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Calcium Looping Post Combustion CO_2 Capture: A promising technology for emission free cement production

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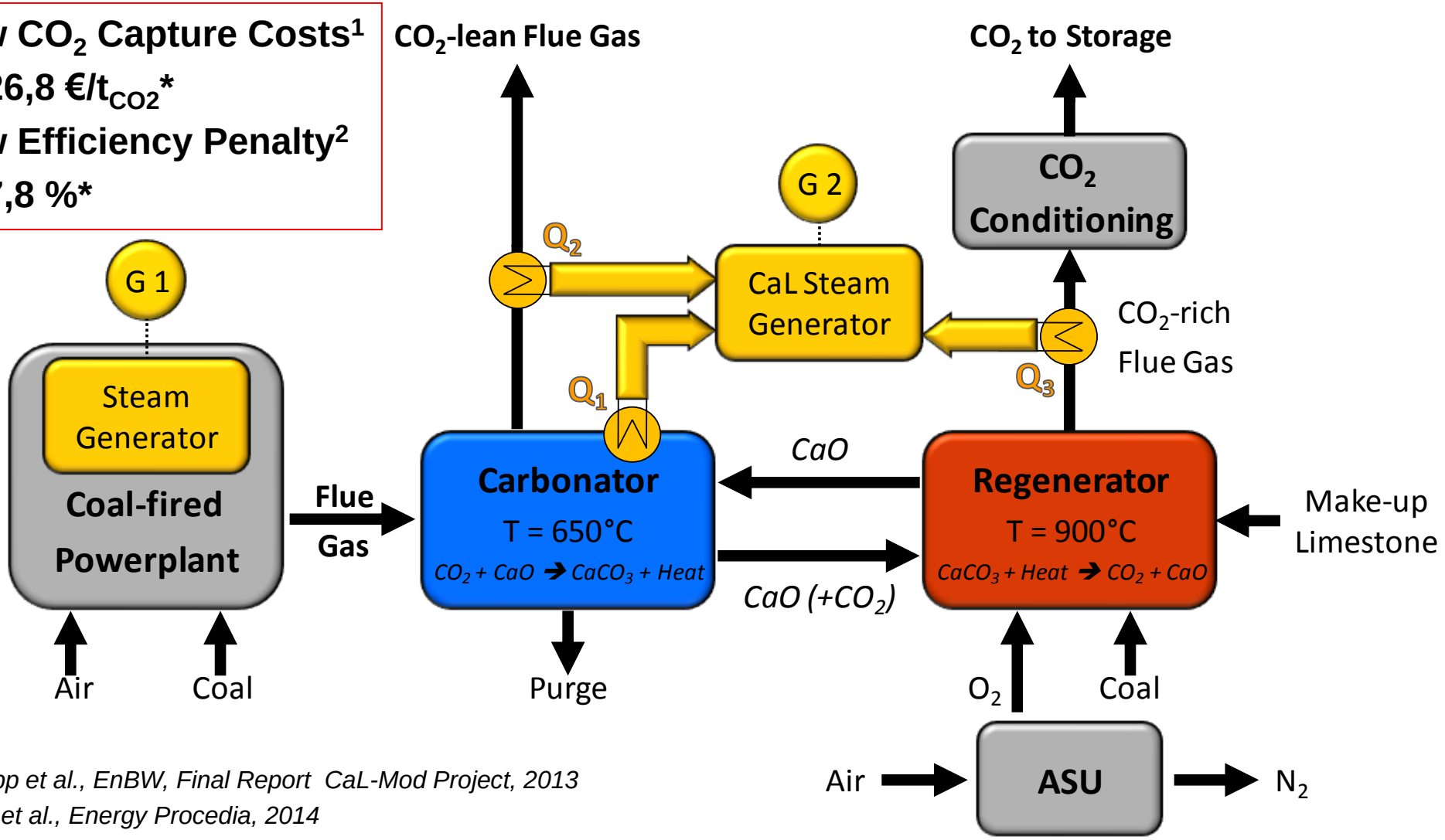
The Calcium Looping Process for Power Plants

Low CO_2 Capture Costs[1]
➔ 26,8 €/t_{CO2}*
Low Efficiency Penalty[2]
➔ 7,8 %*



[1] *Schaupp et al., EnBW, Final Report CaL-Mod Project, 2013*
[2] *Dieter et al., Energy Procedia, 2014*
* *Including compression*

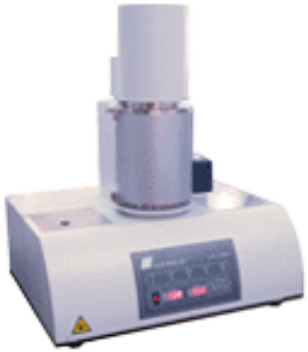
R&D Roadmap Calcium Looping Process

Process Simulation & Cost Calculations

Hawthorne et al., Poboss et al., Abanades et al.

TGA Sorbent Characterisation

Grasa et al.

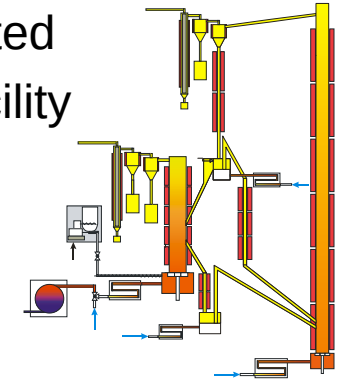


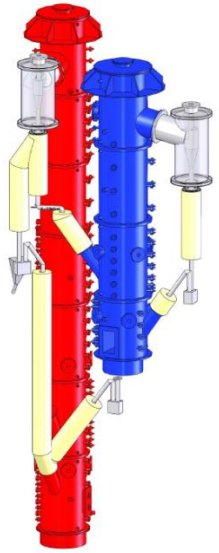
Process Characterisation

Electr. heated

10 kW_{th} facility

Charitos et al., Abanades et al.





Process Demonstration:

Realistic Process Conditions

- No external heating
- Real Flue Gas
- Oxyfuel Calcination
- Coal influence (S, ash)

Shimizu et al. 1999

Process Idea

Labscale

Process Simulation

10 kW_{th} – DFB Facility

0,2 -1,7 MW_{th} Pilot Plants Process Demonstration

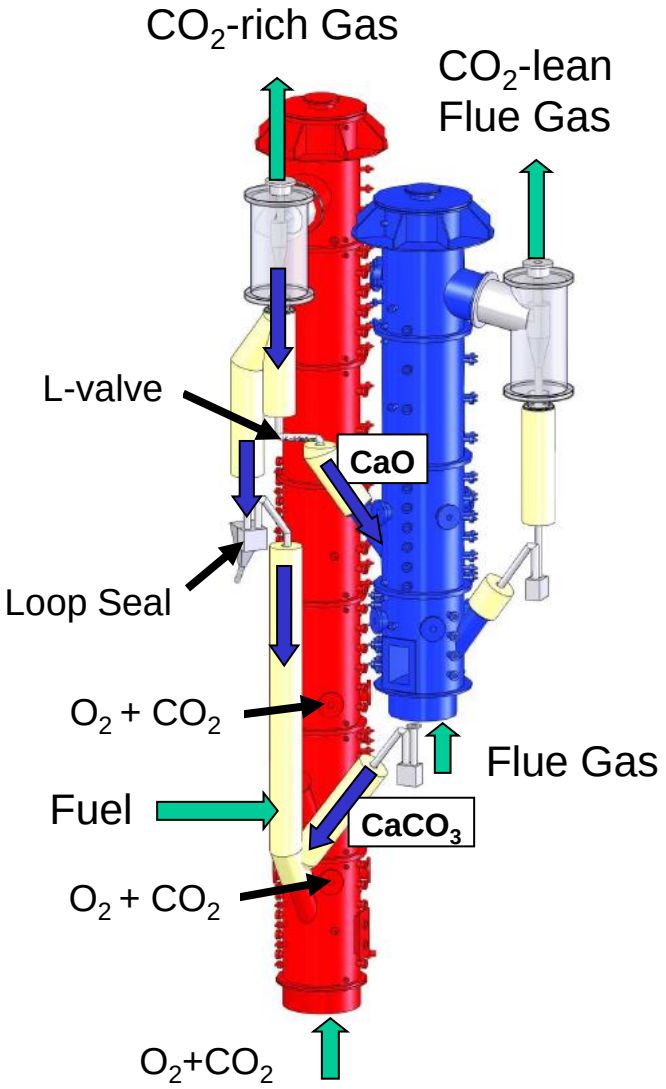
Demo Plants (20 MW_{th})

Commerical Plant

The 200 kW_{th} Calcium-Looping Pilot Plant

Turbulent Carbonator

- High flue gas load flexibility
- BFB-TFB-CFB
- No entrainment required for solid cicrulation
- Plant sizes < 200 MW_{th}



Operating Window

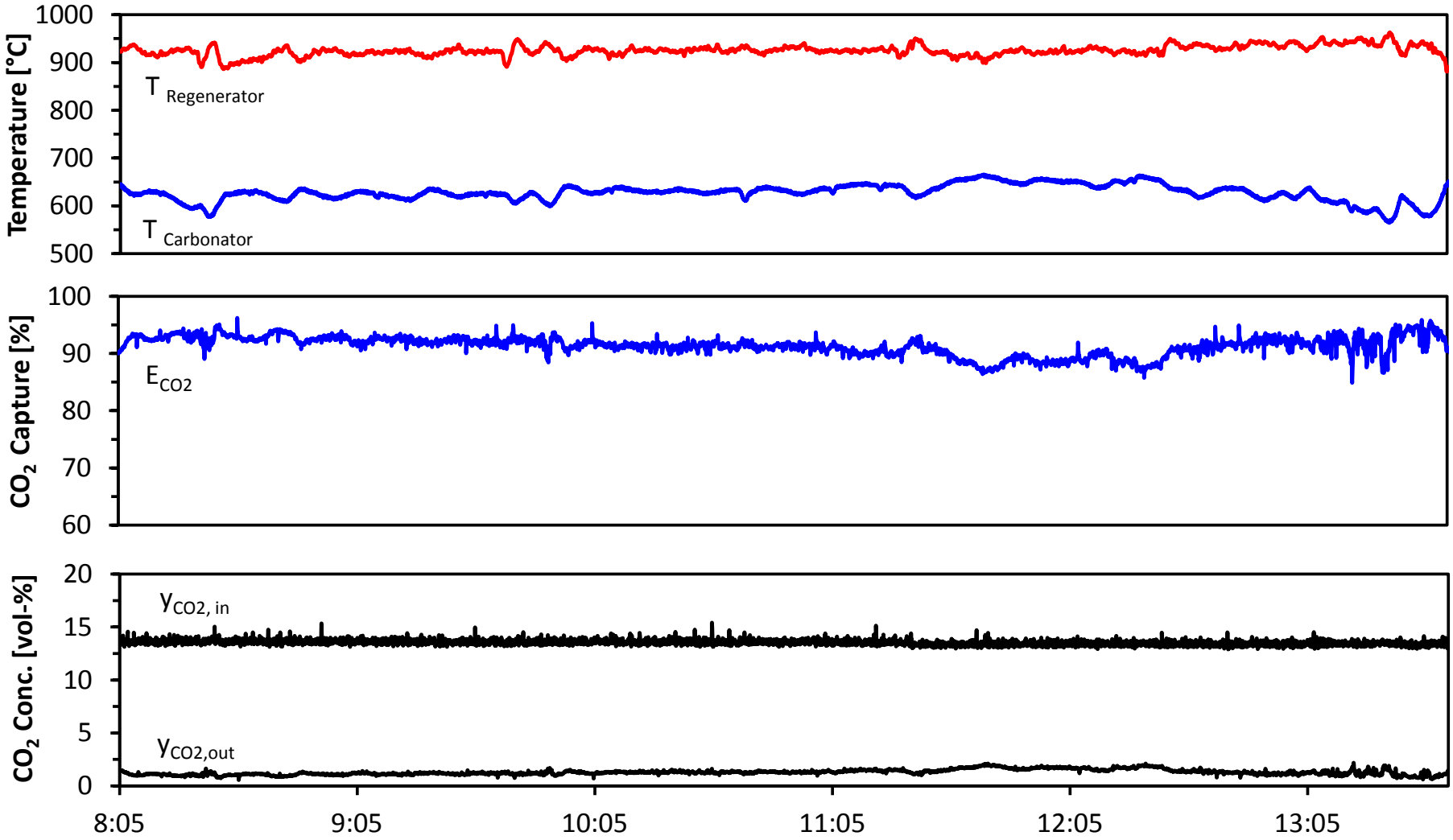
Flue Gas Load:
50 - 200 kW_{th}

Sorbent Looping Ratio:
3-13 mol_{CaO}/mol_{CO2}
(≈ 100-1000 kg_{Ca}/h)

Total Solid Inventory:
70-120 kg $CaO/CaCO_3$

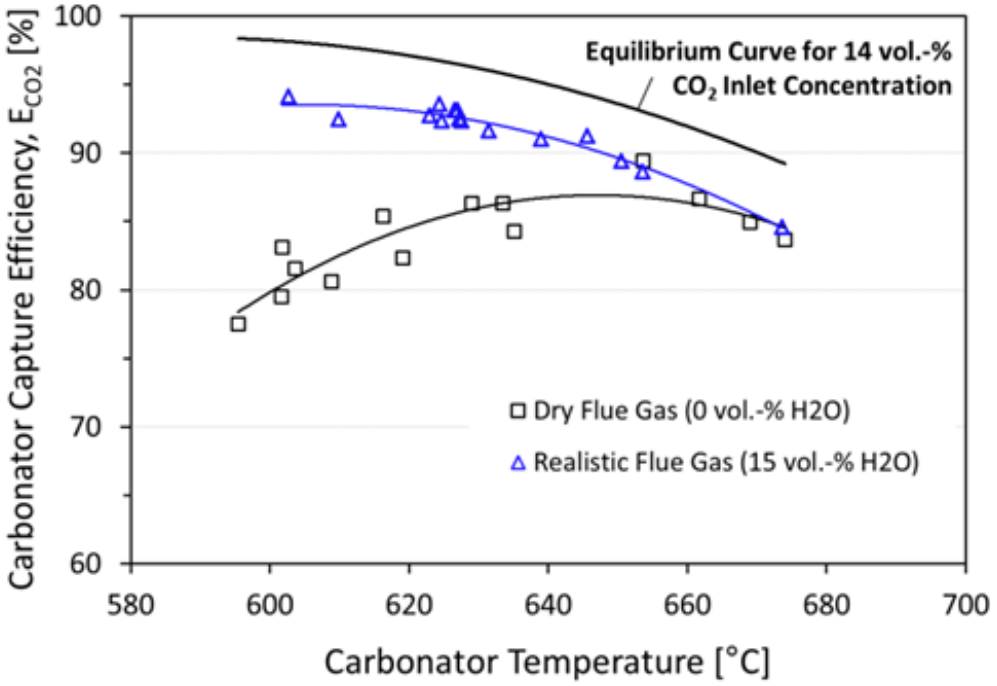
Pilot Plant operational results

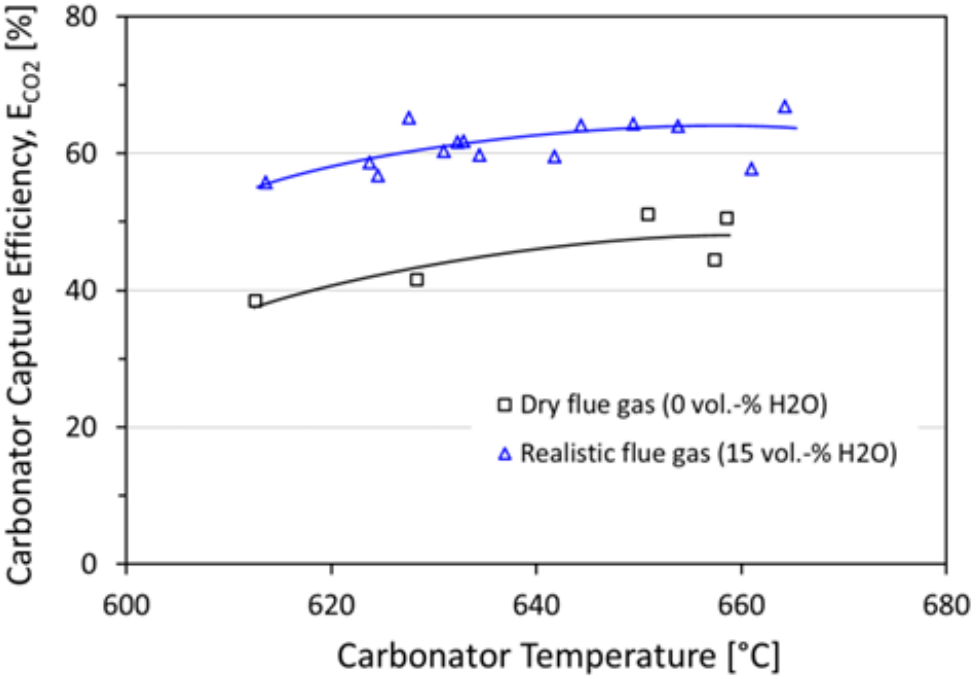
- **Over 90% capture efficiency** achieved over a wide range of operating conditions



Effect of water vapor in real flue gas

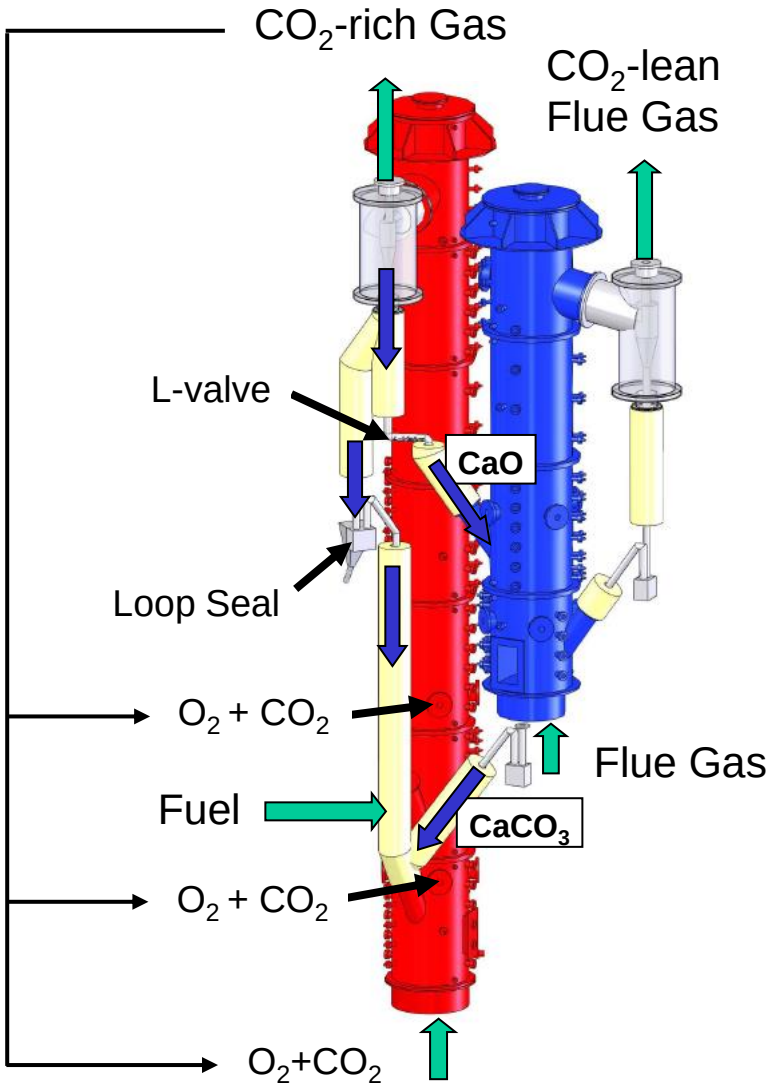
- **Capture efficiencies for real flue gas close to chemical equilibrium**
- **Improvement potential with real flue gas up to 60 % identified in pilot experiments**





⇒ **Efficiency potential identified with real flue gas incl. water vapor (15 vol.-%)**

Calciner performance at oxy-fuel combustion

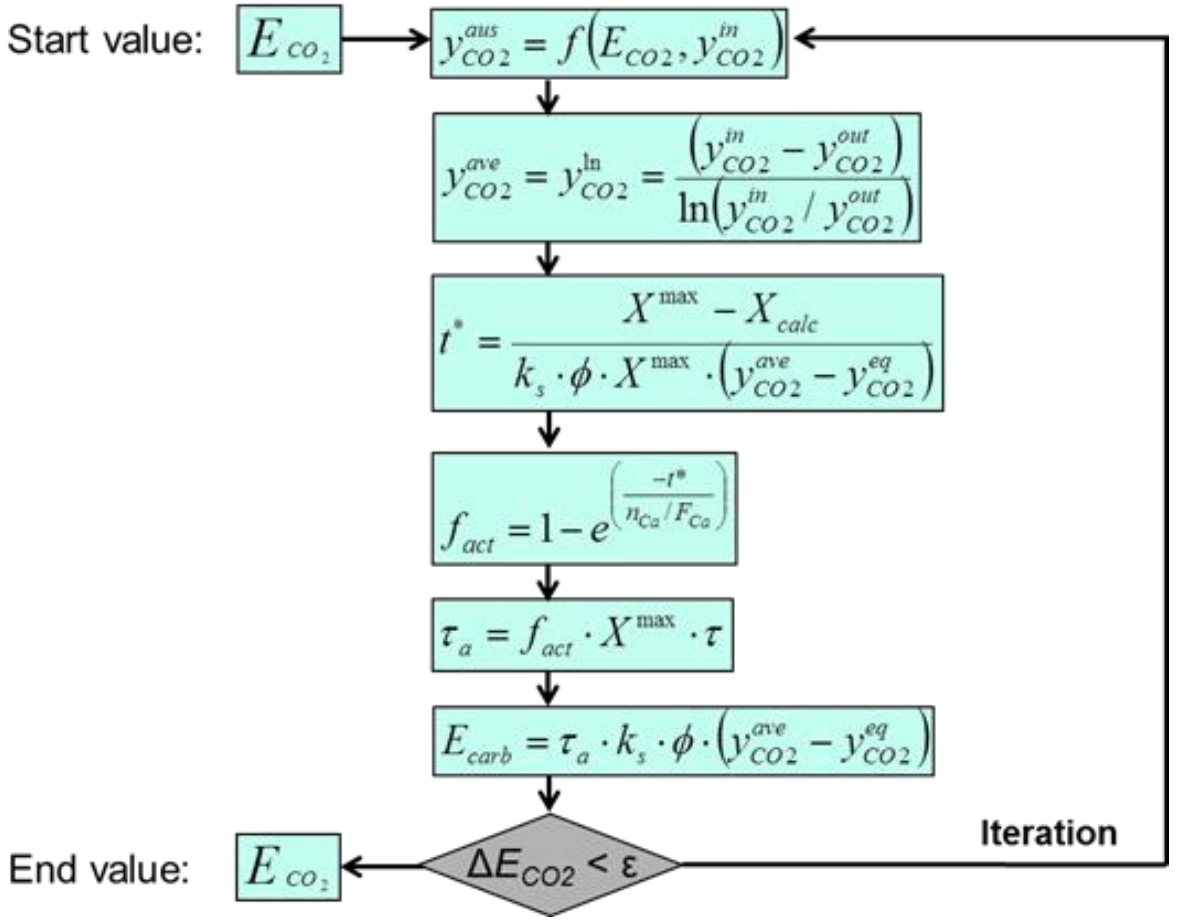


- Successful oxy-fuel regeneration with flue gas recycle
- Full calcination of sorbent
- Calciner CO_2 outlet concentrations above 90 vol.-%,dry
- Excess O_2 outlet concentrations below 3 vol.-%,dry
- Inlet O_2 concentrations above 50 vol.-%,dry without temperature peaks in the riser

Simulation of process efficiency

CO_2 capture model:

- Implemented in ASPEN Plus® Simulation
- Prediction of CO_2 capture efficiency
- Validated with data from pilot scale experiments



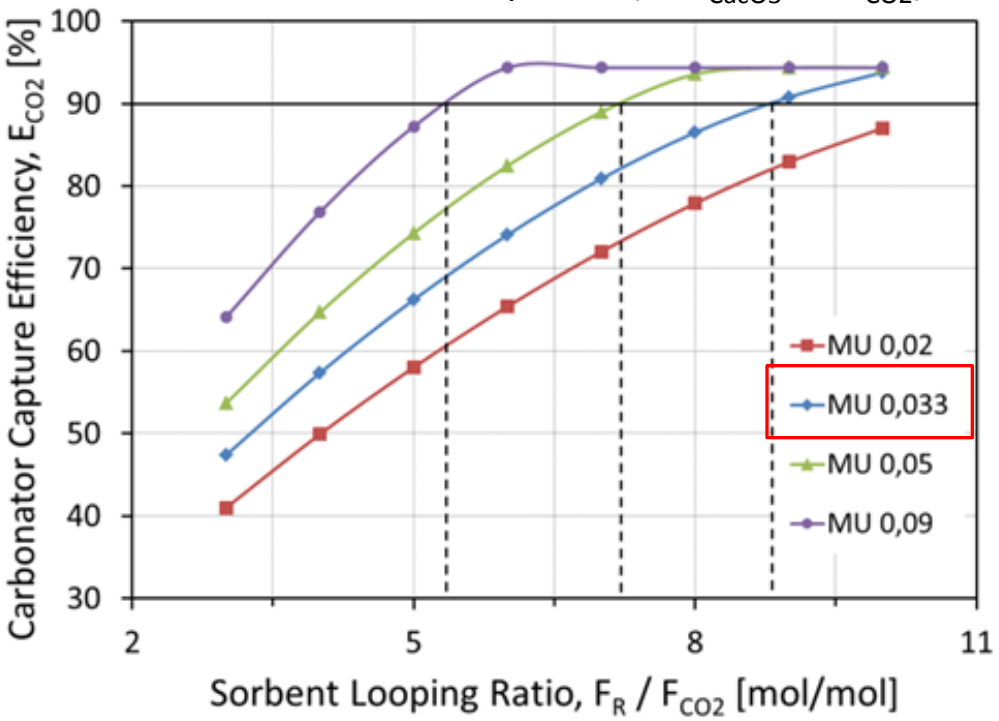
⇒ **Used for process optimization and identification of efficiency potential**

Charitos et al.

Process optimization by simulations

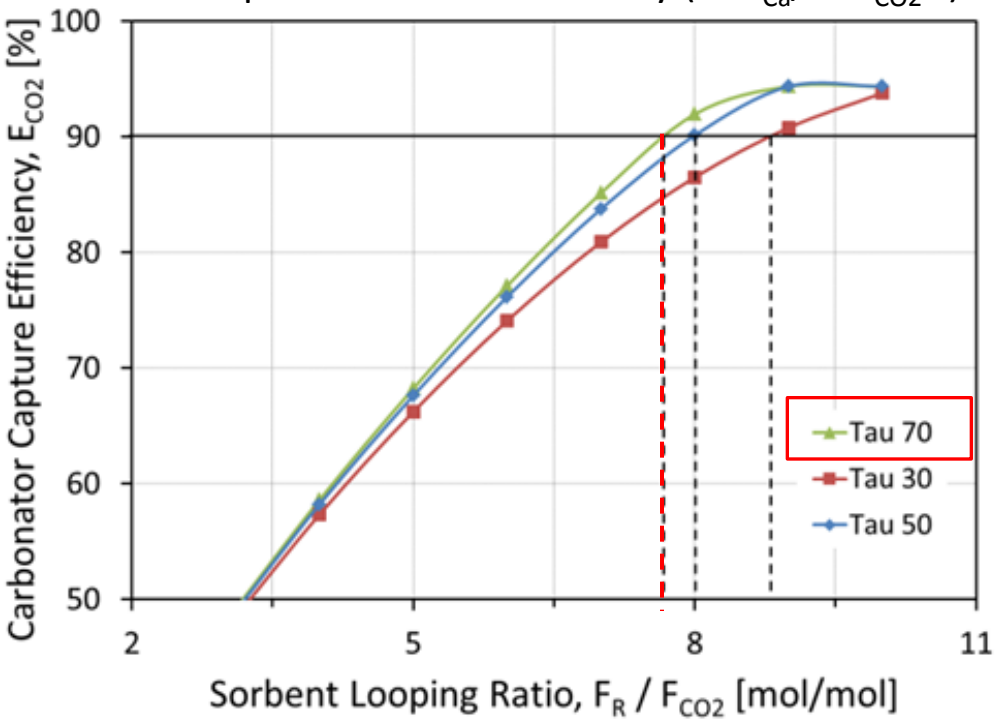
- **Identification of minimum required sorbent make-up ratio**

MU= Sorbent Make-Up ratio (mol_{CaCO3}/mol_{CO2})



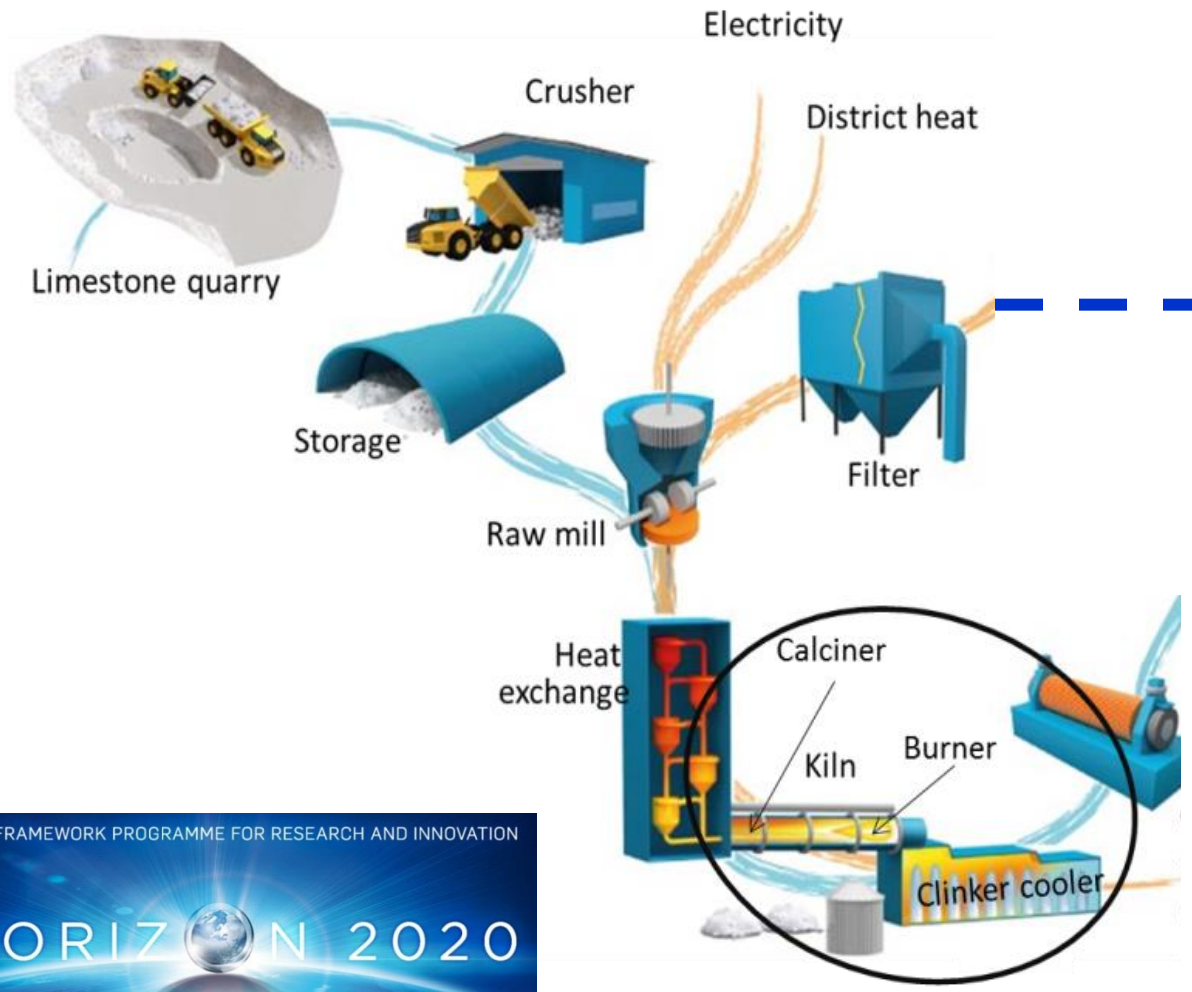
- **Optimization of looping ratio to safe fuel for calcination**

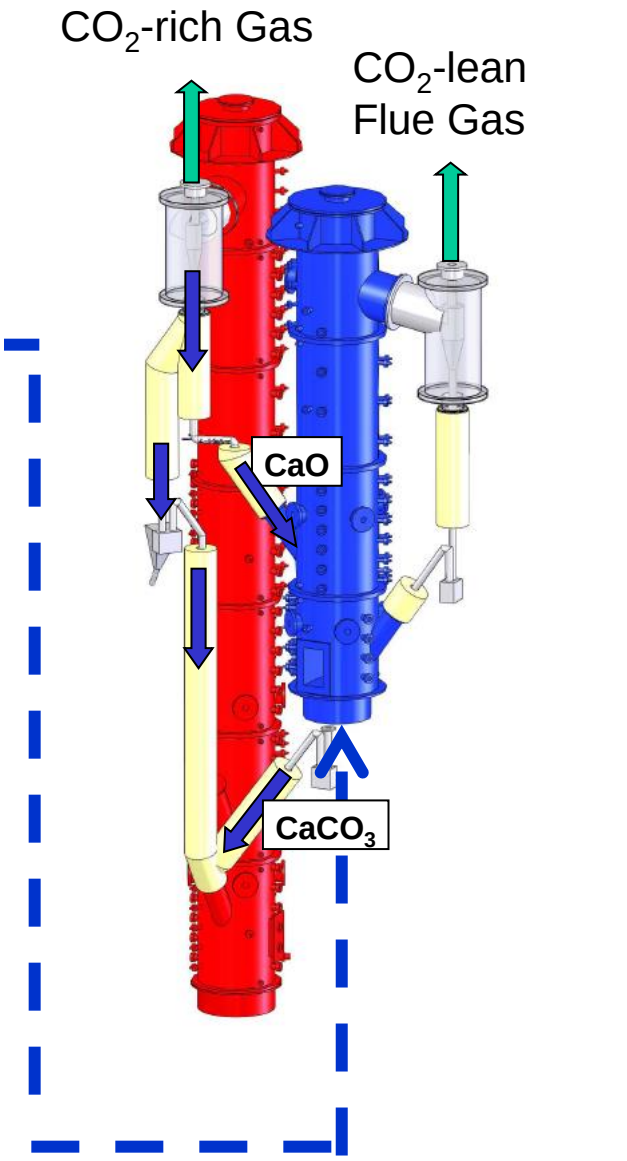
Tau= specific sorbent inventory (mol_{Ca}/mol_{CO2} s)



⇒ **Design tool to identify optimum operating points by process simulations**

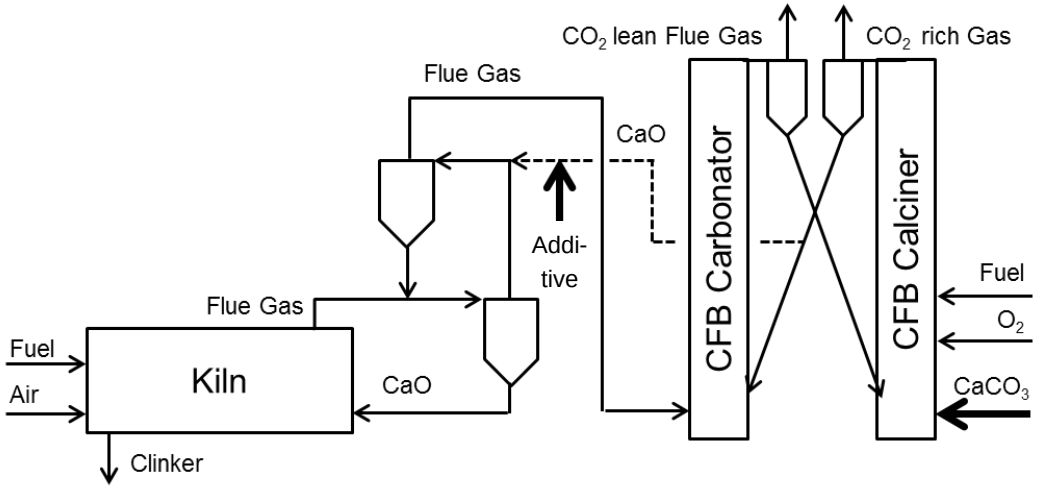
The Horizon 2020 project CEMCAP





Goals of CEMCAP

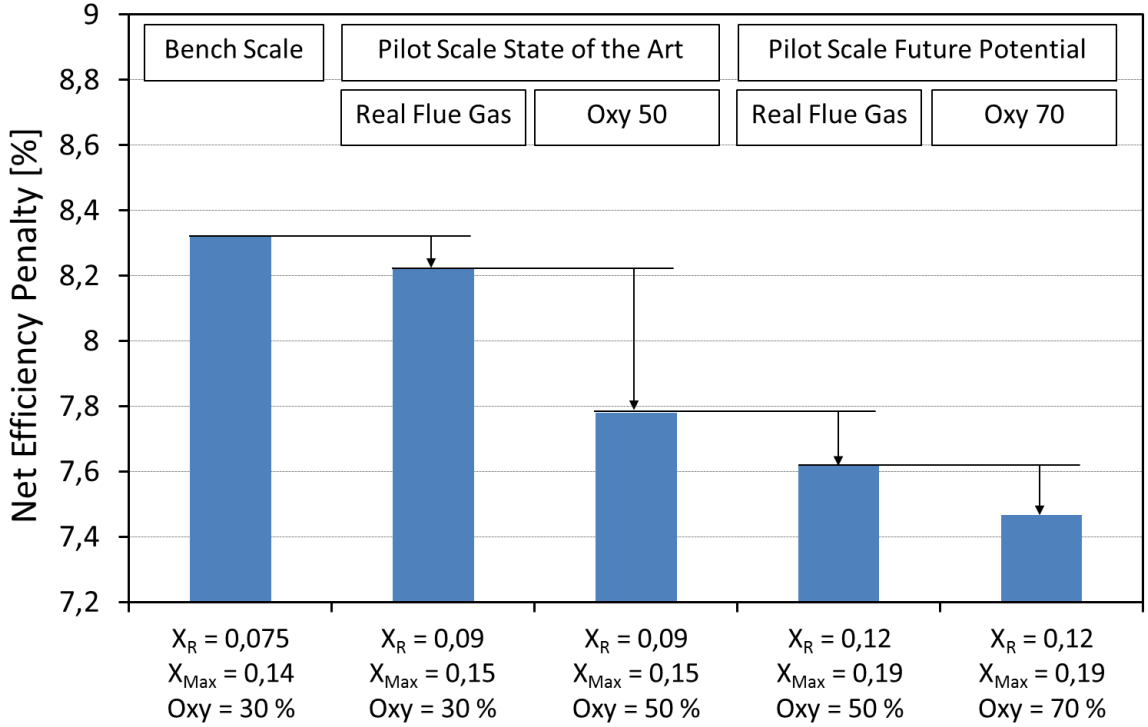
- Demonstration of Calcium Looping post combustion capture for cement
- Optimization of operating and process conditions
- Development of an integrated Calcium Looping cement process



Calcium Looping Post combustion capture

Summary

- **Calcium Looping successfully demonstrated at pilot scale for power plants**
- **Validated process model developed as process design tool for scale up**



Next steps:

- **Demonstration and optimization of Calcium Looping for cement application**

Thank you for your interest!

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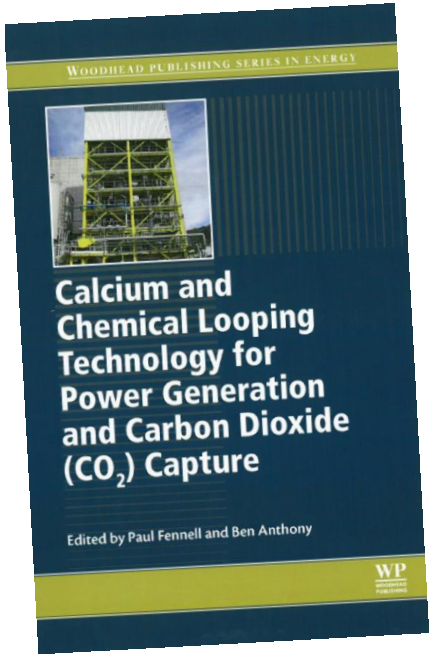

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