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from CO_2 to energy

Carbon capture in cement production and its reuse

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ECRA/CEMCAP/CLEANKER workshop - Brussels

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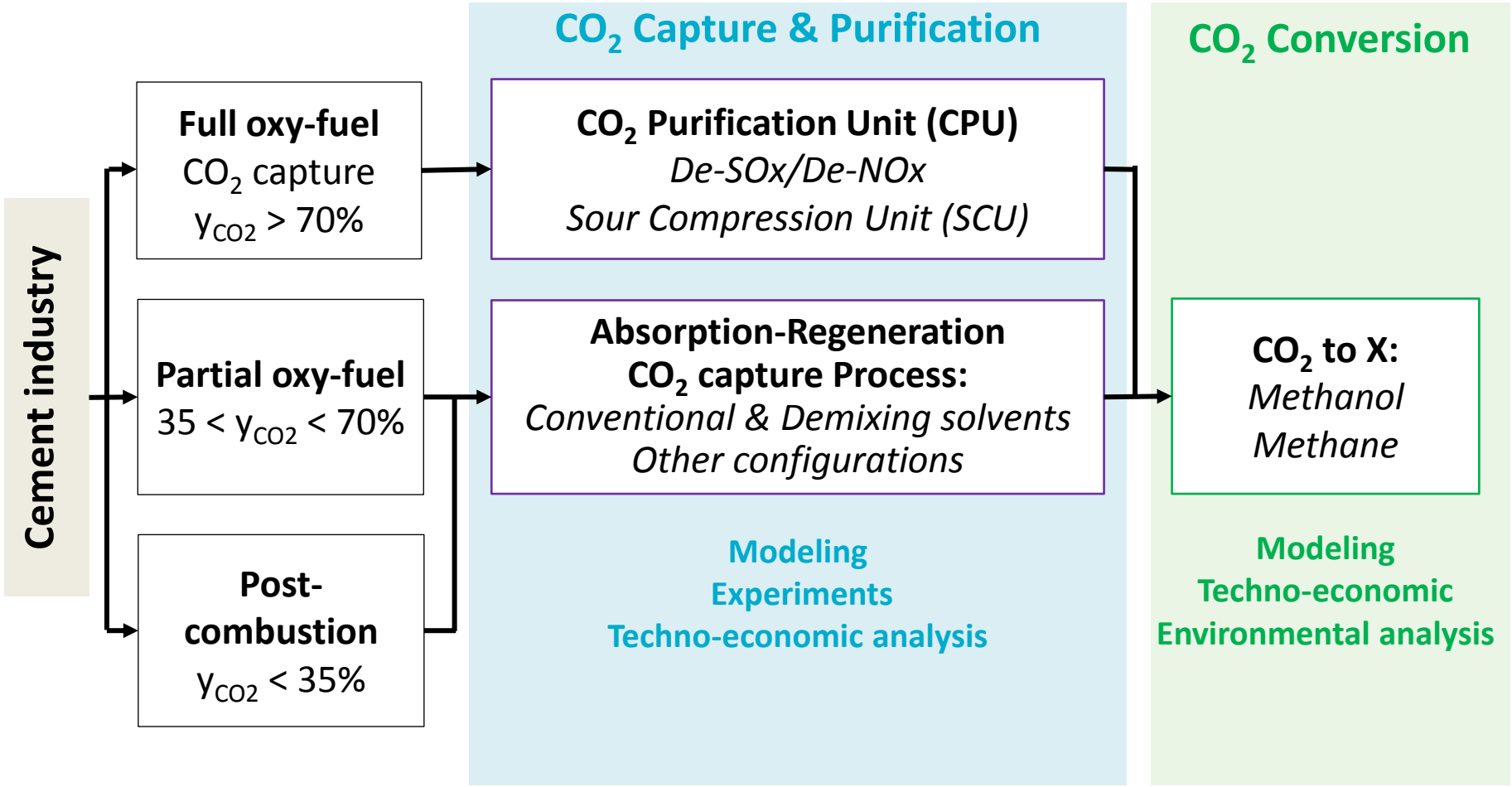
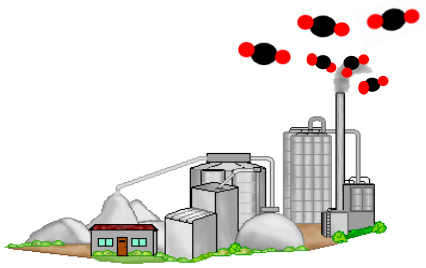


Collaborative team work between 4 PhD, 1 Post Doc

Context: Carbon Capture & Utilization (CCUS)

CCS/CCU

CO_2 capture and purification



Amine scrubbing
Membrane
Pressure Swing
Adsorption etc.

Capture and Storage (CCS)

Sequestration
Geological storage
Saline aquifers

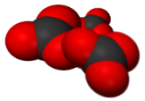
Capture and Utilization (CCU)

Conversion
Chemicals
Mineralization
Biological
etc.

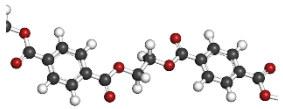
CCU

Fuels

Organic chemicals



Carbonates

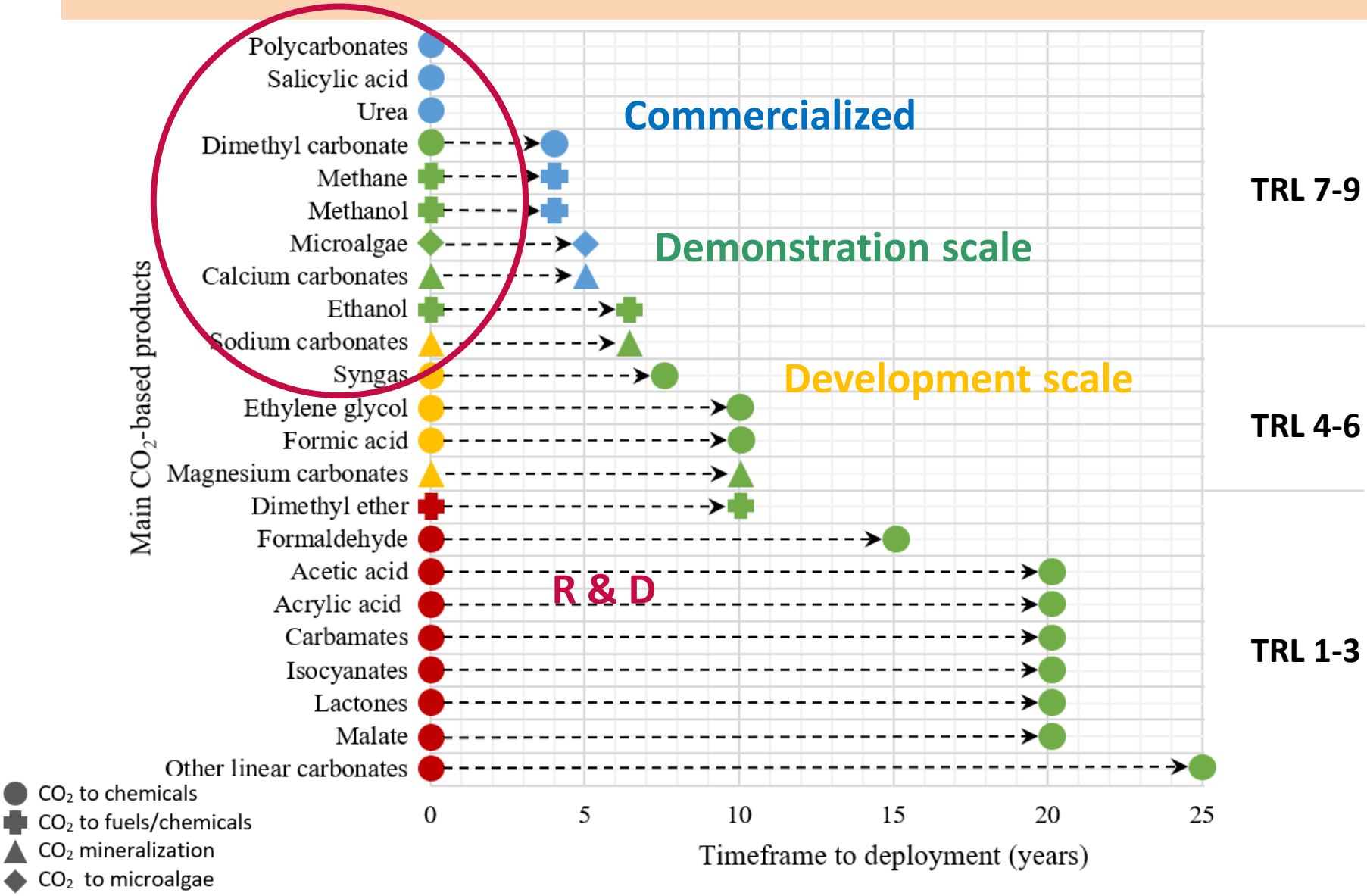


Polymers

Microalgae

Non exhaustive

Technology Readiness Level for main CO_2-based products

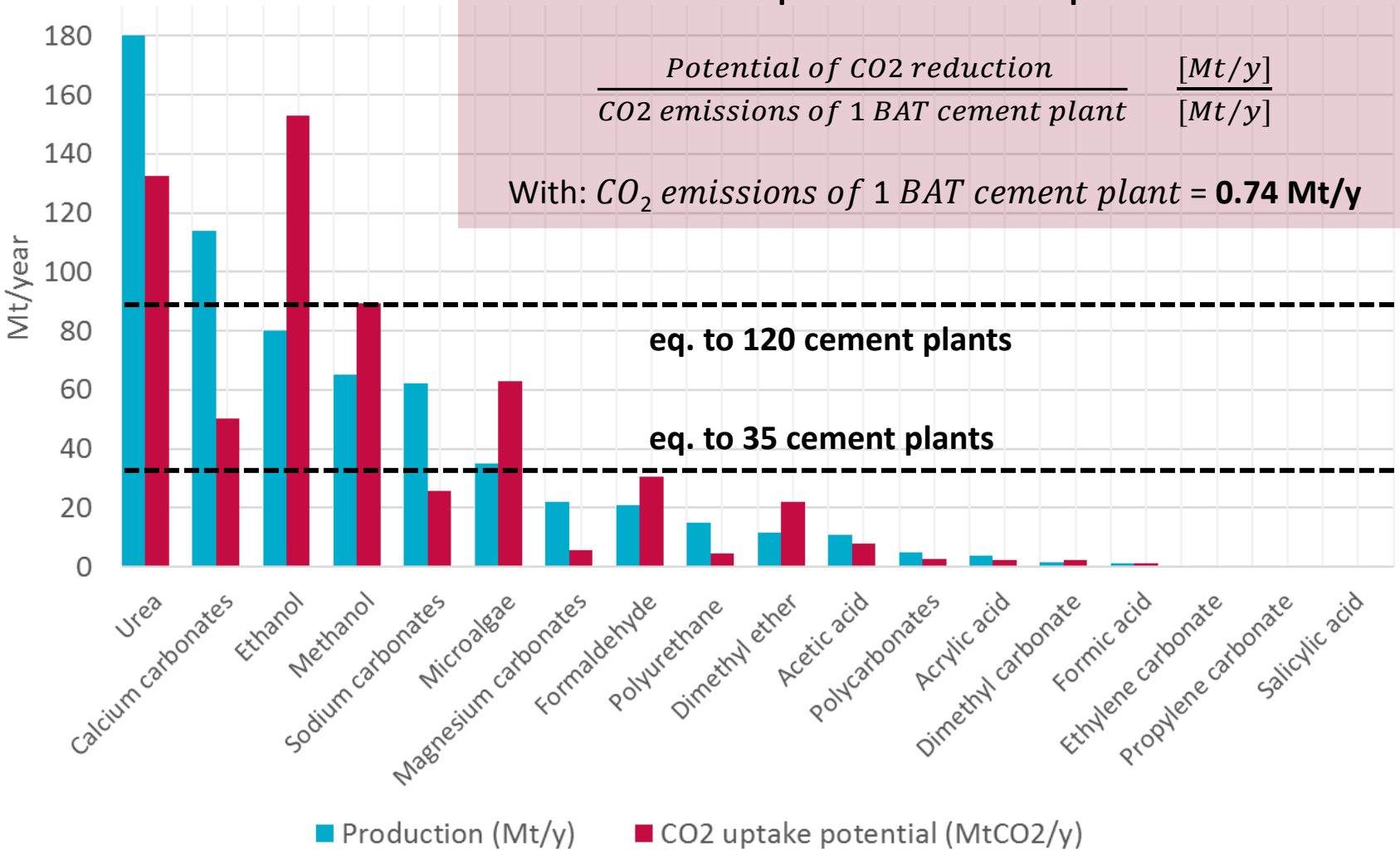


Size of CO_2 utilization (non-exhaustive)

No Equivalent of cement plants:

$$\frac{Potential\ of\ CO2\ reduction}{CO2\ emissions\ of\ 1\ BAT\ cement\ plant} \quad \frac{[Mt/y]}{[Mt/y]}$$

With: $CO_2\ emissions\ of\ 1\ BAT\ cement\ plant$ = **0.74 Mt/y**



Selection of CO_2-based conversion pathways

Identification

> 100 conversion pathways

Pre-selection

Reduction of the panel

Selection

Multicriteria assessment

Methodological selection [1]

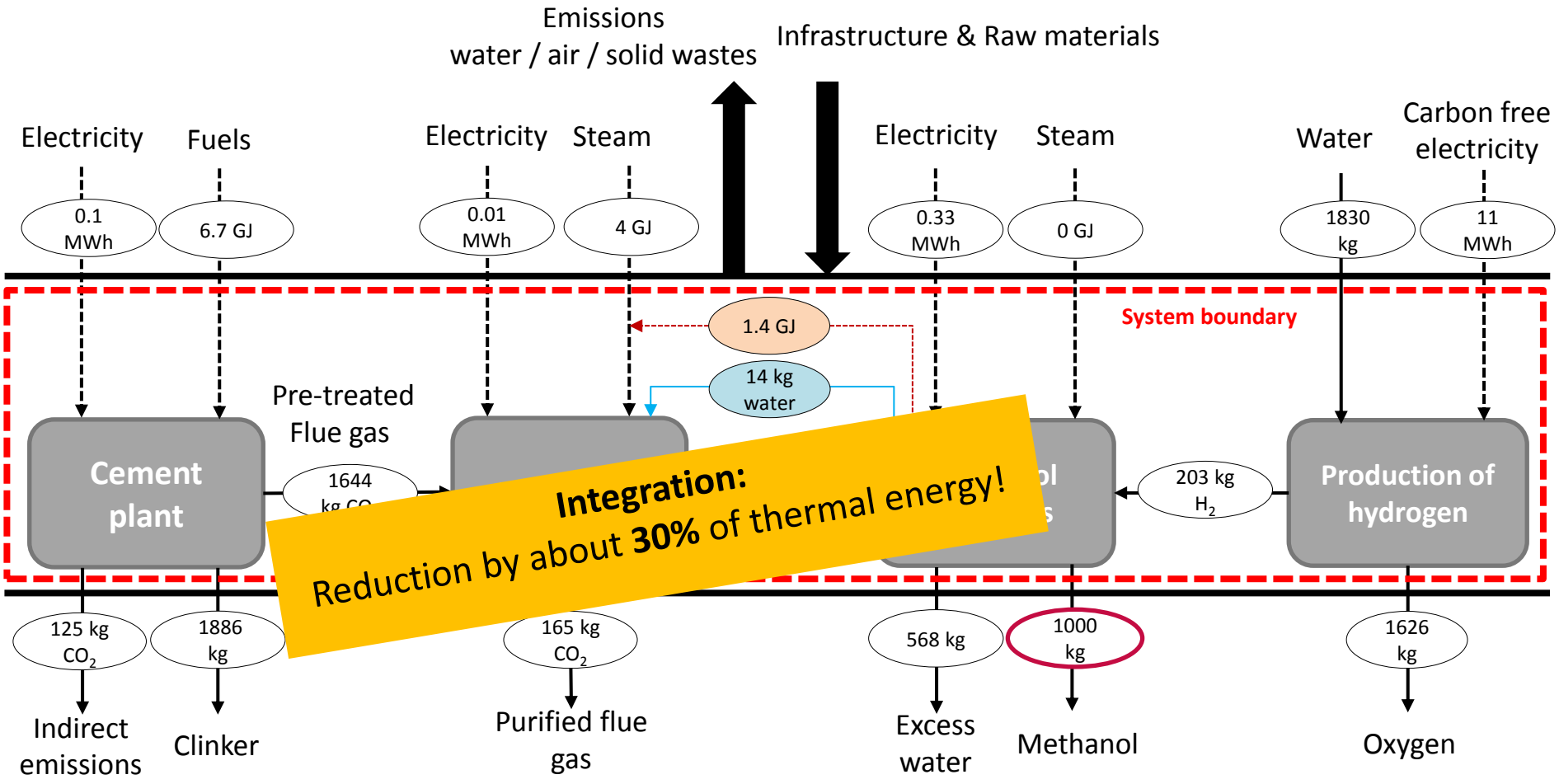
CO_2-based compound	CO_2-conversion process	Interest
Methanol	Hydrogenation	*****
Methane	Hydrogenation	*****
Dimethyl carbonate	Organic synthesis	*****
Calcium carbonates	Mineral carbonation	*****
Microalgae	Biological process	****
Polycarbonates	Organic synthesis	****
Sodium carbonates	Mineral carbonation	***
Ethanol	Microbial process	**
Syngas	Dry reforming	**
Formic acid	CO_2 Electroreduction	*

CO_2 conversion alternatives

[1] Chauvy R, et al. Selecting emerging CO_2 utilization products for short to mid-term deployment (2018)

CO_2 to methanol: Global Chain

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



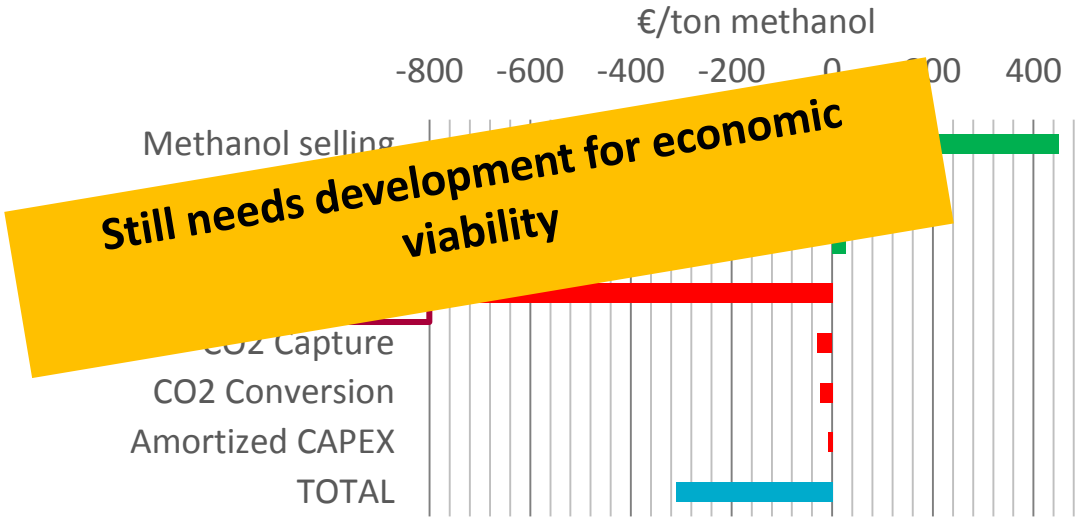
CO_2 to methanol: Economics

Project Capital Costs for CO_2 Capture & Conversion

60 M€ Global CAPEX
Project Investment
CO_2 Capture (37 %)
CO_2 Conversion (63 %)


H_2 production
CAPEX: 438 M€


Cost Estimations of Operational Expenses (per ton methanol)



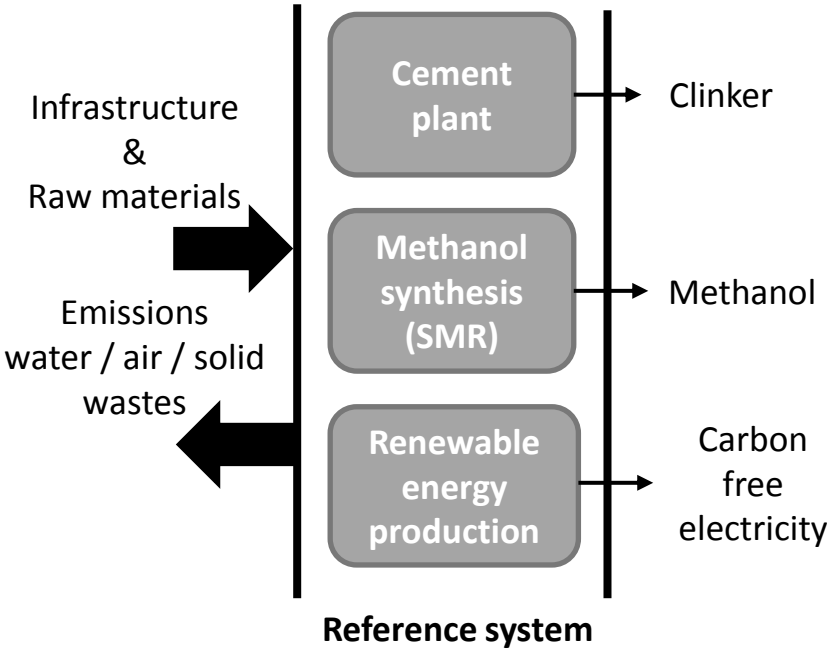
Still needs development for economic viability

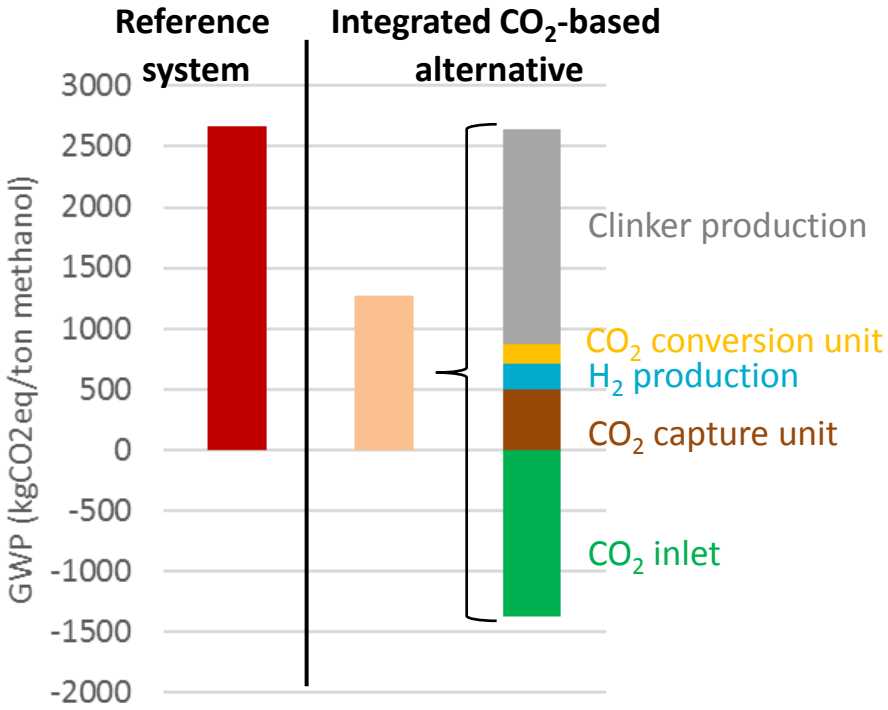
O_2 Selling: 86 €
CO_2 Credit Tax: 20 €

Global OPEX
90 € per ton CO_2

CO_2 to methanol: Carbon footprint

Comparison between the environmental impacts of reference system and CO_2-based alternative





- Maximum Reduction by **50%** of CO_2 emissions!
- Need of additional scenarios

Concluding remarks

- **Economic viability** of CCU process highly dependent on the assumptions (e.g. **price of electricity**)
- CO_2 reduction may be possible only if **renewable energy use as input**
- Mitigation potential of CCU to methanol: **50% of the original emissions** of the reference system without CCU
- Need to perform additional scenarios
- **CCU is NOT in competition with CCS: COMPLEMENTARY approach for CO_2 mitigation**
- CO_2 to methanol, CO_2 to methane (Power to gas), CO_2 to formic acid : study cases in progress
- Propose **environmentally friendly**, **integrated** and **optimized** **CO_2 conversion** processes applied to the **cement sector** !

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Thank you for your attention

We gratefully acknowledge the ECRA for its technical and financial support

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