CEMCAP

TECHNOLOGICAL ACHIEVEMENTS AND KEY CONCLUSIONS

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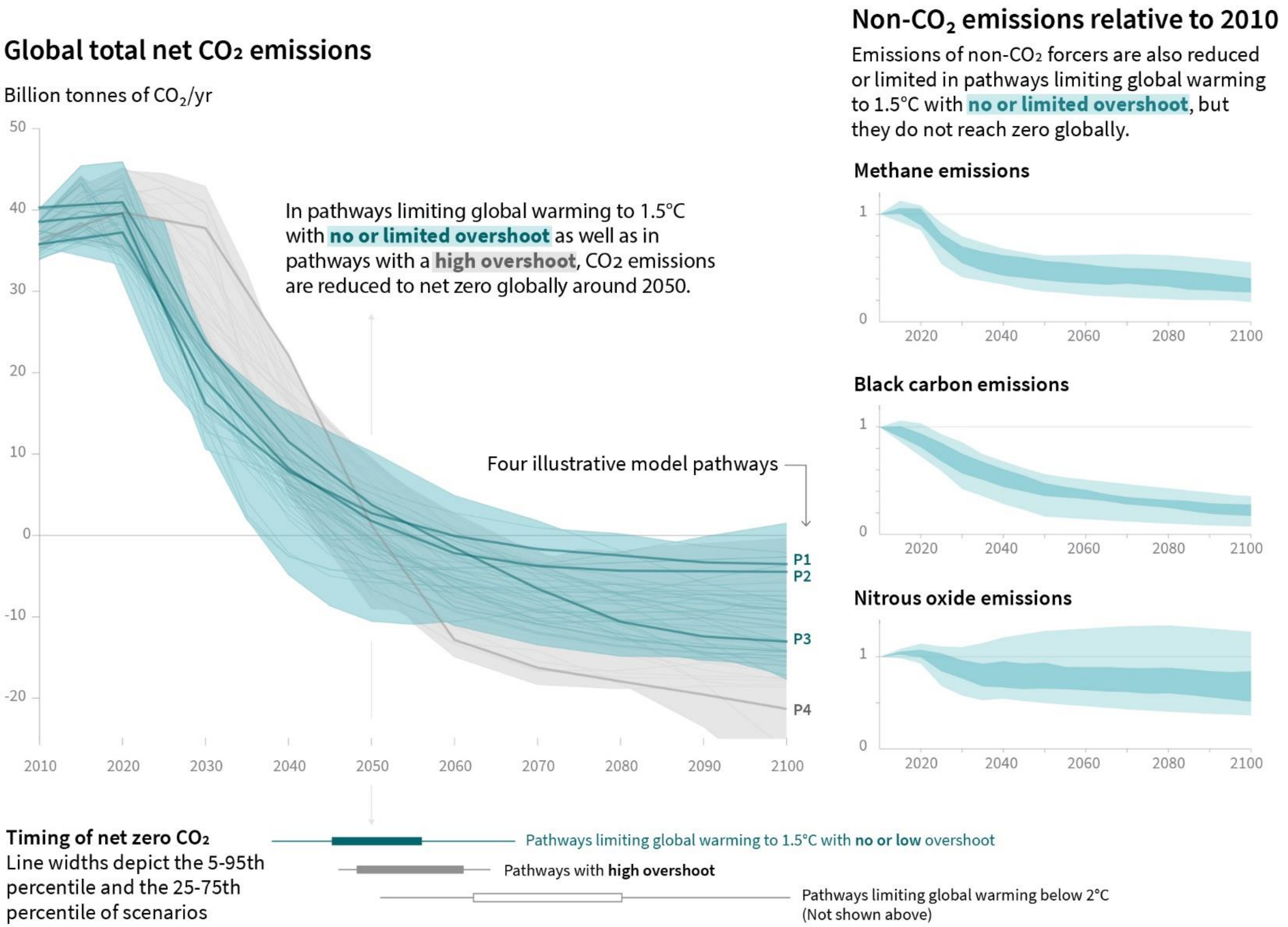
1.5°C global emissions pathway characteristichs (IPCC)



Source: IPCC. Global warming of 1.5°C. Summary for policymakers. October 6, 2018.

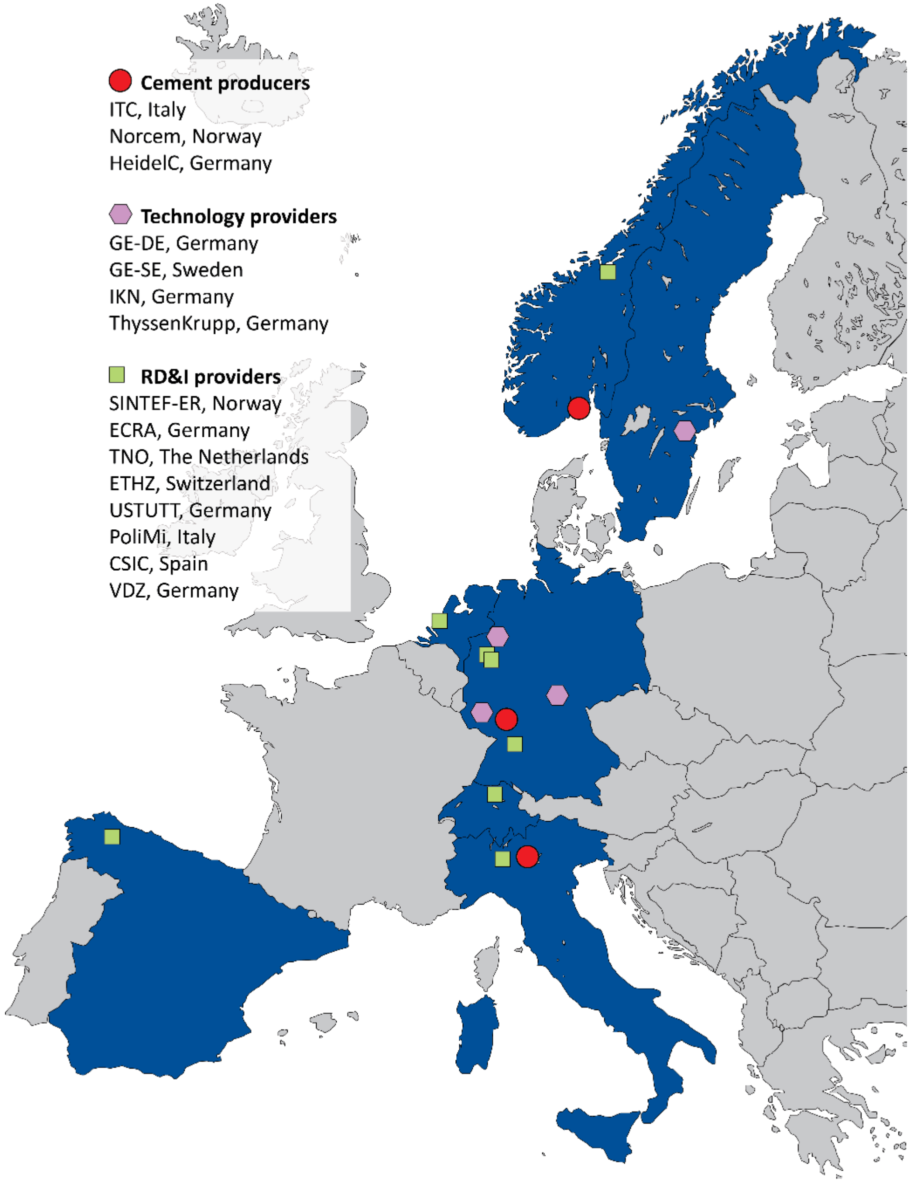
About CEMCAP

Duration: May 2015-October 2018

Budget: €10,030,120.75

EU contribution: €8,778,701.00

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



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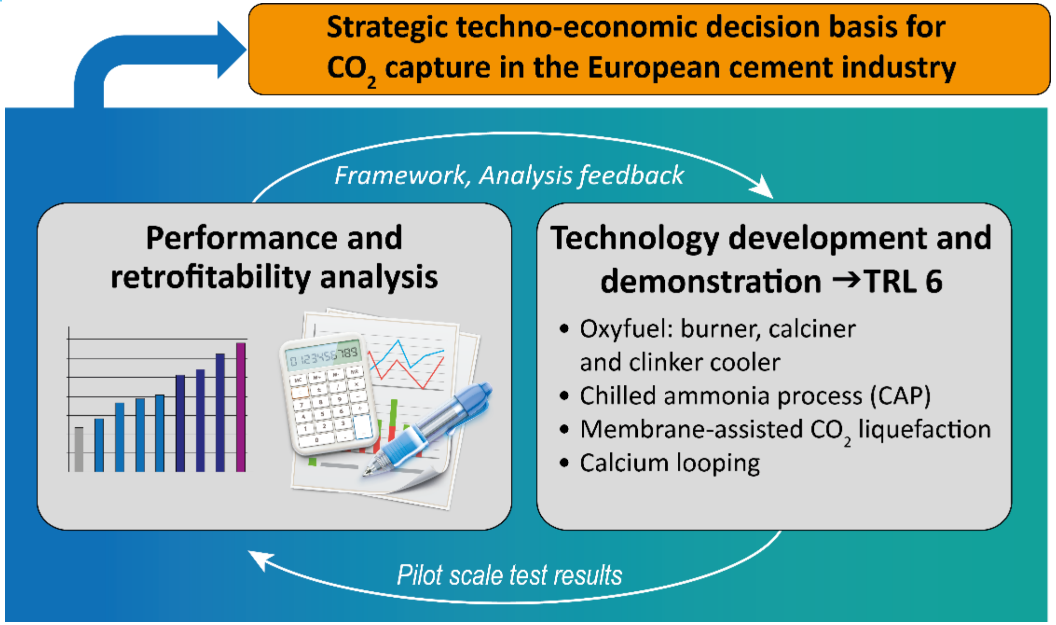
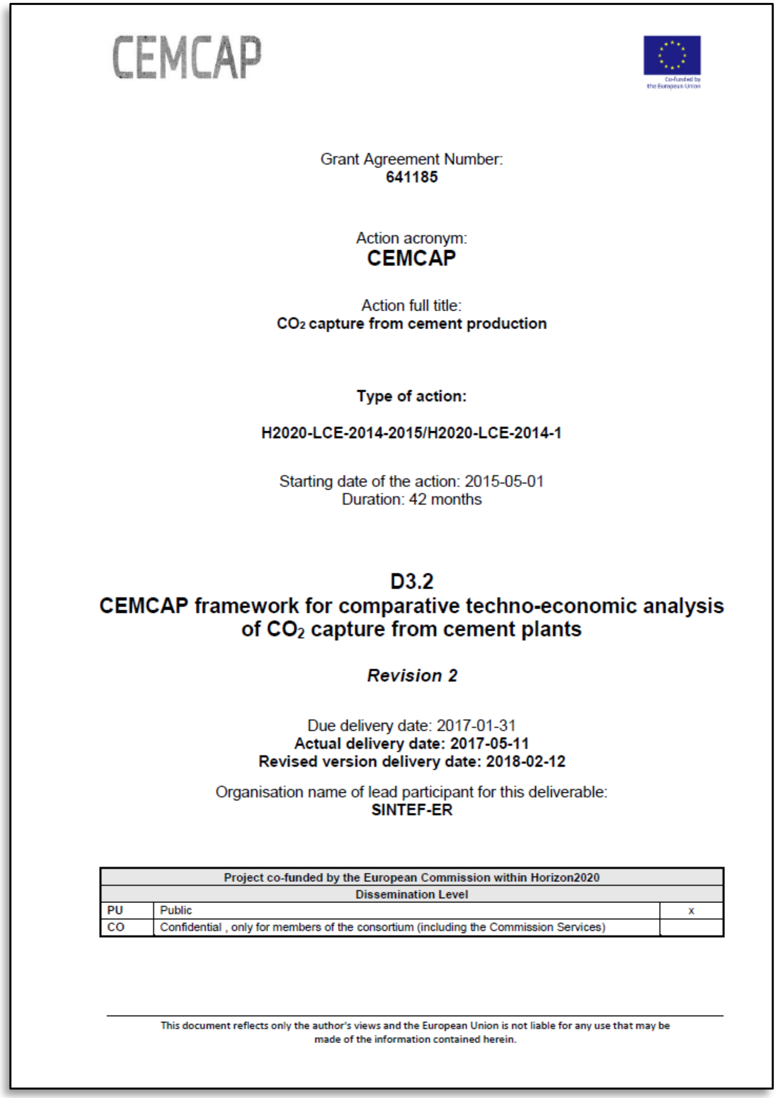
A consistent project



- Tight connection analytical ⟺ experimental work
- A common framework document established to ensure project consistency



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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

Revision 2

Due delivery date: 2017-01-31
Actual delivery date: 2017-05-11
Revised version delivery date: 2018-02-12

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)	

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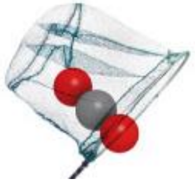

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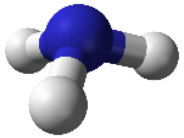
CO_2 capture technologies in CEMCAP

Capture technology	Oxyfuel	Chilled Ammonia Process	Membrane-Assisted Liquefaction	Calcium Looping	
				Tail-end	Integrated

The capture technologies are fundamentally different, with different advantages and challenges

Energy provision	Power	Steam and power	Power	Fuel and power	

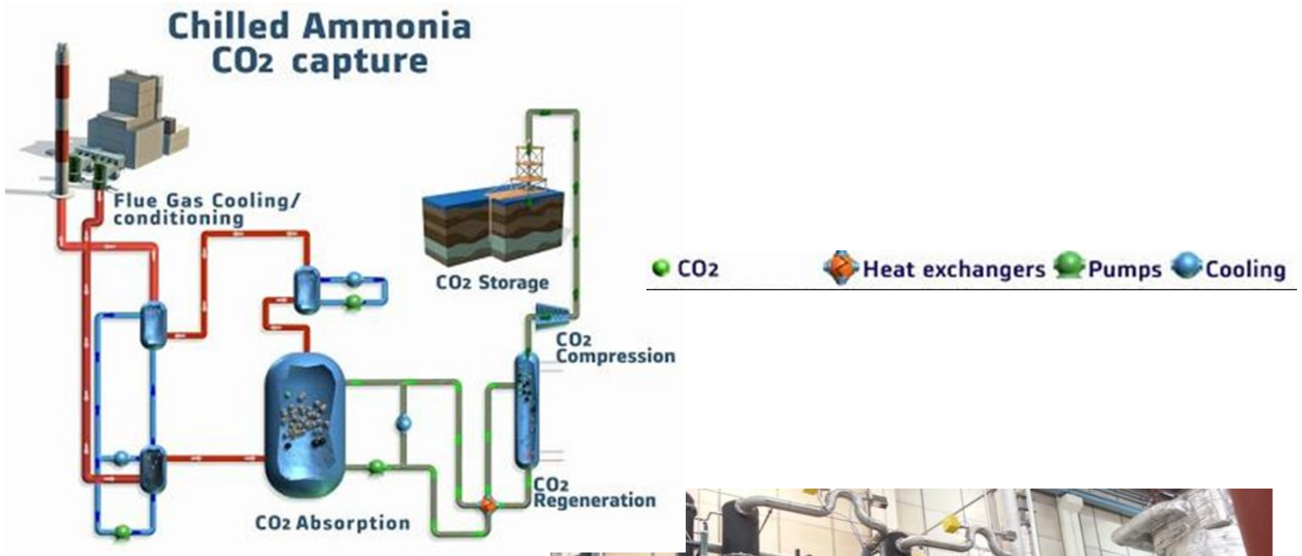
CO_2 capture requires energy and costs money – CEMCAP did not change this fact but we have decreased the uncertainty about the numbers for the cement industry



NH_3

- commodity chemical
- globally available
- chemically stable

Chilled Ammonia Process (CAP)



- Principle
  - Aqueous ammonia absorbs CO_2 in absorption column
  - Solution is regenerated through heating at pressure

Pilot at GE's technical centre Växjö, Sweden

- Research:
  - In pilot scale investigate process differences between cement and power
  - Thermodynamic and kinetic model development
  - Process optimization for cement application

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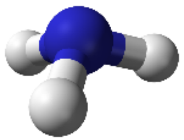
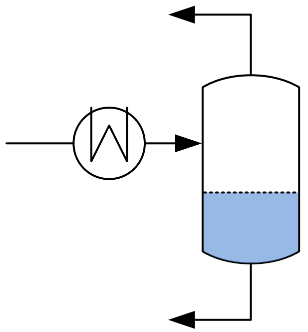


- commodity chemical
- globally available
- chemically stable

CAP: achievements in CEMCAP

- Validated process models
- CAP exploits high CO_2 concentrations for highly efficient capture
- Validated CAP functionality
  - All process units that are affected by new flue gas composition tested
  - CAP ready for on-site demonstration

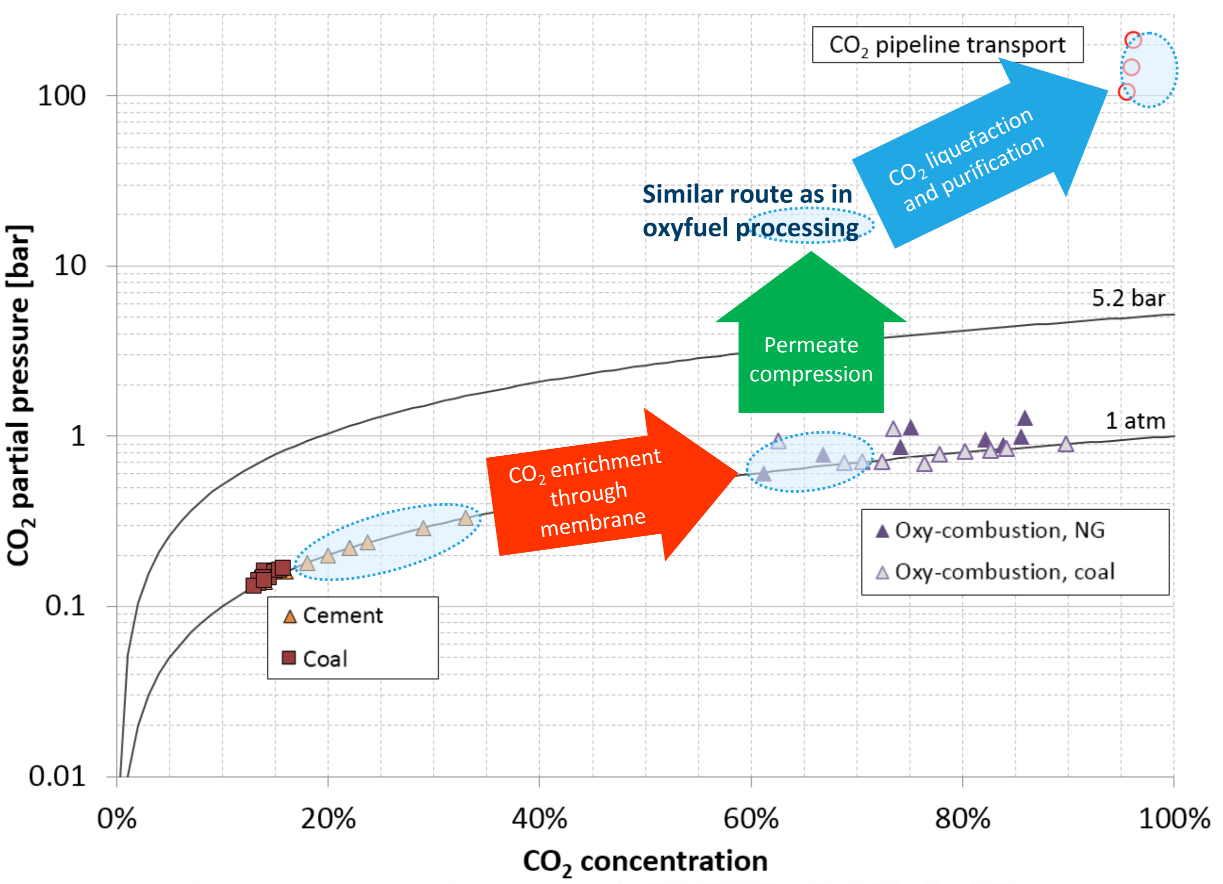
Product Validation Facility at the Mountaineer power plant, WV (50 MW_{th}):8000 h in 2009-2011

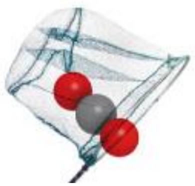


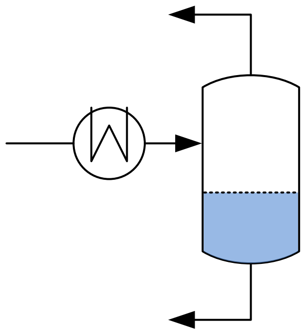
Membrane-Assisted Liquefaction (MAL)

- Principle: Flue gas is CO_2-enriched through membranes to "low-end oxyfuel" conditions. Thereafter compressed, cooled and condensed

- Research:
  - Membrane testing in lab
  - Development of MAL process schemes
  - Demonstration of CO_2 liquefaction on pilot scale



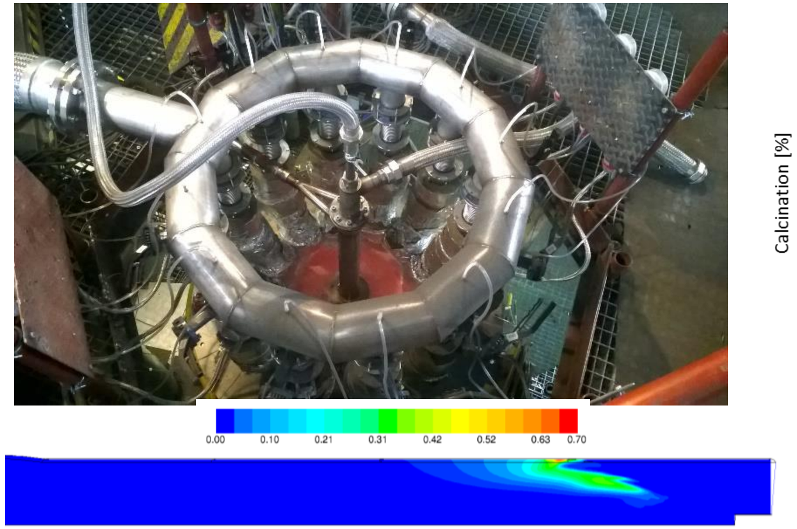




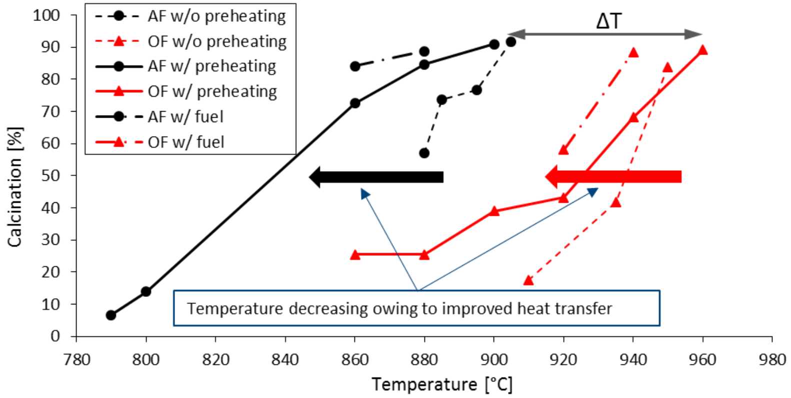
MAL: achievments in CEMCAP

- Polymeric membranes
  - Tested selectivity and permeability of two membrane materials
  - CO_2/N_2 selectivity sufficient: provides sufficient CO_2 concentration for efficient liquefaction
- Demonstrated operability of CO_2 liquefaction in 5-10 ton/day scale
  - Binary CO_2/N_2 mixtures with CO_2 concentration relevant for MAL applications
  - Very high CO_2 product purity measured, up to 99.8 %

Oxyfuel: Achievments in CEMCAP



Oxyfuel burner testing and simulations



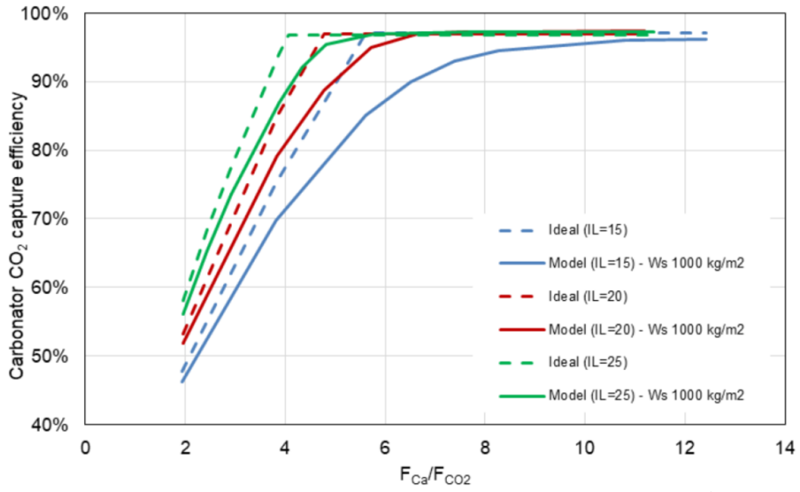
Entrained flow oxyfuel calcination testing

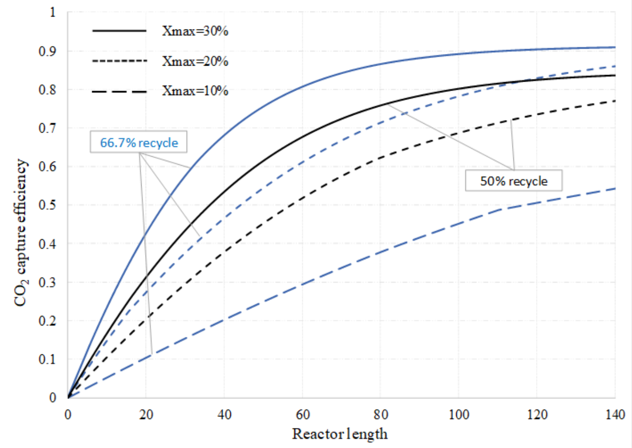
Oxyfuel clinker cooler prototype testing

The existing ECRA/VDZ oxyfuel process model was adapted in accordance with the experimental results

Calcium Looping (CaL): Achievments in CEMCAP

- Two configurations investigated
  - Tail-end: most mature
  - Integrated entrained flow: more energy efficient
- High CO_2 capture rates (up til 98%) with tail-end CaL. Ready for on-site demo after CEMCAP
- Integrated entrained flow CaL spin-off: CLEANKER project (on-site demo)





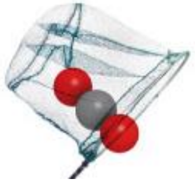
The next steps for the CEMCAP technologies

- Oxyfuel: ECRA CCS project plans for 2 demos at Colleferro (IT) and Retznei (AT)
- CAP: Pilot plant of 100,000 tCO_2/year envisioned
  - GE has full EPC capacity
- MAL: needs on-site screening of different membranes at operating cement kiln.
  - Liquefaction needs to be tested/demonstrated with flue gas impurities
- Tail-end CaL: ready for on-site testing
- Entrained-flow CaL: Is being brought to on-site demo in the CLEANKER project

Post-capture CO_2 management

- Cement production is a potential carbon source in a fossil-free future
  - But CO_2 is a very stable molecule, its conversion processes are normally highly energy intensive
- 16 CO_2-based products evaluated in CEMCAP
  - Current CO_2 utilization (CCU) routes have limited opportunity for climate change mitigation in the cement industry context
  - Likely < 10% of CO_2 from a cement plant can be used for CCU
  - Niche applications with positive CCUS business cases
- CCU should be considered in combination with CO_2 storage

Product	Market	Energy demand	Maturity	Price
$CaCO_3$ (GCC)				
$CaCO_3$ (PCC)				
Aggregates				
Carbonated concrete				
Methanol				
DME				
Methane				
Ethanol				
Isopropanol				
Biodiesel from microalgae				
PPC				
Polyols				
Cyclic carbonates				
Formic acid				
CO_2 (food-grade)				
CO_2 (greenhouses, NL)				



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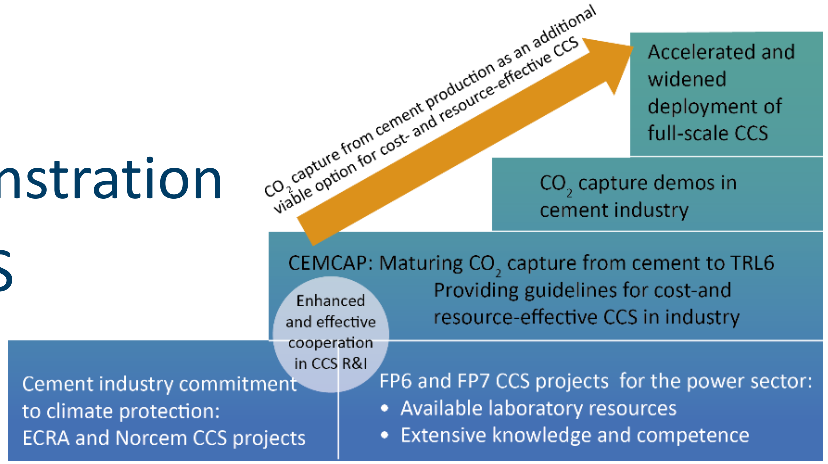
To sum up

- CEMCAP has expanded the knowledge base for future CCS deployment
- CEMCAP delivers a techno-economic decision base for retrofittable CO_2 capture from cement
  - The framework and results are suitable for in-house evaluations of CCUS in the cement sector. Use them!
- CEMCAP has provided 5 candidate technologies for CO_2 capture demos in the cement sector
  - Presentations on Norcem and LEILAC projects later today
- Funding and industrial ownership required for demonstration
- Business models required for moving to full scale CCS



CEMCAP Partners

Cement Producers

Italcementi HEIDELBERGCEMENT Group

NORCEM HEIDELBERGCEMENT Group

HEIDELBERGCEMENT

Technology providers

GE

IKN ENGINEERING THE FUTURE

thyssenkrupp

R&D providers

SINTEF

ecra european cement research academy

TNO innovation for life

ETH zürich

University of Stuttgart

POLITECNICO MILANO 1863

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More about CEMCAP

Sign up for our final webinars on October 29: www.sintef.no/cemcap

CEMCAP deliverables repository: www.zenodo.org/communities/cemcap/

Twitter: @CEMCAP_CO2

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