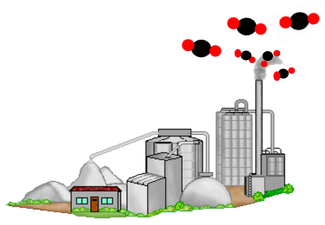
From CO_2 to Energy:
Carbon Capture in Cement Production and its Re-use

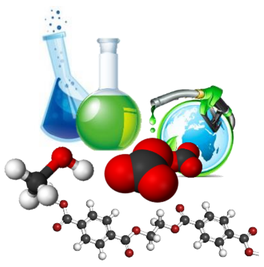
UMONS
ecra chair
from CO_2 to energy

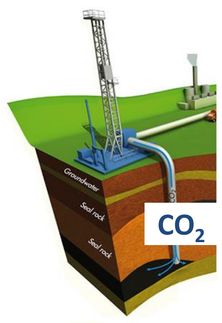
The **ECRA (European Cement Research Academy) Academic Chair** was established at UMONS in 2013, focusing on the CO_2 capture and reuse applied to the cement industry.



Cement plant

CO_2 capture and Purification





Fuels, organic & inorganic chemicals, microalgae, polymers, etc.

CO_2 Utilization or Storage

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Selecting emerging CO_2 utilization products for short- to mid-term deployment

- Development of an **Original multi-step method** to :
  1) Reduce the panel of CO_2 conversion alternatives,
  2) Select the best emerging options to be implemented short- to mid-term (15 years)
- **Multi-criteria assessment**
- Definition of **9 KPIs** grouped into the **3E performance criteria** (Engineering-Economic-Environmental) to evaluate the shortlisted CO_2 technologies identified after preliminary assessment

Identification of CO_2-based alternatives

STEP 1: Reduction of the panel
Reviewing CO_2-based alternatives
Reducing the panel by answering:
Is the alternative expected to operate within the next ten years?
Is the alternative validated, at least at pilot-scale?

STEP 2: Semi-quantitative analysis
Defining the sets of criteria and indicators
Computing the vector of criteria and indicator weights
Checking the consistency of the weight vector
Computing the performance matrix of alternative scores
Ranking the alternatives

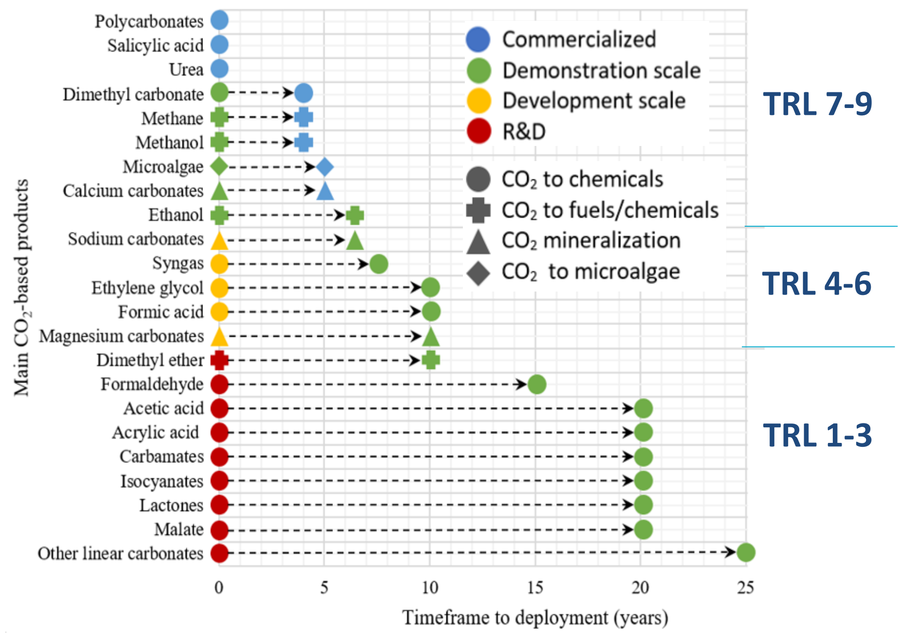
STEP 3: Qualitative uncertainty assessment and sensitivity analysis
Qualitative uncertainty assessment
Computing the performance matrix of alternative scores
Evaluating the uncertainty
Sensitivity analysis
Computing new vectors of criteria weights
Ranking the alternatives
Determining Pearson correlation coefficients between alternative rankings
Comparing how the rankings of alternatives change with criteria weight variation

Results interpretations and discussions

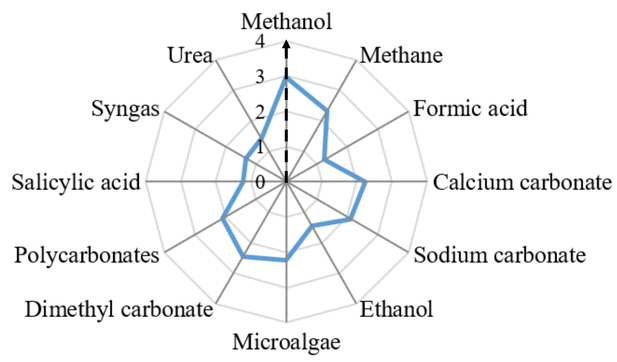
Definition of KPIs

	Criteria	KPIs
1	Engineering performance	Technological maturity
		Geographical constraints
		Fossil-free operations
2	Economic performance	Size of the market
		Competitiveness with other technologies
		Relative added value
3	Environmental, health & safety performance	CO_2 uptake potential
		Environmental potential
		Health and safety

Technology Readiness Level for main CO_2-based products



Total weighted scores of the selected CO_2-based products
(Score Max: 4)

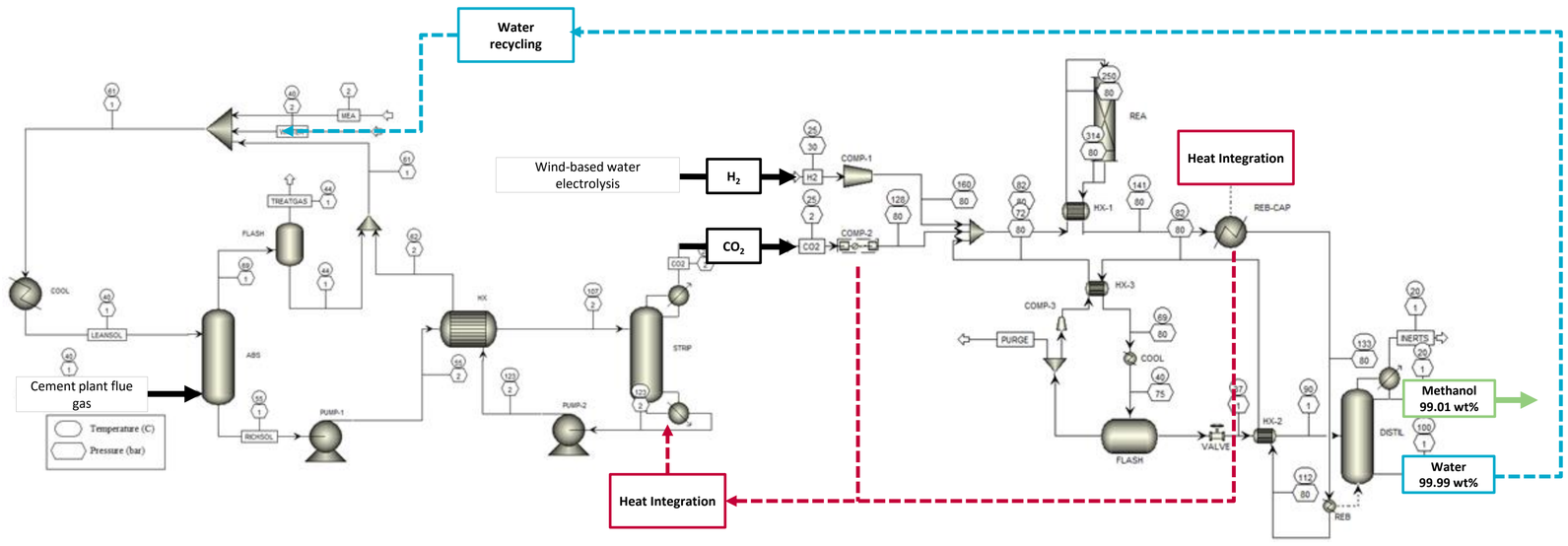


→ Methanol, methane : promising alternatives

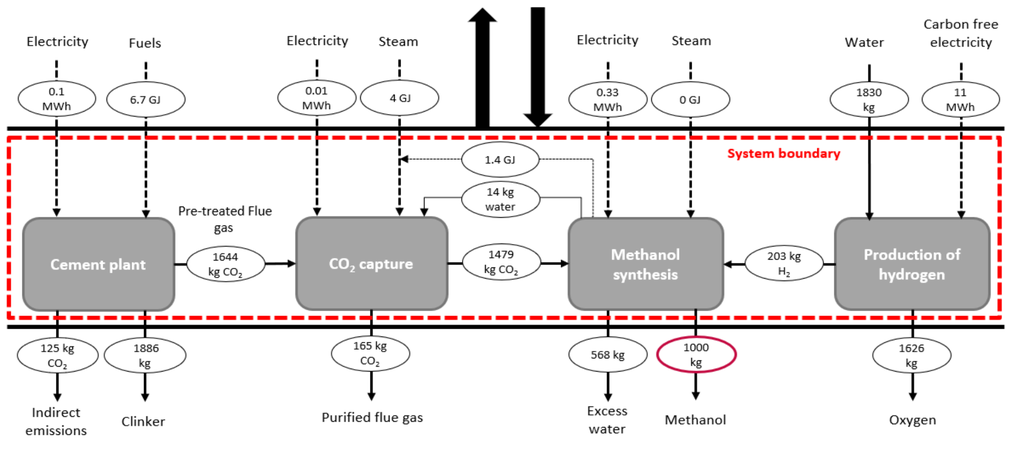
CO_2 capture & conversion: Alternative production of methanol

- CO_2 conversion into methanol: **simulation of the global chain** and **optimization** including energy integration with the CO_2 capture
- Designed to treat CO_2 coming from a conventional BAT cement plant producing 3,000 tons clinker per day, corresponding to 2,475 tCO_2 per day (90% CO_2 capture rate), and producing 1,546 tons methanol per day

Process flow sheet of the CO_2 capture and conversion units (Aspen Plus ™)



Technological metrics of the CO_2 capture and conversion units normalized to the production of one-ton methanol



→ **CAPEX**: 47.30 M€ (Electrolysers for H_2 production not taken into account)
→ **OPEX**: 55 €/tCO_2 (electricity: 70 €/MWh, steam cost: 30 €/MWh, catalyst: 10 €/kg, MEA: 1.03 €/kg)
→ Economic breakthrough occurring for an electricity price of 46 €/kWh
→ Environmental study: **reduction by 50% of CO_2 emissions** compared to the original emissions of a reference system without CCU

- Processes optimization and integration required to lower energy and resources consumption
- Economic viability of CCU processes highly dependent on assumptions (e.g. price of electricity)
- CO_2 reduction may be possible only if renewable energy use as input