ECRA’s cement carbon capture project

Martin Schneider

ECRA/CEMCAP/CLEANKER Workshop
Brussels, 17 October 2018
ECRA: The European Cement Research Academy

ECRA is an internationally recognised European research body in the field of cement and concrete technology.

- ECRA was founded in 2003:
  - as a platform to stimulate and undertake research activities in the context of the production of cement and its application in concrete
  - to facilitate and accelerate innovation to guide the cement industry by creating and disseminating knowledge from research.

- ECRA initiates and provides seminars and workshops teaching state-of-the-art knowledge on cement and concrete technology and communicating the latest research findings

- ECRA undertakes dedicated research projects

- ECRA focuses on issues which individual companies may not be able to tackle alone and are of major importance to the cement industry as a whole

- ECRA currently has a membership of over 45 cement producers, associations and equipment suppliers worldwide
Climate policy context

**Paris agreement**
Limit global warming to 2°C
Net zero greenhouse gas emissions to reach carbon neutrality by 2050
Technology Roadmaps of the cement industry

WBCSD IEA Cement Technology Roadmap 2009

Regional Roadmaps

India 2013

Egypt 2016

European Bank for Reconstruction and Development

Brazil 2016/17

Several states in Brazil are establishing state regulation
Goal: Elaborate an internal mapping, with consensus of the industry, portraying the real potential
Guide for decision makers
Cooperation between CSI, SNIC, ABCP, IEA, IFC
Timeline: 18 months

Policy Roadmap for the Low-Carbon Egyptian Cement Industry

Contract number: C31840/SEMD-2015-07-21
Egypt: Technology and Policy Scoping for a Low-Carbon Egyptian Cement Industry
Net zero greenhouse gas emissions - cement production

Schematic figure. 
*) Global CO$_2$ estimate is subject to data constraints.

<table>
<thead>
<tr>
<th>Today’s emissions (global 2016)</th>
<th>Breakthrough technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Contribution</td>
<td></td>
</tr>
<tr>
<td>Thermal efficiency</td>
<td></td>
</tr>
<tr>
<td>Alternative fuels</td>
<td></td>
</tr>
<tr>
<td>Clinker factor</td>
<td></td>
</tr>
<tr>
<td>New binding materials</td>
<td></td>
</tr>
<tr>
<td>Carbon capture</td>
<td></td>
</tr>
<tr>
<td>External contribution</td>
<td></td>
</tr>
<tr>
<td>Renewable electrical energies</td>
<td></td>
</tr>
<tr>
<td>Transport efficiency</td>
<td></td>
</tr>
<tr>
<td>Re-carbonation of concrete</td>
<td></td>
</tr>
</tbody>
</table>

~2.4 Gt CO$_2$
Current R&D in capture technologies:

- Oxyfuel carbon capture technology ECRA project and:

- Post-combustion capture technologies
  - Absorption technologies:
  - Calcium Looping:
  - Algae capture

- Indirect calcination:
CCS technologies for the cement industry

Conventional clinker burning process

Air (O₂, N₂) → Clinker Burning Process → CO₂, N₂, etc.

Clinker burning process with post-combustion carbon capture

Air (O₂, N₂) → Clinker Burning Process → CO₂ capture

Oxyfuel clinker burning process

Air (O₂, N₂) → Air separation → Clinker Burning Process → CO₂

N₂
Potential capture solution for the cement industry

**Post-Combustion:** Tail-end separation of CO$_2$ from flue gas by e.g. chemical absorption, adsorption, membranes or Ca-looping.

- A very energy-intensive technology.
- Important projects: Norcem’s Brevik project (pilot testing), CEMCAP (prototype testing).

**Oxyfuel Technology:** Combustion with pure oxygen instead of air in combination with flue gas recirculation to increase the CO$_2$ concentration.

- Requires process and design adaptations.
- Important projects: ECRA (complete oxyfuel), LafargeHolcim/AirLiquide/FLSmidth (pilot testing of partial oxyfuel), CEMCAP (prototype testing).
## CCS in the cement industry: Two options

<table>
<thead>
<tr>
<th>Issue</th>
<th>Oxyfuel Technology</th>
<th>Post-combustion capture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Concept</strong></td>
<td>Integrated concept</td>
<td>End-of-pipe technology</td>
</tr>
<tr>
<td><strong>Effect on cement kiln operation</strong></td>
<td>Process and material reaction is influenced</td>
<td>Minimal impact on existing cement kiln process</td>
</tr>
<tr>
<td><strong>Development status</strong></td>
<td>Oxygen enrichment has been applied to cement kilns</td>
<td>Commercially available in other industry sectors</td>
</tr>
<tr>
<td></td>
<td>Oxyfuel technology still requires some R&amp;D, but ready for demonstration</td>
<td>Pilot-scale testing in cement industry initiated</td>
</tr>
<tr>
<td><strong>Time horizon for commercial application</strong></td>
<td>not before 2025</td>
<td>not before 2020</td>
</tr>
<tr>
<td><strong>CO₂ purity</strong></td>
<td>CO₂ from the combustion (~ 85 vol.%) process is concentrated and purified in CO₂ purification unit (CPU)</td>
<td>Pure CO₂ stream for compression (90 - 99 vol.%)</td>
</tr>
<tr>
<td><strong>Energy demand</strong></td>
<td>Doubling of power demand per tonne of cement produced</td>
<td>Doubling of electrical and thermal energy demand per tonne of cement produced</td>
</tr>
<tr>
<td></td>
<td>Thermal energy demand could be reduced</td>
<td></td>
</tr>
</tbody>
</table>
Challenges of carbon capture

- Significant increase in production costs
- Currently, the legal and economic conditions of these technologies would impair the competiveness of cement production
- CO₂ storage or reuse strategy and infrastructure
- Oxyfuel still requires R&D
- Post-combustion requires further development of high-performance capture materials to reduce energy demand
Post-Combustion: The Norcem Project

- Testing of Post-Combustion technologies in industrial surrounding:
  - Solid sorbents
  - Amine
  - Membrane
  - Calcium Looping
- Period: 2013 - 2016
- Evaluation concerning:
  - Suitability
  - Energy demand
  - CAPEX/OPEX
  - Capture rates
- Perspective: 40 – 50% capture rate based on waste heat utilisation
ECRA’s approach towards carbon capture

Phase I
- Literature study (January - June 2007)

Phase II
- Study about technical and financial aspects of CCS projects, concentrating on oxyfuel and post-combustion technology (summer 2007 – summer 2009)

Phase III
- Laboratory-scale / small-scale research activities (autumn 2009 – autumn 2011)

Phase IV
- Prepare pilot plant (time-frame: 2 - 3 years)

Phase V
- Build and operate pilot plant (time-frame: 3-5 years)

Phase VI
- Demonstration plant (time-frame: 3-5 years)
## Organisation of the CCS project

### Steering Committee

<table>
<thead>
<tr>
<th>Company</th>
<th>Company</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buzzi Unicem</td>
<td>CEMBUREAU</td>
<td>CSI</td>
</tr>
<tr>
<td>Cimpor</td>
<td>CRH</td>
<td>LafargeHolcim</td>
</tr>
<tr>
<td>HeidelbergCement</td>
<td>Italcementi</td>
<td>PCA</td>
</tr>
<tr>
<td>MPA</td>
<td>Norcem</td>
<td>thyssenkrupp Industrial Solutions</td>
</tr>
<tr>
<td>Schwenk</td>
<td>Secil</td>
<td>VDZ</td>
</tr>
<tr>
<td>Titan</td>
<td>VICAT</td>
<td></td>
</tr>
</tbody>
</table>

### External project partners

<table>
<thead>
<tr>
<th>Company</th>
<th>Company</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aixergee</td>
<td>Cinar</td>
<td></td>
</tr>
<tr>
<td>Danish Technical University</td>
<td>Fives FCB</td>
<td></td>
</tr>
<tr>
<td>IKN</td>
<td>IrishCement</td>
<td></td>
</tr>
<tr>
<td>Praxair</td>
<td>Refratechnik Cement</td>
<td></td>
</tr>
</tbody>
</table>

### Cooperations

<table>
<thead>
<tr>
<th>Company</th>
<th>Company</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Mons</td>
<td>Norcem Projekt</td>
<td>CEMCAP</td>
</tr>
</tbody>
</table>

Quelle: Springerprofessional
ECRA cooperation in EU CO₂ capture research projects

- Oxyfuel carbon capture technologies for the cement industry based on ECRA project
- 2016 to 2018: Testing of key technologies under cement industry conditions
- Successful demonstration of key oxyfuel technologies; advancement to technological readiness level (TRL 6)

Next step:
Demonstration of a complete oxyfuel capture system prototype in a cement plant (TRL 7 and 8)
Two cement plants are identified for the oxyfuel project

- RETZNEI, LafargeHolcim
- COLLEFERRO, Italcementi

Project in two phases to ensure oxyfuel prototype plant operation under different local and plant-specific conditions

Industrial-scale carbon capture project
ECRA press release January 2018
https://ecra-online.org/press-releases/
ECRA CCS Project: Current status and upcoming activities

- Site selection process for oxyfuel pilot project completed
- Required budget around 80 Mio. €
- Cement industry committed to sponsor a significant amount to the budget
- Significant funding from European or national funding schemes required
- Additional work packages assigned
Thank you for your attention!