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CEMCAP – a Horizon 2020 project on retrofittable CO2 capture from cement plants

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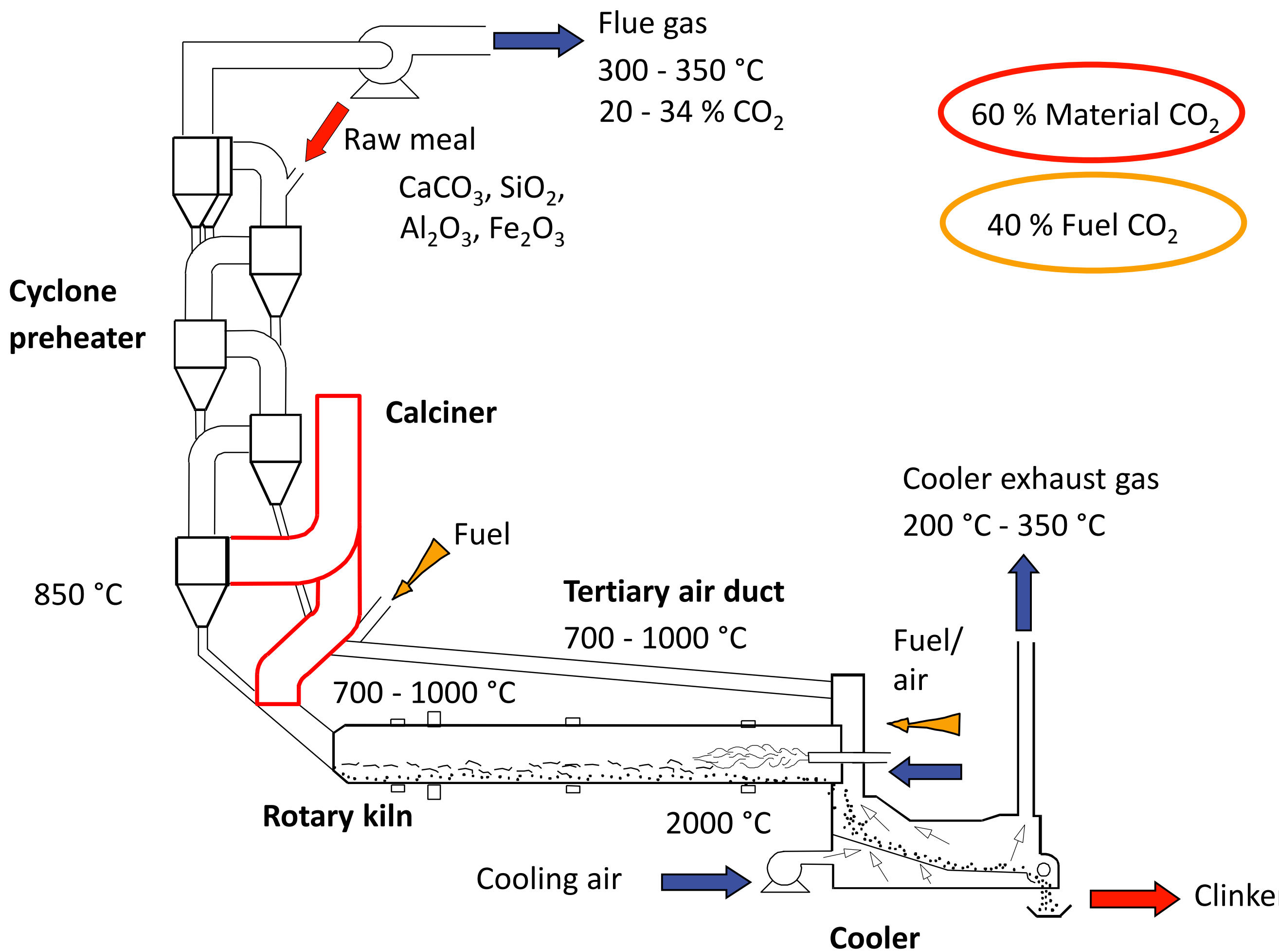
Co-funded by the European Union

Introduction and Framework

CO_2 emissions in the cement industry

- Cement production constitutes ~ 5 % of global anthropogenic CO_2 emissions
- In 2013 ~ 20 % of global CO_2 emissions from cement production originated from Europe



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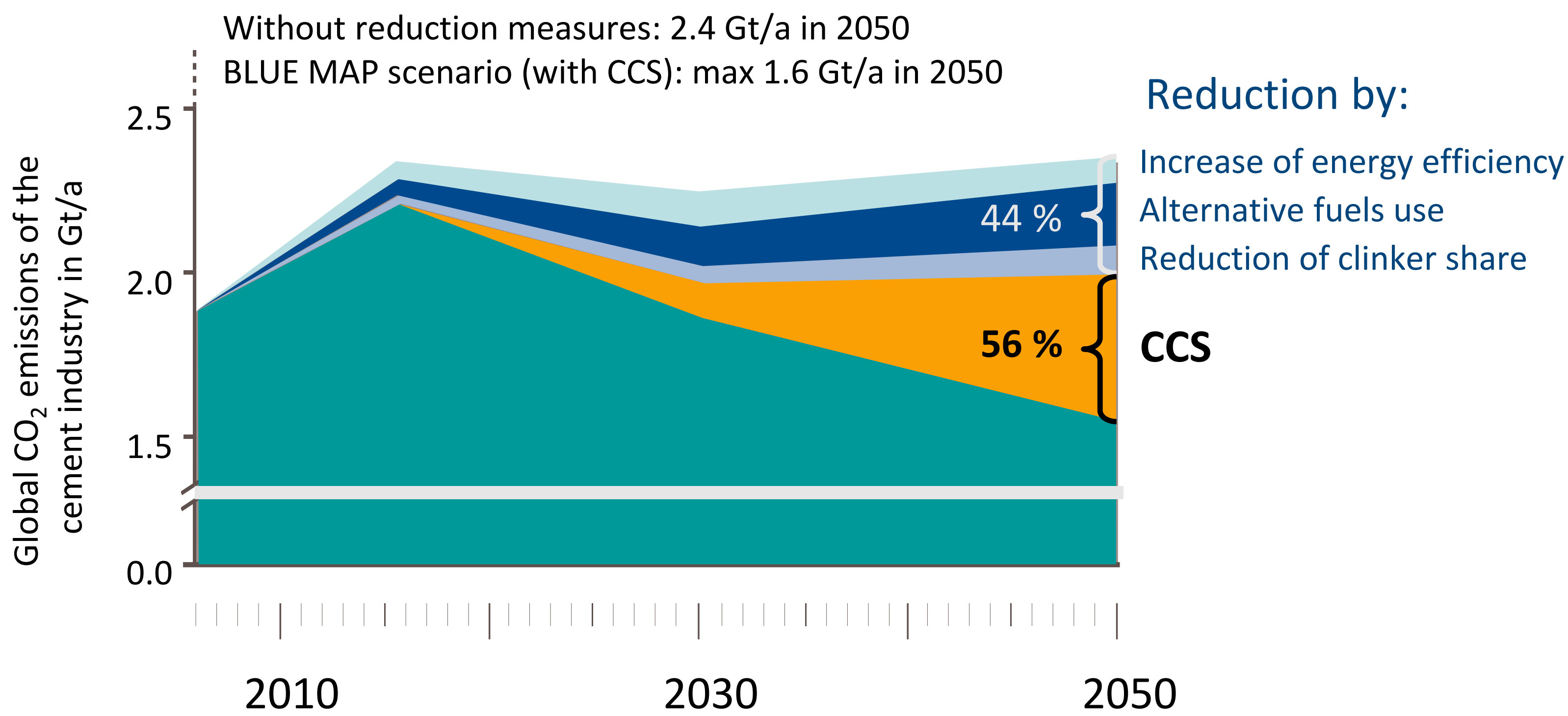
The need for CCS in Cement production



Source: IEA Cement Roadmap

- IEA target for 2050: 50 % of all cement plants in Europe, Northern America, Australia and East Asia apply CCS
- Cement plants typically have a long lifetime (30-50 years or more) and very few (if any) are likely to be built in Europe → Retrofit

CEMCAP Consortium

<u>Cement Producers</u>

CTG (*Group Technical Centre of Italcementi*), IT

Norcem, NO

HeidlebergCement, DE

<u>Technology Providers</u>

GE Carbon Capture (GE-DE), DE

GE Power Sweden (GE-SE), SE

IKN, DE

ThyssenKrupp Industrial Solutions, DE

<u>Research Partners</u>

SINTEF Energy Research, NO

ECRA (European Cement Research Academy), DE

TNO, NL

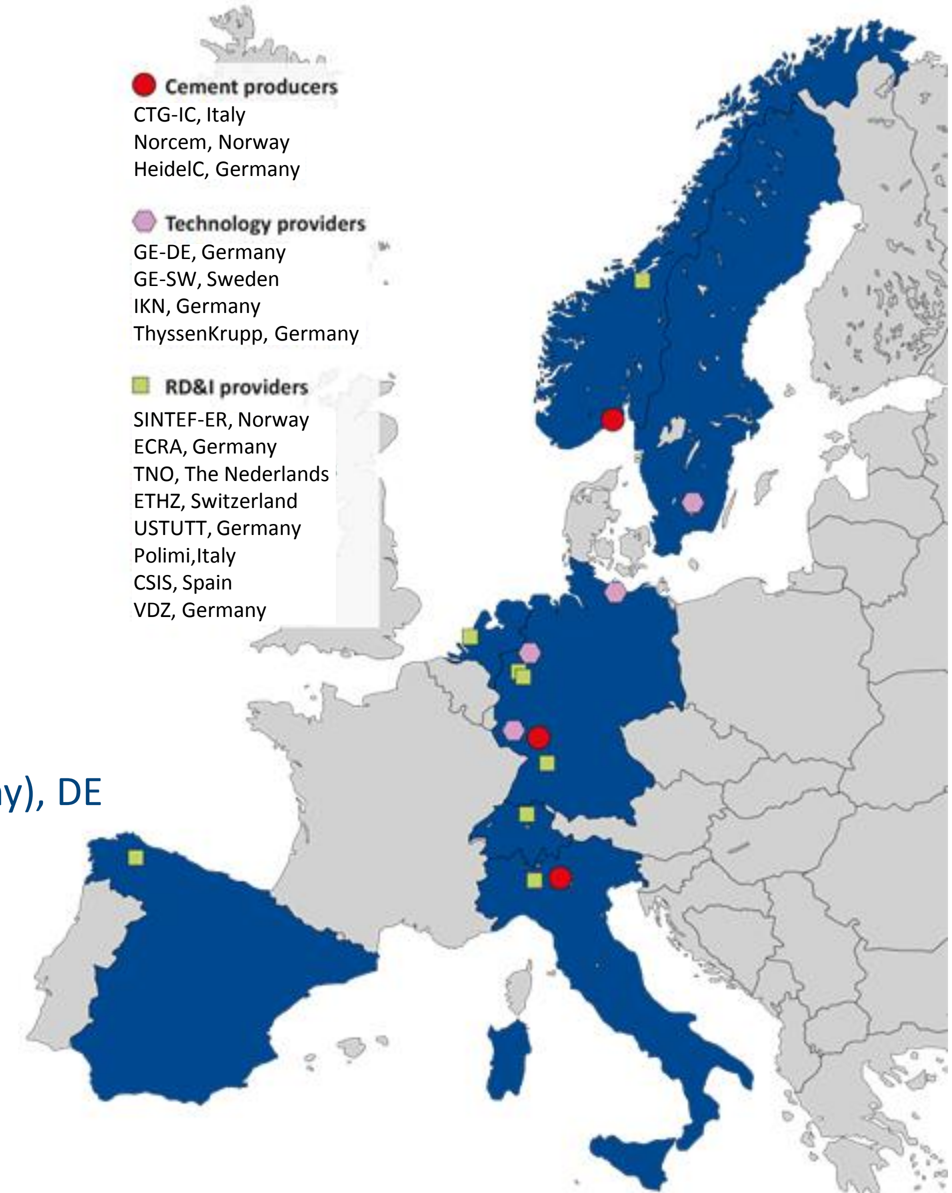
ETHZ, CH

University of Stuttgart, DE

Politecnico di Milano, IT

CSIC, ES

VDZ, DE



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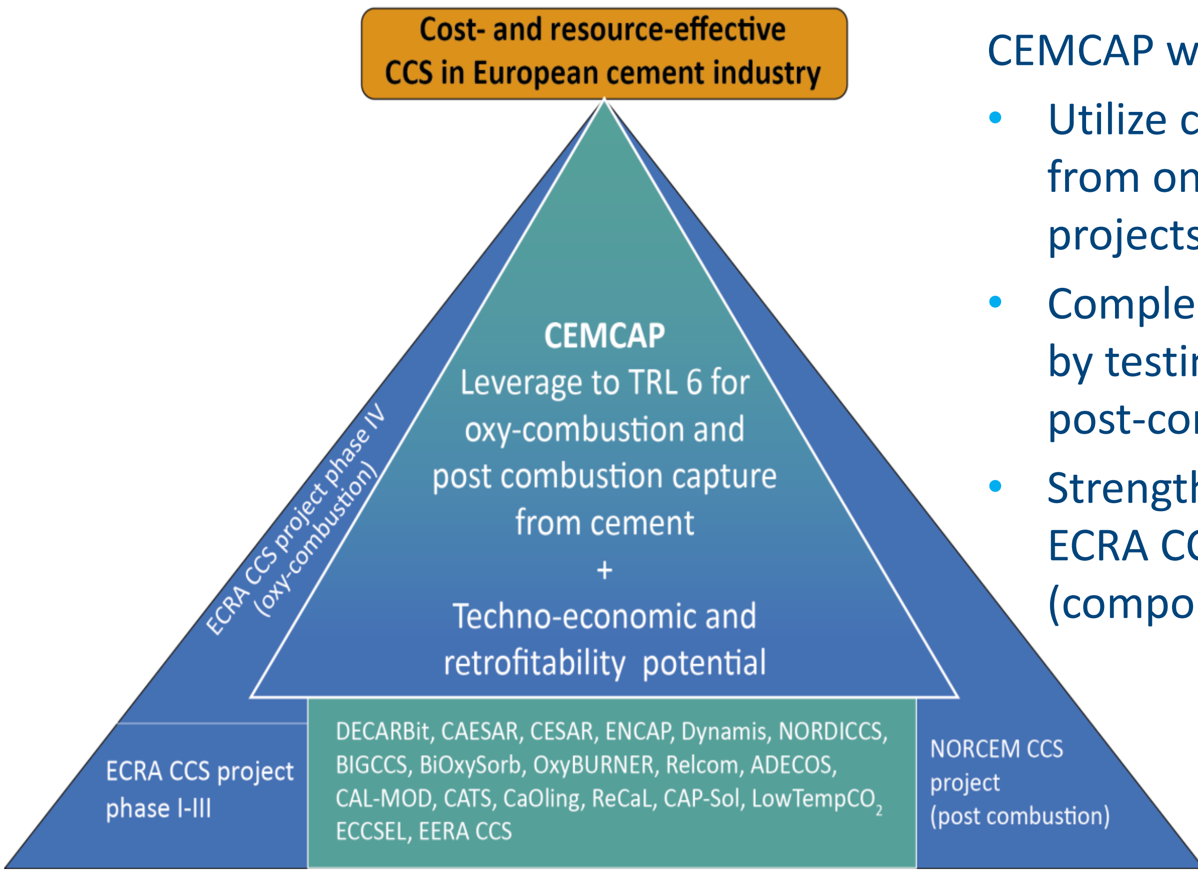
CEMCAP – positioned to complement and strengthen the Norcem and ECRA CCS projects



CEMCAP will

- Utilize competence and knowledge from ongoing and concluded CCS projects for power industry
- Complement the Norcem CCS project by testing and evaluating additional post-combustion capture technologies
- Strengthen and advance the ongoing ECRA CCS project for cement industry (component testing for oxyfuel)

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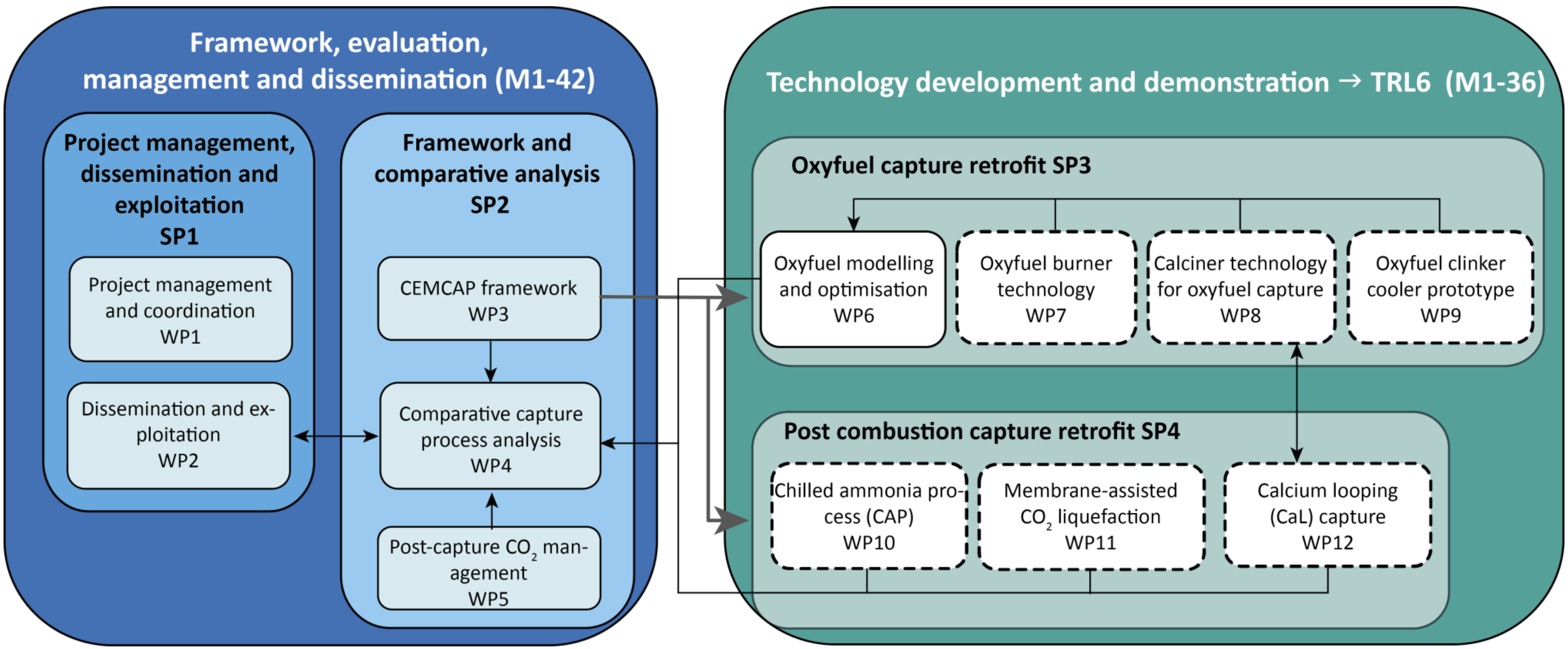
Project structure



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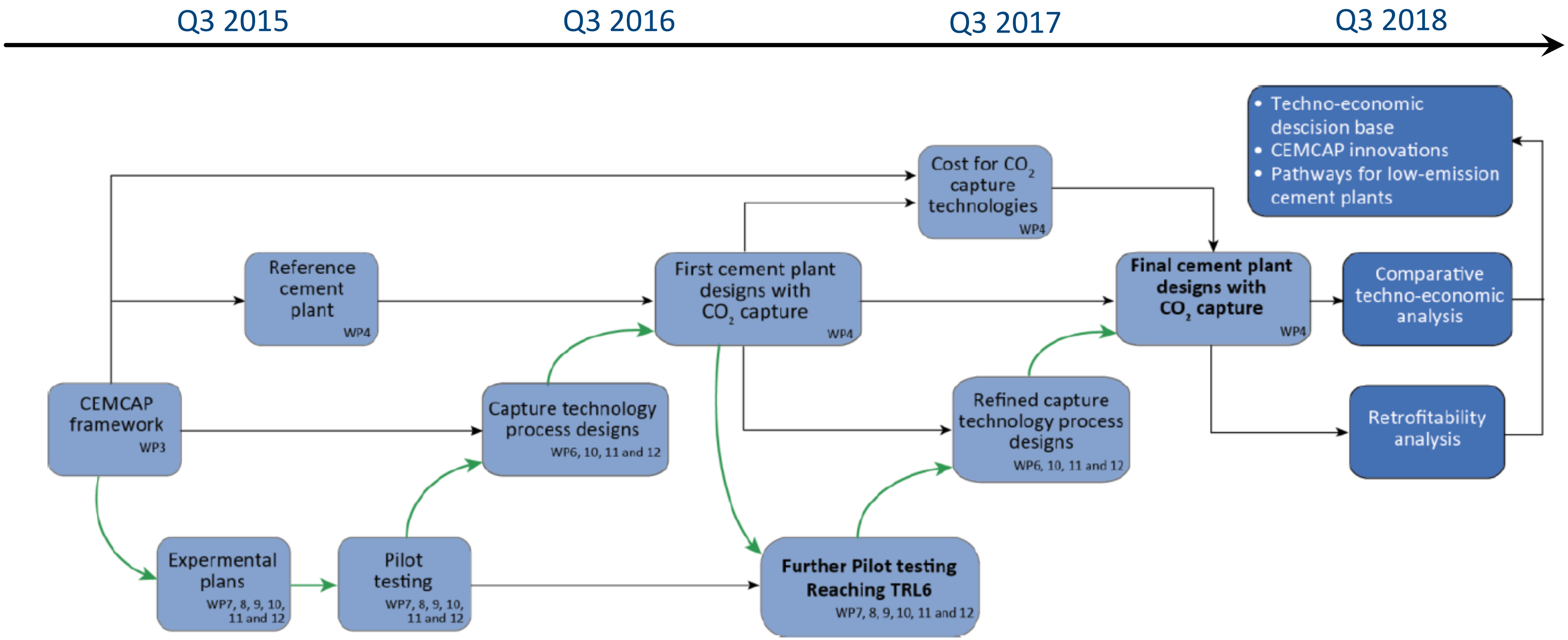
Project schedule



CEMCAP framework: Reference plant

- Cement plants differ in size, process technology, operational mode, fuel mix, raw material composition influencing energy efficiency, flue gas characteristics etc.
- A reference kiln system has been defined, based on Best Available Techniques level including
  - 5-stage cyclone preheater
  - Calciner with tertiary air duct
  - Modern grate clinker cooler
- Representative average values of European cement plants define the key data:
  - Plant Size: 3000 t/d (1 Mt clinker/y)
  - Annual cement production: 1.36 Mt/y
  - Clinker/cement ratio: 73.7 %
  - 320 days of non-stop operation (85 % capacity rate), typcially 3-4 weeks of winter revison
- The reference plant without CO_2 capture will be the basis for performance evaluation of all CEMCAP technologies (cost, energy consumption, CO_2 quality…)

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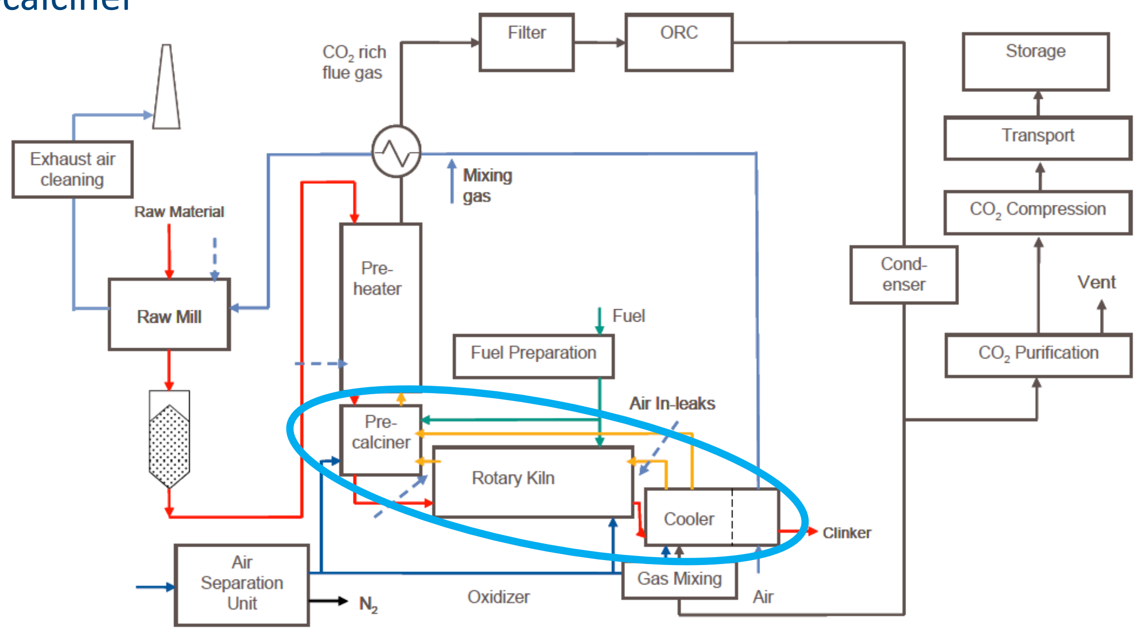
SP3 – Oxyfuel capture

Oxyfuel cement plant

- CO_2 capture by N_2 free combustion
- Oxyfuel combustion influences:
  - Heat transfer in rotary kiln (gas atmosphere)
  - Calcination kinetics in pre-calciner (CO_2 partial pressure)
- New clinker cooler design required (operation with recycle gas)



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Technologies to be tested - oxyfuel

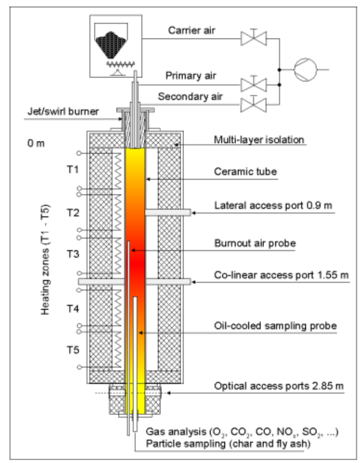
<u>Oxyfuel burner</u>

Existing 500 kW_{th} oxyfuel rig at USTUTT was modified for CEMCAP experiments

Partners: USTUTT, TKIS, SINTEF-ER

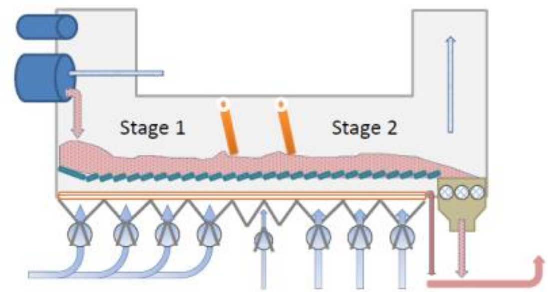
<u>Calciner test rig</u>

Existing <50 kW_{th} entrained flow calciner (USTUTT) will be used for oxyfuel calcination tests



Partners: USTUTT, VDZ, IKN, CTG

<u>Clinker cooler</u> Drawings completed, is being built for on-site testing at HeidelbergCement in Hannover (summer 2016)



Partners: IKN, HeidelC, VDZ

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SP4 – Post Combustion Capture

Technologies to be tested – post-combustion capture

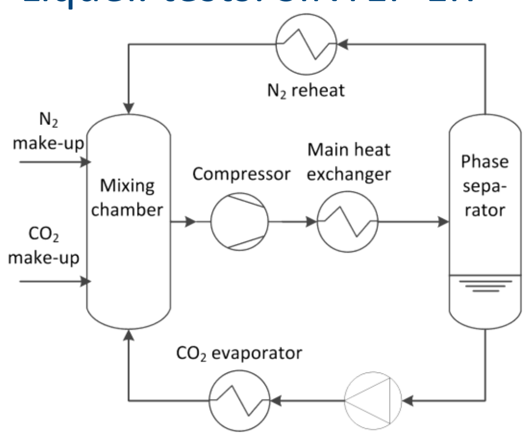
Chilled Ammonia Process (CAP)
Absorber tests at GE Power Sweden (never tested for such high CO_2 concentrations before, up to 35 %)

Partners: ETHZ, GE-SE, GE-DE

Membrane assisted CO_2 liquefaction

Novel concept, suitable for high CO_2 concentrations
Membrane tests: TNO

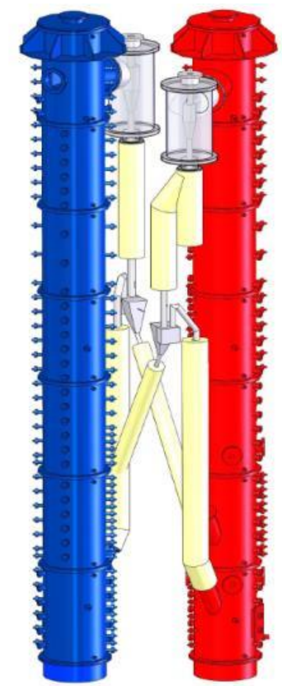
Liquef. tests: SINTEF-ER



Partners: TNO, SINTEF-ER

Ca-looping (USTUTT, CSIC rigs)

End of pipe CaL as well as integrated CaL tests



Partners: USTUTT, CTG, PoliMi, CSIC, IKN

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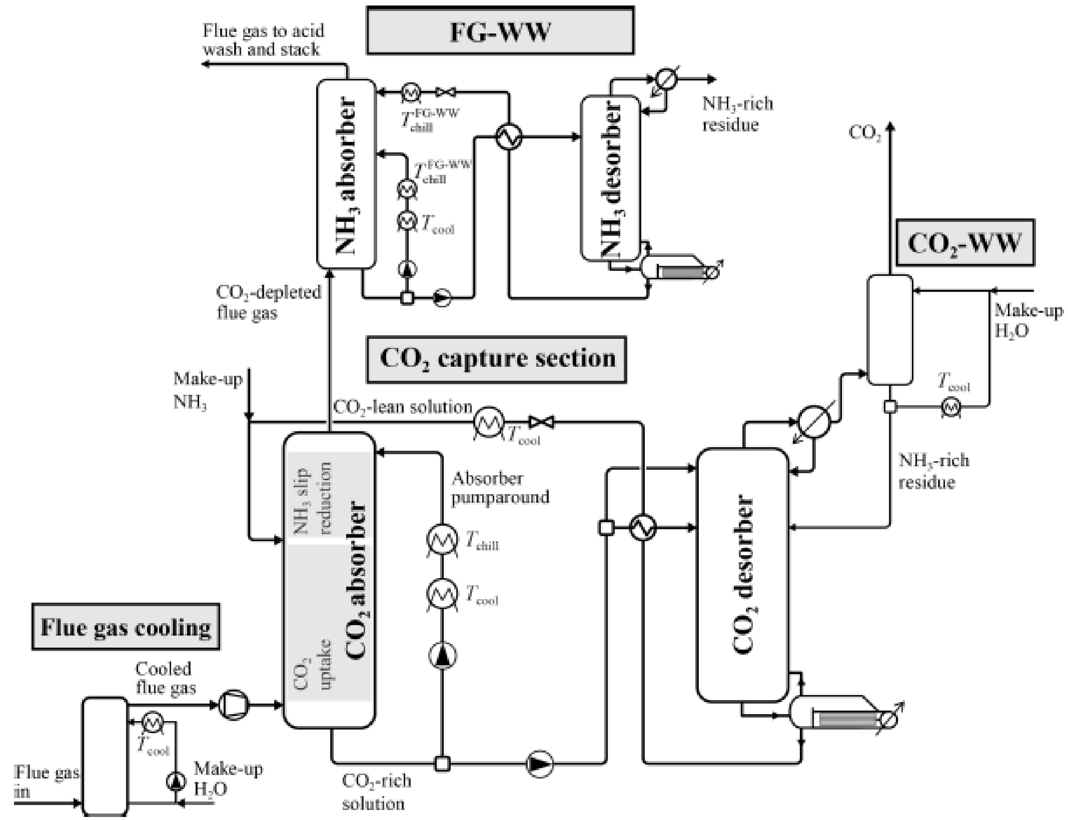
Chilled Ammonia Process (CAP)

- CO_2 separation by cyclic absorption/ desorption in NH_3
- Lower regeneration effort
- High sorbent stability

- Experimental work on:
  - CO_2 capture performance
  - Flue gas pretreatment
    - Cooling
    - Removal of impurities
  - NH_3 slip reduction

- Simulation work on:
  - Model enhancement and validation
  - Overall CAP simulation and optimization



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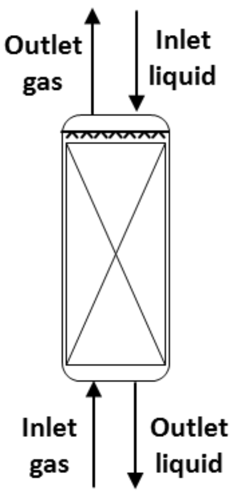
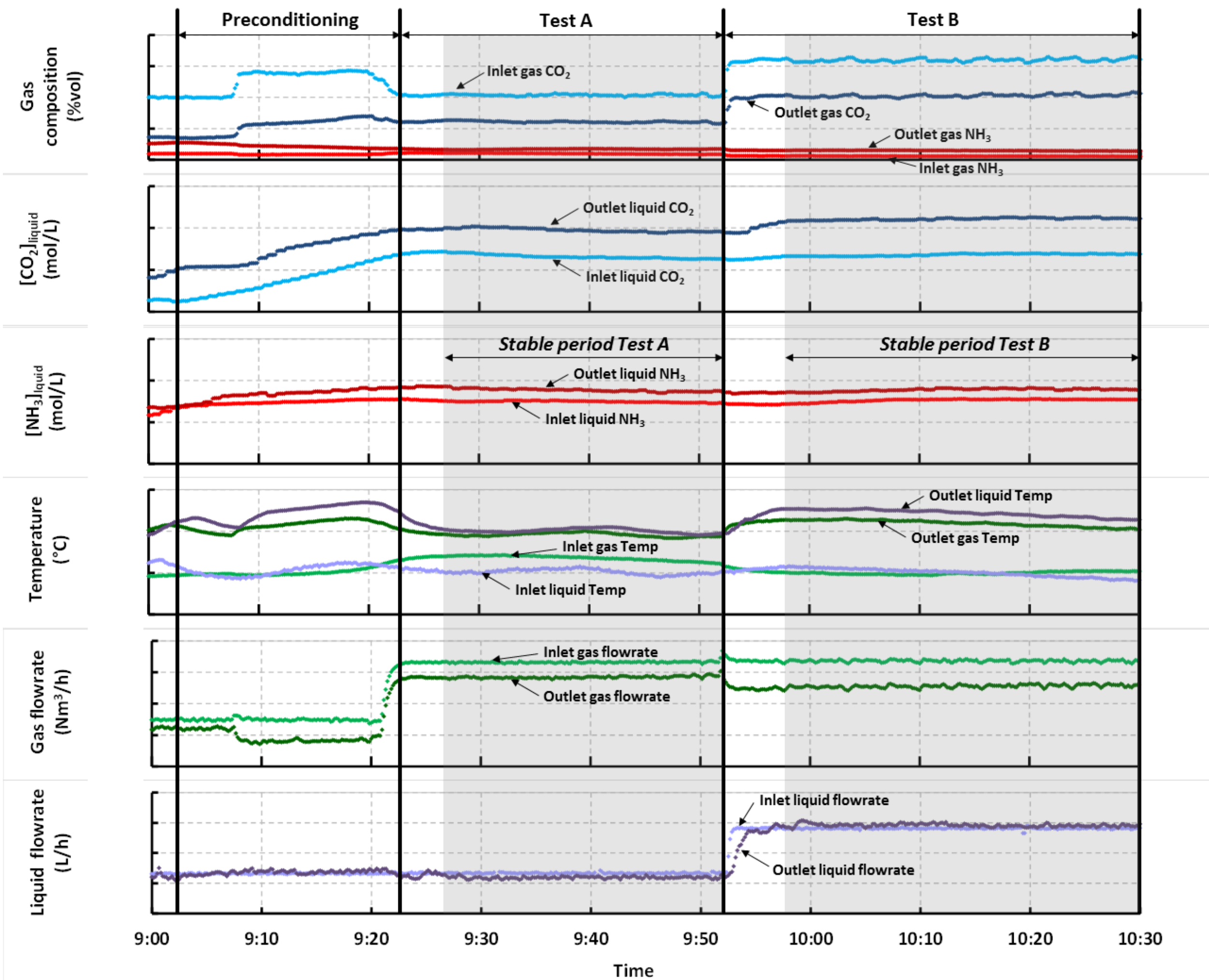
Preliminary Results - **C**hilled **A**mmonia **P**rocess (CAP):

- Large scale testing at Växjö (500 m³/h)
- 50 pilot plant tests of the CO_2 absorber at different experimental conditions





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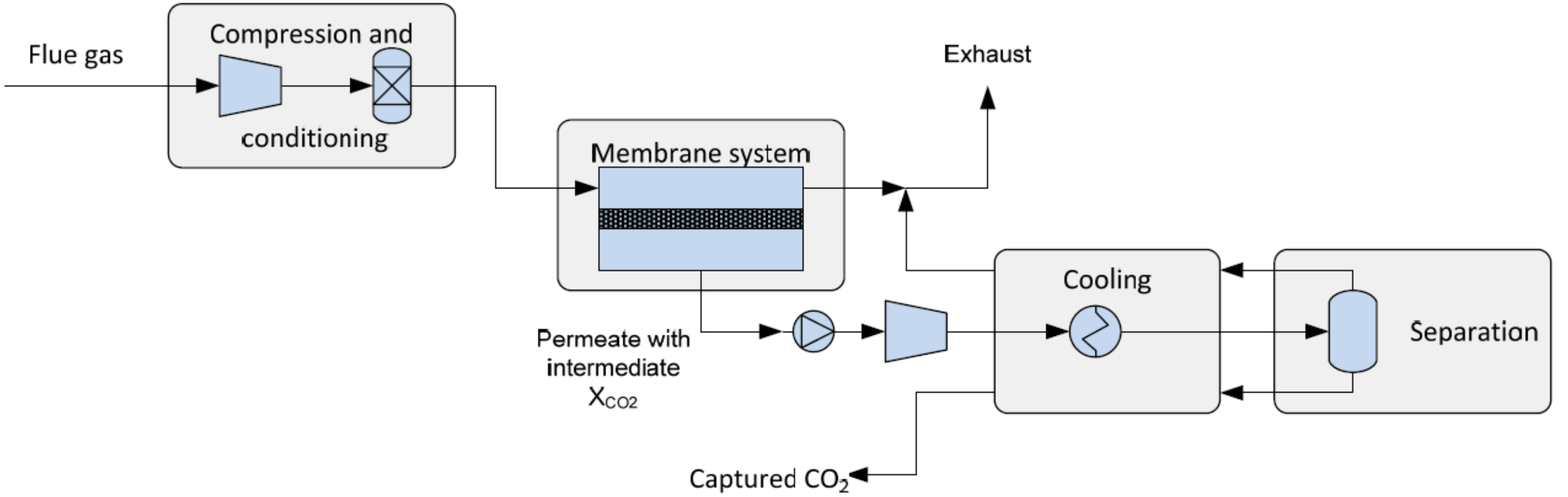
Membrane assisted CO_2 liquefaction

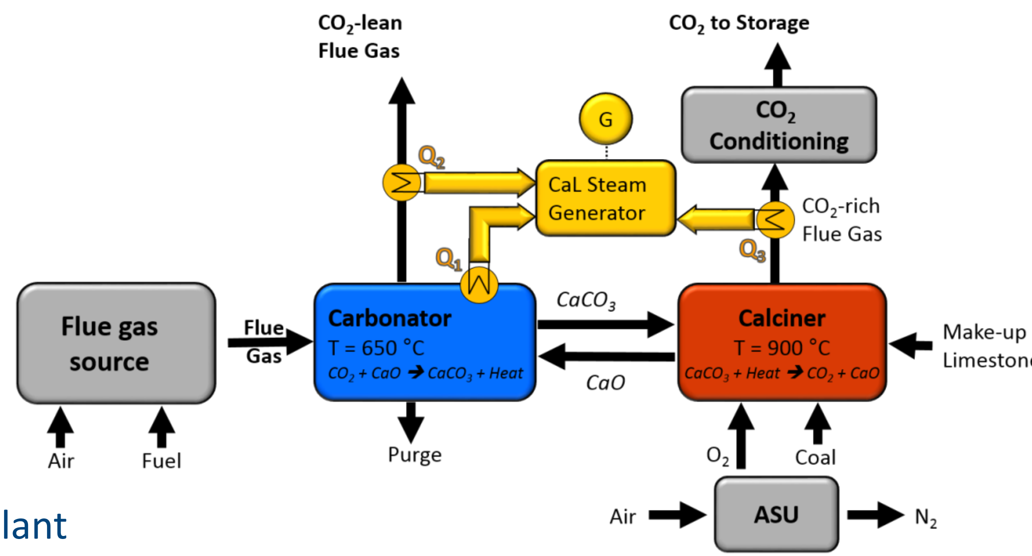
- Membrane screening
- Experimental work on
  - Membrane performance
  - Liquefaction and purification process
- Simulation work on combined membrane- and liquefaction capture system



Calcium Looping (CaL)

- CO_2 separation by cyclic calcination/carbonation of $CaCO_3$
- Low efficiency penalty / separation cost due to efficient heat recovery / heat integration
- Synergies between cement plant and CaL

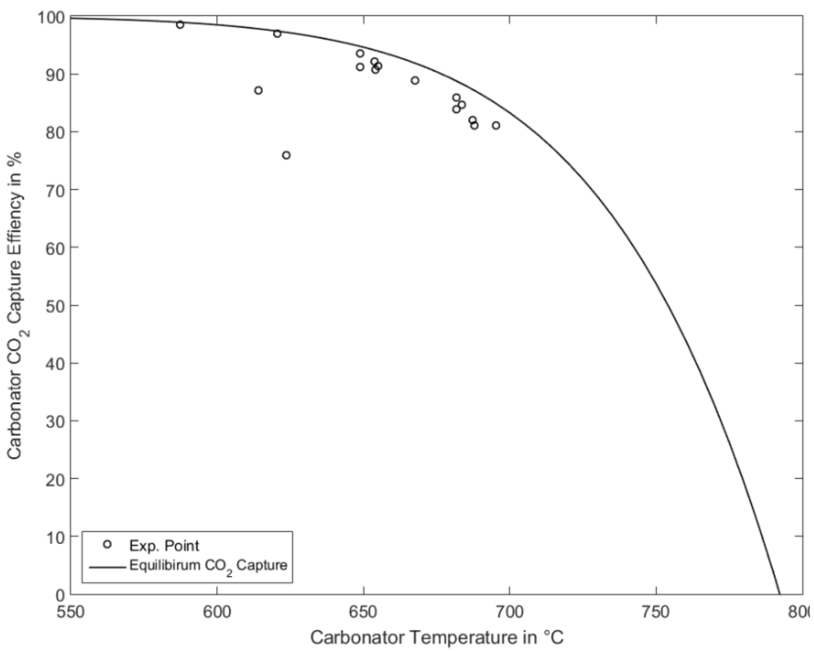
- Experimental work on
  - Sorbent screening
  - CO_2 capture performance
  - Entrained flow CaL system
- Simulation work on
  - Entrained flow carbonator
  - CaL integration into the cement plant

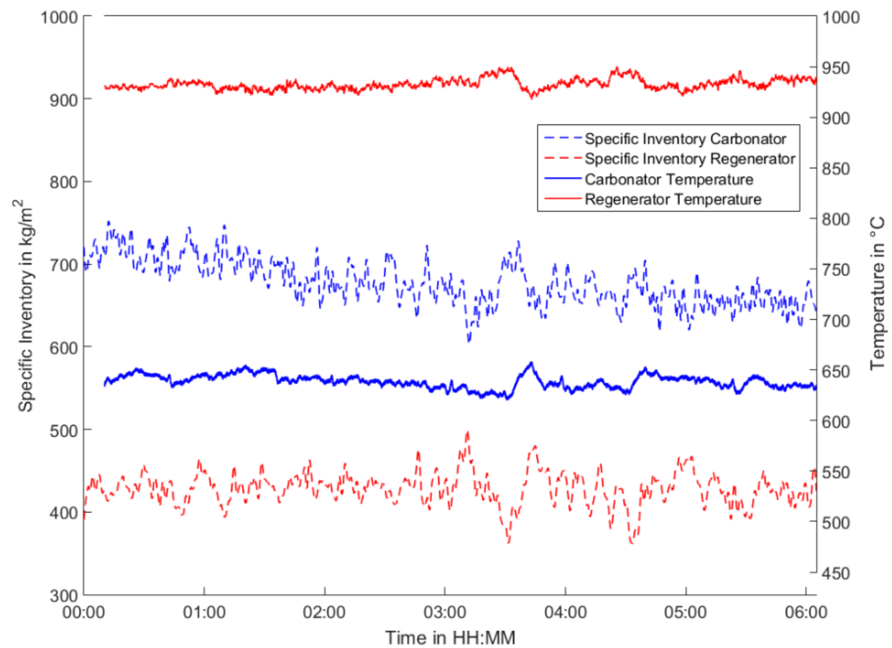


Preliminary Results - **Ca**lcium **L**ooping (CaL):

Calcium **L**ooping (CaL)

- Demonstration at 200 kW_{th} pilot plant at IFK, University of Stuttgart
- CO_2 capture up to 95 % (near equilibrium capture rate)





Outlook

- CEMCAP results will be presented during GHGT-13 in Lausanne (9 contributions)
- Next CEMCAP/ECRA workshop in spring 2017
- Experimental work finished by Q4 2017
- Comparative techno-economic analysis by Q3 2018
- Newsletter subscription on website (www.sintef.no/cemcap)

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