TCCS9 Trondheim June 12-14, 2017

Preparing the ground for CCS in the European cement industry – CEMCAP status

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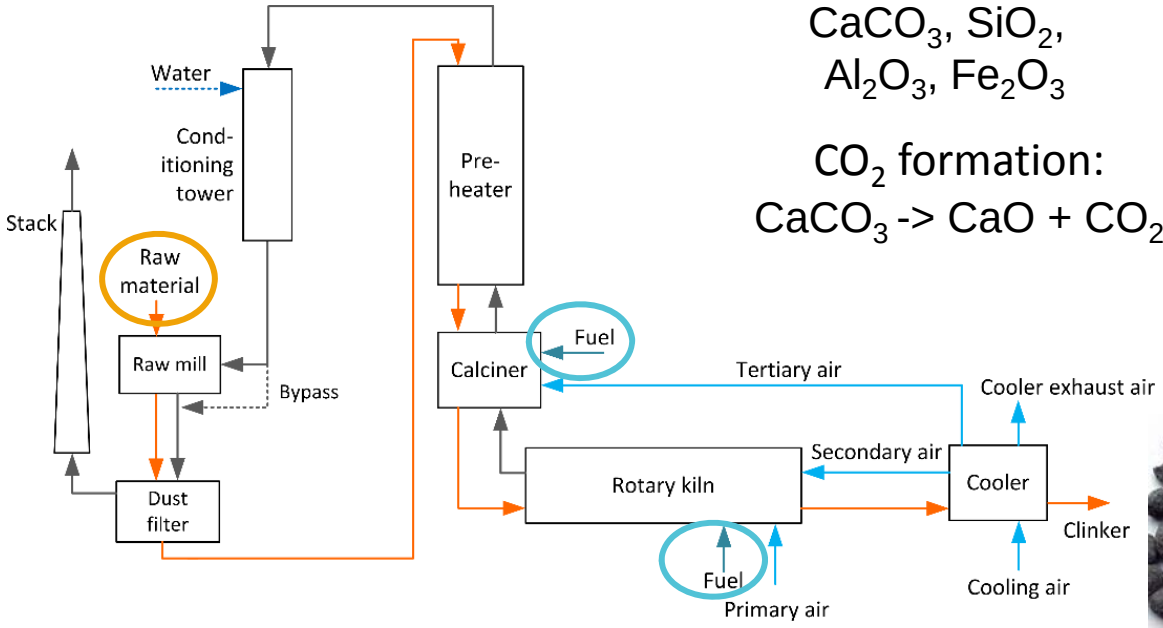
CO_2 emissions from cement production

- Cement production constitute ~5-7% of global anthropogenic CO_2 emissions
- ~60% of the cement plant CO_2 comes from the raw material
- Fuel substitution is not enough for deep emission cuts



Raw materials:

$CaCO_3$, SiO_2, Al_2O_3, Fe_2O_3

CO_2 formation:

$CaCO_3 \rightarrow CaO + CO_2$

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CEMCAP Consortium

Cement Producers

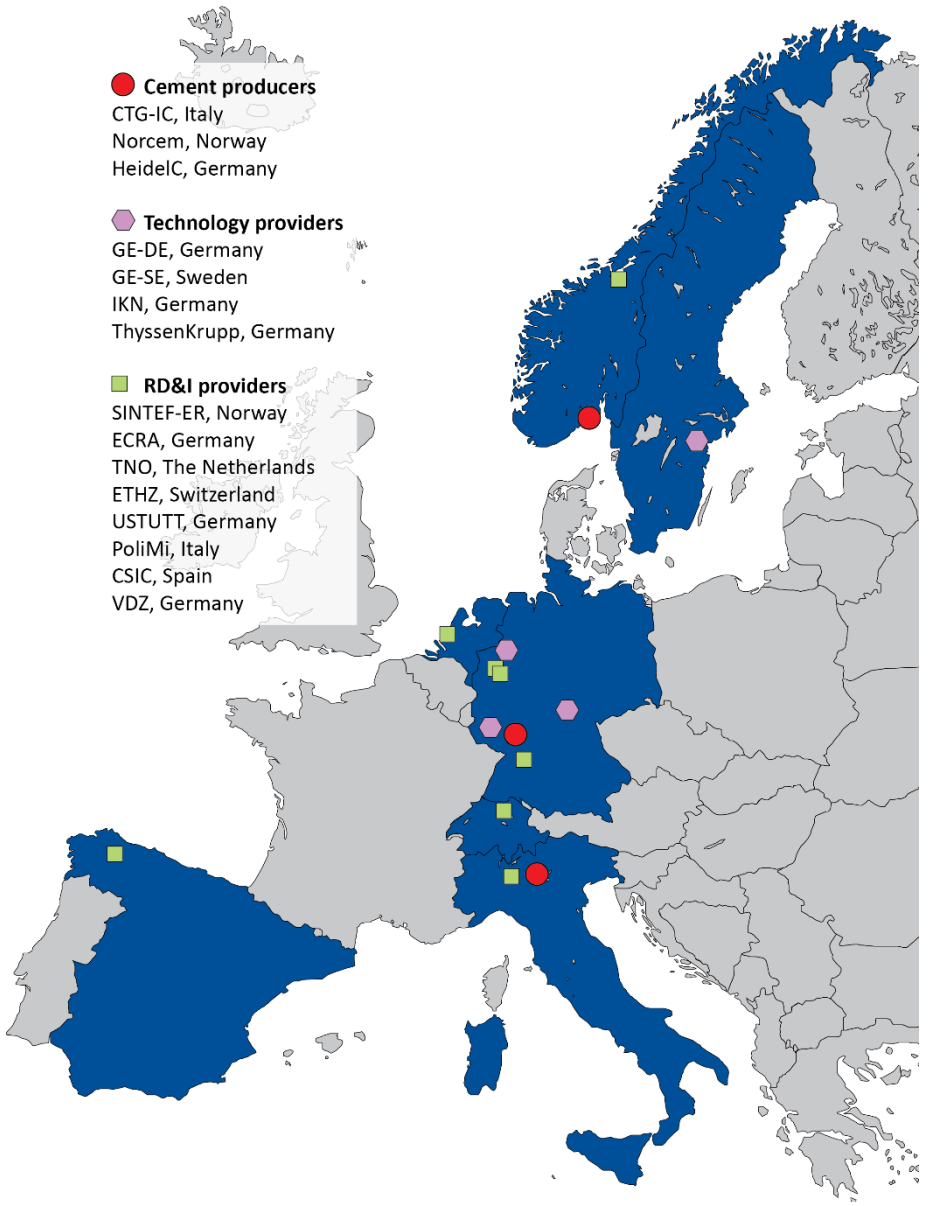
Italcementi, IT
Norcem, NO
HeidelbergCement, DE

Technology Providers

GE Carbon Capture (GE-DE), DE
GE Power Sweden (GE-SE), SE
IKN, DE
ThyssenKrupp Industrial Solutions, DE

Research Partners

SINTEF Energy Research, NO
ECRA (European Cement Research Academy), DE
TNO, NL
EHTZ, CH
University of Stuttgart, DE
Politecnico di Milano, IT
CSIC, ES
VDZ, DE



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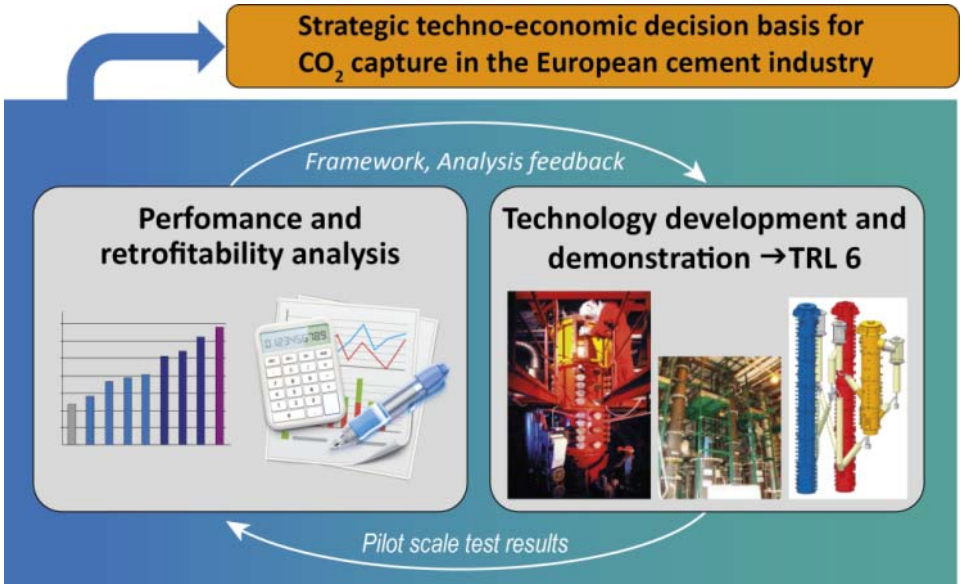
CEMCAP approach: iteration between analytical and experimental research



<u>Analytical work</u>

Framework document

Capture process simulations

Simulations of full cement plants (kilns) with CO_2 capture

Cost estimations/benchmarking

Retrofitability analysis

<u>Experimental work</u>

Testing of three components for oxyfuel capture (linked to ECRA CCS project)

Testing of three different post-combustion capture technologies

~10 different experimental rigs

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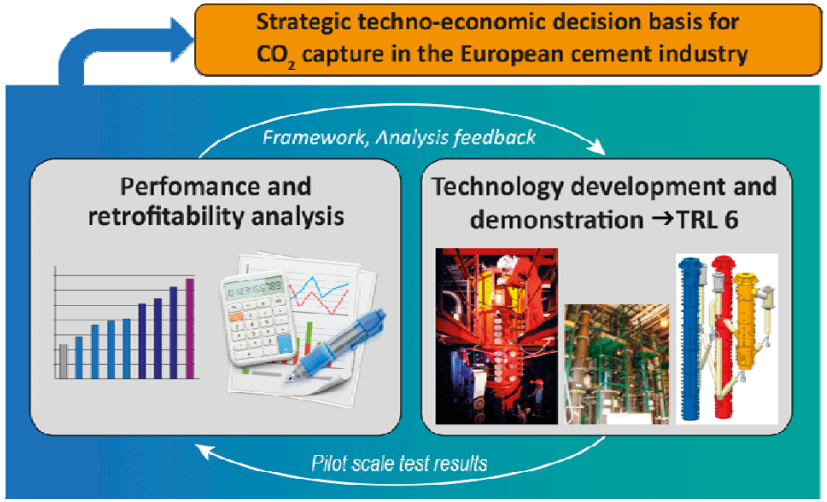
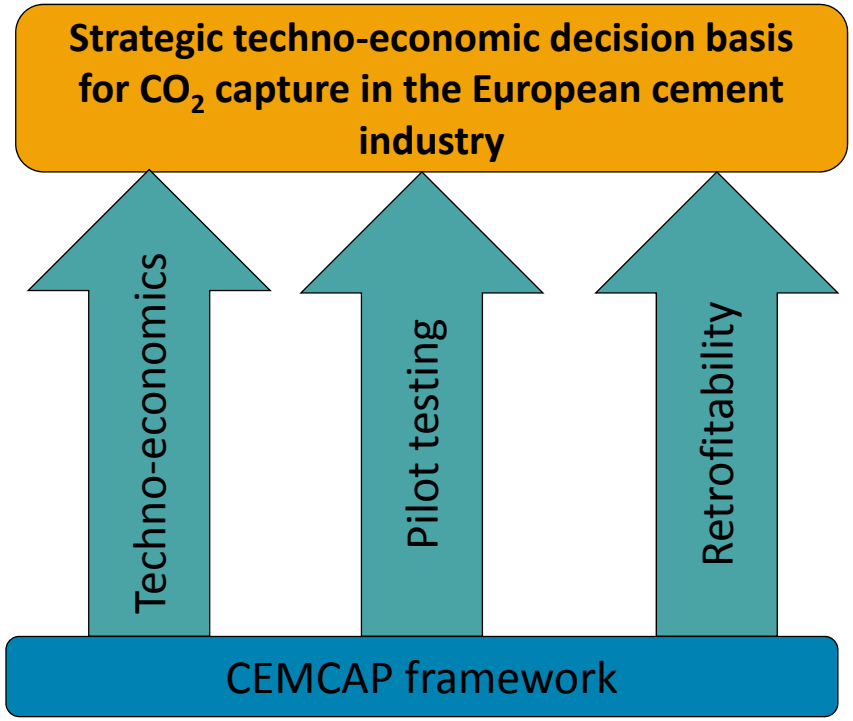
CEMCAP concept and outcome





Capture technologies in CEMCAP:

- Oxyfuel capture
- Chilled ammonia process
- Membrane-assisted CO_2 liquefaction
- Calcium looping

Retrofitability: cement plants differ in construction, raw material, fuel et.c.
E.g. the capture technology suitable for Norcem in the Norwegian full-scale project is not suitable for all other cement plants

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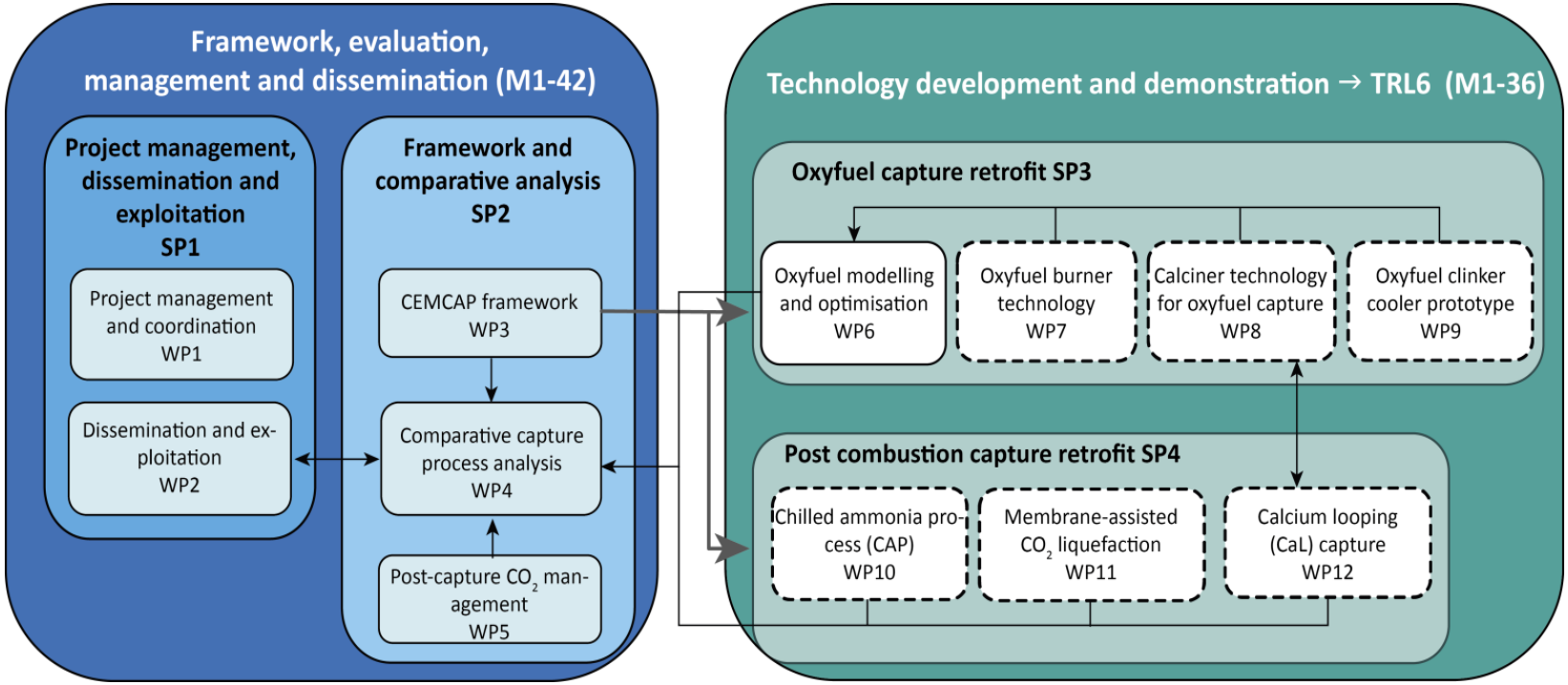
CEMCAP structure



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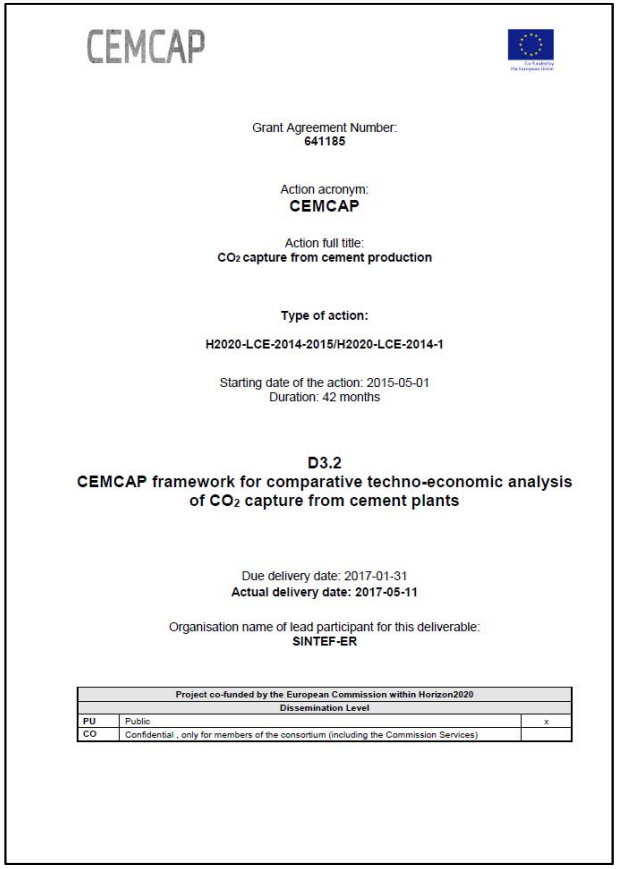
WP3: CEMCAP framework – finished and ready for sharing!

- For consistent comparative assessment of capture technologies
- Provides information relevant for experimental and simulation work
- Defines:
  - A reference cement burning line
  - Specs for standard process units
  - Utilities description, cost and climate impact
  - Extent of capture and CO_2 specs
  - Economic parameters
  - Key performance parameters



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Grant Agreement Number:
641185

Action acronym:
CEMCAP

Action full title:
CO_2 capture from cement production

Type of action:

H2020-LCE-2014-2015/H2020-LCE-2014-1

Starting date of the action: 2015-05-01
Duration: 42 months

D3.2
CEMCAP framework for comparative techno-economic analysis of CO_2 capture from cement plants

Due delivery date: 2017-01-31
Actual delivery date: 2017-05-11

Organisation name of lead participant for this deliverable:
SINTEF-ER

Project co-funded by the European Commission within Horizon2020		
Dissemination Level		
PU	Public	x
CO	Confidential , only for members of the consortium (including the Commission Services)	

"A framework for CO_2 capture from cement production"
Presentation by Mari Voldsund, Session D2, 14.00

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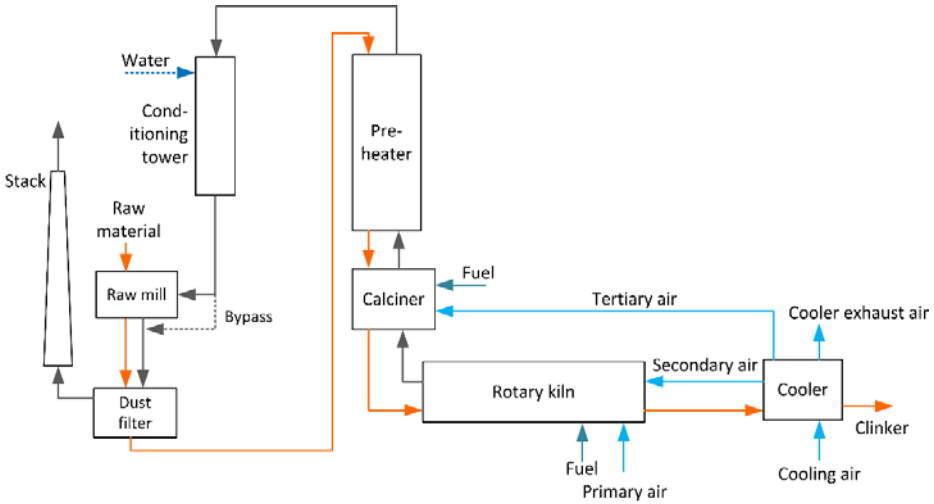
WP4 Comparative capture process analysis

- Concluded and avaialble on the cemcap website:
  - A BAT reference cement plant report, relying on the CEMCAP framework
  - A cement plant reference case with MEA (also poster/paper at GHGT13)



- Ongoing or confidential:
  - First process simulations with CO_2 capture have been done and compared, and feedback provided to partners (intermediate results, therefore confidential)
  - Costing methodology report (preliminary, therefore confidential)

- Remaining work:
  - Retrofitability study
  - Final techno-economic comparison

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WP5 – Post capture CO_2 management

- Cement-production post-capture CO_2 management routes investigated in CEMCAP:

1. CCS: Geological sequestration: option to be defined (TNO)
2. CCS: Mineralization to $MgCO_3$ (ETH Zurich)
3. CCU: CO_2 hydrogenation to ethanol (TNO)
4. CCU: CO_2 polymerization to Poly(propylene carbonate) (TNO)
5. CCU: food-grade CO_2 (TNO)

"CO_2 utilization by Ethanol production in the Cement Industry"
Presentation by Juliana Monteiro, session D5, 13.00

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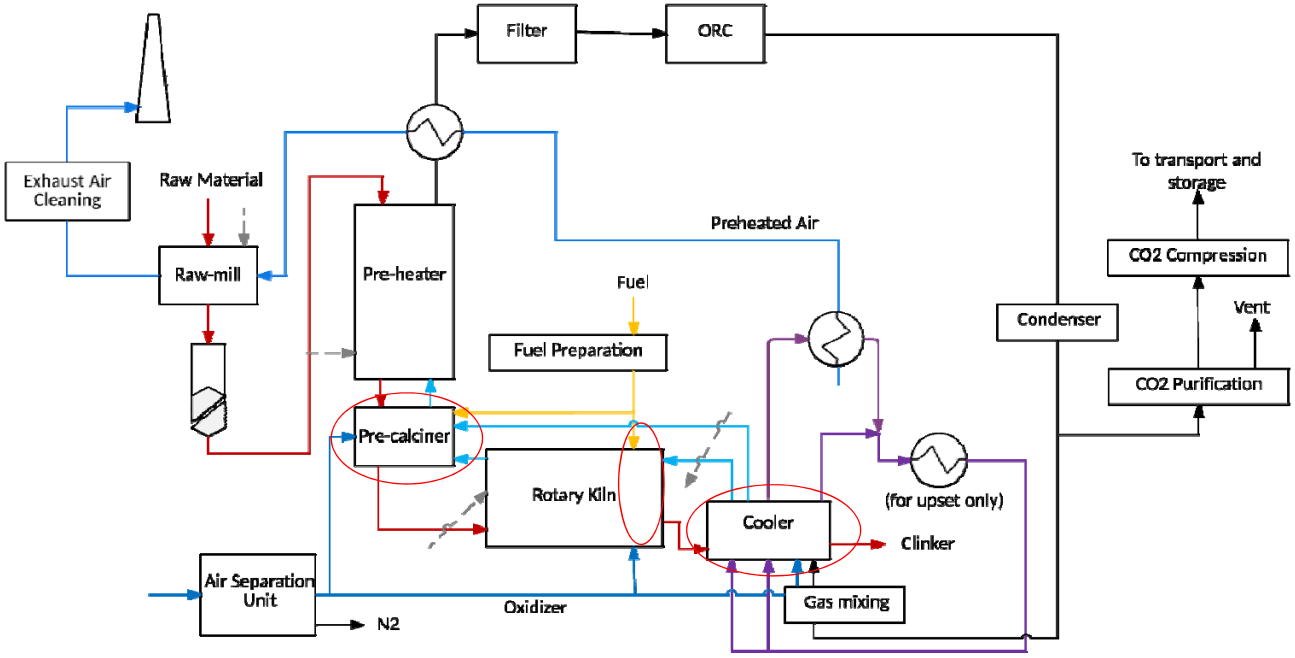
WP6: Oxyfuel modelling

Purpose: Optimization of the oxyfuel clinker burning process based on process modeling verified by prototype results

Oxyfuel principle: Air is replaced by recirculated CO_2 in the plant, to enable capture of highly concentrated CO_2

Oxyfuel research in CEMCAP is closely connected to the ECRA CCS project



Pre-calciner, burner and clinker cooler tested in CEMCAP

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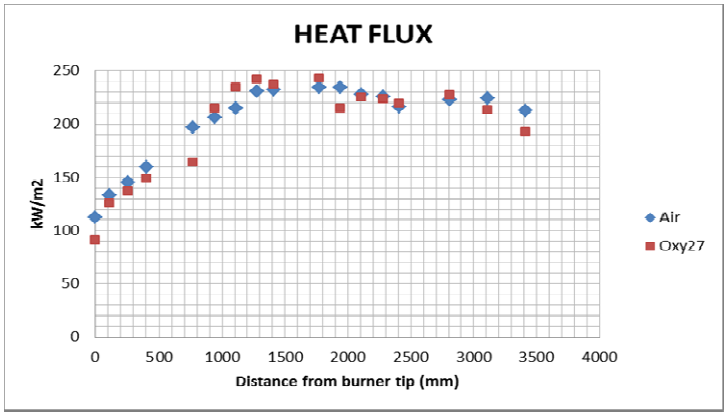
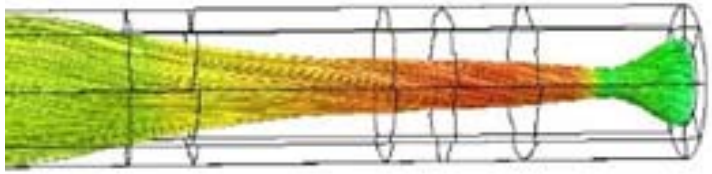
WP7: Oxyfuel cement burner tests

Oxyfuel burner design by ThyssenKrupp for cement plant operating conditions



Measurements of incident total heat flux to the furnace wall during second test campaign.

Oxyfuel burner testing at IFK, University of Stuttgart



Result from the SINTEF CFD simulation of the oxy-fuel case tested in the second campaign showing streamlines coloured by temperature.

"Investigations on oxyfuel combustion in a cement kiln prototype burner"
TCCS-9 poster by Francisco Carrasco

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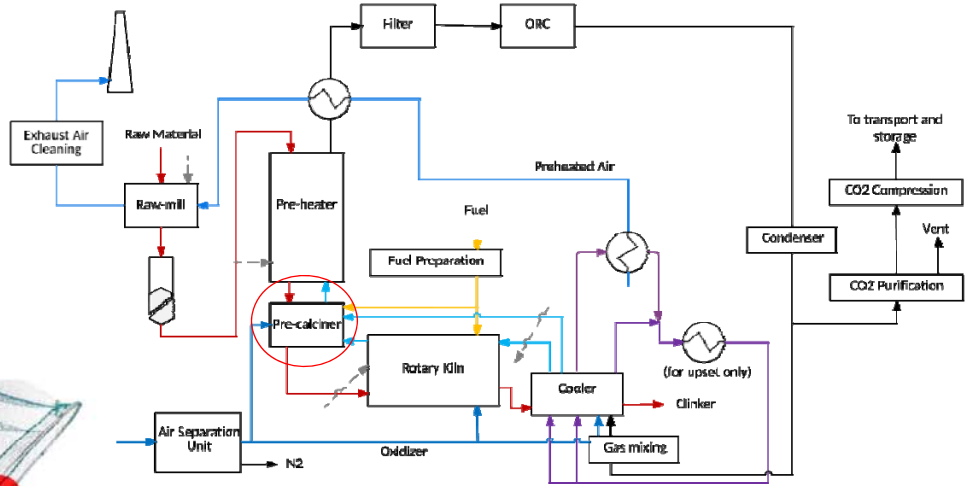
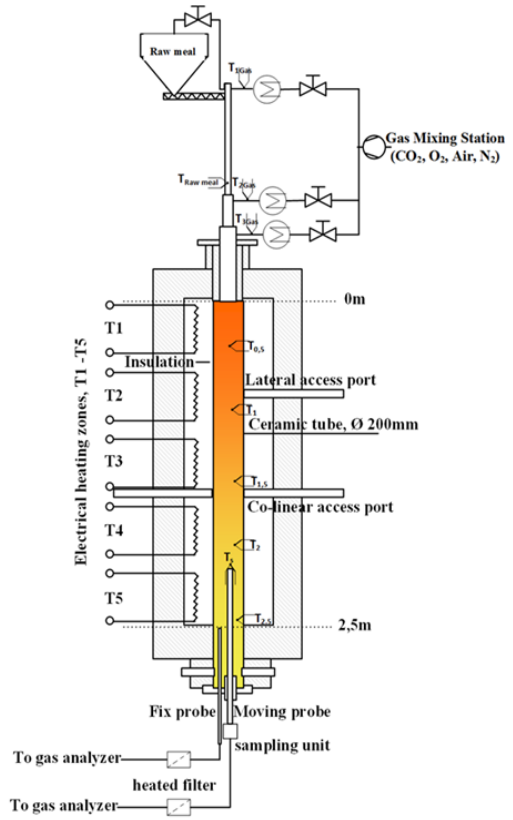
WP8: Calciner technology for oxyfuel capture

- Purpose is experimental investigation of suspension calcination under industrially relevant oxy-fuel conditions
- Aim is to verify sufficient calcination of the raw material before its entering into the rotary kiln
- Experimental work is ongoing





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WP9: Oxyfuel clinker cooler – designed, built, tested

Clinker cooler prototype and recirculation system installation at HeidelbergCement in Hannover

Hot commissioning of the oxyfuel clinker cooler and first oxyfuel clinker samples

A clinker cooler film is under prepration, will be published on YouTube

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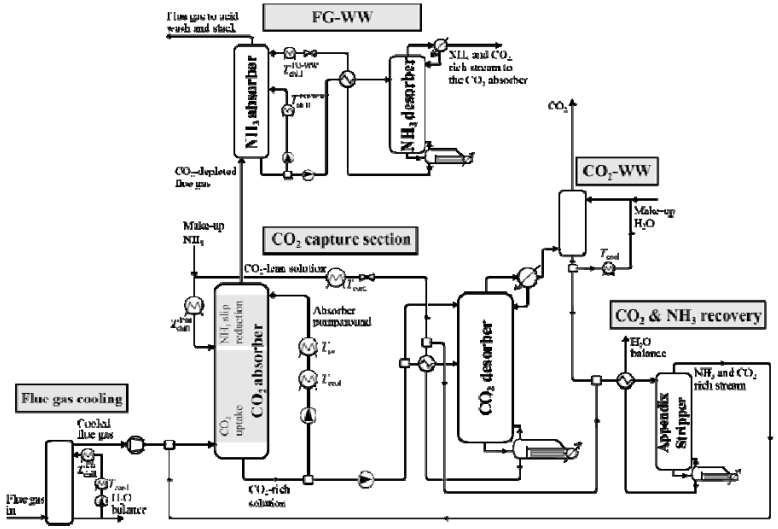
WP10: Chilled ammonia for cement plant CO_2 capture

- ETHZ has simulated and adapted the CAP system to different cement-plant flue gases; a new rate-based model was developed and used to validate full-scale CAP simulations for cement plants. Upcoming work: CAP optimization
- The Absorber and Direct Contact Cooler (DCC) units were tested under cement-like conditions at GE Power Sweden, Water wash section will be tested later in 2017



CAP process flowsheet

DCC pilot at GE Power Sweden

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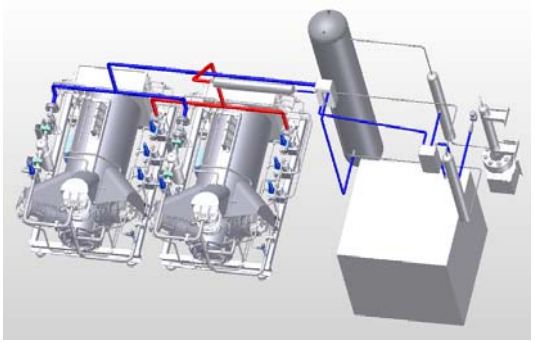
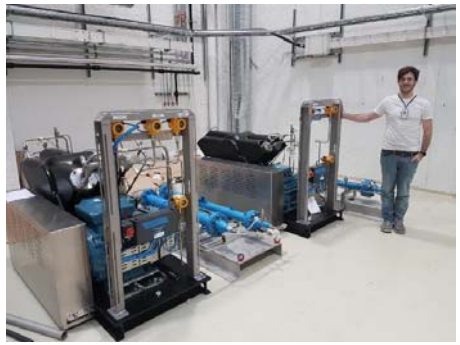
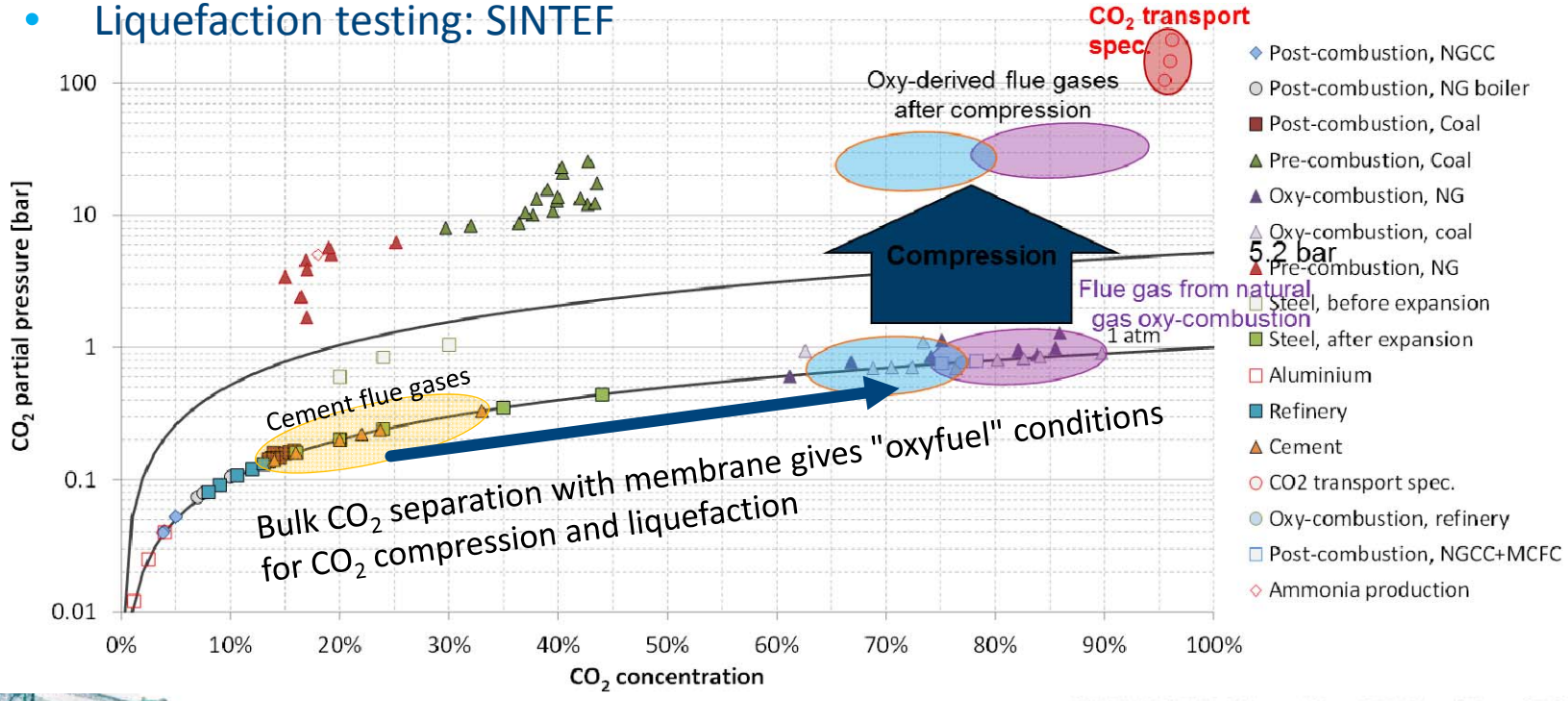
WP11: Post combustion capture from cement: Membrane-assisted CO_2 liquefaction

- End-of-pipe technology (requires De-SOx, De-NOx, dehydration)
- No fuel input, only power
- Membrane testing: TNO
- Liquefaction testing: SINTEF







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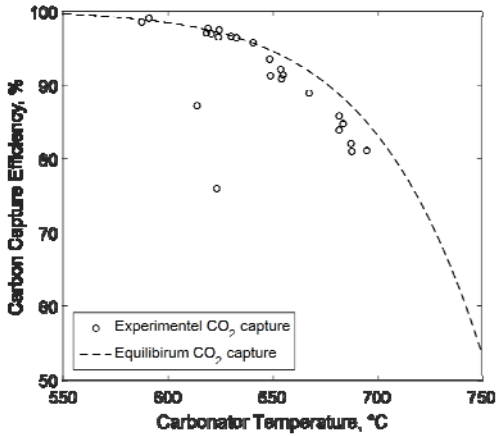
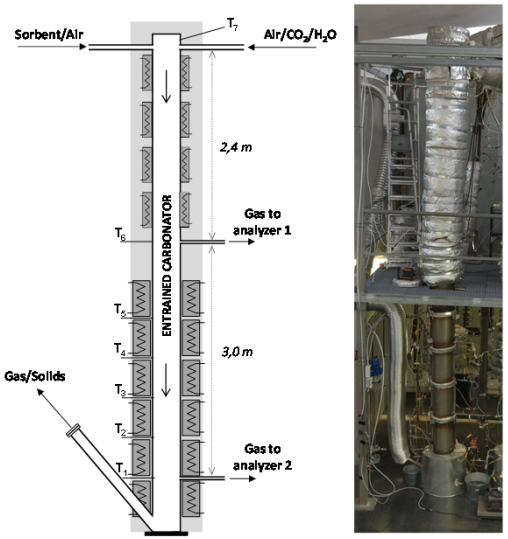
WP12: Calcium looping for cement plants

- Tail-end CO2 capture: tests at 200 kW Ca-looping CFB test facility at IFK/Stuttgart University



Experimental results on CaL CO_2 capture efficency versus equilibirum CO_2 capture (IFK/USTUTT)

- Entrained-flow (integrated) Ca-looping: tests at CSIC



Experimental setup at CSIC

- Process simulations/sizing of full-scale Ca-looping conducted alongside exp work

"CCS in cement industry – Application of the Calcium Looping technology"
Presentation by Matthias Hornberger, Session D2, 15.00

"CO2 capture in cement plants by entrained flow reactors Ca-looping process" TCCS9 poster by Maurizio Spinelli

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To conclude: CEMCAP – aiming to be a visible project with an impact

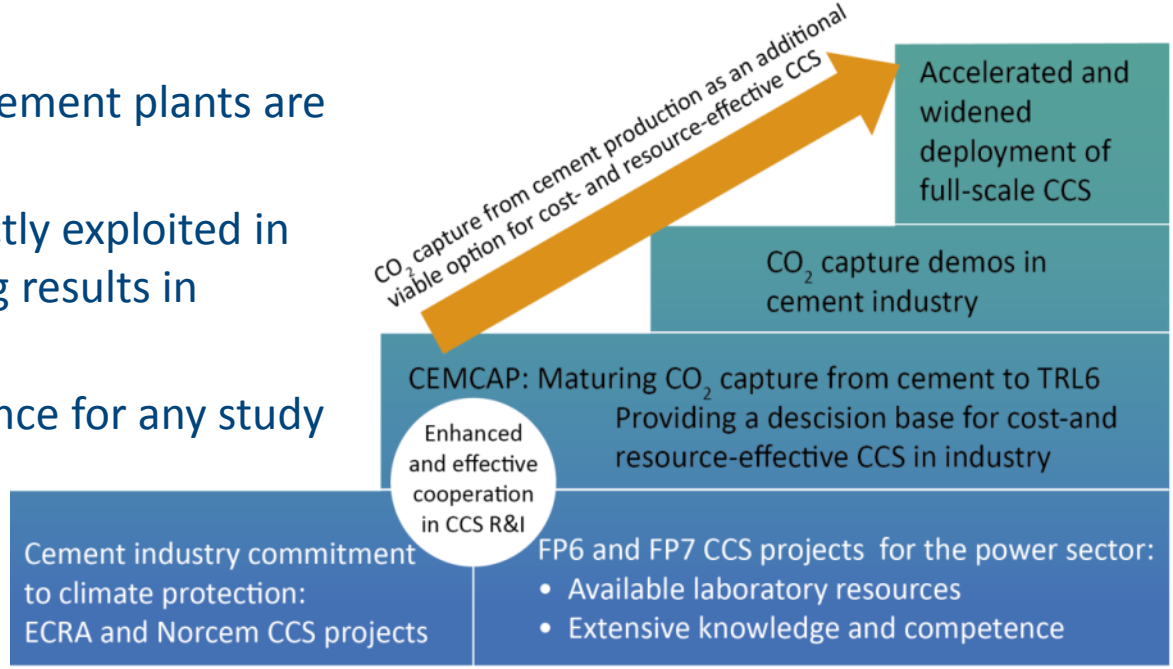
CEMCAP will deliver strategic conclusions for how to progress CO_2 capture from cement plants from pilot-scale testing to demonstration

Recommendations will be given for different scenarios (i.e. different types of cement plants at different locations in Europe)

Focus is on retrofit – very few new cement plants are foreseen to be built in Europe

CEMCAP oxyfuel results will be directly exploited in the ECRA CCS project, Ca-looping results in CLEANKER project

CEMCAP framework: a useful reference for any study on CO_2 capture from cement



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- On twitter (@cemcap_co2) we announce newly published deliverabes, newsletters, blogs and other CEMCAP-related info and events
- Subscribe to newsletters: send an e-mail to cemcap@sintef.no
- **Open seminars** about CEMCAP results, organised jointly with ECRA:
  - Tentatively: 7 November 2017, in Düsseldorf
  - Mid-october 2018 in Brussels (final CEMCAP/ECRA workshop)
  - Seminars will be announced on the website, in newsletters and on Twitter

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