UMONS ecra chair — from CO_2 to energy

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ECRA ACADEMIC CHAIR "FROM CO_2 TO ENERGY" AT THE UNIVERSITY OF MONS: CO_2 CAPTURE & REUSE IN THE CEMENT INDUSTRY

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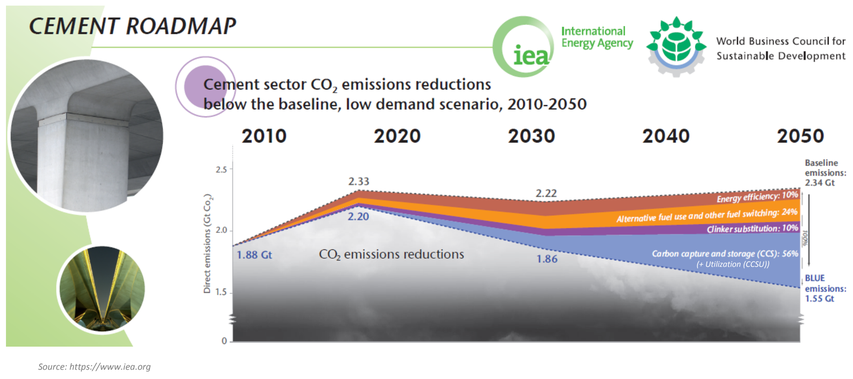
CEMENT INDUSTRY CONTEXT

Cement plants ≈ 30% of the industrial CO_2 emissions



Source: https://www.iea.org

CO_2 emissions reductions

44% thanks to:
- Energy efficiency
- Alternative fuel
- Clinker substitution

56% thanks to:
Carbon Capture Storage & Utilization (CCSU)

The reduction of the CO_2 emissions from different industries (power plants, cement plants, etc.) at world scale requires the implementation of **Carbon Capture, Storage and Utilization (CCSU) processes**. The application of CCSU to power plants flue gases (CO_2 contents from 5% to 15%) has already been considered in many studies but there is still a lack of data concerning its specific application to the **cement industry** (y_{CO2} > 15%).

Regarding the capture phase, two technologies are adapted to the cement industry, namely:
- the **post-combustion CO_2 capture** (currently tested at pilot scale in the cement industry), where the CO_2 in the pretreated flue gas (containing from 20% to 30% CO_2) is conventionally captured thanks to an absorption-regeneration process where it is absorbed in a solvent (such as monoethanolamine 30 wt.%) which is then regenerated requiring energy;
- the **oxy-fuel combustion CO_2 capture** (the selection of a cement plant for pilot tests is undergoing), where the combustion is performed with pure oxygen leading to flue gases highly concentrated in CO_2 (>80%) which need to be purified (de-SO_x, de-NO_x, etc.) prior to conversion into valuable products such as methanol.
Another option envisaged by the cement industry is the "**partial oxy-fuel combustion CO_2 capture**" which corresponds to an hybrid process which combines the combustion with O_2-enriched air (CO_2 contents in the flue gas between 40% and 60%) and post-combustion CO_2 capture by the absorption-regeneration process.

In this context, the **ECRA (European Cement Research Academy) Academic Chair** was established at UMONS in 2013, focusing on the CO_2 capture and reuse applied to the cement industry. Initially scheduled for a first period of 3 years, the ECRA Academic Chair has been recently prolonged until mid-2019!

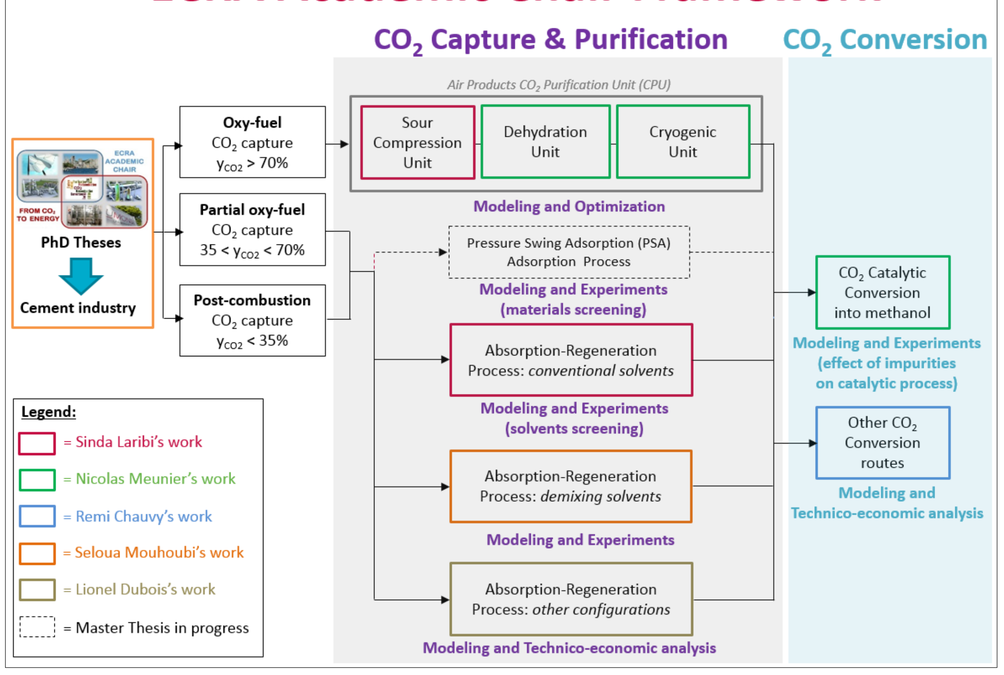
April 2013: Important scientific agreement between ECRA (European Cement Research Academy) and UMONS (University of Mons)

ECRA ACADEMIC CHAIR — FROM CO_2 TO ENERGY

Centre of scientific expertise in the specific field of "carbon capture in cement production and its re-use"

Promotion of research and innovation through:
→ PhD theses + Post-Doc
→ Projects for undergraduated students + ECRA Award
→ External communications
→ Technical/scientific Events
→ Visits of professors & experts

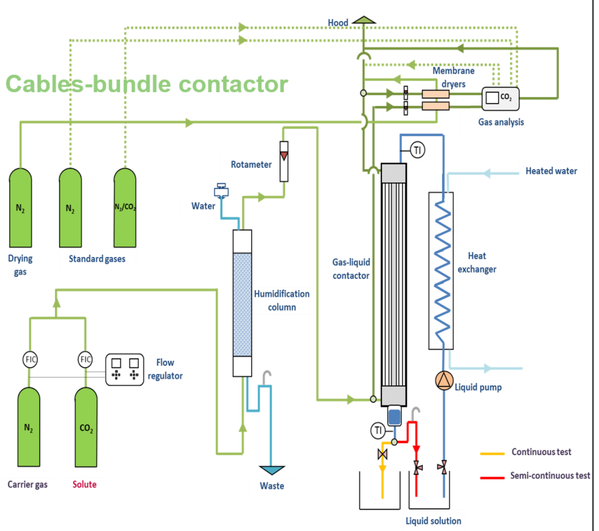
ECRA Academic Chair Framework

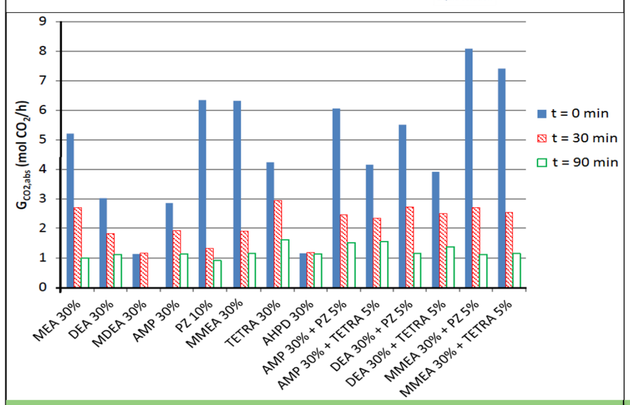


CO_2 CAPTURE — CO_2 PURIFICATION — CO_2 CONVERSION

EXPERIMENTS

Cables-bundle contactor



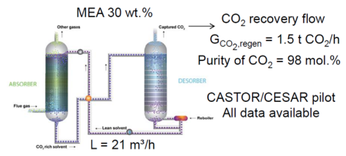


This graph shows that the ranking of the solvents based on their $G_{CO2,abs}$ is modified during the semi-continuous test due to the CO_2 loading.

SIMULATIONS

NORCEM HEIDELBERGCEMENT Group

Brevik cement plant = ECRA reference
Single European project for testing CO_2 capture from cement industry



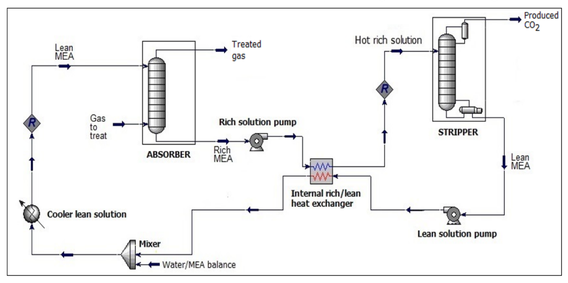
CO_2 recovery flow
$G_{CO2,regen}$ = 1.5 t CO_2/h
Purity of CO_2 = 98 mol.%

CASTOR/CESAR pilot
All data available

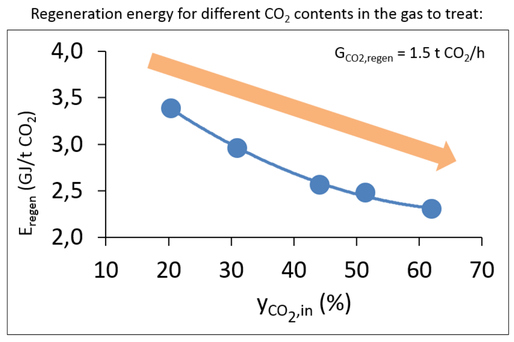
- Aspen Hysys V8.6
- Acid gas package
- Thermodynamic models: Peng-Robinson (gas) and e-NRTL (liquid)
- Reactions sets included in the package (validated with literature)

G_{in} = 4000 m³/h; $y_{CO2,in}$ = 20.4 mol.% (base case); A = 90 mol.%

Aspen Hysys flow sheet of the classical absorption-regeneration configuration:

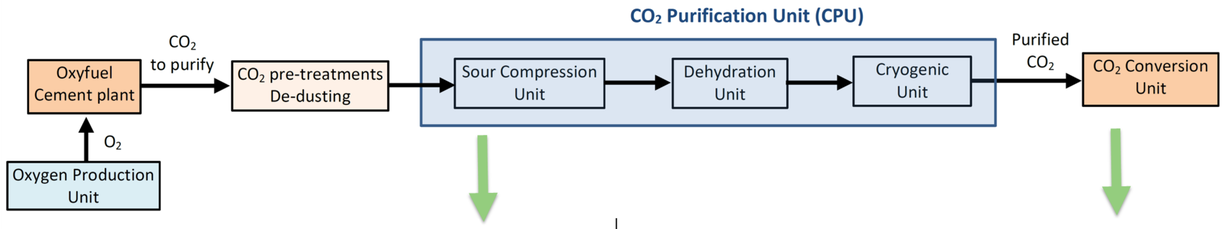


Regeneration energy for different CO_2 contents in the gas to treat:

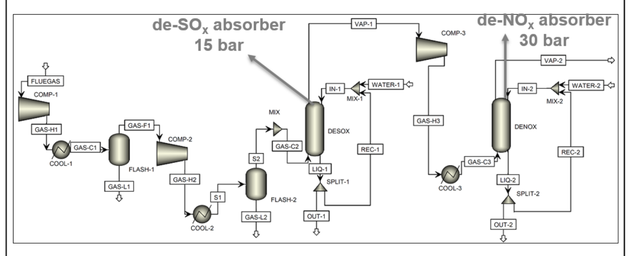


Increasing the CO_2 content into the gas to treat lead to a decrease of the regeneration energy of more than 30 % !

CO_2 Purification Unit (CPU)



SCU Process for de-SO_x and de-NO_x Simulation in Aspen Plus



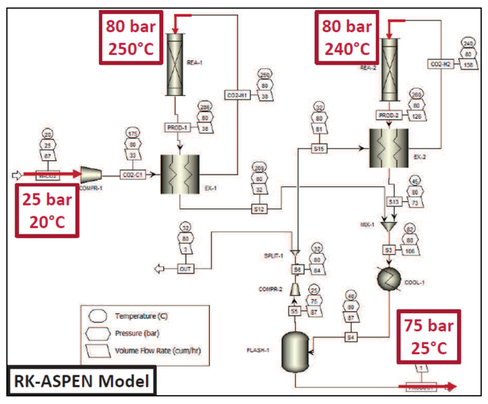
Gas composition (%.mol)	Inlet de-SO_x column	Outlet de-SO_x column	Outlet de-NO_x column
CO_2	83.13	83.82	83.89
N_2	11.11	11.25	11.32
O_2	3.27	3.21	3.23
Ar	1.34	1.36	1.37
H_2O	1	0.35	0.19
NO_2	96 ppm	28 ppm	3 ppm
NO	861 ppm	Trace	Trace
SO_2	156 ppm	Trace	Trace

Energy requirements

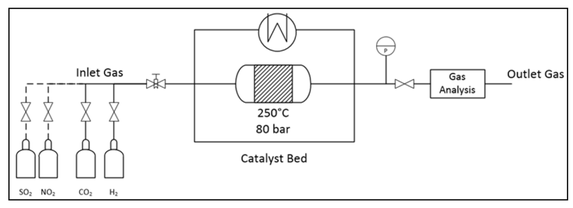
Power type	Operation	Power (kW)	%
Electrical	1 - 15 bar compression	14.58	81
	15 - 30 bar compression	3.42	19
	Total	18	100
Thermal	1 - 15 bar cooler (30°C)	- 16.47	80
	30 bar cooler (30°C)	- 4.19	20
	Total	- 20.66	100

The SCU process is efficient for the de-SO_x and de-NO_x of flue gas coming from oxy-fuel combustion cement plant.

CO_2 catalytic conversion into methanol Simulation in Aspen Plus



Experimental device under development



The simulated results were successfully validated with literature. 15-25% of the CO_2 entering the process is converted in the first reactor and about 90% considering the whole process.

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ECRA Academic Chair references:

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Meunier N., Laribi S., Dubois L., Thomas D., De Weireld G., CO_2 capture and re-use from oxyfuel cement kilns: Process simulation of the CO_2 purification and catalytic conversion into methanol, International Conference on Carbon Dioxide Utilization (ICCDU XIII), Singapore, 2015.

Dubois L., Laribi S., Meunier N., De Weireld G., Thomas D., Global optimization of the CO_2 capture and reuse applied in the cement industry, Brussels sustainable Development Summit 2015, Belgium, 2015.

09-10th November 2016
Save the date!

The European Cement Research Academy (ECRA) and the University of Mons (UMONS) are pleased to invite you to the Second Scientific Event of the ECRA Academic Chair:

« CO_2 Capture & Reuse in the cement industry: from the lab to the plant »

Workshop organized at Mons (Belgium) on the 09th November 2016
+ Visit of the Lixhe Cement plant on the 10th November 2016

ECRA Academic Chair website: http://hosting.umons.ac.be/html/ecrachair