The role of CCU in the the building sector

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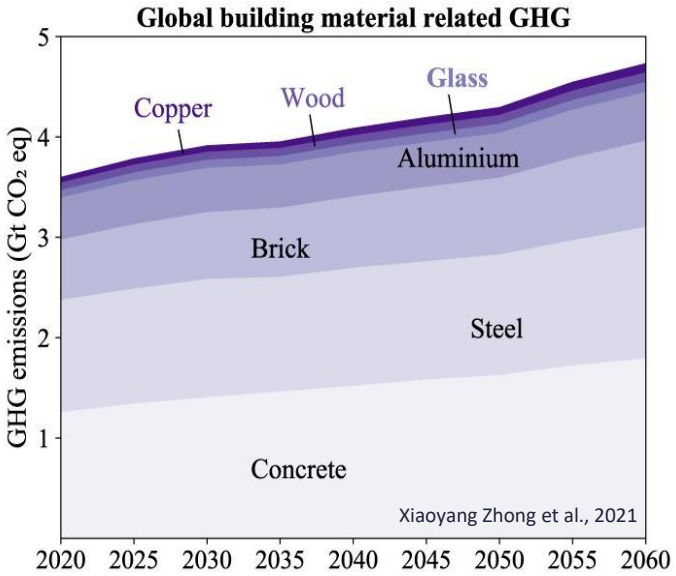
Contents

- CO_2 footprint of construction materials
- Focus on the concrete industry
- Carbonation and mineralisation as a CCU technology
- Products from carbonation
- Value generation and capture capacity
- Summary and conclusions

CO_2 footprint of the construction industry



- Increased urbanization
- Construction industry responsible for 11-38% of global energy related emissions
- Cement industry 7-8% of global emissions

Carbon Footprint of Concrete

- CO_2/tonne of concrete produced in 2018 = 72.1 kg (mpa, 2020)
  - Reduction of 30% compared with the 1990 baseline
  - (Glass has a footprint of 3.09 tonnes CO_2 per tonne of glass)
- Lot of work on reducing the CO_2 in the cement component of the concrete – 75% of the embodied CO_2
  - Reduced by 30% over the last 30 years
- The GCCA has a roadmap to net zero which involves six elements
  1. Replacing fossil fuels to fire the cement kilns
  2. Using renewable energy for the indirect energy emissions
  3. Deploying Carbon Capture at scale
  4. Reducing the amount of clinker in cement and cement in concrete
  5. Recycling more concrete from construction and demolition waste
  6. Enhancing the level of CO_2 uptake in concrete through recarbonation and enhanced recarbonation
- Five of these six elements, directly or indirectly involve carbonation or mineralization

Carbonation & Mineralisation

- A natural process
- Ca and Mg ions converted to limestone or dolomite
- Very stable form of CO_2
- Limestone used extensively as a building material
- Aggregate or dimension stone
- Concrete will carbonate through reaction with CO_2 in air

$$CaO + CO_2 = CaCO_3$$

Carbonation & Mineralisation

- Carbonation can be accelerated by using increased concentration of CO_2
- Calcium and Magnesium silicates, oxides and hydroxides can react with CO_2 to form carbonates
- These minerals can be found in
  - Basic and ultrabasic rocks (basalts, serpentinites, dunites)
  - Industrial thermal residues (steel slags, ashes from EfWs, cement and concrete residues etc)
- Reaction is exothermic
- Does not require large amounts of energy for the transformation of the CO_2 molecule
- Permanent capture of CO_2
- Can use pure CO_2 or CO_2 directly captured from flue stacks or the air (DAC)

Products from carbonation

- Supplementary cementitious materials (SCM)
  - Replacement for Portland Cement clinker
- Carbonatable cements
- Concrete Blocks
  - Strength derived from carbonation rather than cement hydration
- Aggregate
  - Calcium carbonate, cold bonded, manufactured aggregate for variety of construction application

Supplementary Cementitious Materials

- Construction and Demolition Waste (C&D)
  - Several projects on the use of C&D waste to make SCM
    - Partially driven by the reduction in availability of pfa from coal
  - Carbonation of the calcium silicates in the cement
    - produces calcium carbonate and a silica phase so
    - the carbonated cement provides a limestone filler and pozzolan
- Carboncure
  - Add CO_2 to fresh concrete as it is poured
  - Enhances the hydration of the cement
  - Less cement for the same strength
  - “160,000 tonnes of CO_2 saved”

Carbonatable Cements

- Cements manufactured from a variety of natural minerals or industrial wastes
  - Calcium/magnesium silicates which do not hydrate but will carbonate
- Solidia
  - Manufacture a cement from wollastonite type silicate
  - Use the cement to make concrete blocks by curing in a CO_2 chamber

Concrete blocks

- Steel slags
  - Formed into blocks
  - Cured at high temperatures and pressures
  - Orbix – Carbstone in Belgium
  - Carbicrete in Canada
- Nickel mining waste – Mci
  - Pilot stage process uses wet carbonation to manufacture blocks or boards for construction from $MgCO_3$
- Serpentinites – Cambridge Carbonates
  - Pilot stage manufacture of $MgCO_3$ blocks

Carbicrete.com

Aggregates

- C&D waste
  - Blue Planet – USA
    - Extract the natural aggregate and sand
    - Leaves the cement fines
    - Wet process to solubilize the calcium ions and precipitate $CaCO_3$
  - Neustark - Switzerland
    - Carbonating crushed concrete
    - The first company to earn methodology approval for removal certification in the voluntary market
    - Concrete with a 10% improvement in carbon footprint
- Other industrial residues
  - Carbon8 Systems

Carbonation of Industrial residues

Key industry	Waste streams	Global volume (million tonnes)	European volume (million tonnes)	Current average cost of disposal (£/tonne)	Total European market size (£million)	Tonnes of CO_2 captured in Europe (million tonnes)
EfW	APCr, fly ash, bottom ash	75	45	120	5,400	4.41
Cement	Cement Bypass Dust (CBPD), Cement Kiln Dust (CKD)	410	21	50	1,086	4.78
Steel	Steel slag, stainless steel slag, EAF dust	507	63	50	3,171	11.42
Biomass	APCr, fly ash, bottom ash	70	35	60	2,106	5.63
Paper & Pulp	APCr, fly ash, bottom ash	45	12	60	729	1.94
TOTAL		**1,105**	**177**		**12,492**	**28.18**

Summary & conclusions

- Companies are already fully commercial
- Large number of major investments over past few months and recognition in the voluntary carbon credits market
- Potential to **permanently** capture Gts of CO_2 in a value generating process
- Products tend to be low value but high volume
  - Other higher value products possible
- Growth in market for low-carbon building materials – EPD and LCA
- For further growth need:
  - CO_2 footprint labelling
  - Whole life assessments for public procurement
  - CO_2 value – tax incentives
  - Incentives to recover wastes and process waste materials

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