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)

Kristin Jordal, Sigmund Ø. Størset, Nils A. Røkke

SINTEF Energy Research

CEMCAP

Co-funded by the European Union

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

CEMCAP

Co-funded by the European Union

Ongoing CCS research projects in the Cement industry

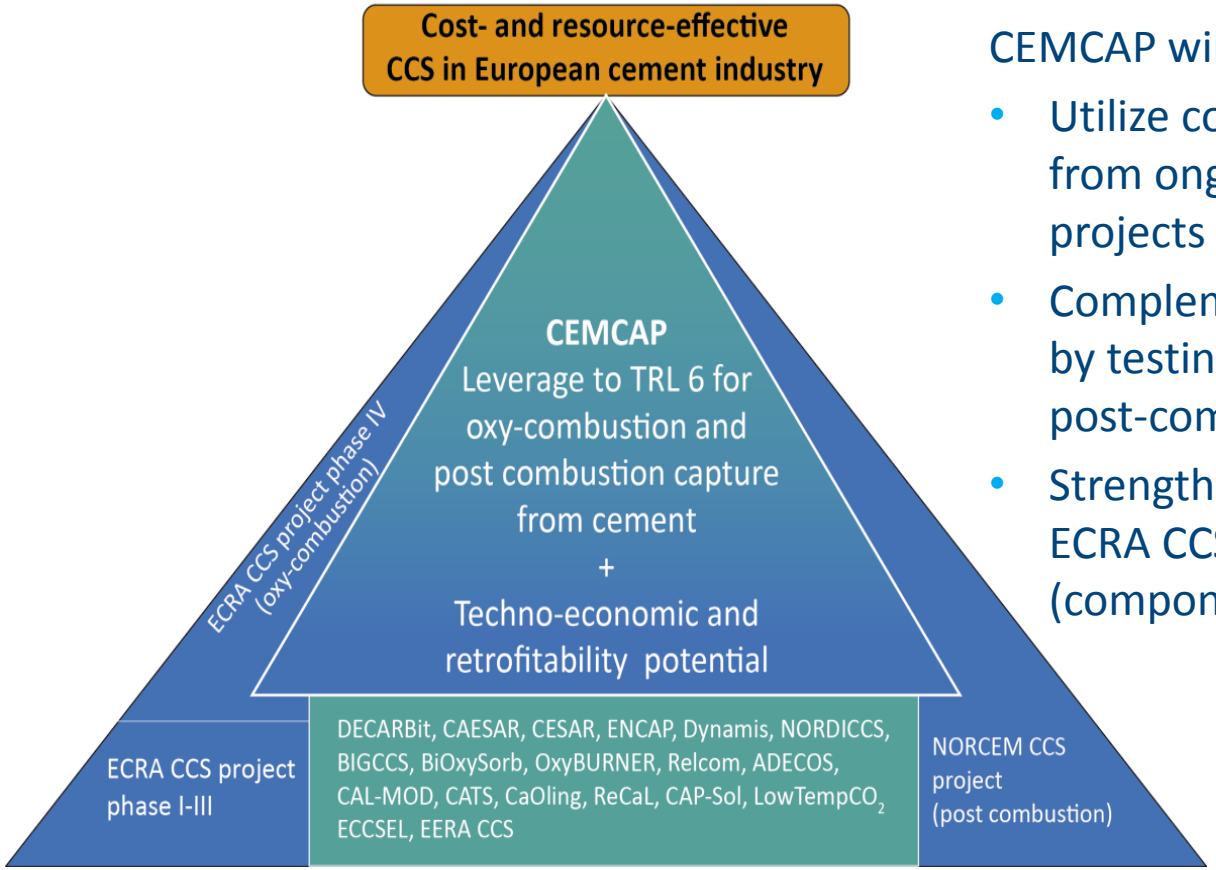
- The **Norcem CCS project** – post-combustion capture (presented by Liv Bjerge in this session)
  - Testing of amines, membranes, solid sorbent, Ca-looping

- 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

CEMCAP

Co-funded by the European Union

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)

CEMCAP

Co-funded by
the European Union

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

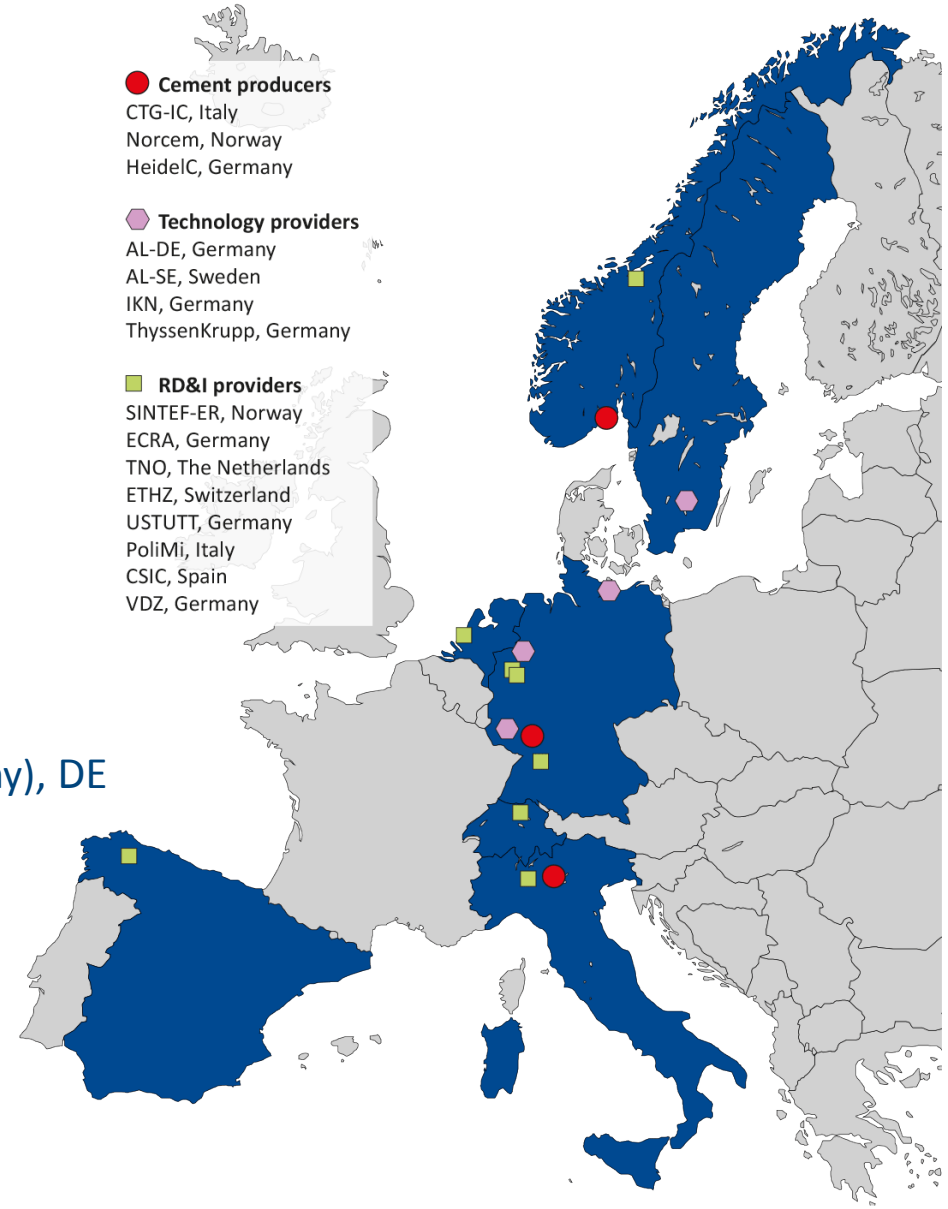
EHTZ, CH

University of Stuttgart, DE

Politecnico di Milano, IT

CSIC, ES

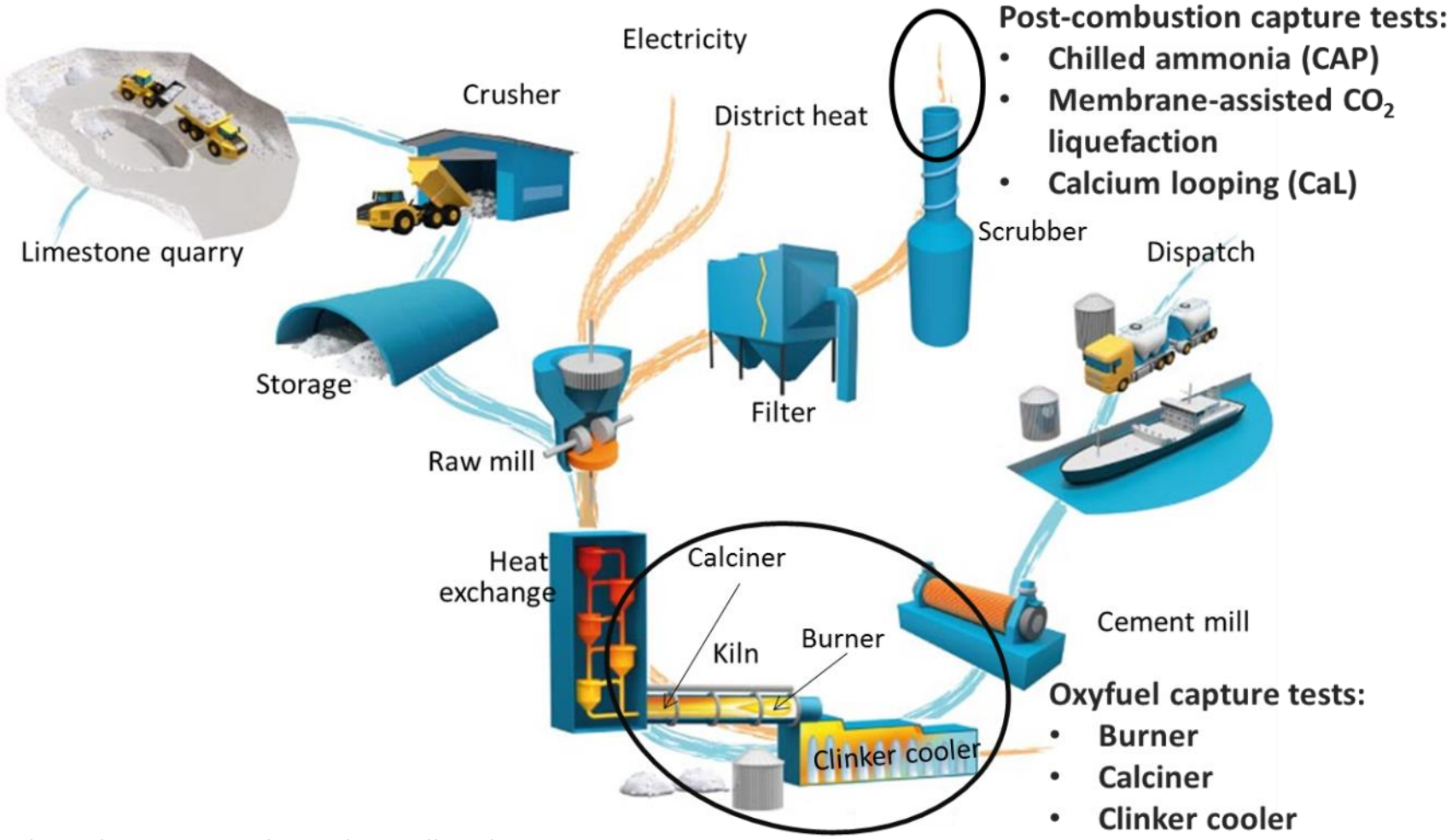
VDZ, DE



CEMCAP

Co-funded by the European Union

Technologies to be tested in CEMCAP, reaching TRL6*



*Technology demonstrated in industrially relevant environment

CEMCAP

Co-funded by the European Union

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.

CEMCAP

Co-funded by the European Union

Technologies to be tested - oxyfuel

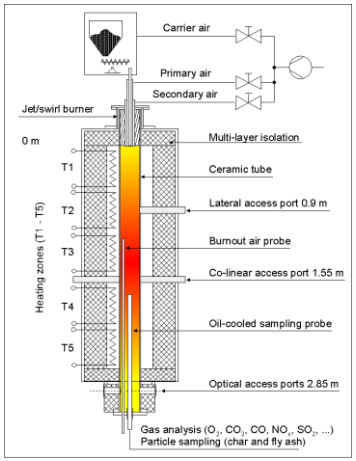
Oxyfuel burner

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

Partners: USTUTT, TKIS, SINTEF-ER

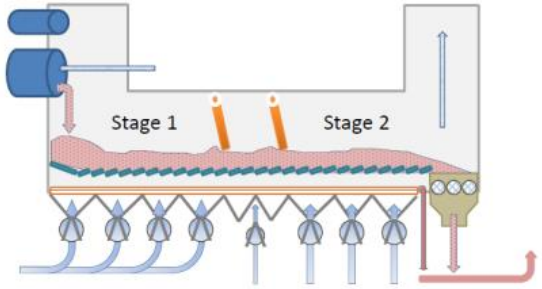
Calciner test rig

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

CEMCAP

Co-funded by the European Union

Technologies to be tested – post-combustion capture

Chilled Ammonia Process (CAP)

(Alstom Power Sweden)

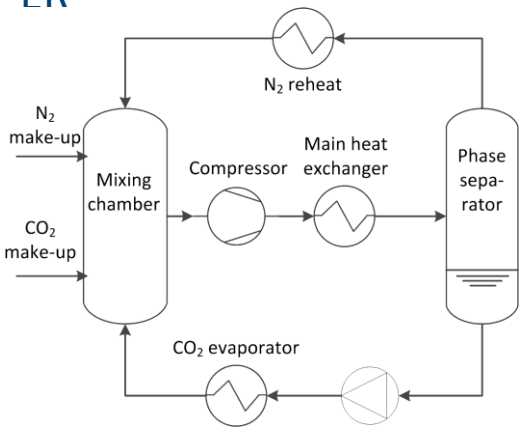
CAP never tested for such high CO_2 concentrations before

Partners: ETHZ, AL-SE, AL-DE

Membrane assisted CO_2 liquefaction

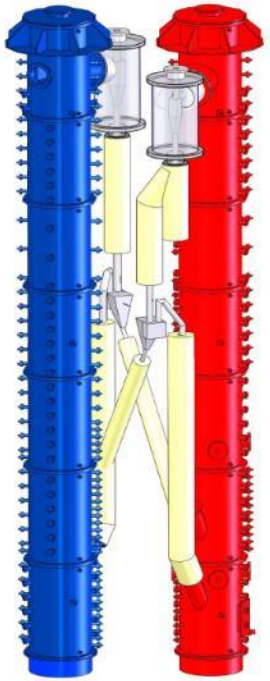
Membrane tests: TNO

Liquefaction tests: SINTEF-ER



Partners: TNO, SINTEF-ER

Ca-looping (USTUTT, CSIC rigs)

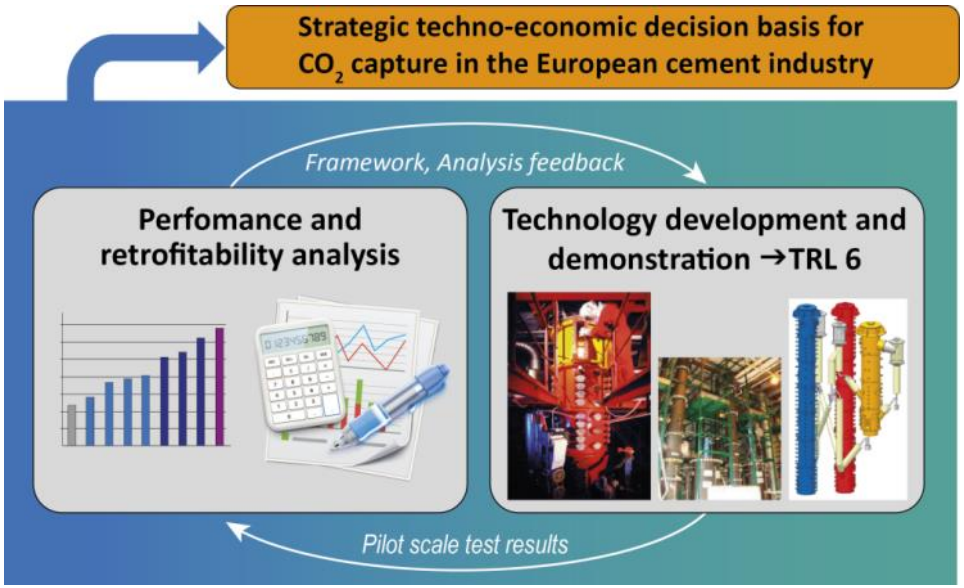


Partners: USTUTT, CTG, Polimi, CSIC, IKN

CEMCAP

Co-funded by the European Union

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

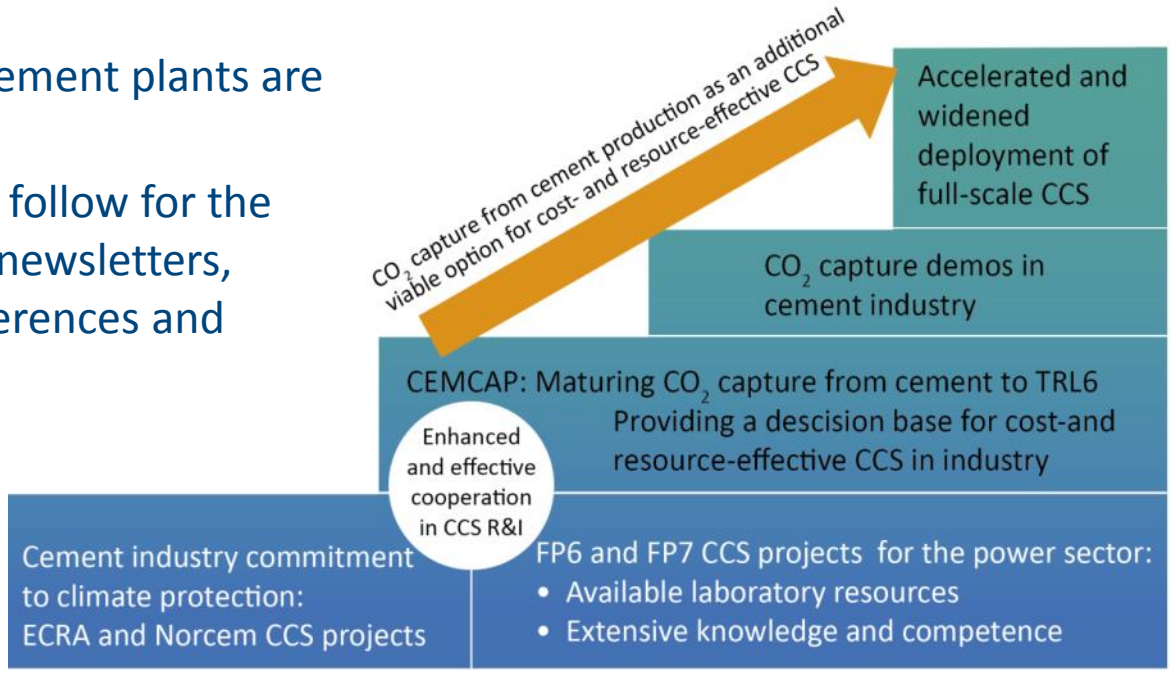
Final deliverable October 2018: Techno-economic decision basis

CEMCAP

Co-funded by the European Union

CEMCAP – aiming to be a visible project with an impact

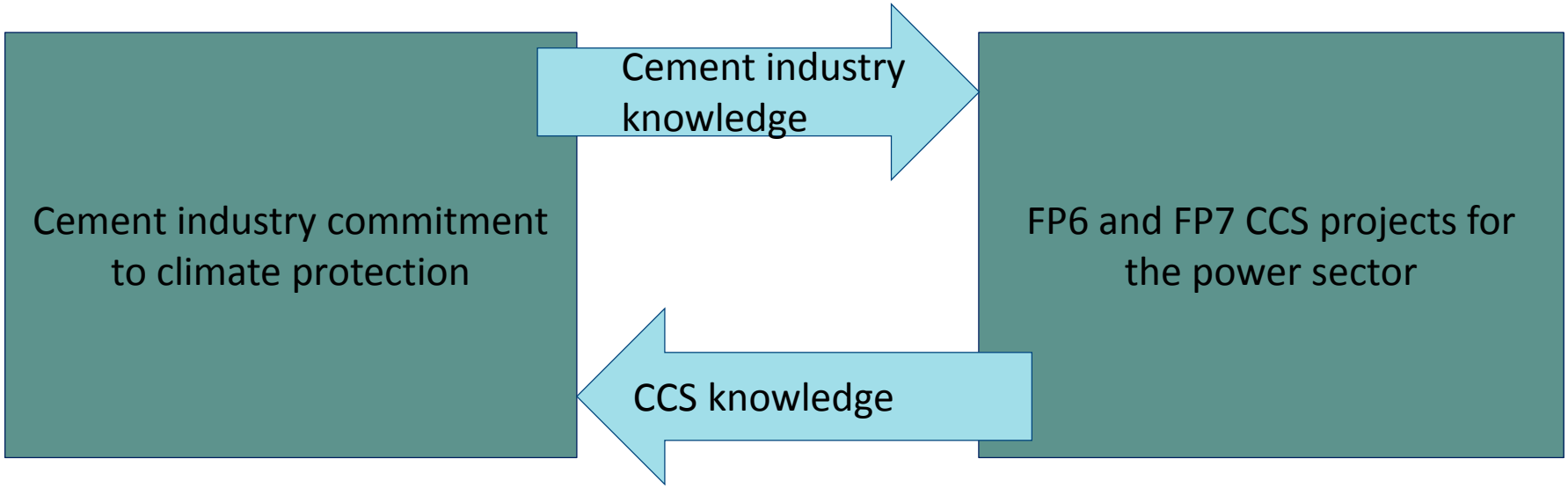
- CEMCAP will deliver strategic conclusions for how to progress CO_2 capture from cement plants from pilot-scale testing to demonstration
- Recommendations will be given for different scenarios (i.e. different types of cement plants at different locations in Europe)
- Focus is on retrofit – very few 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



CEMCAP

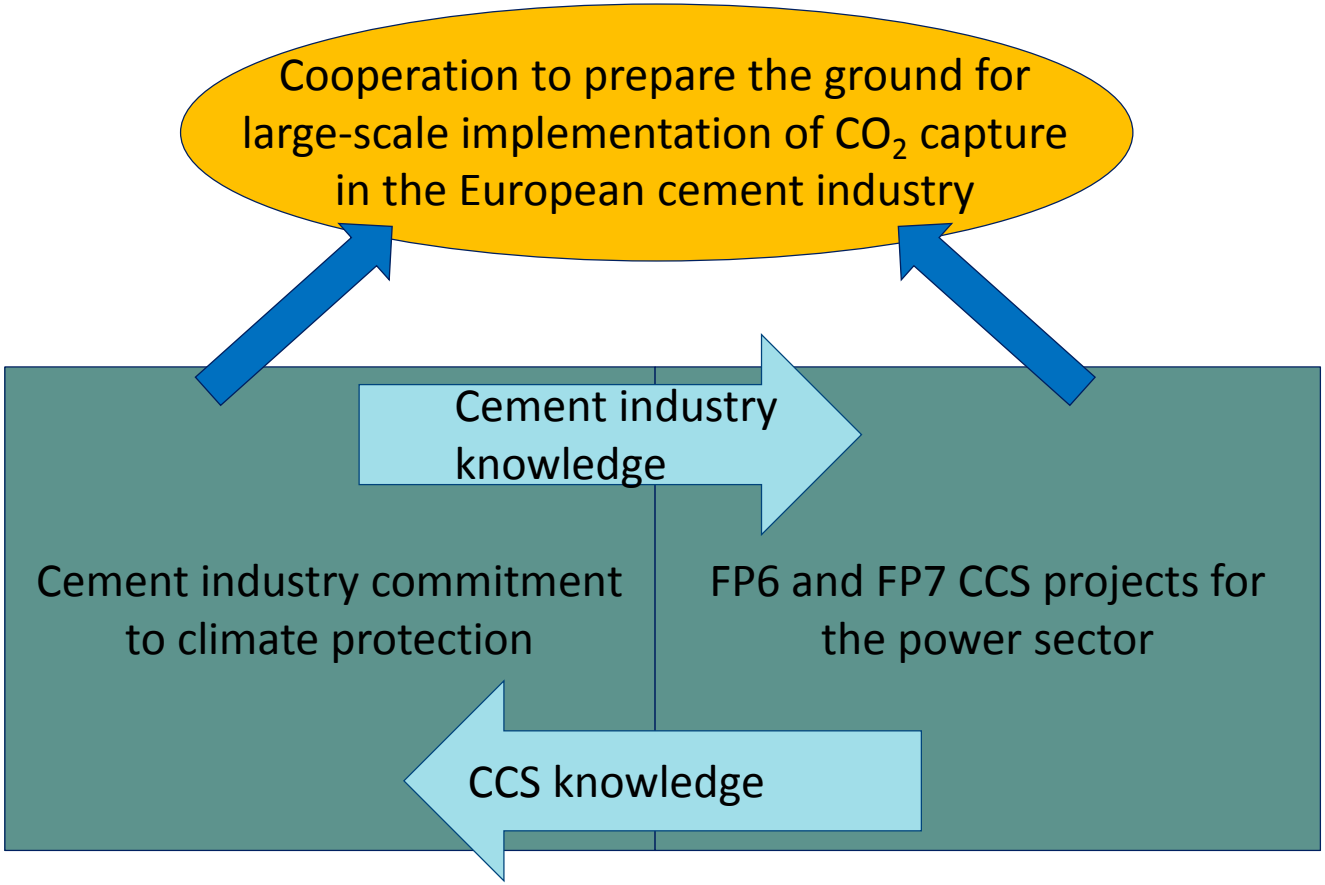
Co-funded by the European Union

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



Co-funded by the European Union

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



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%.

CEMCAP

Co-funded by the European Union

Thank you for your attention!

Acknowledgement

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 641185

www.sintef.no/cemcap

Twitter: @CEMCAP_CO2

CEMCAP

Co-funded by the European Union