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CO₂ mineralisation of steel slags for sustainable concrete

An environmental analysis of different available options

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Highlights

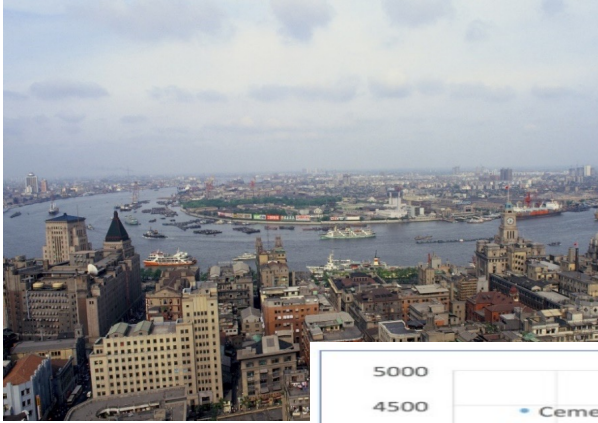


- Sustainable concrete made through CO₂ mineralization is potentially carbon negative, and presents an environmental and economic opportunities
- Use of Energy and CO₂ recovery technology are key parameters to improve environmental performance.
- New policy is strongly needed to strive for opportunities and overcome barriers

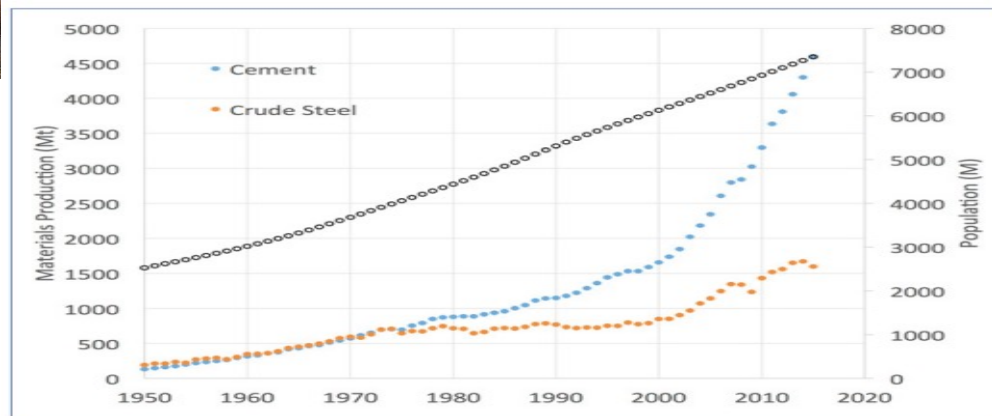
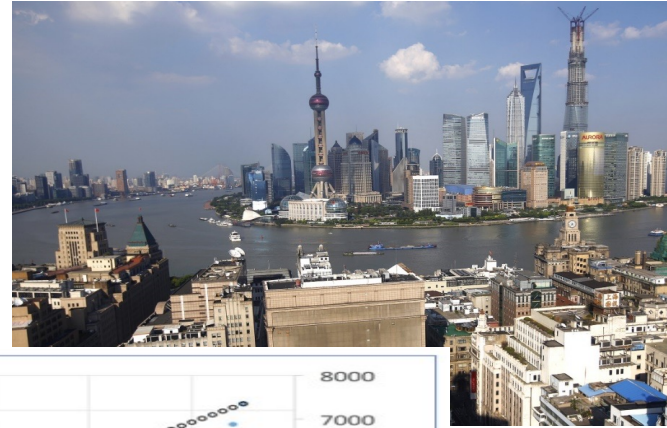
Why Sustainable Concrete



Shanghai, 1987



Shanghai, 2013

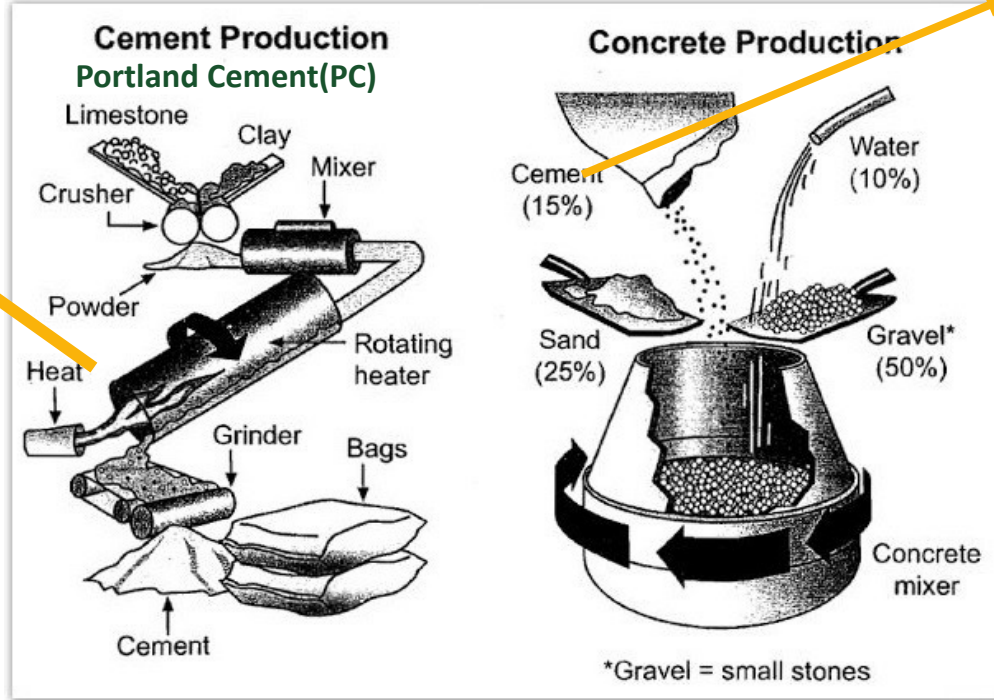


Role of cement in sustainable concrete



1. CO₂ emissions (calcination)
2. Fossil fuels/electricity

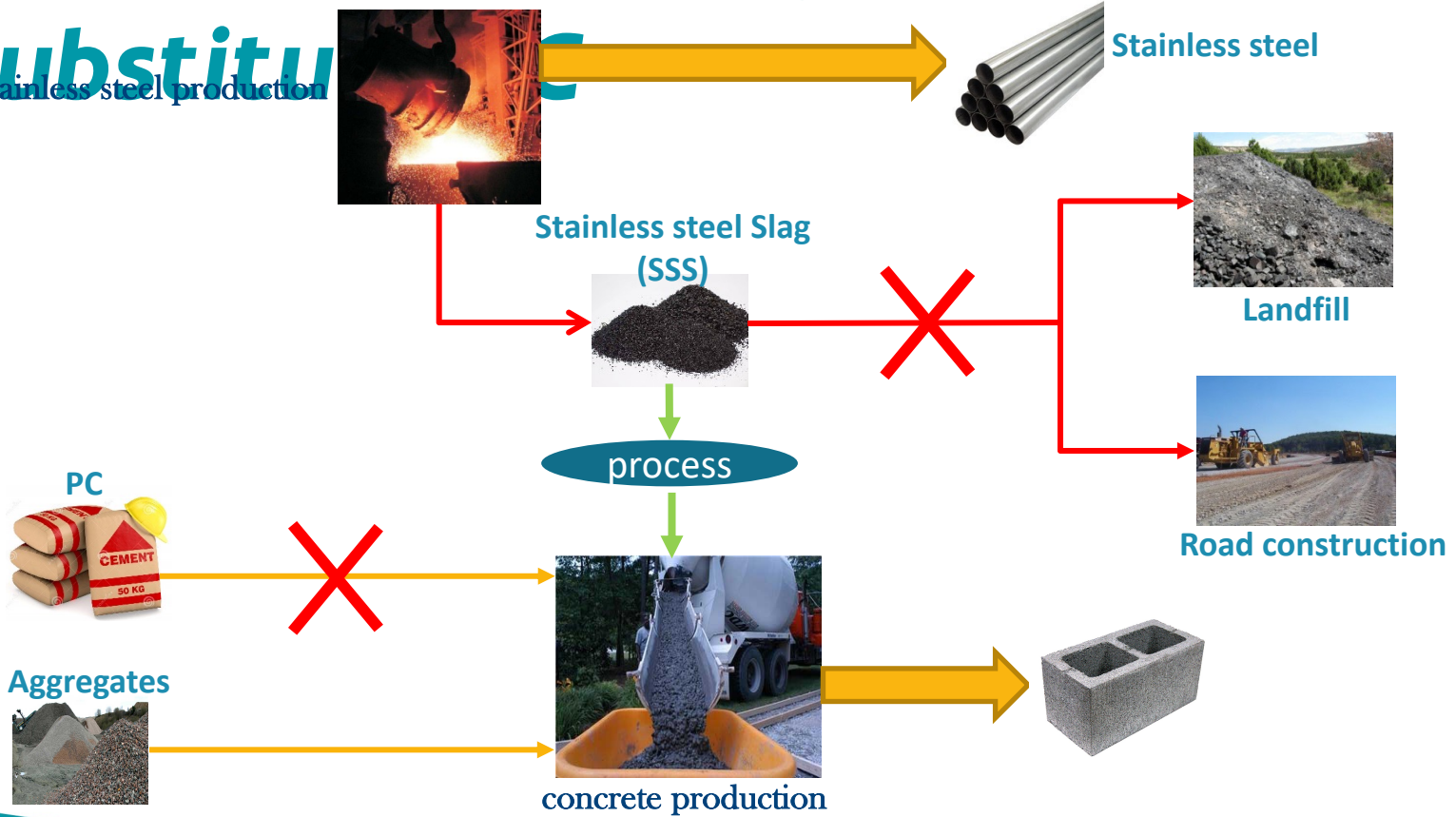
74 ÷ 81% of the total carbon footprint of concrete



Reduce/eliminate the cement in concrete



Stainless steel slag to substitu



Why SSS?

- Powder texture
- Cementitious properties

How do we activate the SSS?

- Carbonation
- ...



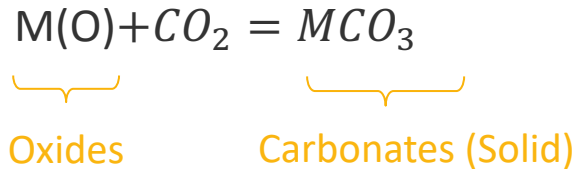
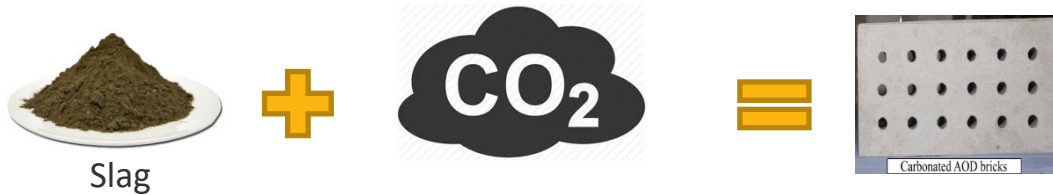
Carbonated blocks



- Carbstone: industrial pilot

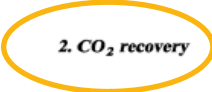
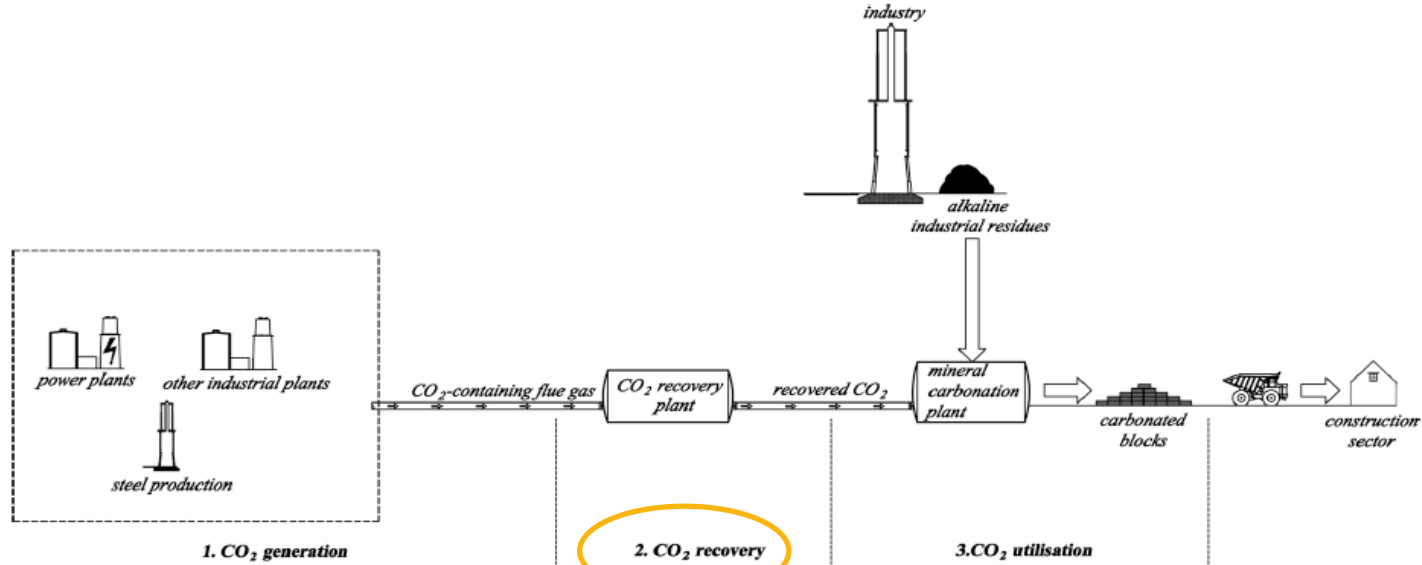


- Carbonation



- pressure and temperature required
- No binder

Carbstone production process

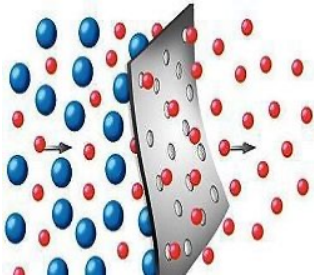


How do we recover CO₂ ?

CO₂ recovery

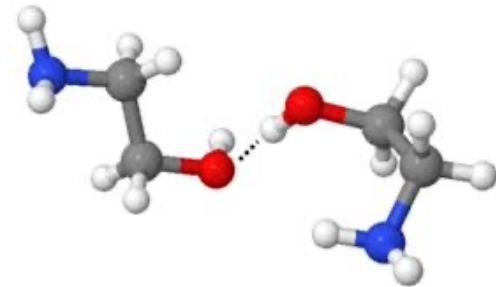


1. Cryogenic separation

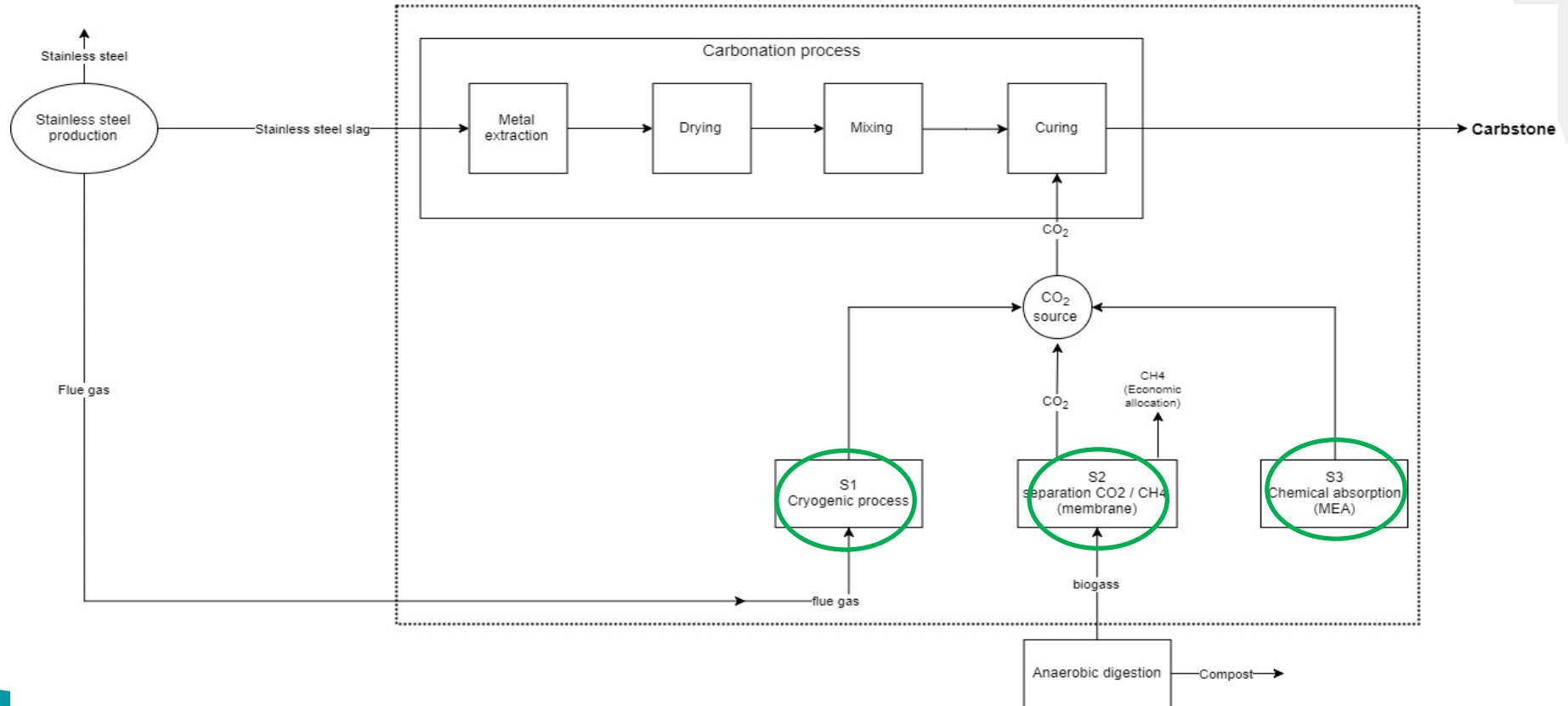


2. Membrane separation

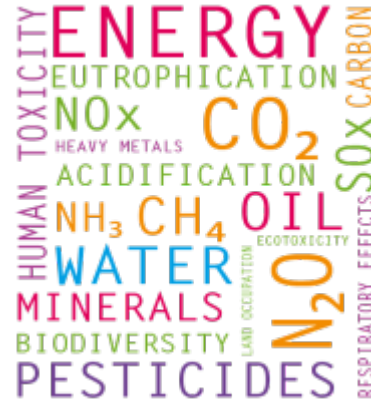
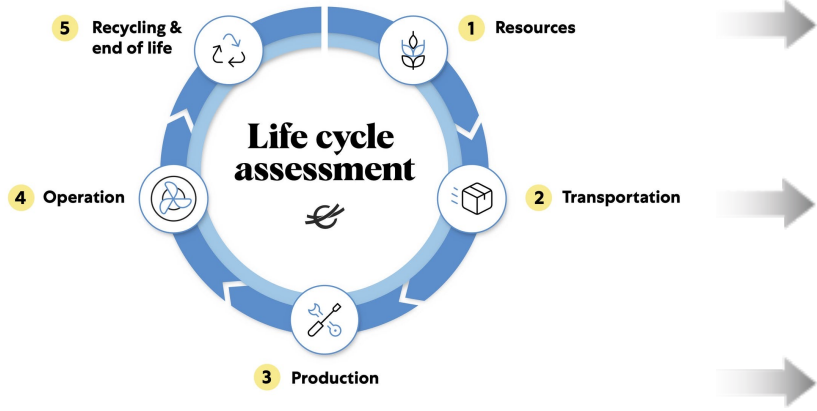
3. Chemical absorption (MEA)



Analysed system



LCA- Environmental impact



More than just Carbon emissions



Climate change



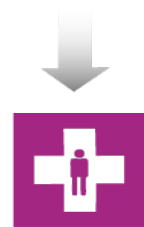
Water footprint



Ecosystems quality



Natural resources



Human health

Calculation methodology



Substances

Raw Materials
Land use
CO ₂
VOC
P
SO ₂
NO _x
CFC
...



Envir Categories

Unit

Acidification	Mole of H+ eq
Global Warming	kg CO2 eq
Global Warming _{bio}	kg CO2 eq
Ecotoxicity Freshwater	CTUe
Eutroph Freshwater	kg P eq
Eutroph Marine	kg N eq
Eutroph Terrestrial	Mole of N eq.
Human toxicity	CTUh
Ionising Radiation	kBq U235 eq
Land Use	Kg C deficit eq
Ozone Depletion	Kg CFC-11 eq
Particulate Matter	PM2.5 eq
Resource Depletion	Kg SB eq
Water Depletion	m ³ eq

Calculation: an example

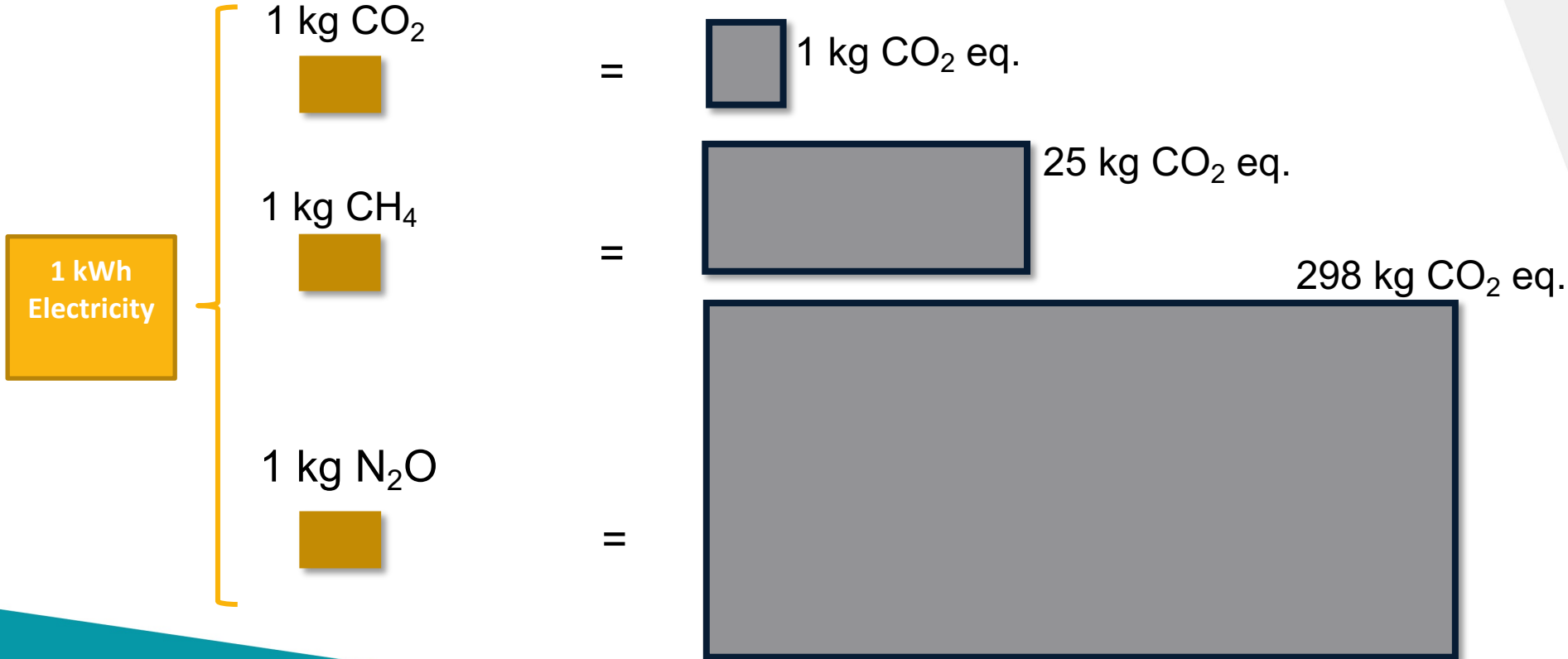


Unit process

Substances

Characterization

Climate change: Global Warming potential
(CO₂-eq)



Goal of the study



Environmental footprint comparison



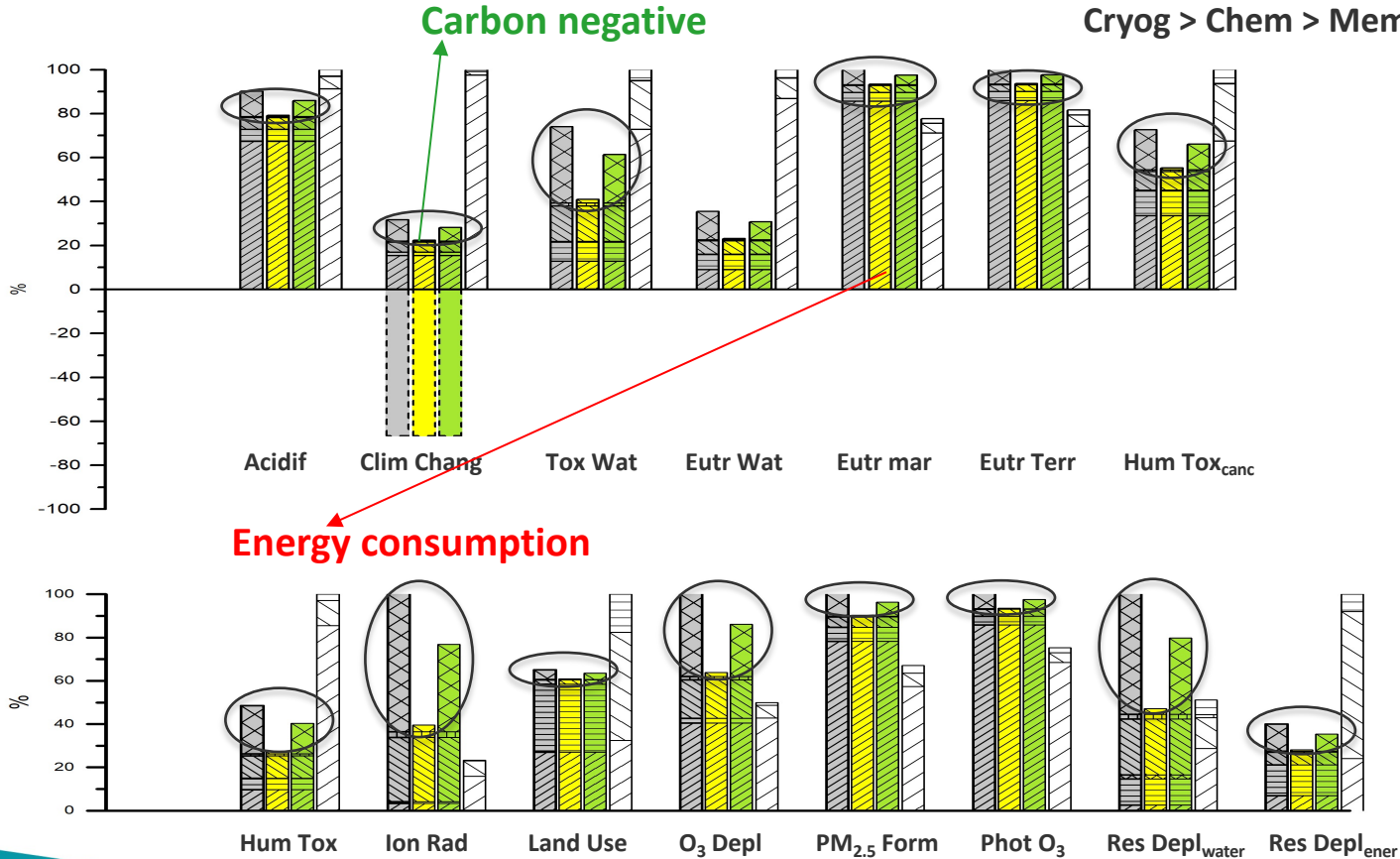
FU: 1 m² of material, providing a compressive strength of 40 MPa

Results

9/16 better than PC

7/16 worse than PC

Cryog > Chem > Membr



- S1-Cryogenic
- S2-Membrane
- S3-Chemical abs.
- PC-concrete.

- Electricity (CO₂ production)
- CO₂ uptake
- Electricity (curing)
- Electricity (mixing)
- Water
- Sand
- Diesel (drying)
- Sand
- Water
- Gravel
- Portland Cement

Conclusions

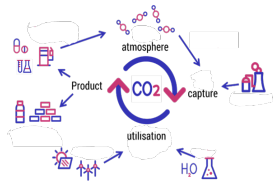


- **Potential of Carbstone to reduce the CO₂ –eq emissions (carbon negative?)**
- **Among the CO₂ recovery, cryogenic has the highest impacts in most of environmental categories**
- **Some limitation:**
 - **Energy consumption in the carbonation process**
 - **Source and recovery of CO₂**
 - **Scale of the pilot**

Policy implications



Opportunities



CO₂ valorization network



Green public procurement



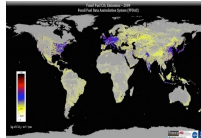
Economic potential

Barriers

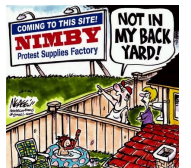
Constrained technology



Regional CO₂ accounting



Perception as waste



Want to know more?

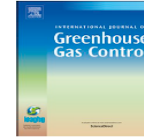
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Environmental assessment of CO₂ mineralisation for sustainable construction materials

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Thank you !

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