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Demonstration of Steady State CO_2 capture in a 1.7 MW_{th} Calcium Looping Pilot

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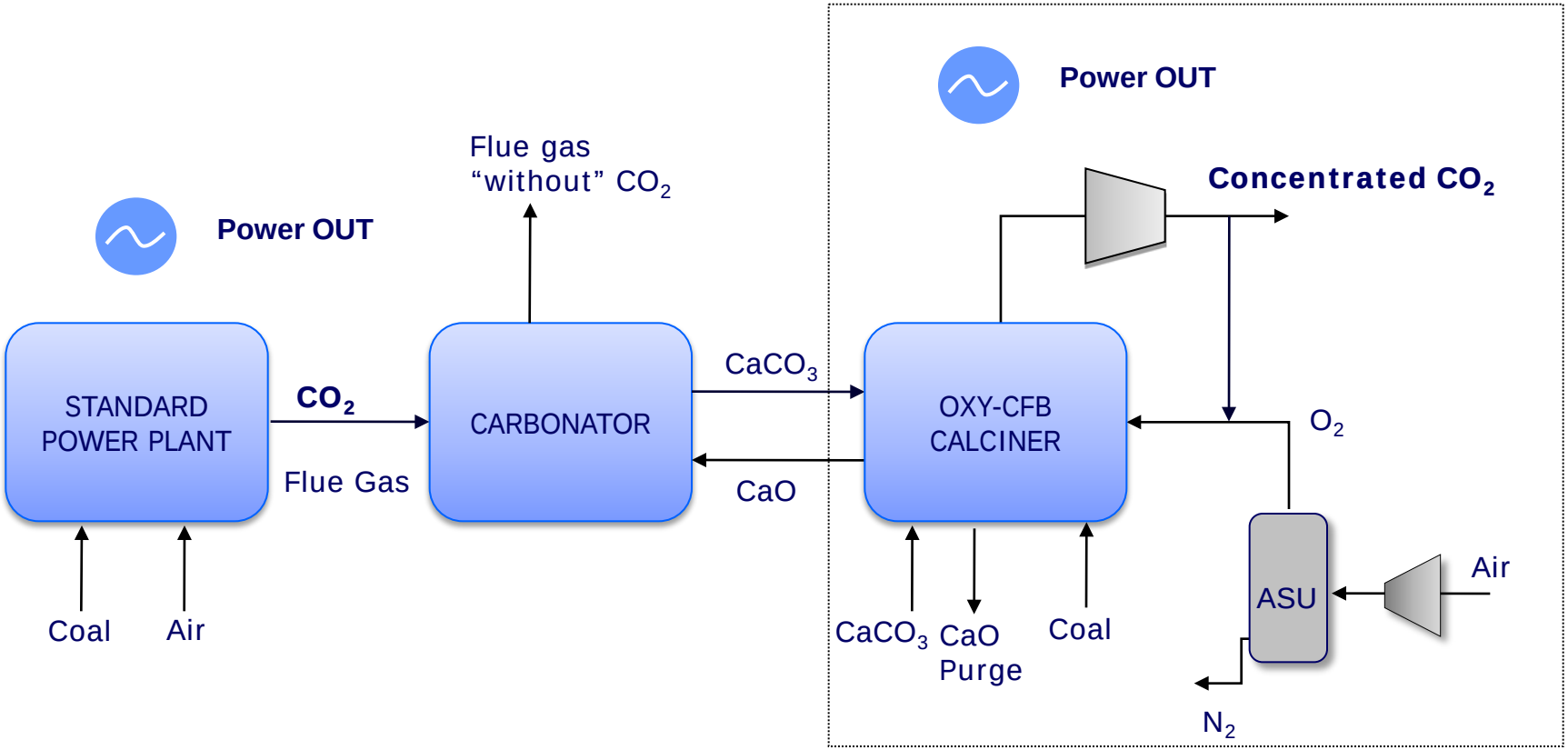
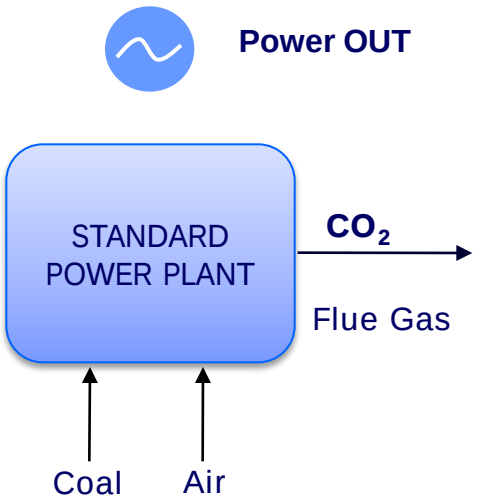
OUTLINE

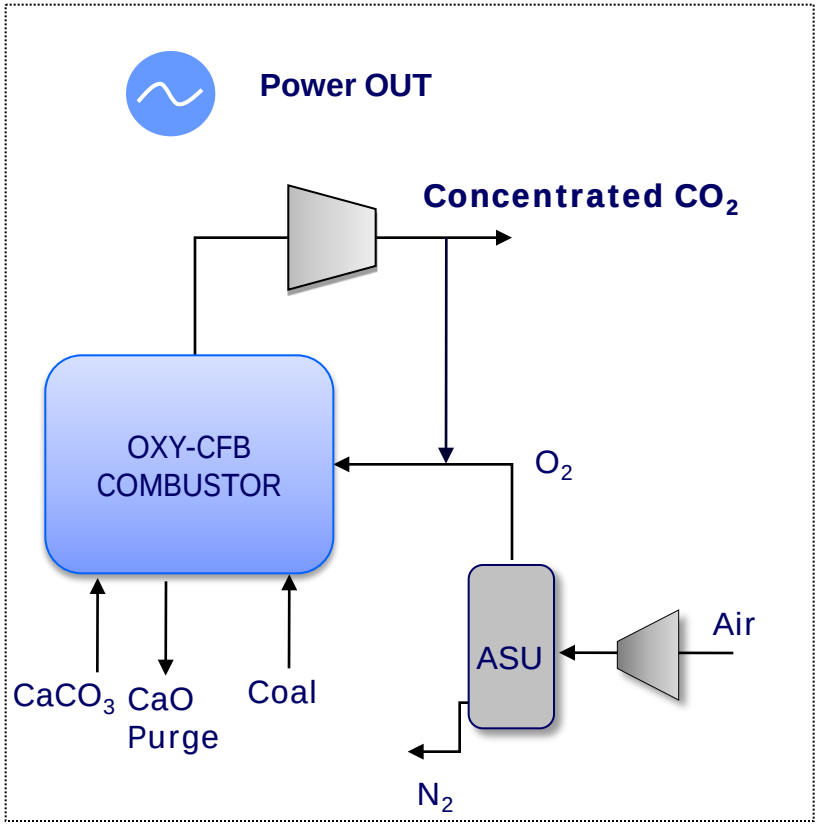
- The concept of Calcium Looping
- Description of “la Pereda” 1.7 MW_{th} pilot
- Steady state results from the pilot
- Conclusions

Calcium looping: postcombustion process concept ?

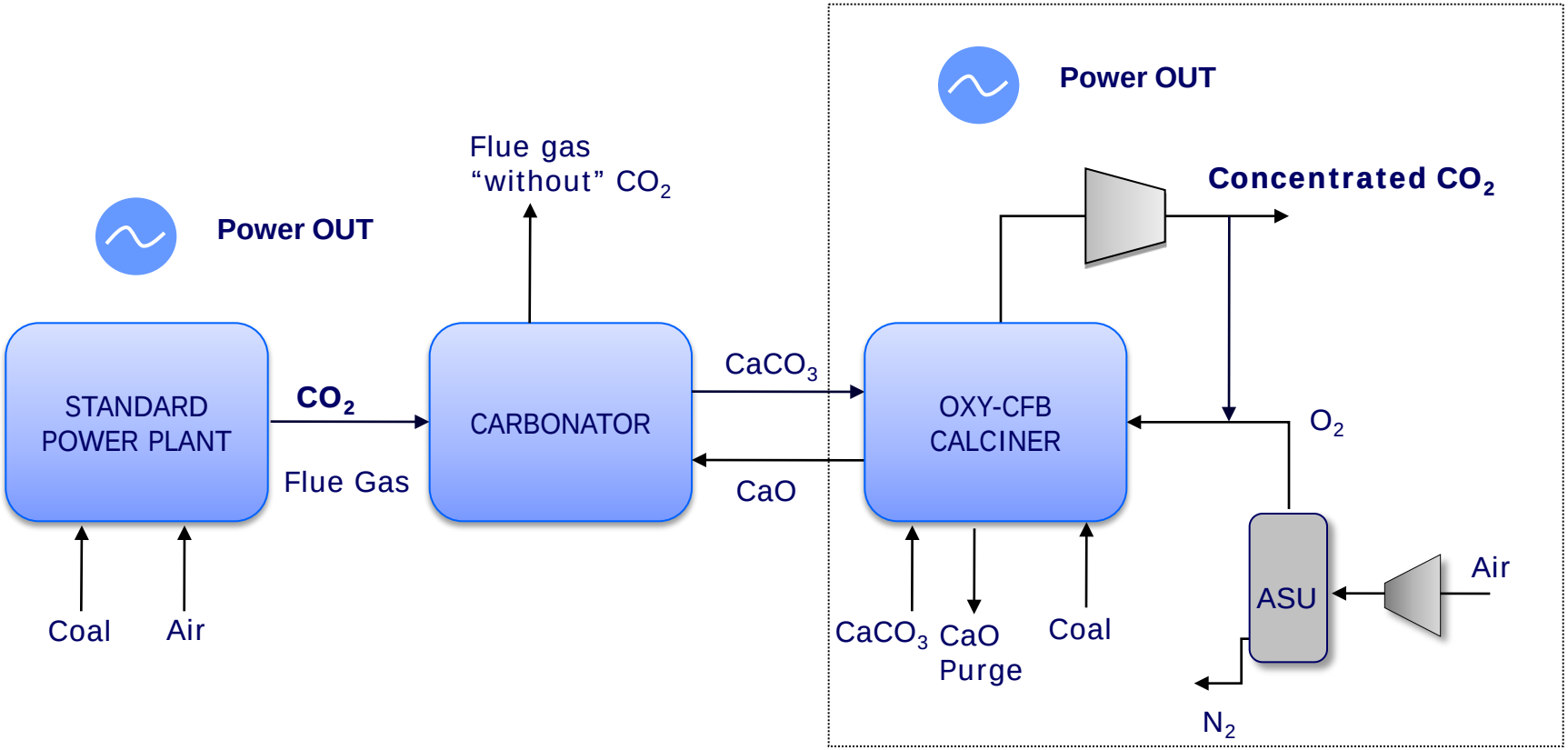


Process concept : post-combustion Ca-L technologies … in OCC3 ?

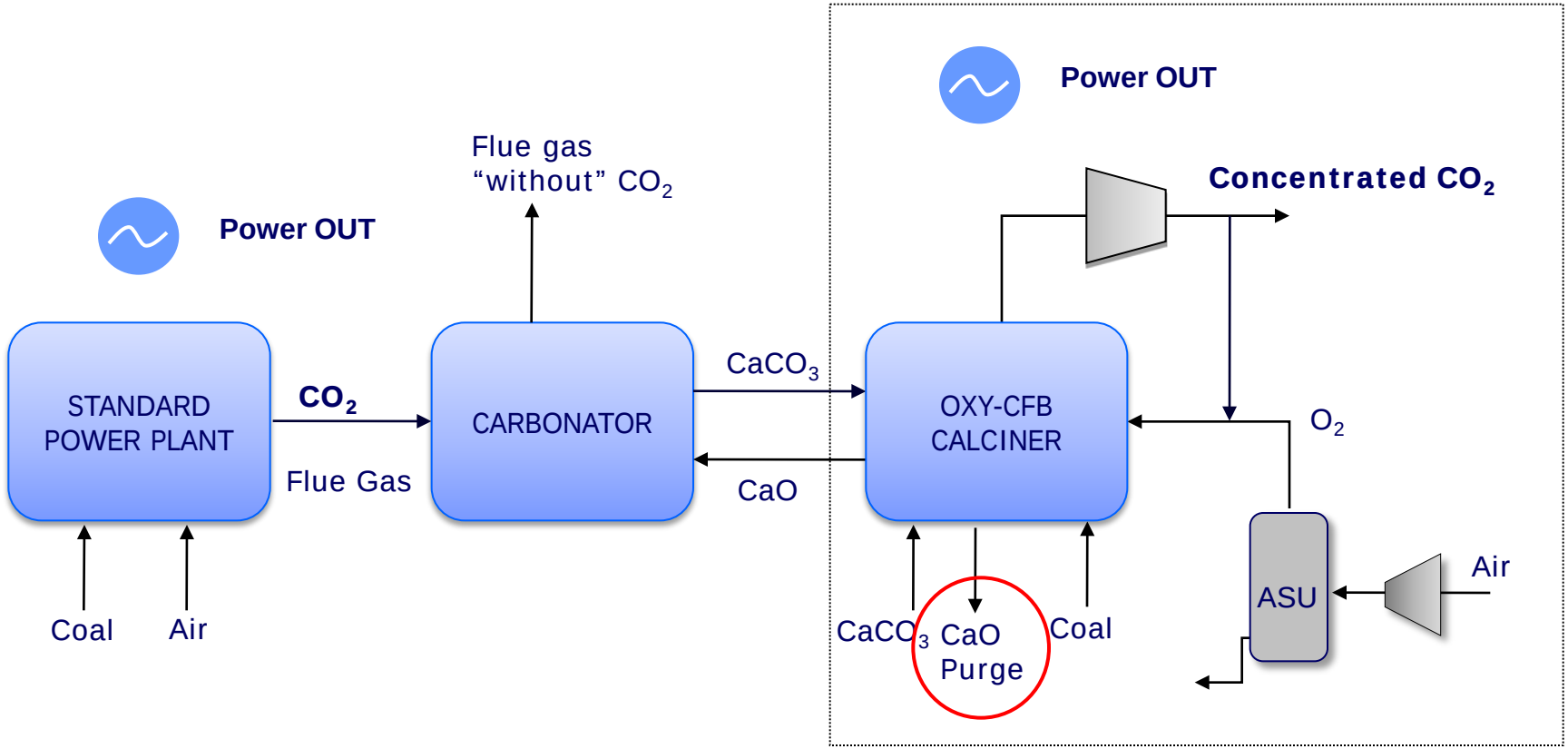




Process concept 1: post-combustion Ca-L technologies



Process concept 1: post-combustion Ca-L technologies



Some advantages of postcombustion Ca-looping :

- **Low energy penalty (6-7 net points)/low cost per ton CO_2 captured (~30% reduction)**
- **Purge of CaO: synergies with cement industry if necessary**
- **Pre-treatment of flue gas no needed (SO_2 co-capture)**
- **Large scope for further cost reductions (indirect heating calcination, sorbent uses etc)**

Developing process leading to “la Pereda 1.7 MWth” pilot

Multicycle testing TG at CSIC

Reactions kinetics, deactivation studies, reactivation methods

From 2000

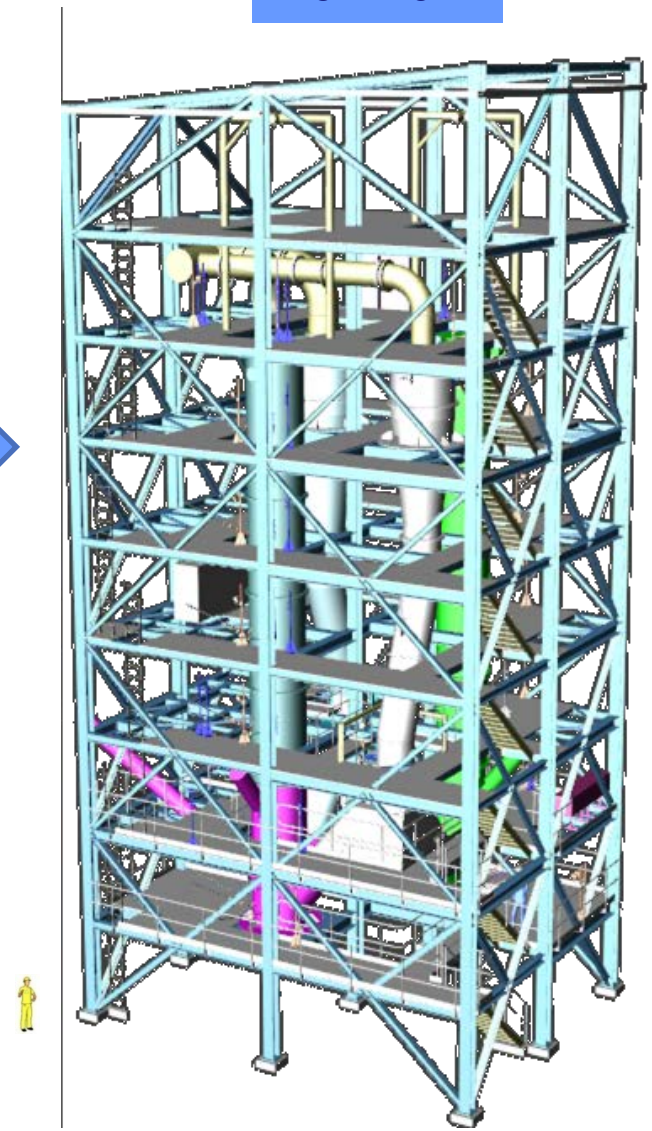
Industrial partners

0.03 MWth pilot at INCAR-CSIC

Twin CFB reactor concept validation in lab scale. Basic reactor and process modeling

From 2008

From 2012



24 m

La Pereda CO_2 pilot plant: Current status

LA PEREDA CO_2 CAPTURE PILOT PLANT: DESCRIPTION

grupohunosa endesa generación CSIC Consejo Superior de Investigaciones Científicas FOSTER WHEELER

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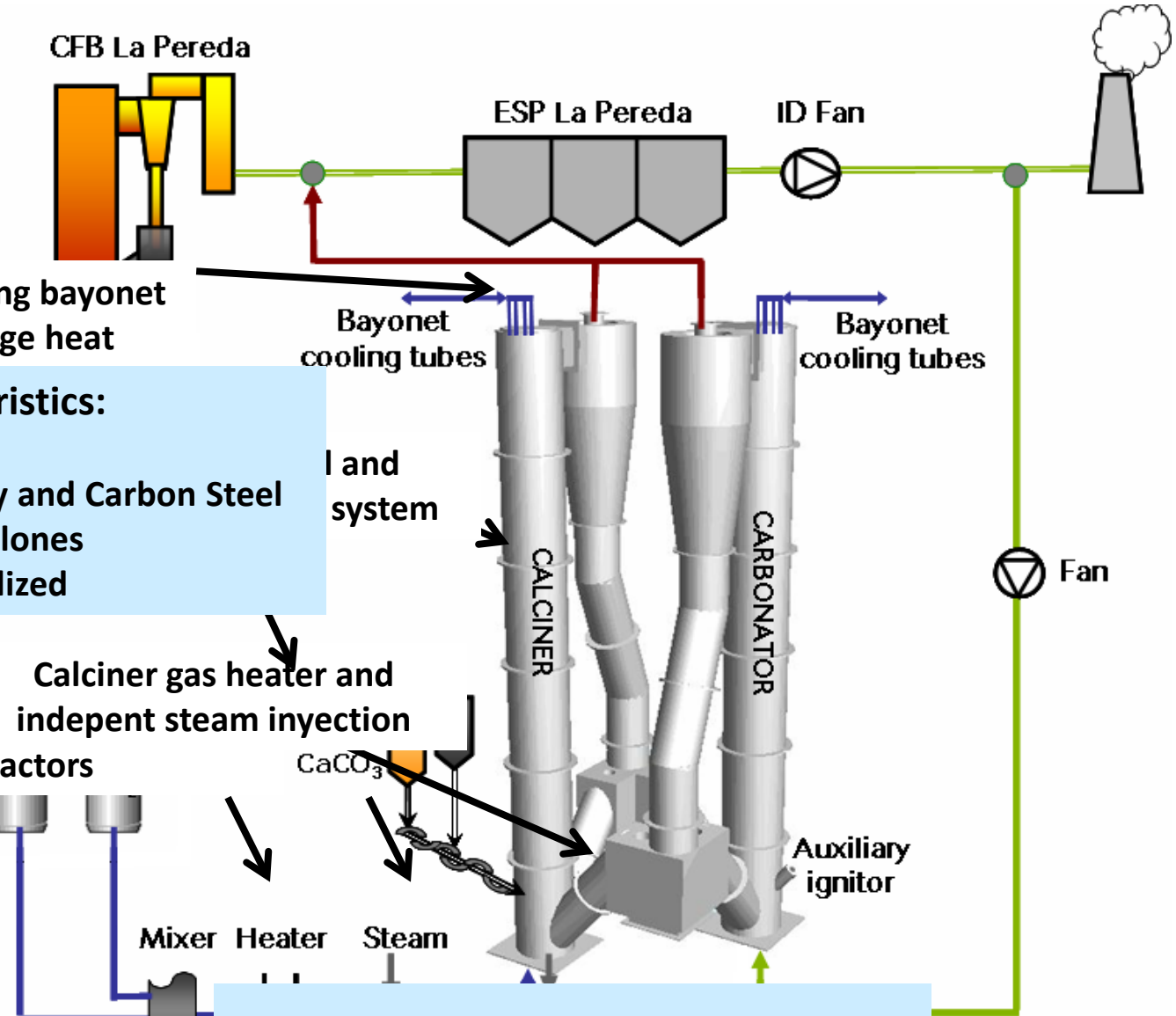


Removable cooling bayonet tubes to change heat

Reactor Characteristics:

- Height: 15 m
- Made of refractory and Carbon Steel
- High efficiency cyclones
- Fully instrumentallized

l and system

Double lo solid circ reactors

Calciner gas heater and indepent steam inyection

www.caoling.eu

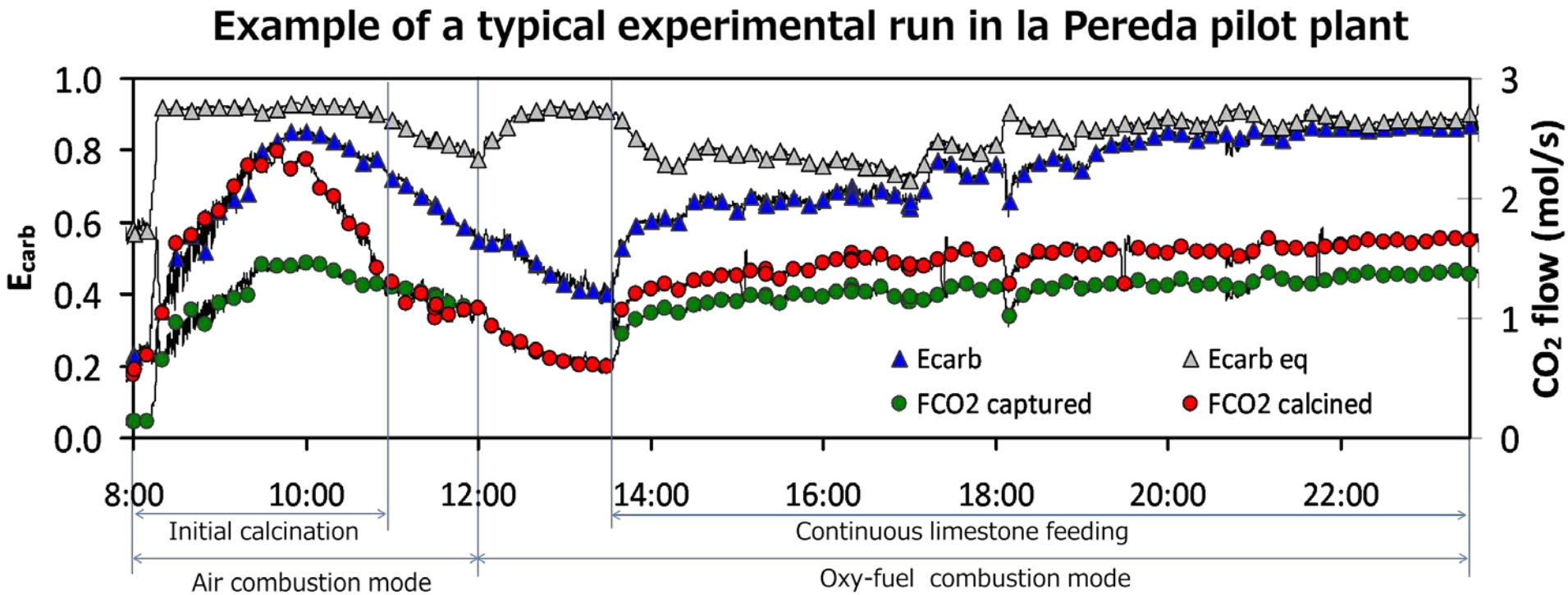
Range of conditions during the CO_2 capture test:

Carbonator temperature (ºC)	600-715
Carbonator superficial gas velocity (m/s)	2.0-5.0
Inlet CO_2 volume fraction to the carbonator	0.12-0.14
Inlet SO_2 concentration to the carbonator (mg/m^3)	100-250
Inventory of solids in the carbonator (kg m^{-2})	100-1000
Maximum CO_2 carrying capacity of the solids	0.10-0.70
Calciner temperature (ºC)	820-950 ºC
Inlet O2 volume fraction to the calciner	0.21-0.35
Inlet CO2 volume fraction to the calciner	0-0.75
CO_2 capture efficiency	0.4-0.95
SO_2 capture efficiency	0.95-1.00

These conditions include the operating window expected in large scale systems

Results from the 1.7 MWth CaL pilot plant of la Pereda

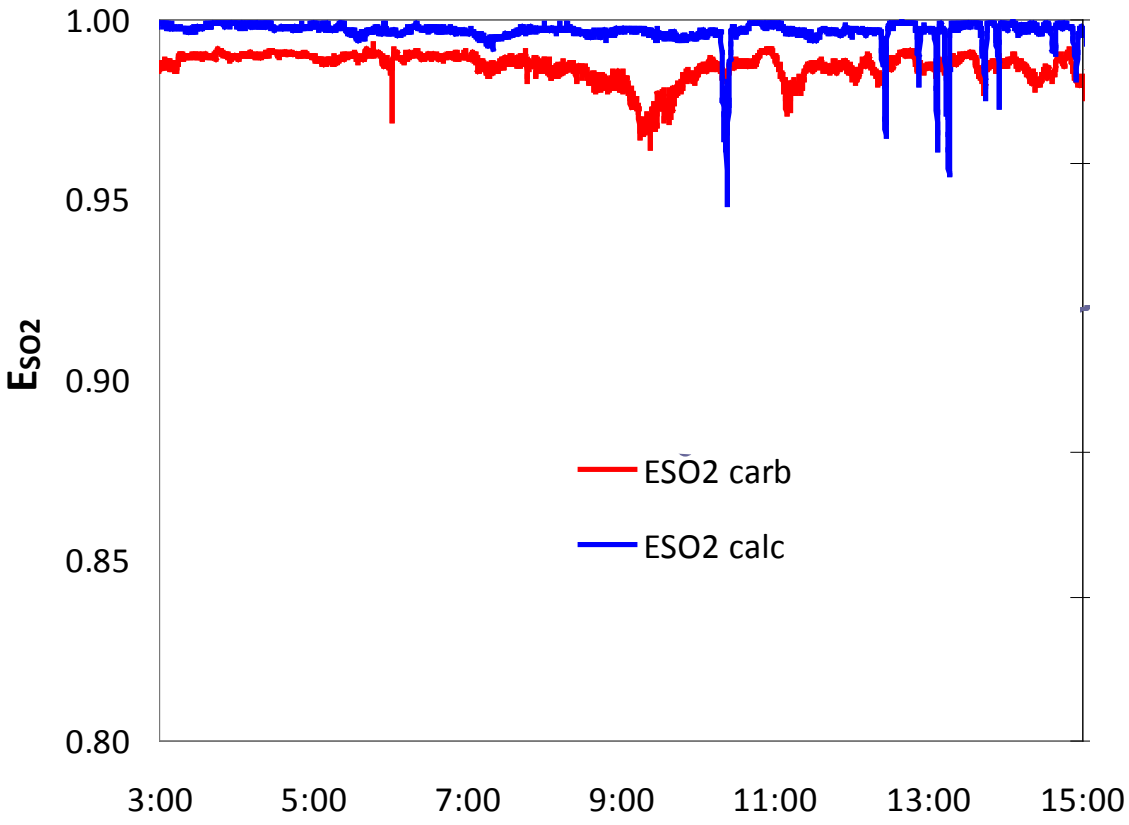
Typical start up and steady state experiment



~ 380 h in steady state CO2 capture mode (170 h with the calciner working under oxy-fuel conditions). 2000 hours in other combustion modes

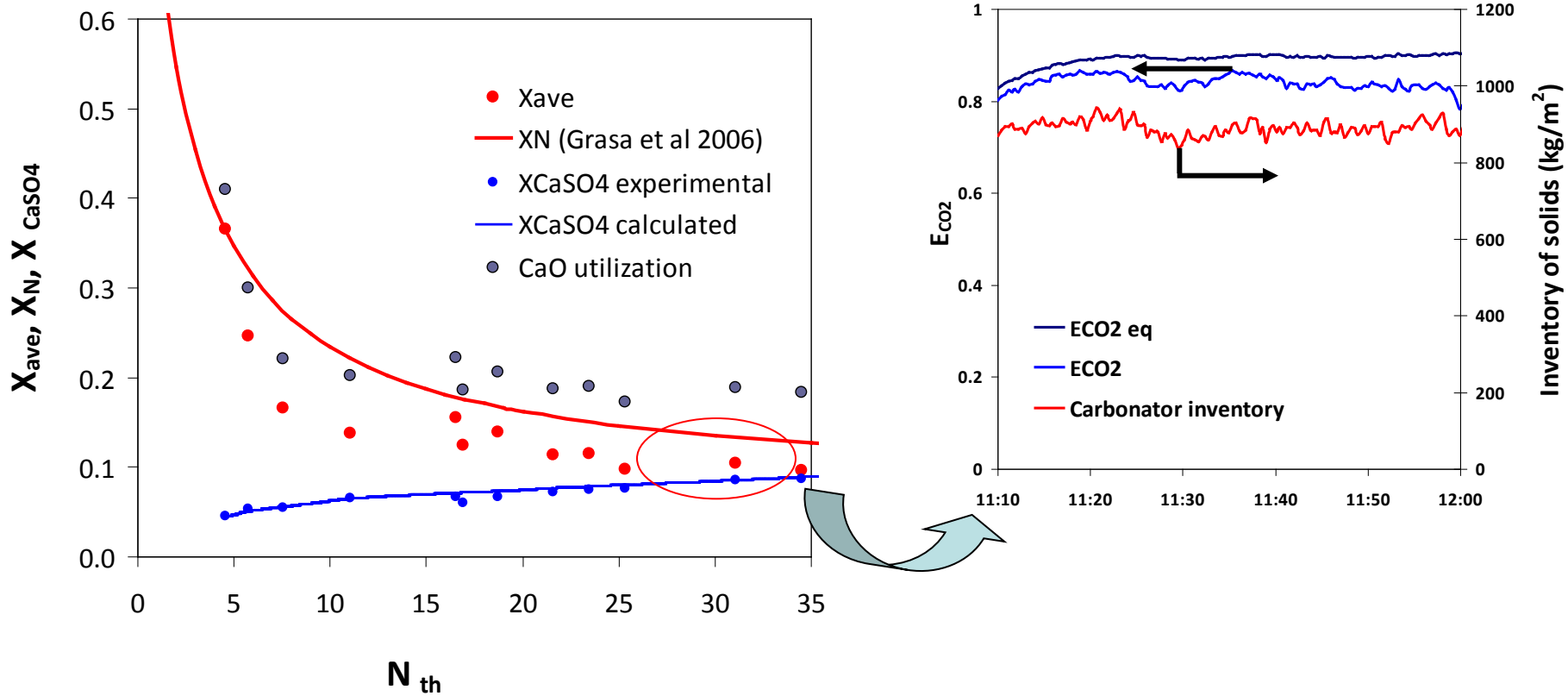
Results from the 1.7 MWth CaL pilot plant of la Pereda

SO_2 capture in the Ca-looping facility

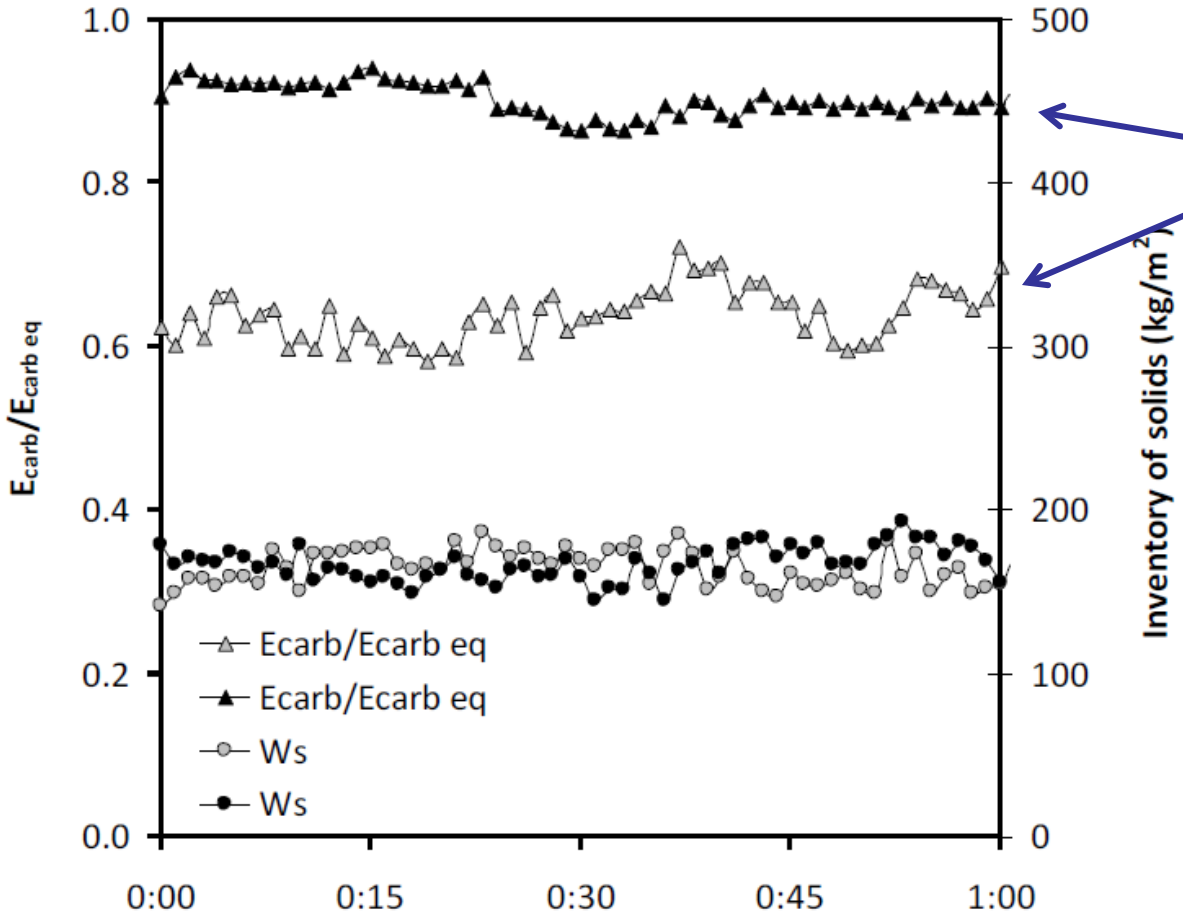


Results from the 1.7 MWth CaL pilot plant of la Pereda

Evolution of sorbent utilization with "lifetime" of particles in the system



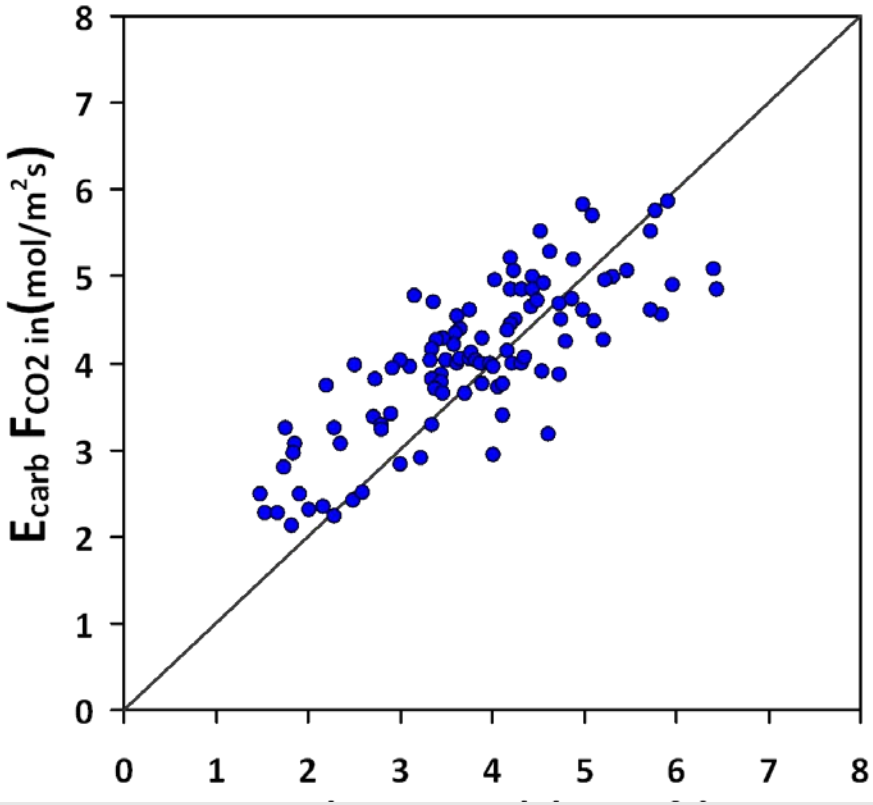
Effect of average sorbent activity on CO_2 capture efficiency (Oxyfuel combustion-calcination mode)



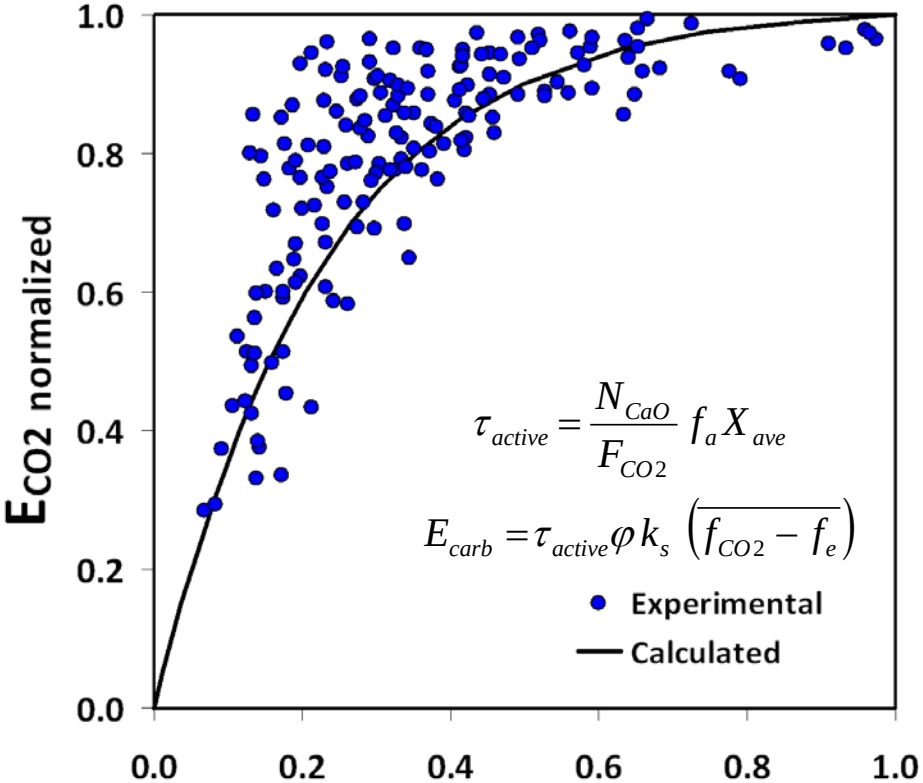
u_{carb} = 4.0-4.3 m/s
T_{carb} = 660-690ºC
X_{ave} = 0.21
X_{ave} = 0.11

Results: Characterization of the carbonator reactor

CO_2 removed from flue gas = $CaCO_3$ in circulating solids



CO_2 removed from flue gas = CO_2 reacting with CaO



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MAIN CONCLUSIONS

- A flexible pilot experimental facility is in operation in La Pereda Power Plant to validate Calcium Looping in the 1MW's size
- CO_2 capture efficiencies over 90% achievable in a CFB carbonator reactor operating with "standard" CaO solids, bed inventories, gas velocities, solid circulation rates and reaction conditions in the carbonator and in the calciner reactor operating in oxyfuel coal combustion mode.
- SO_2 capture in the CFB reactors is between 95-99.5 %
- Ca-looping is rapidly developing: scale up is "easy" by/if exploiting synergy with CFBCs; cost prospects are already very good for the "standard CaL concept" and further cost reductions are credible with recent innovations and advanced process schemes.

SEVENTH FRAMEWORK PROGRAMME

Ca-ling