TCCS8 June 18 2015

# CEMCAP

## $CO_2$ capture from cement production

Horizon 2020 project coordinated by SINTEF Energy Research

Duration : May 2015-October 2018 (3.5 years)

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SINTEF Energy Research

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# The need for CCS in Cement production

- Cement production constitute ~5% of global anthropogenic $CO_2$ emissions
- In 2013 approximately 20% of global $CO_2$ emissions from cement production originated from Europe
- About 60% of the $CO_2$ emissions originate from the conversion of $CaCO_3$ to CaO, the rest is from combustion of fossil fuels and electric power generation
- Cement plants typically have a long lifetime (30-50 years or more)

- Consequently:
  - CCS is the only viable measure to significantly reduce $CO_2$ emissions from the cement industry
  - $CO_2$ capture must be retrofitted to existing cement plants

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# Ongoing CCS research projects in the Cement industry

- The **Norcem CCS project** – post-combustion capture (presented by Liv Bjerge in this session)
  - Testing of amines, membranes, solid sorbent, Ca-looping

- The **ECRA CCS project**
  - Reports from phases I-III available on www.ecra-online.de
  - Focusing on oxyfuel retrofit in the current phase IV – pilot plant preparation
  - CEMCAP enables testing of three key components before the design of the full oxyfuel pilot plant

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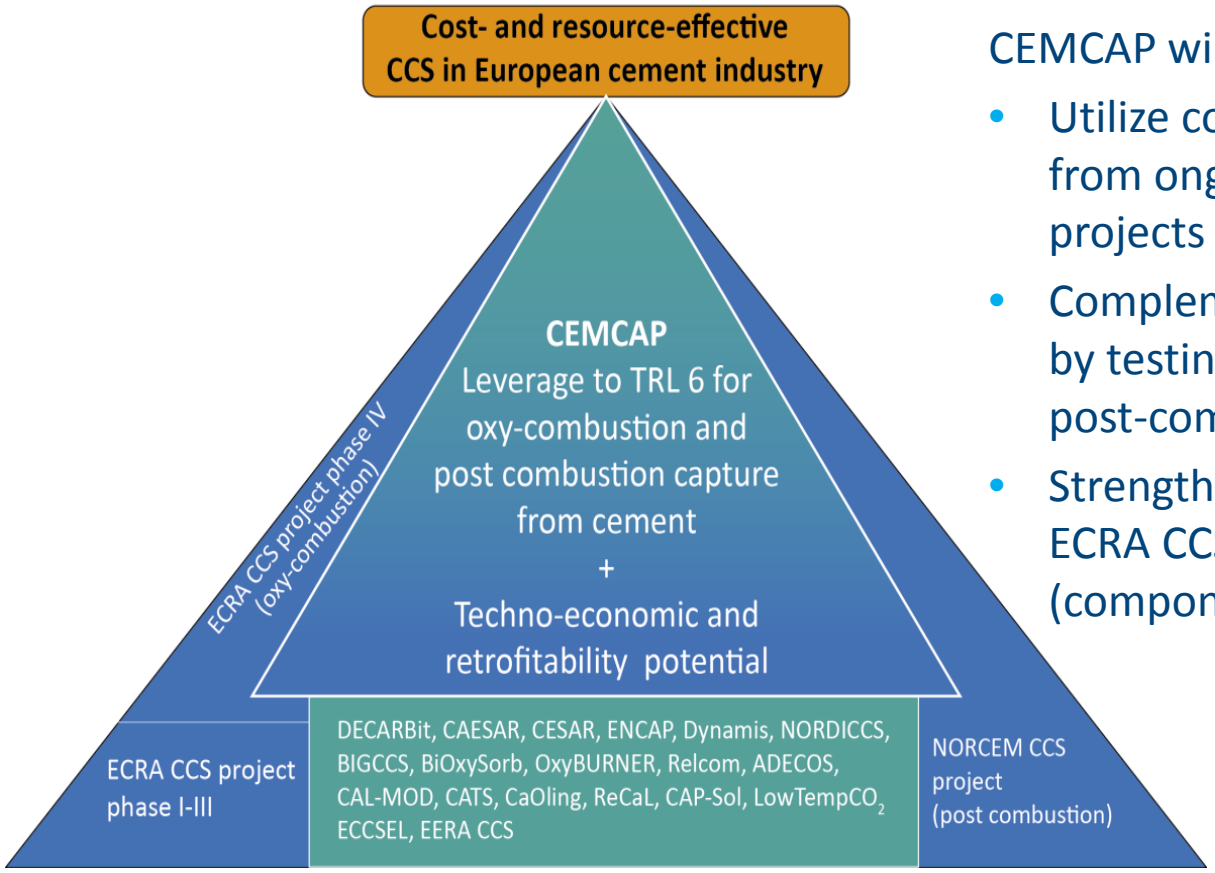
# CEMCAP – positioned to complement and strengthen the Norcem and ECRA CCS projects




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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# CEMCAP Consortium

Cement Producers

CTG (Group Technical Centre of Italcementi) IT

Norcem, NO

HeidlebergCement, DE

Technology Providers

Alstom Carbon Capture (AL-DE), DE

Alstom Power Sweden (AL-SE), SE

IKN, DE

ThyssenKrupp Industrial Solutions, DE

Research Partners

SINTEF Energy Research, NO

ECRA (European Cement Research Academy), DE

TNO, NL

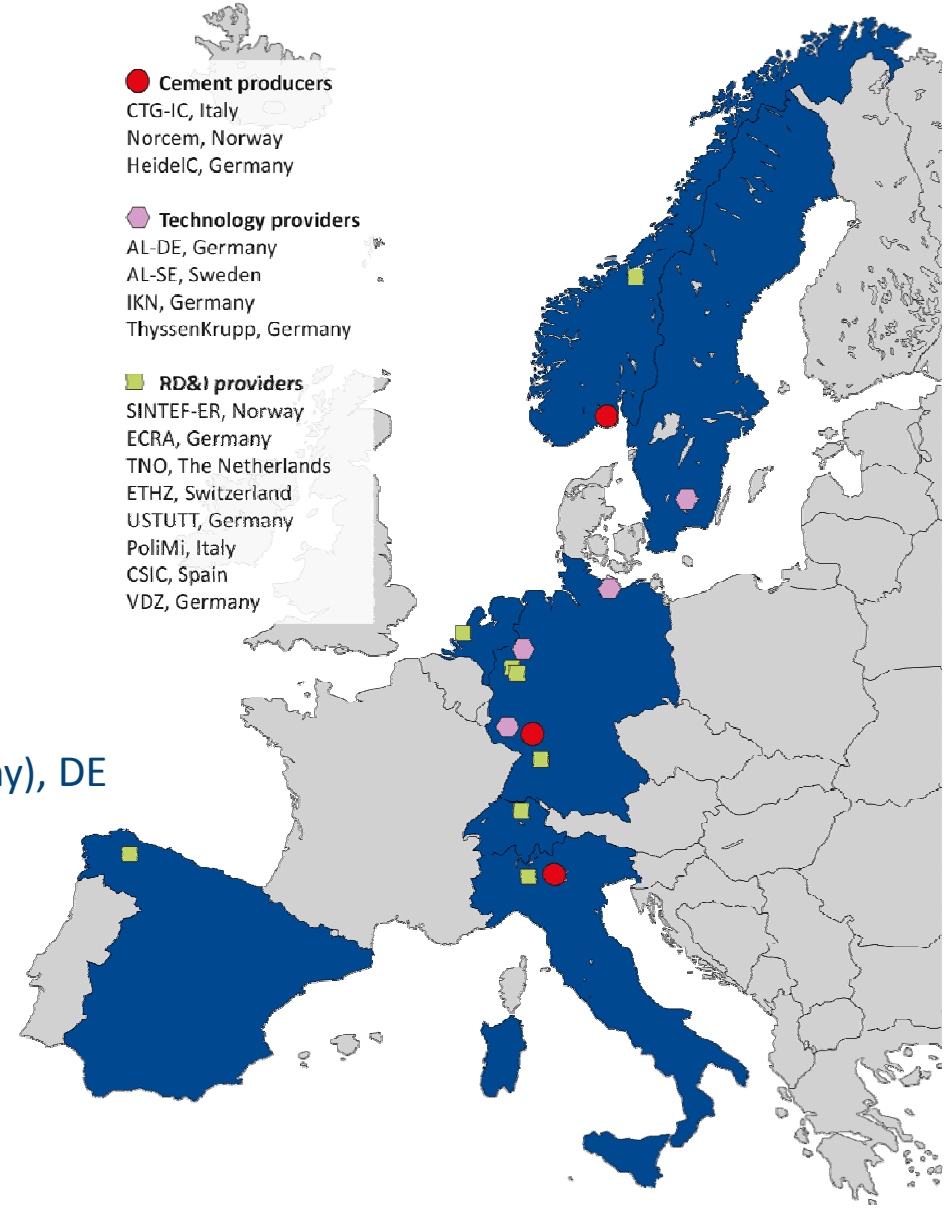
EHTZ, CH

University of Stuttgart, DE

Politecnico di Milano, IT

CSIC, ES

VDZ, DE

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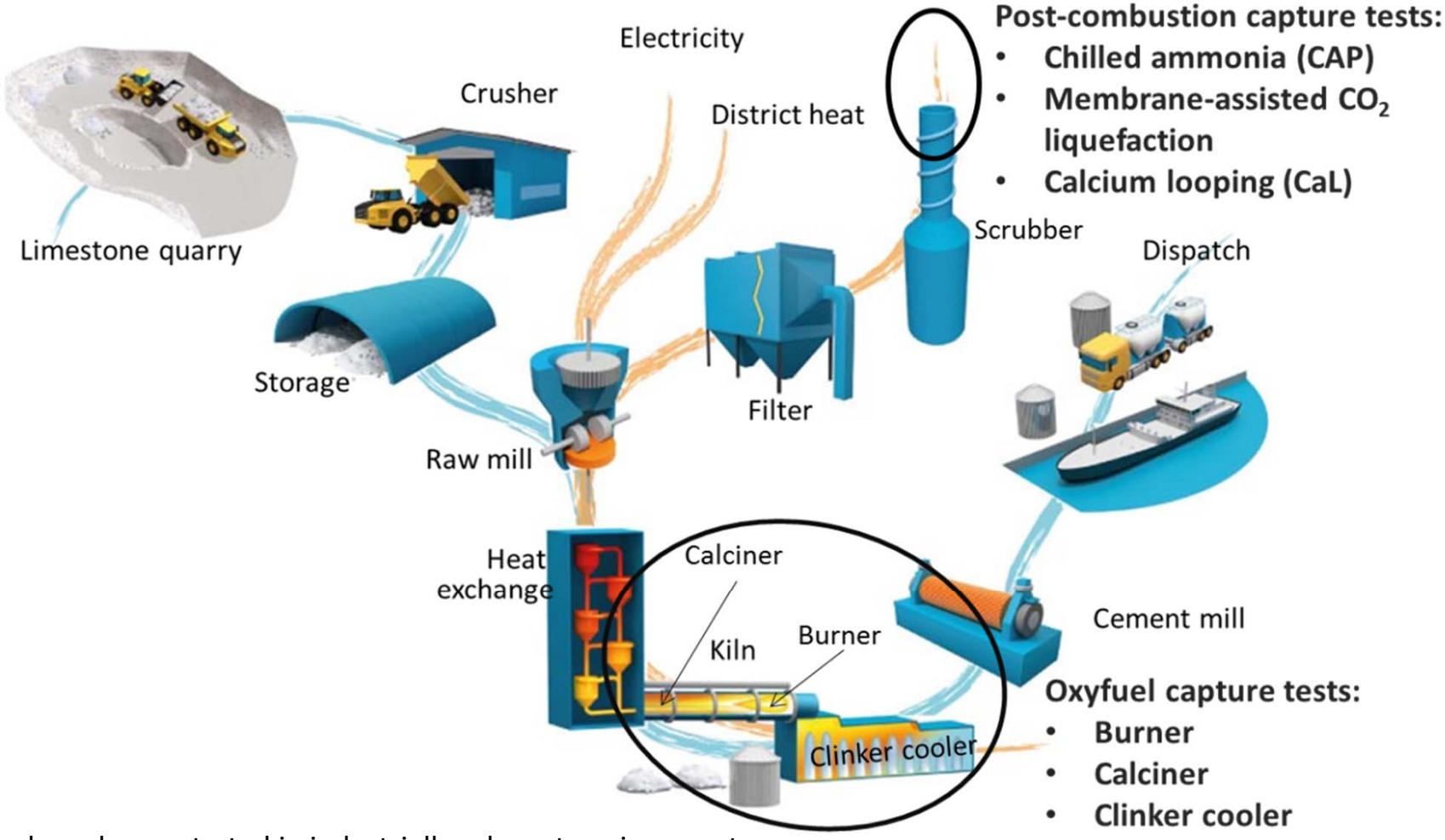
# Technologies to be tested in CEMCAP, reaching TRL6*




*Technology demonstrated in industrially relevant environment

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# Technologies to be tested have different characteristics!

| | Oxyfuel capture | Post combustion capture technologies | | |
|---|---|---|---|---|
| | | Chilled ammonia | Membrane-assisted $CO_2$ liquefaction | Calcium Looping |
| **$CO_2$ capture principle** | Combustion in oxygen (not air) gives a $CO_2$-rich exhaust. $CO_2$ is separated through condensation after compression and cooling. | Exhaust passes through a cold $NH_3$/water mixture, which absorbs $CO_2$. $CO_2$ is released as heat is added to the solution in a subsequent vessel. | A polymeric membrane is used to increase exhaust $CO_2$ concentration. $CO_2$ is separated through condensation after compression and cooling. | CaO particles react with $CO_2$ to from $CaCO_3$. $CO_2$ is released in a subsequent vessel through the addition of heat. |
| **Required cement plant modifications** | Retrofit possible through modification of burner and clinker cooler. | Retrofit appears simple, minor modifications required for heat integration. | No modifications of cement plant necessary. SOx, NOx, $H_2O$ removal required upstream of capture unit. | $CaCO_3$/CaO integration: Waste from capture process (CaO) is cement plant raw material. |
| **Clinker quality** | Maintained quality must be confirmed. | Unchanged. | Unchanged. | Clinker quality is very likely to be maintained. |
| **$CO_2$ purity and capture rate** | $CO_2$ purification unit (CPU) needed. High capture rate and $CO_2$ purity possible (trade-off against power consumption). | Very high $CO_2$ purity, can also capture NOx, SOx. High capture rate possible. | High $CO_2$ purity (minor $CO_2$ impurities present). Trade-off between power consumption and $CO_2$ purity and capture rate. | Rather high $CO_2$ purity (minor/moderate $CO_2$ impurities present). High capture rate. |
| **Energy integration** | Fuel demand remains unchanged. Increase in power consumption (vs. integration of waste heat recovery systems). | Auxiliary low-pressure steam boiler required. Can make use of cement plant waste heat. Electricity required for chilling. | Increase in power consumption, no heat integration. | $CaCO_3$ regeneration requires additional fuel, which also enables low-emission electricity generation. |

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# Technologies to be tested - oxyfuel

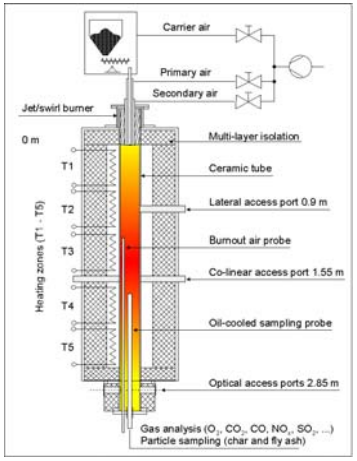
## Oxyfuel burner

Existing 500 kWth oxyfuel burner at USTUTT to be modified for CEMCAP

Partners: USTUTT, TKIS, SINTEF-ER

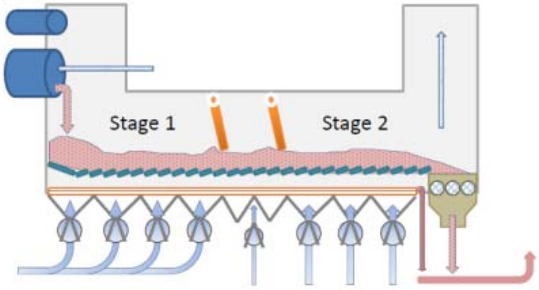
## Calciner test rig

Existing >50 kWth entrained flow calciner (USTUTT) to be used for oxyfuel calcination tests




Partners: USTUTT, VDZ, IKN, CTG

## Clinker cooler To be designed and built for on-site testing at HeidelbergCement Hannover




Partners: IKN, HeidelC, IKN, VDZ

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# Technologies to be tested – post-combustion capture

Chilled Ammonia Process (CAP)

(Alstom Power Sweden)

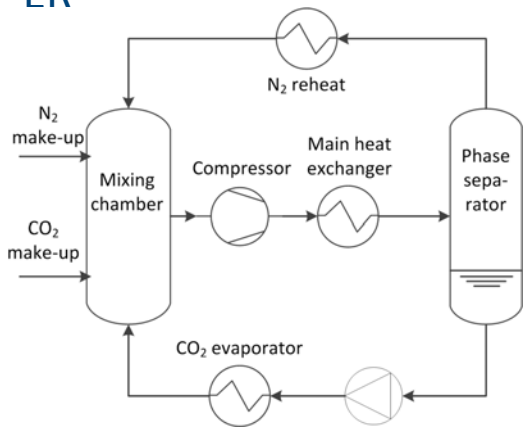
CAP never tested for such high $CO_2$ concentrations before

Partners: ETHZ, AL-SE, AL-DE

Membrane assisted $CO_2$ liquefaction

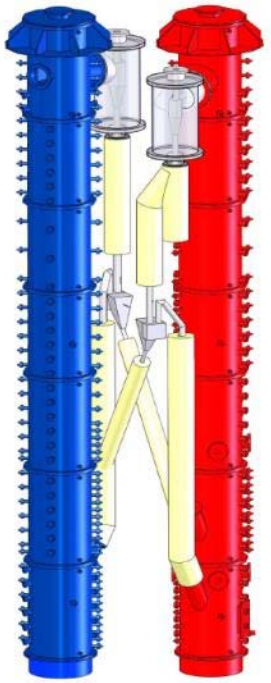
Membrane tests: TNO

Liquefaction tests: SINTEF-ER




Partners: TNO, SINTEF-ER

Ca-looping (USTUTT, CSIC rigs)



Partners: USTUTT, CTG, Polimi, CSIC, IKN

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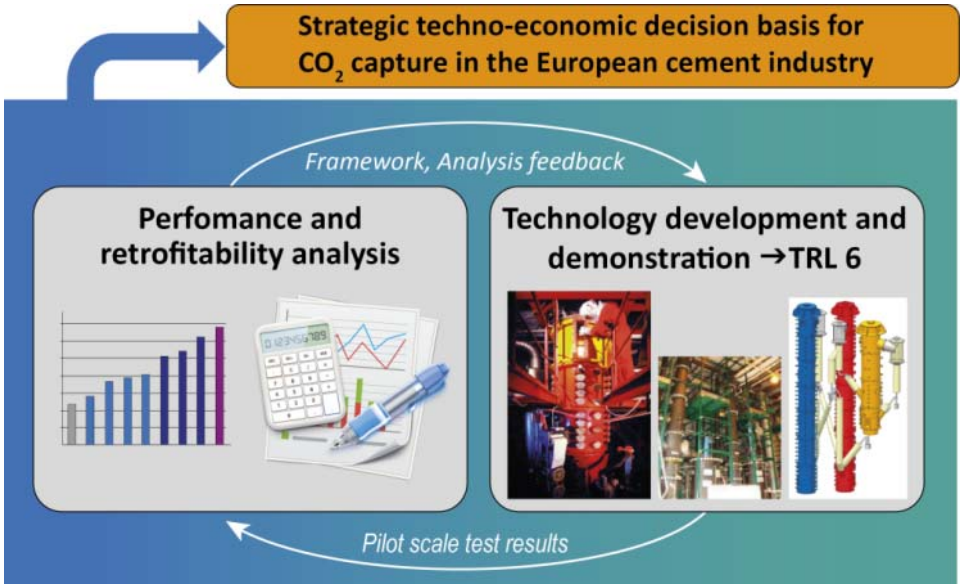
# Analytical work




CFD simulations of oxy-combustion

Capture process simulations

Simulations of full cement plants (kilns) with $CO_2$ capture

Cost estimations on a consistent basis for all investigated technologies + MEA ( combine with Norcem public results)

Benchmarking of $CO_2$ capture from cement plants

Retrofitability analysis

Final deliverable October 2018: Techno-economic decision basis

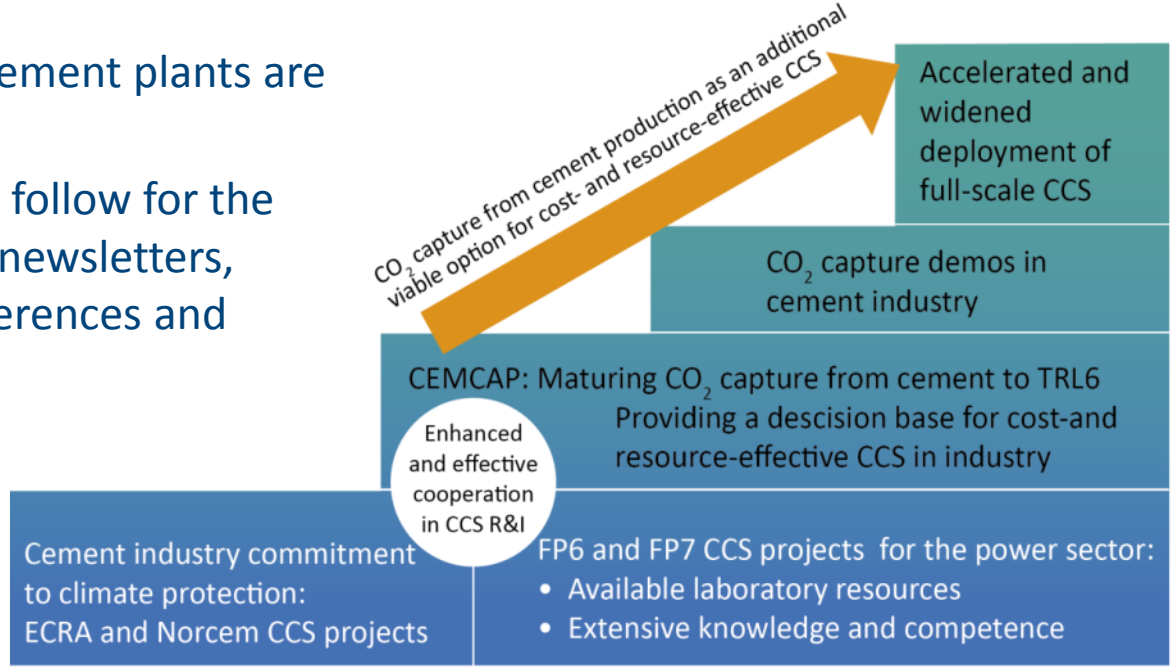
# CEMCAP – aiming to be a visible project with an impact

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 progress will be possible to follow for the interested public through blogs, newsletters, website, Facebook, Twitter, conferences and popscience articles

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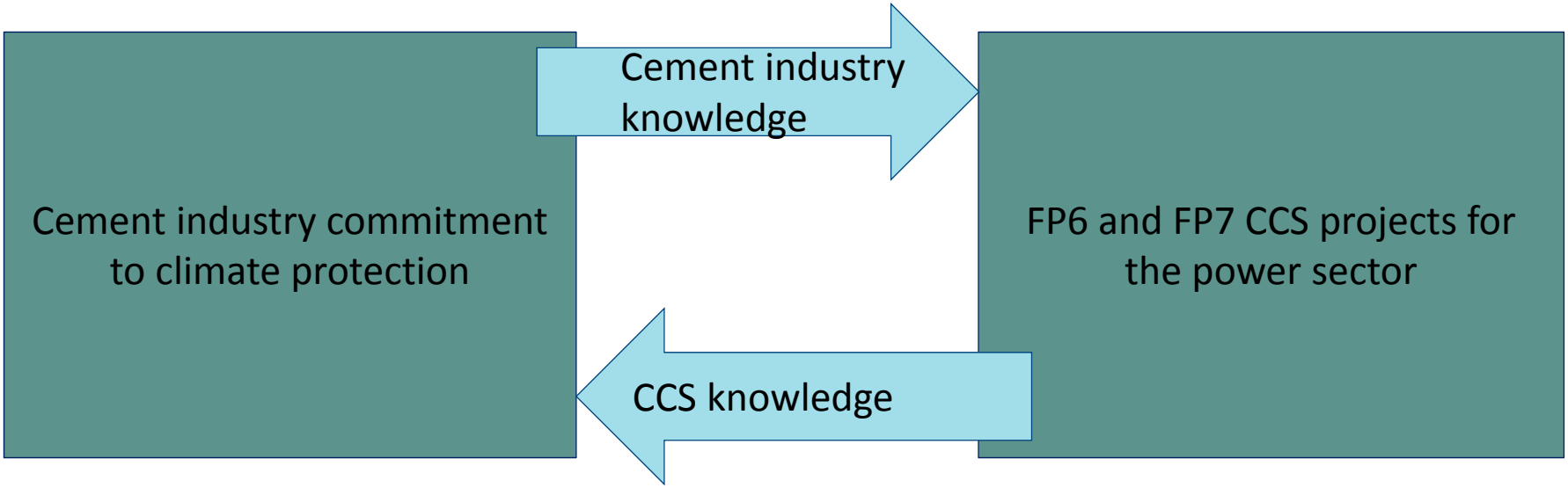
# In CEMCAP a pool of CCS expertise is made avialable to the cement industry

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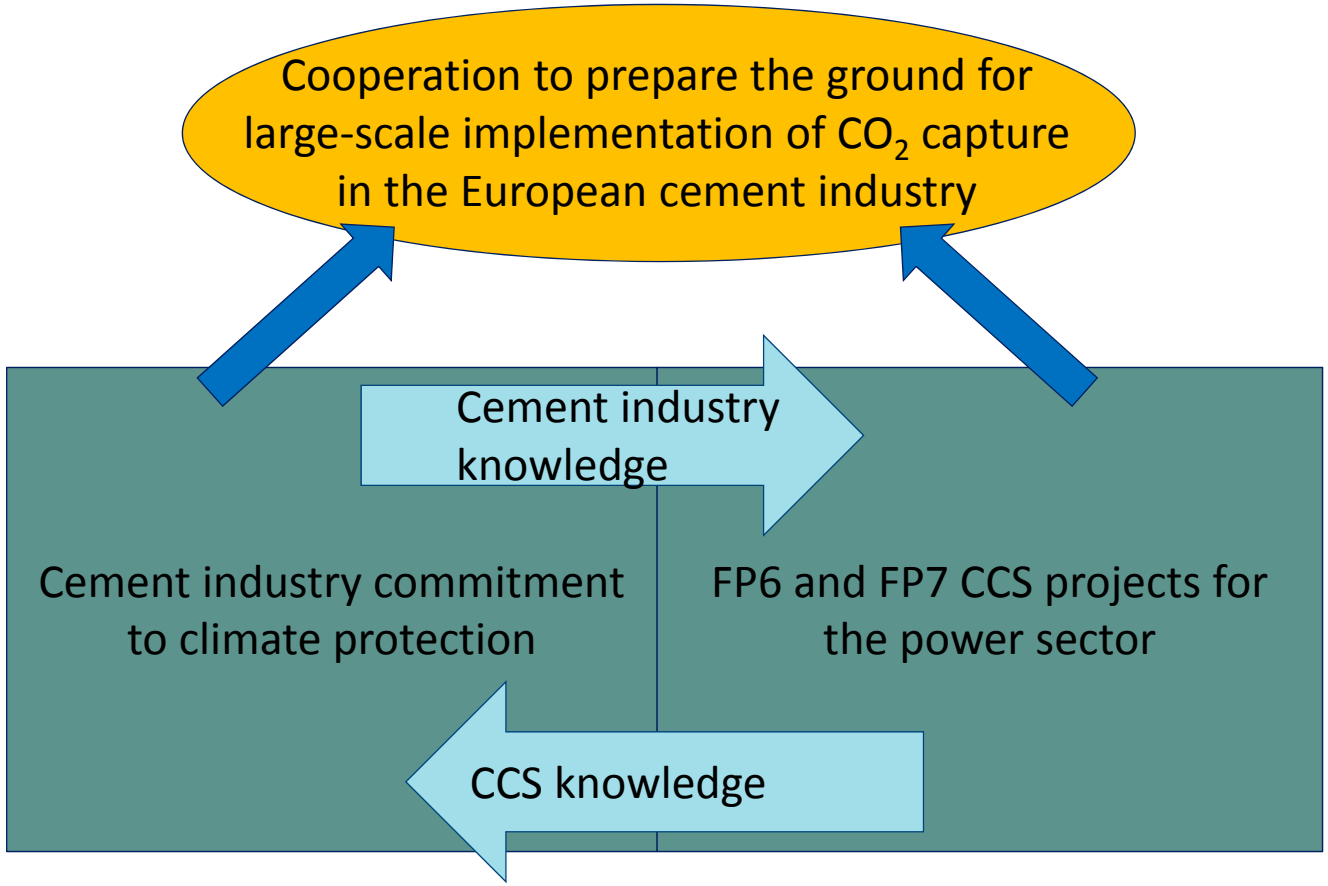


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# To conclude: the CEMCAP objectives

The **primary objective of CEMCAP** is

***To prepare the ground for large-scale implementation of $CO_2$ capture in the European cement industry***

To achieve this objective, **CEMCAP will**

*Leverage to TRL6 for cement plants the oxyfuel capture technology and three fundamentally different post combustion capture technologies, all of them with a targeted capture rate of 90%.*

*Identify the $CO_2$ capture technologies with the greatest potential to be retrofitted to existing cement plants in a cost- and resource-effective manner, maintaining product quality and environmental compatibility.*

*Formulate a techno-economic decision-basis for $CO_2$ capture implementation in the cement industry, where the current uncertainty regarding $CO_2$ capture cost is reduced by at least 50%.*

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# Thank you for your attention!

**Acknowledgement**

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www.sintef.no/cemcap

Twitter: @CEMCAP_CO2

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