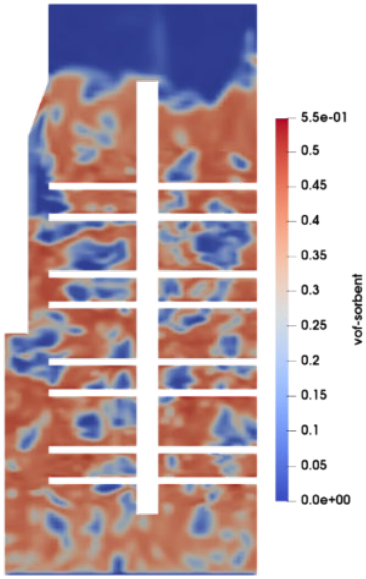
- Next pilot tests in Summer 2022 with solid fuels and cement raw meal

WP 3 – Reactor Development

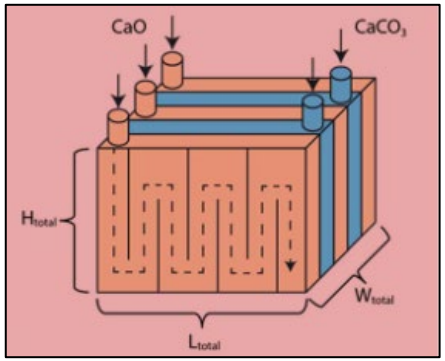
- Reactor models developed



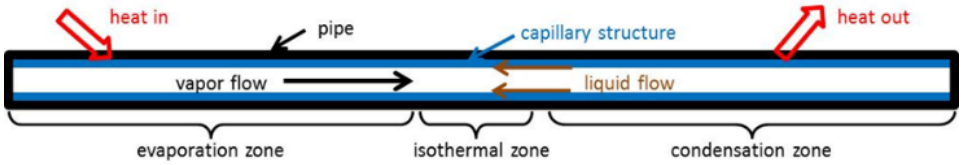
- Lagrangian-Eulerian CFD model of pilot plant validated



- Assessment of 4 concepts for a solid/solid heat exchanger completed



- Development of improved heat pipes in progress



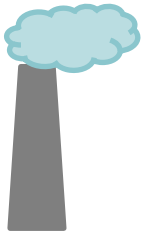
WP 4 – Process Assessment

- Risk assessment (in progress)
  - Quantitative risk assessment (Monte Carlo)
  - Qualitative risk assessment (FMECA)

Description of the unit			Description of the failure			Effect of the failure				Probability of occurrence	Risk Priority Number Rodif severity x probability >9	Risk reducing measures	Comments
Component	Function	Operational Mode	Failure mode	Failure cause or mechanism	Difficulty of detection	On the component	On the system	Health & Safety	Severity ranking				
					1 to 5				1 to 5	1 to 5			

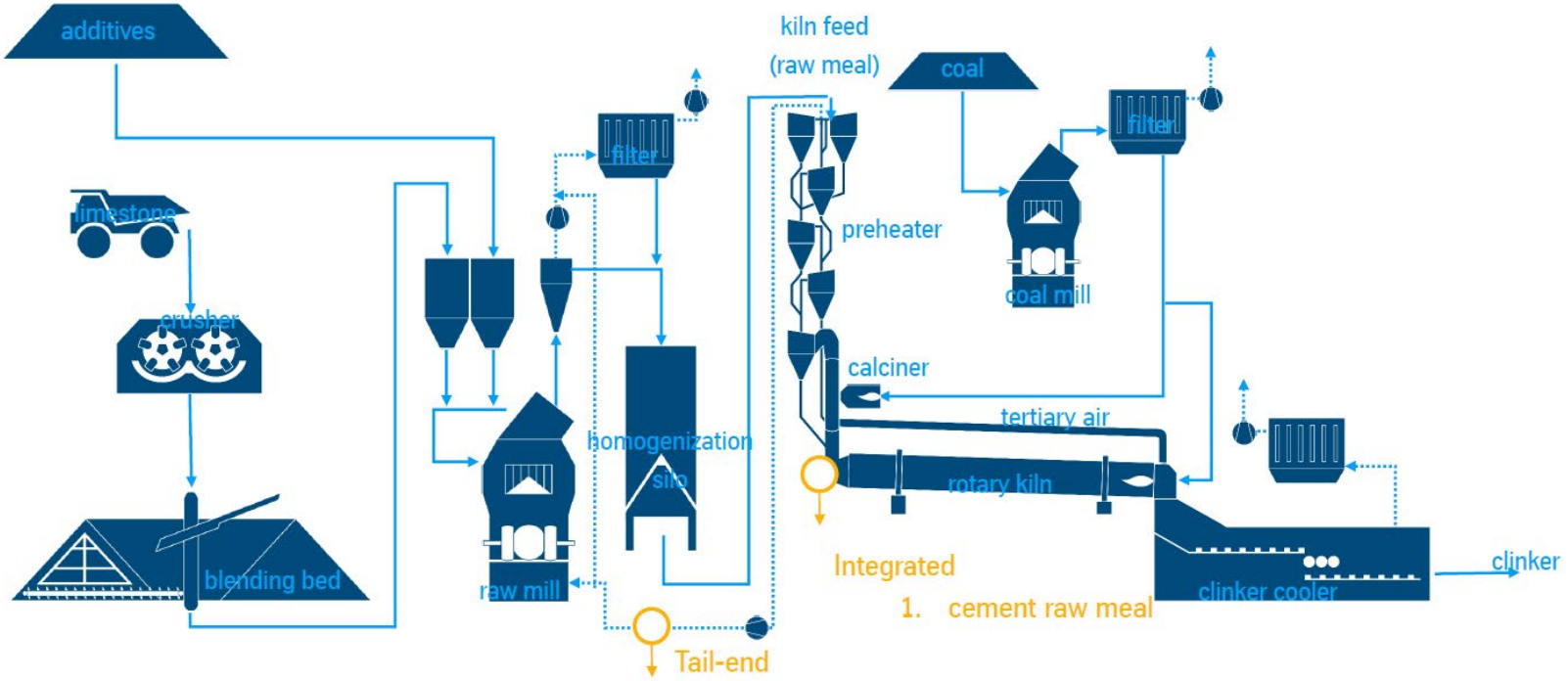
- Techno-economic assessment (in progress)
  - Preliminary CO_2 avoidance costs for cement plant:
    - 24.3 €/t (30% SRF)
    - 36.4 €/t (100% coal)

- Life-cycle assessment (in progress)
  - Large reduction on global warming impact
  - Use of SRF is beneficial



WP 5 – Design of a demo plant

- Integration scenario defined:
  - Tail-end plant with high quality limestone cycle



- Basic layout definition in progress
- First heat & mass balances calculated
- Size: ~ 3 MW_{th} fuel power
- Site to be selected

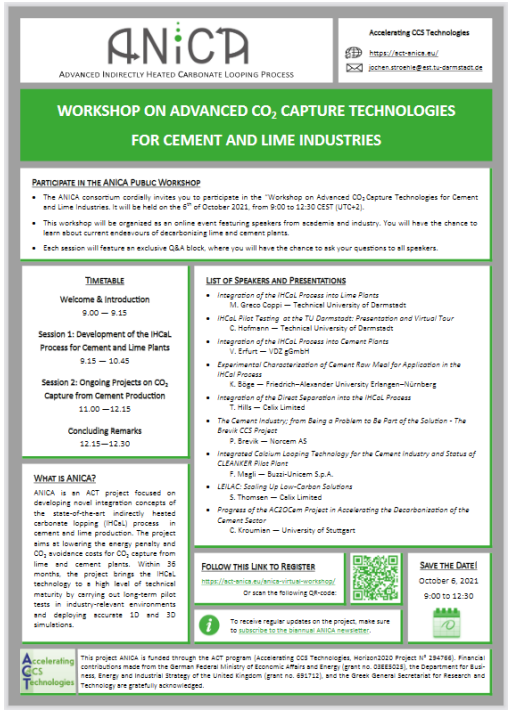
WP6 – Direct Separation Roadmap

- Combination of IHCaL with Direct Separation (CALIX)
- Several Scenarios defined
- Heat & mass balances in progress

WP7 – Dissemination and Exploitation

ANICA Project Website

4 Industrially Oriented Newsletters



Public workshop
6 Oct 2022 (online)

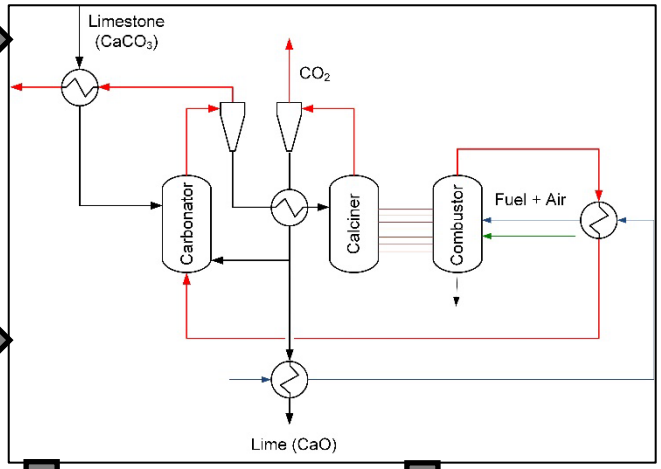
9 conference presentations
1 journal paper

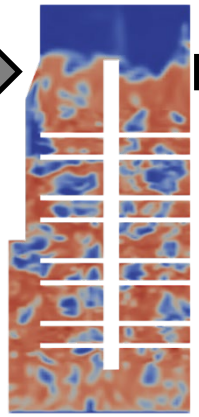
Next Steps in ANICA

Pilot tests
(Jan – Aug 2022)

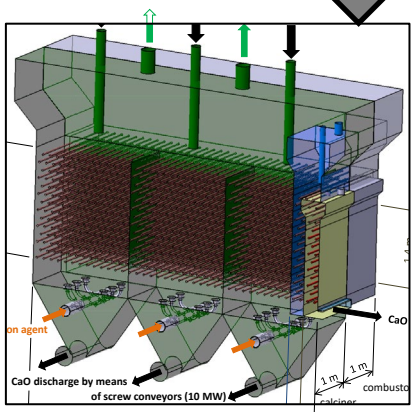
Analysis of sorbents
→ utilization in
production process

Process optimization
(novel reactor concepts, simulations)

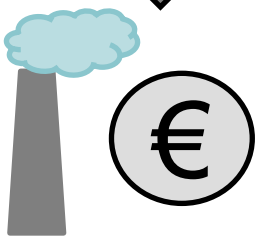




Model
validation



Design of
demonstration
plants



Process assessment
(risks, economics,
environmental impact)

Acknowledgement

The project has been subsidized through ACT (Project no. 299653, ANICA) by the German Federal Ministry of Economic Affairs and Energy based on a resolution of the German Parliament under grant no. 03EE5025, the Department for Business, Energy and Industrial Strategy of the United Kingdom under grant agreement 691712, and the Greek General Secretariat for Research and Technology.

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

Department for Business, Energy & Industrial Strategy

GENERAL SECRETARIAT FOR RESEARCH AND TECHNOLOGY

Thank you for your attention!