UMONS ecra chair from CO_2 to energy · POLYTECH MONS · energy UMONS RESEARCH INSTITUTE FOR ENERGY · HEIDELBERGCEMENT · Trondheim CCS Conference CO_2 Capture, Transport and Storage TCCS-9

OPTIMIZATION OF DIFFERENT CO2 CAPTURE PROCESSES APPLIED TO CEMENT FLUE GASES

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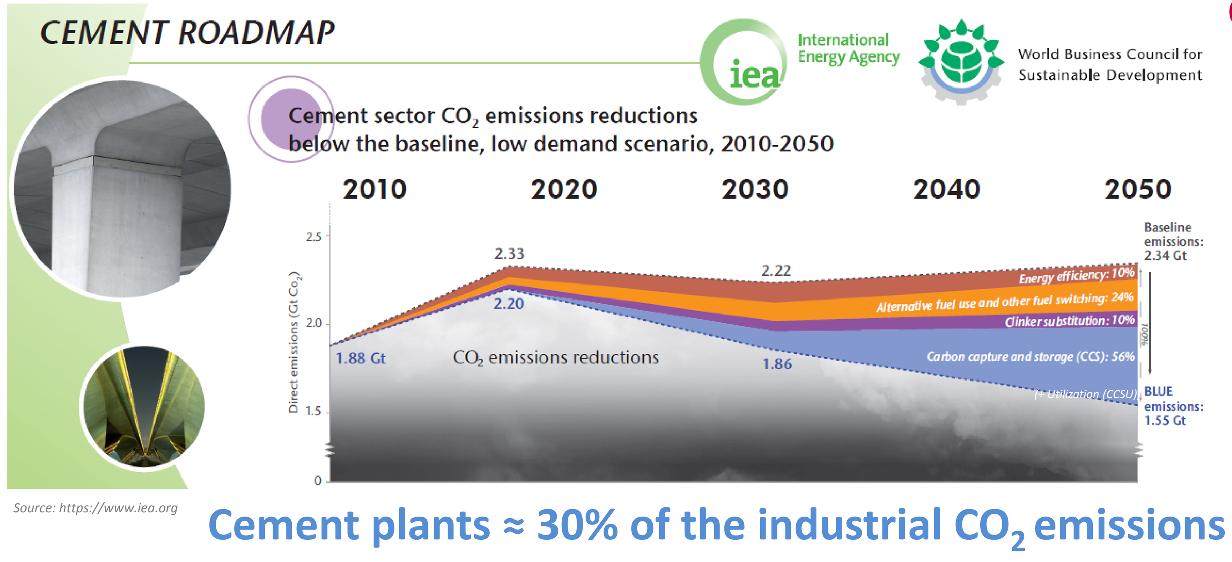
CEMENT INDUSTRY CONTEXT



CO_2 emissions reductions

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

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

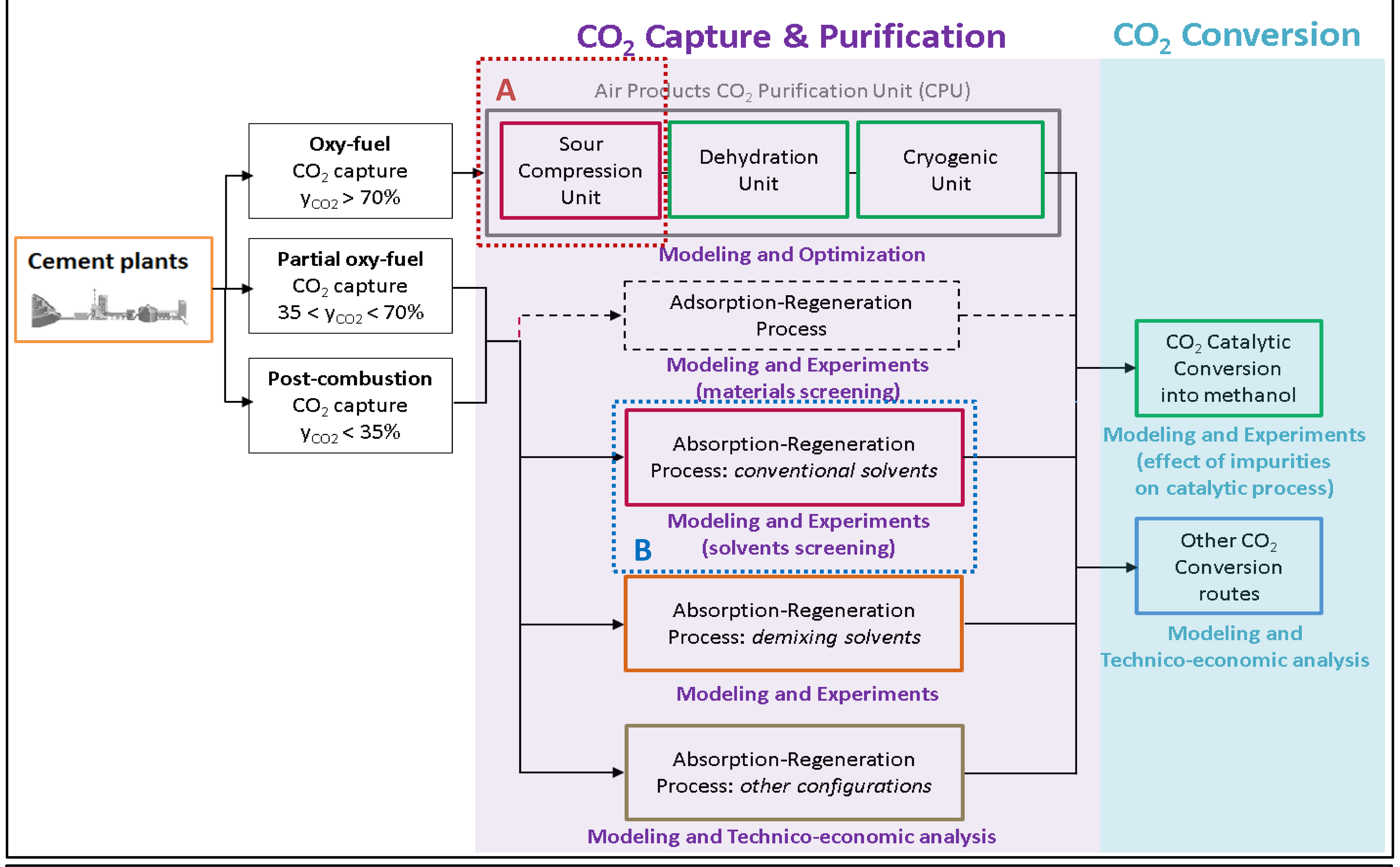
Cement plants ≈ 30% of the industrial CO_2 emissions

Reduction of CO_2 emissions from different industries by Carbon Capture, Storage and Utilization (CCSU) processes but lack of data concerning its specific application to the cement industry (y_{CO2} > 15%).

Two **capture technologies** adapted to the cement industry, namely:
- the post-combustion CO_2 capture *(currently tested at pilot scale in the cement industry)*: 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 MEA 30 wt.%) which is then regenerated requiring energy;
- the oxy-fuel combustion CO_2 capture *(undergoing selection of a cement plant for pilot tests)*: the combustion is performed with pure oxygen, leading to flue gases highly concentrated in CO_2 (>80%) needing to be purified (de-SO_x, de-NO_x, etc.) prior to conversion.

Another **innovative option envisaged by the cement industry** = "partial oxy-fuel combustion CO_2 capture": hybrid process which combines the combustion with O_2-enriched air (CO_2 contents in the flue gas between 20% and 60%) and post-combustion CO_2 capture by the absorption-regeneration process.

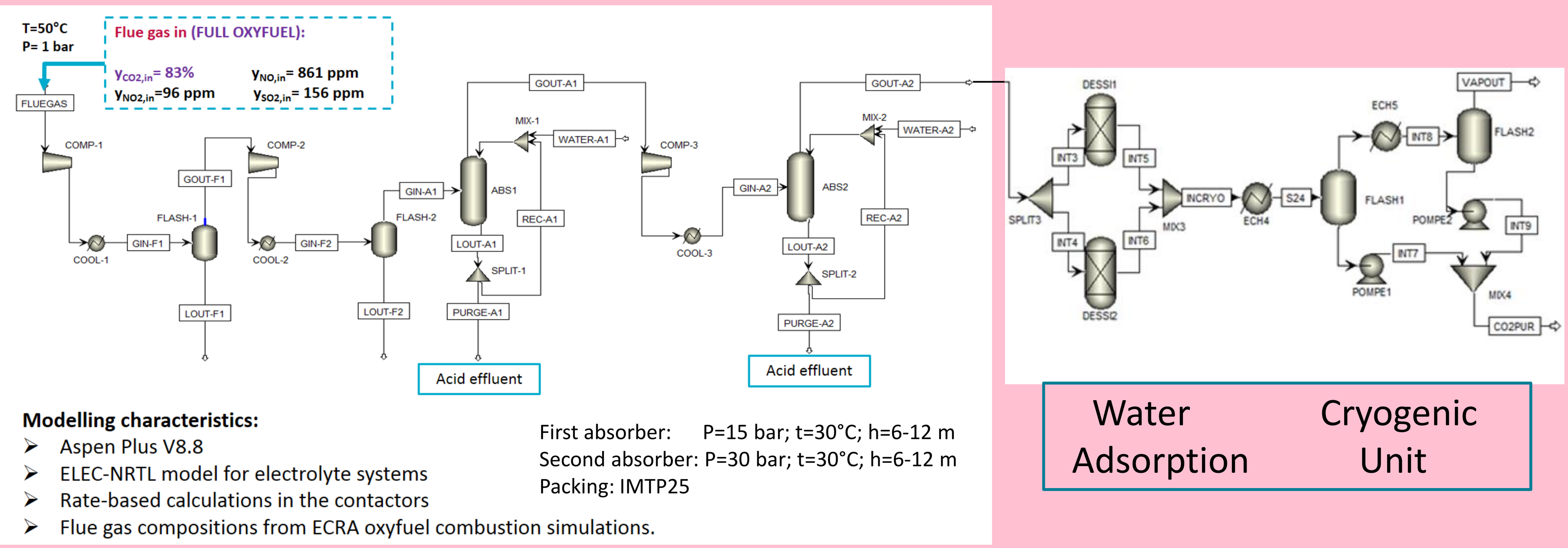
ECRA Academic Chair Framework



Trondheim CCS Conference TCCS-9 — This poster — Oral communication of N. Meunier

A: Full oxy-fuel Combustion → CO_2 PURIFICATION PROCESS (CPU)

Aspen Plus™ simulation flowsheet of the CPU



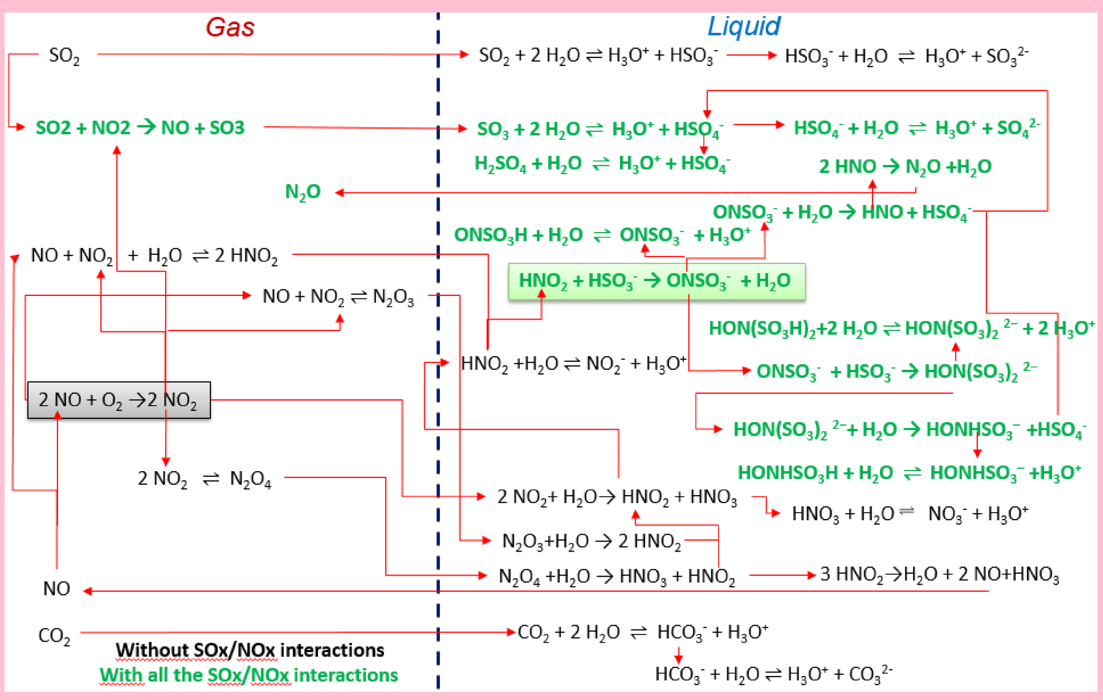
Modelling characteristics:
- Aspen Plus V8.8
- ELEC-NRTL model for electrolyte systems
- Rate-based calculations in the contactors
- Flue gas compositions from ECRA oxyfuel combustion simulations.

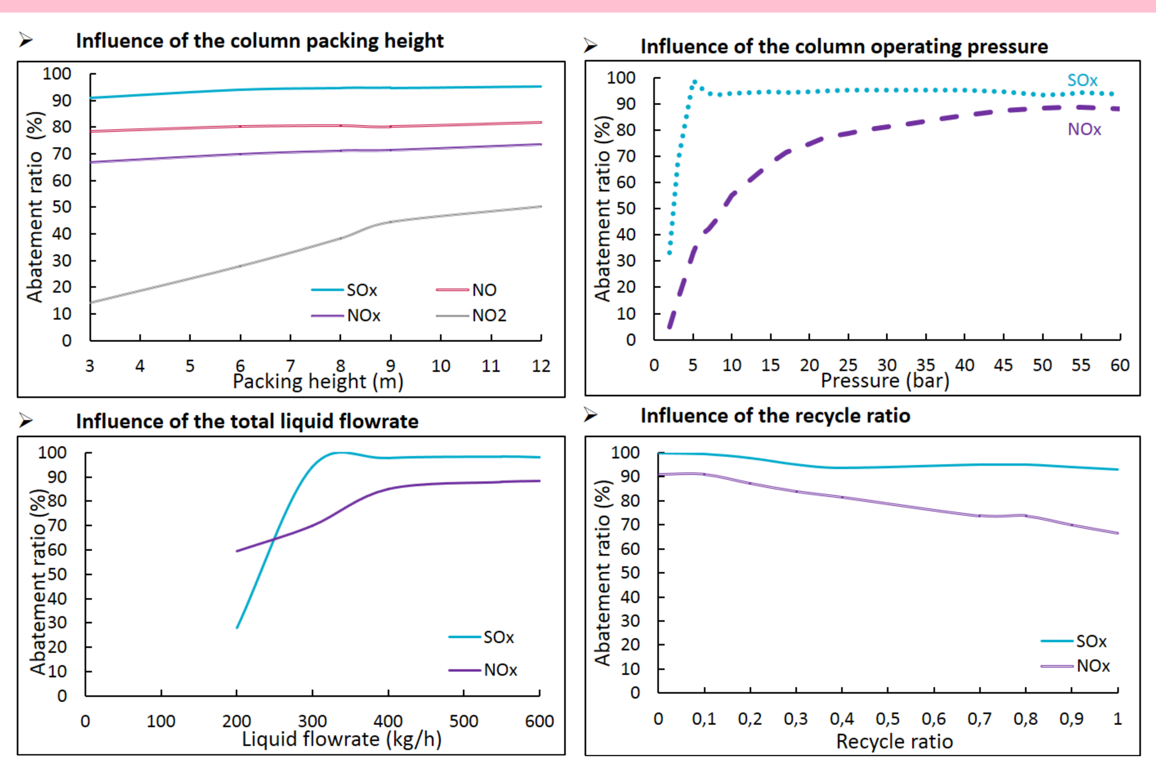
First absorber: P=15 bar; t=30°C; h=6-12 m
Second absorber: P=30 bar; t=30°C; h=6-12 m
Packing: IMTP25

Sour Compression Unit (SCU)

Comprehensive chemical mechanism considered for SCU *(27 reactions)*:

- equilibrium and kinetic reactions;
- essential NOx/SOx interactions;
- pH influence: reactions selected for 1≤pH≤4;
- apparition of nitrogen-sulfur complexes.





Specifications for the parametric study of the SCU:

Top stage pressure (bar)	1-60
Gas flow rate (kg/h)	197
Packing type	IMTP25
Column packing height (m)	3-12
Column diameter (m)	0,15
Total liquid flow rate (kg/h)	200-600
Recycle ratio (%)	0-100

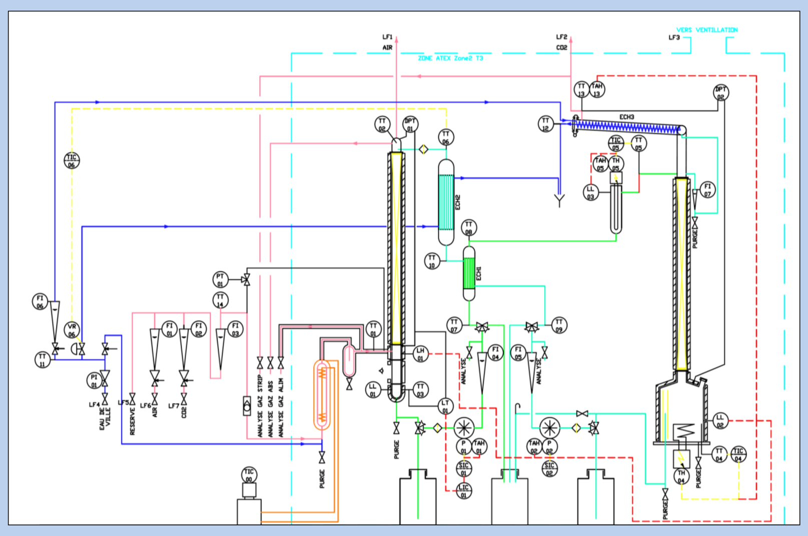
Results of the parametric study for a one-column system:
- limiting NOx absorption;
- important influence of the 4 parameters on the SOx/NOx absorption performances -> DOE.

B: Conventional and Partial Oxy-fuel Combustions → POST-COMBUSTION CO_2 CAPTURE PROCESS BY ABSORPTION-REGENERATION

AMINE SOLVENTS SCREENING AT LAB-SCALE

ABSORTION-REGENERATION TESTS AT MICRO-PILOT SCALE

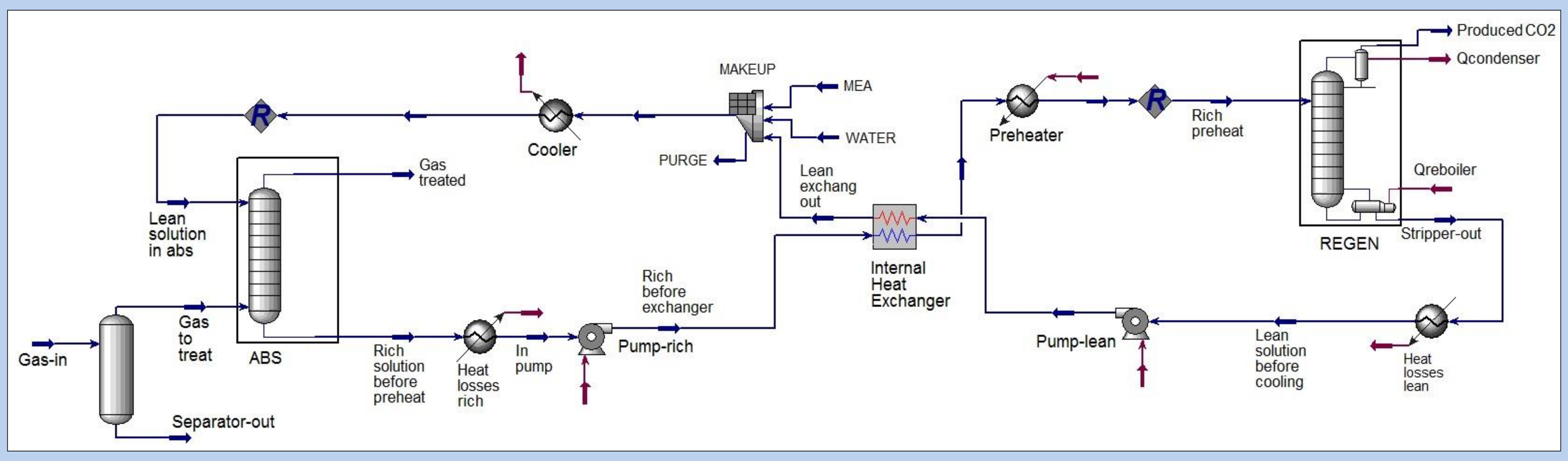
PID of the micro-pilot unit & design and operating conditions

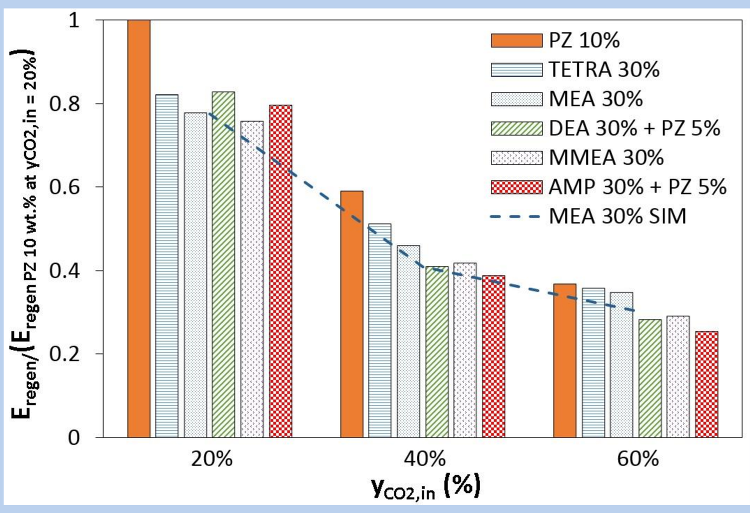


Pressure (kPa])	101
T_{ABS} (°C) (inlet abs. column)	40
T_{preh} (°C) (inlet regen. column)	95
L_{rich} and L_{lean} (l/h)	7 to 19
G= Gas flow rate dry / wet (l/h)	1030 / 1110
Packing type	Glass Raschig rings (6x6 mm)
Column packing heights (m)	
Abs. column / regen. column	1 / 0.5
Columns diameter (mm)	56
P_{boiler} (kW)	2
C_{amine} (max) (wt.%)	35
CO_2 contents ($y_{CO2,in}$) (vol.%)	20 to 60

SIMULATION OF ABSORPTION-REGENERATION SYSTEMS

Aspen Hysys™ simulation flowsheet





Results:

- relative decrease of E_{regen} with increased $y_{CO2,in}$ during absorption-regeneration tests in the micro-pilot unit;
- satisfactory comparison with Aspen Hysys™ simulations for MEA 30% leading to the same conclusion.

Conclusions & Perspectives

✔ Comprehensive modelling of the SCU process (1 or 2 columns) and prediction of performances
SCU configurations determination for required SOx and NOx purity levels (transport, CPU followed by conversion…) **and economic evaluations**

✔ Experiments in micro-pilot unit and simulations with MEA 30 wt.%: increasing the CO_2 content in the gas to treat allowing a significant decrease of the solvent regeneration energy
Application of post-combustion CO_2 capture to partial oxy-fuel combustion in a cement plant = **good option that will be more deeply investigated**

Acknowledgements

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