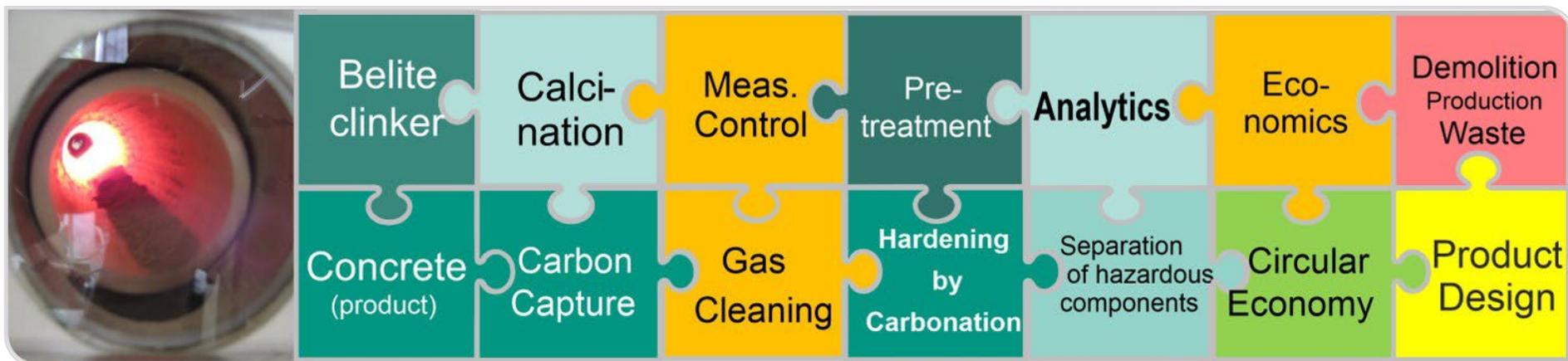


# High-Quality Recycling of Cement-Based Building Materials

Climate Friendly Materials (CFM) Platform Workshop: Towards High-Quality Material Recycling, DIW Berlin

**Dr. Peter Stemmermann**

**Institute for Technical Chemistry, Department Technical Mineralogy**



# Where do I come from..

## Institute for Technical Chemistry (ITC)

Process engineering research for the circular economy →

Chemical  
recycling of  
mixed plastic  
waste

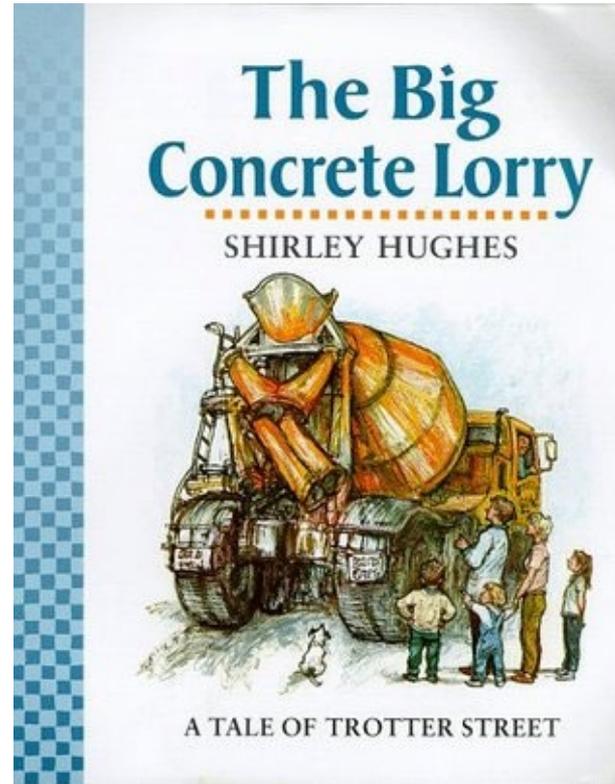
In the context of creating a comprehensive circular economy to protect the climate, the environment and natural resources, sustainable recycling routes are required for all plastic waste. →

CO<sub>2</sub> neutral  
cycles for  
mineral building  
materials

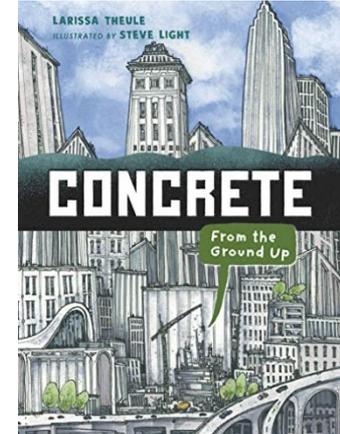
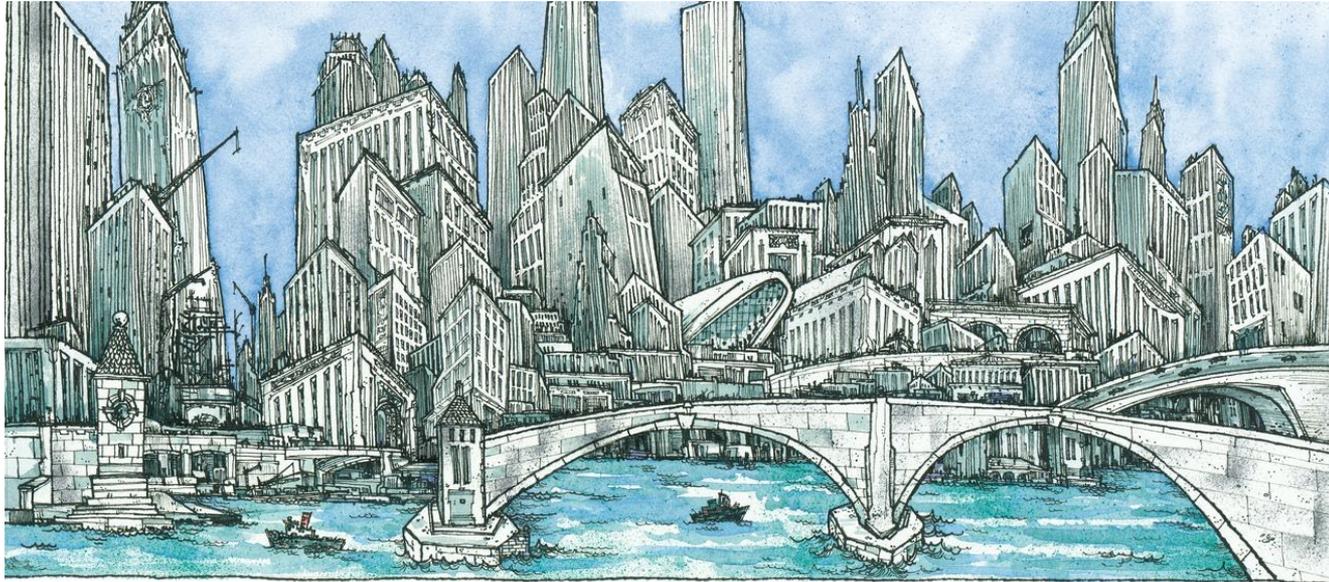
We minimize the use of natural resources and greenhouse gas emissions of the most important mineral building materials from basic research to pilot plants with partners from science and industry. →

Mineralogist  
Sustainable Cements  
HQ Concrete Recycling  
Cofounder and until 2020  
Shareholder of Celitement GmbH

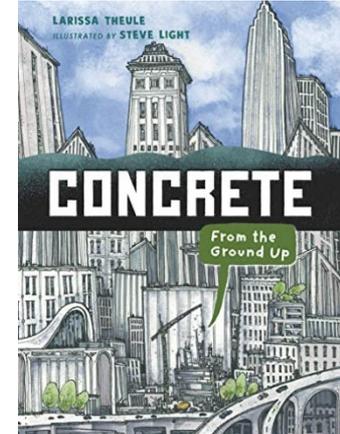
# Everybody knows concrete..



# Everybody knows concrete..



# Everybody knows concrete..

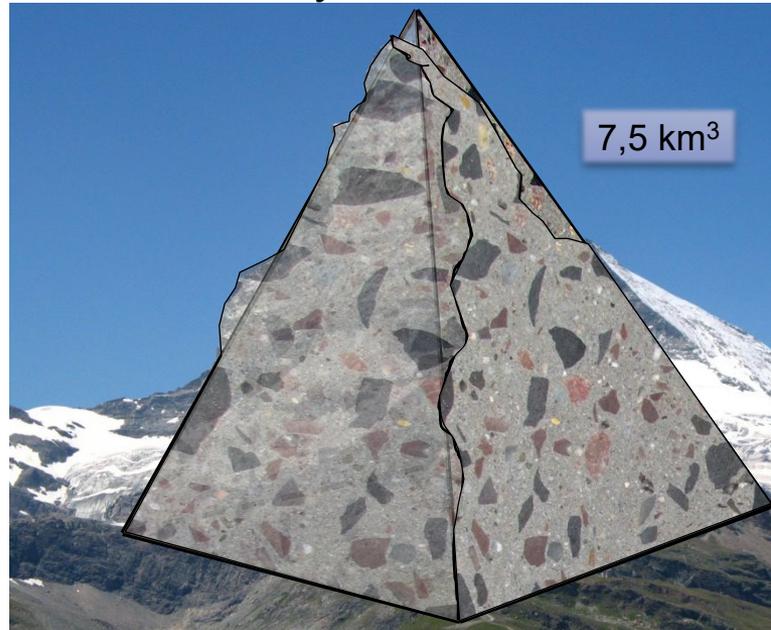


# Global Annual Concrete Production

Pyramide

**1m<sup>3</sup> per capita  
= 7,5km<sup>3</sup>**

Matterhorn,  
Switzerland



**horizontal length 3,3 km**

**Energy**

**Raw  
Materials**

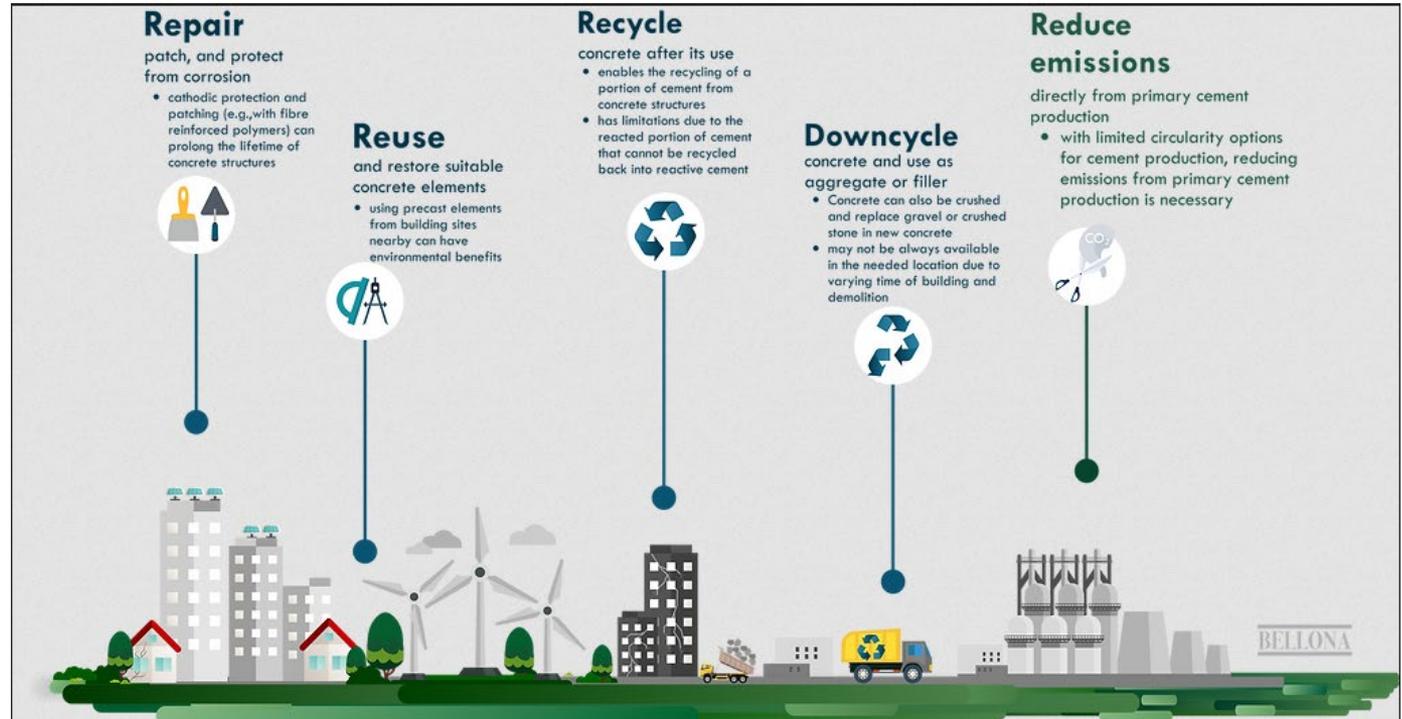
**CO<sub>2</sub>**

# Concrete Solutions

## Design for circularity



## Materials Processes Architecture



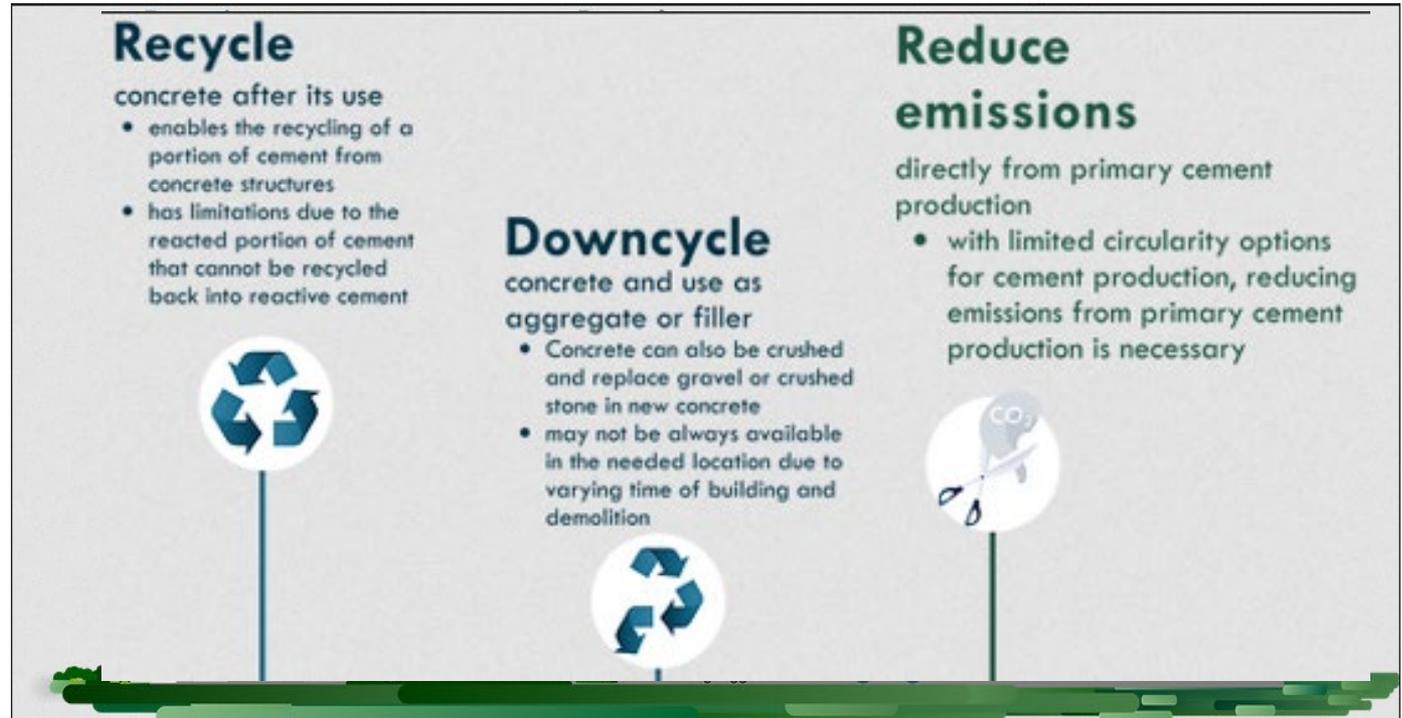
<https://www.frompollutiontosolution.org/circularconcrete>

# Concrete Solutions

## Design for circularity

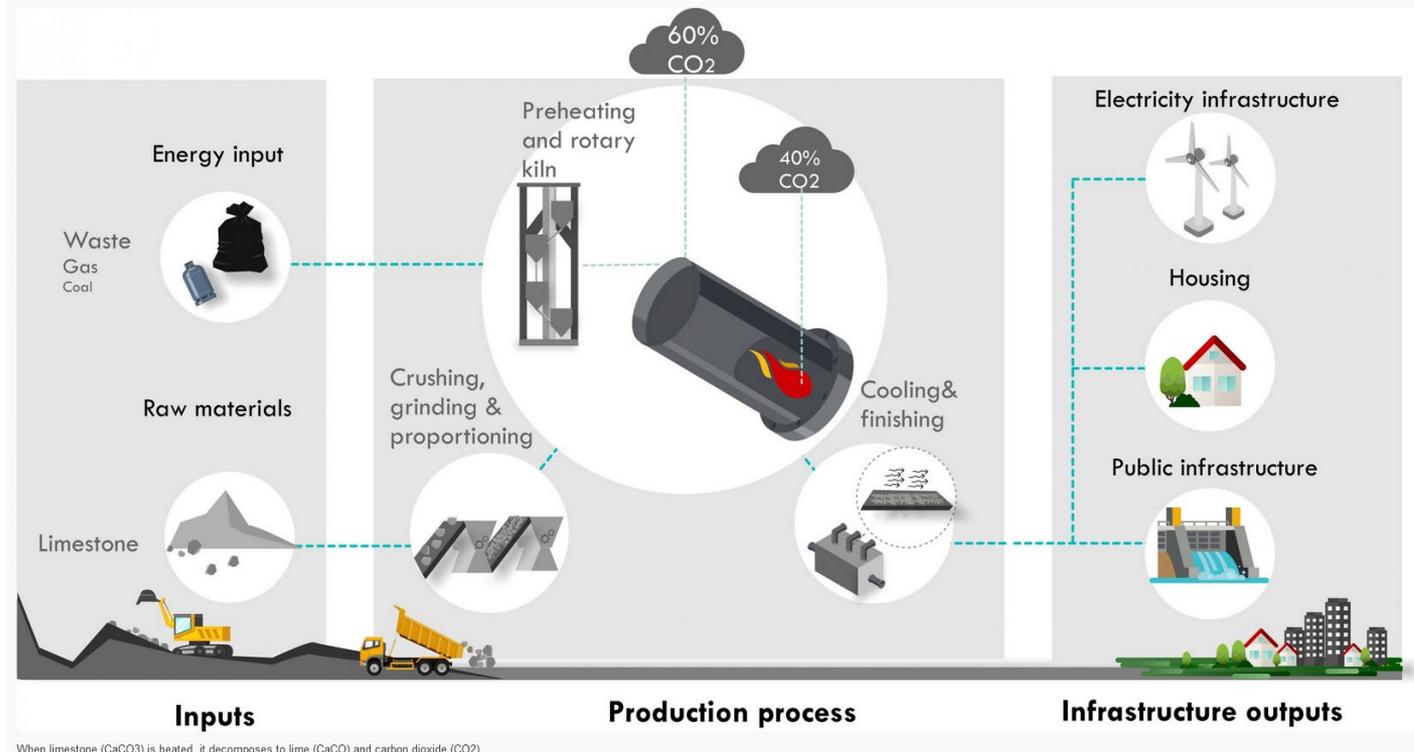


## Materials Processes Architecture



<https://www.frompollutiontosolution.org/circularconcrete>

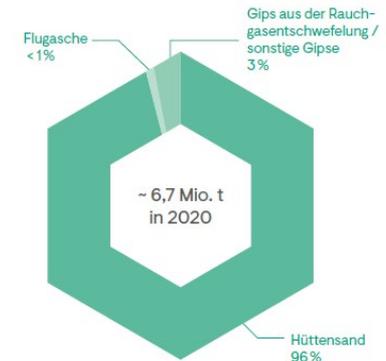
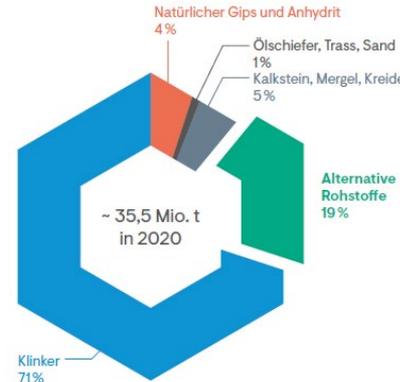
# Processing of cement: CO<sub>2</sub> Sources



<https://bellona.org/news/ccs/2021-01-how-can-recycling-in-the-cement-and-concrete-sector-contribute-to-climate-change-mitigation>

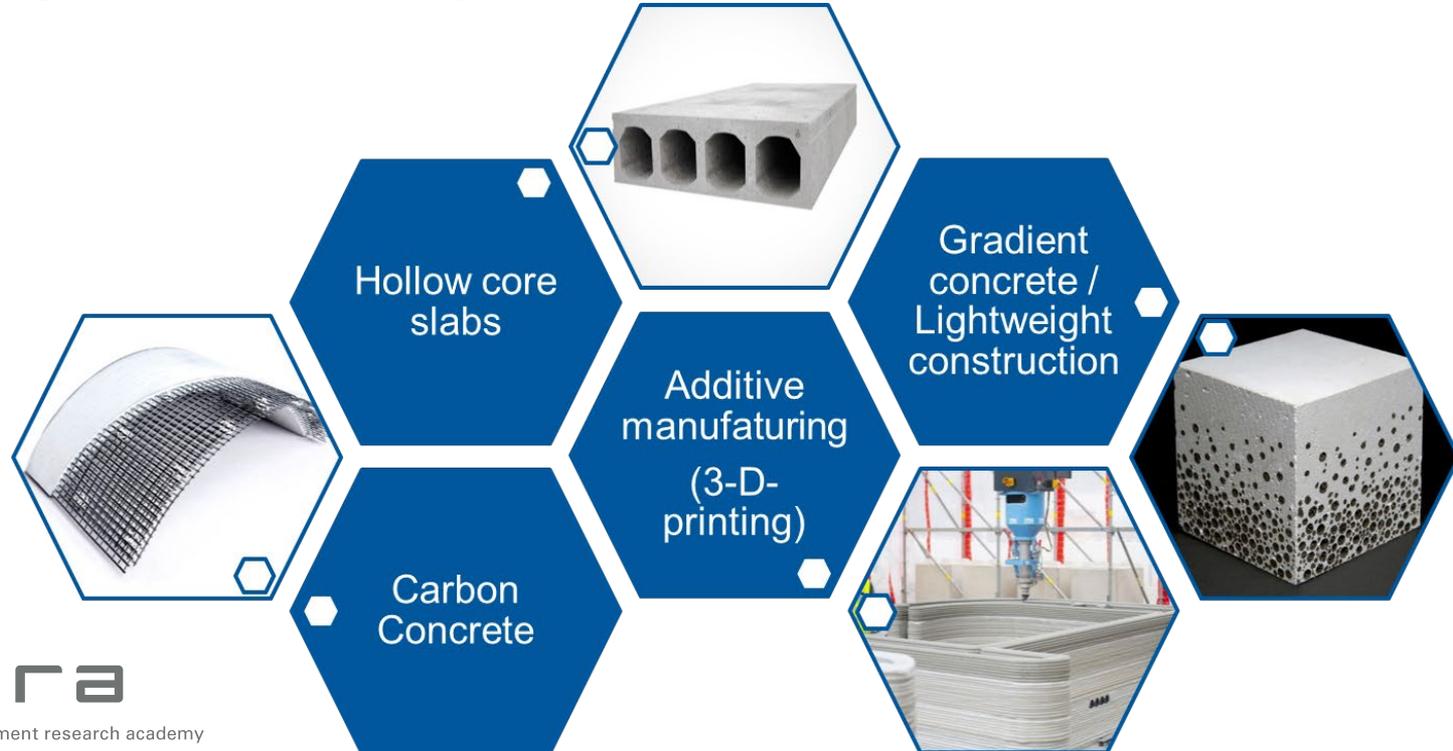
# Reducing Emissions : Change Supplementary Cementitious Materials

- Today:
  - Fly ash from fossil power plants
  - granulated blast furnace slag
- Future:
  - calcined clays
  - crushed fines
  - separated carbonated hardened cement paste



Verein Deutscher Zementwerke, V.D.Z. Ressourcen der Zukunft für Zement und Beton – Potenziale und Handlungsstrategien. Düsseldorf, 2022.

# Reducing emissions by improved Concrete



# Open Grid Europe: Aufbau eines Pipeline Netzes für CO<sub>2</sub>

OGE (14.11.2022). Moving towards climate neutrality with OGE [online] [Zugriff am: 14. November 2022]. Verfügbar unter: <https://co2-netz.de/en>

## Our CO<sub>2</sub> transportation grid

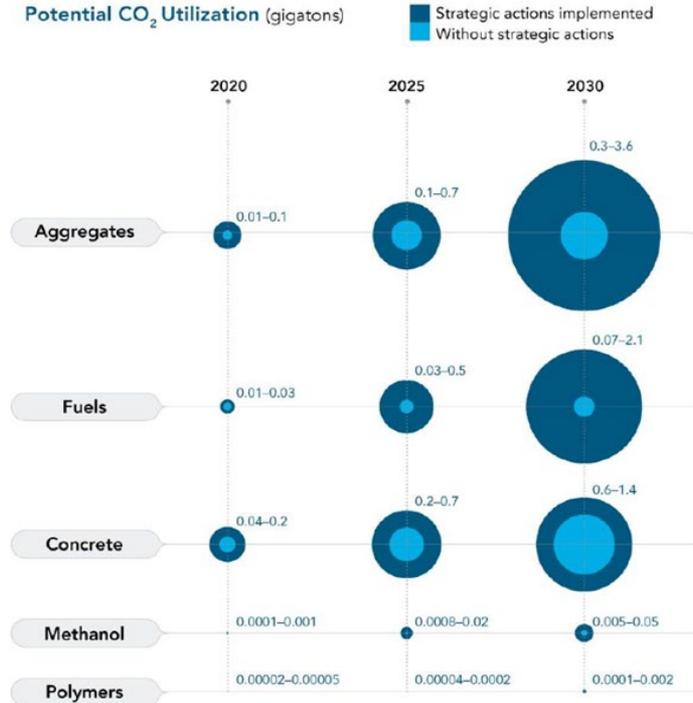
**Join OGE on the path to climate neutrality!**  
We support you in your climate-neutral handling of CO<sub>2</sub> with our own CO<sub>2</sub> transportation infrastructure.



Open Grid Europe betreibt in Deutschland das größte Ferngasnetz

# Challenge: Net-Zero Concrete without CO<sub>2</sub> Transportation Infrastructure

- CO<sub>2</sub> Sequestration in Concrete (Solidia, CarbonCure,..) possible, but limited)
- Biggest Potential: Sequestration in aggregates



Potential CO<sub>2</sub> utilization in 2020, 2025 and 2030. aus: CO<sub>2</sub> Sciences and The Global CO<sub>2</sub> Initiative, "Global Roadmap for Implementing CO<sub>2</sub> Utilization," 2016.

# Approach to Net Zero Concrete: Recycling

- Extended use of construction wastes for the production of **concrete aggregates** and **cement**
  - High quality recycling
  - Increased resource efficiency
- Construction, concrete processing and demolition are local processes
  - Small scale, decentralized processing units from secondary materials needed
  - Expensive transports can be avoided
- Adaption to local needs, e.g. secondary materials from local processing plants, recycling capacities, local concrete mixing plants
  - Variable plant sizes
  - Due to scaling not energy efficient?
  - Economically feasible ?

# Zero-Emission Circular Concrete

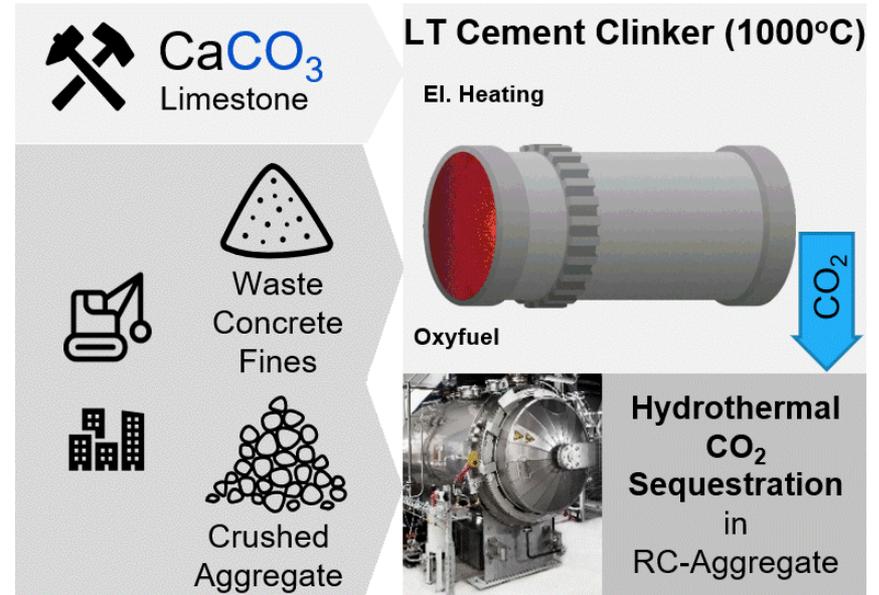
- CO<sub>2</sub>\* footprint of Belite clinker based RC-cement reduced (up to 55%)
- The remaining 45% CO<sub>2</sub> can be sequestered within 2h in RC-aggregate as proven on lab scale<sup>[2]</sup>
- Pilot plant under construction at KIT



Baden-Württemberg

MINISTERIUM FÜR UMWELT, KLIMA UND ENERGIEWIRTSCHAFT

\* with reference to OPC-based concrete; [1] Kalkreuth et al. *Quantification of the degree of carbonation of hardened cement paste via ATR-IR spectroscopy: Method development and validation with multivariate PLS regression (in prep.)*.



**Circular Concrete = RC-Cement + Carbonated RC-Aggregate**

# Session 2:

## Issues and policy needs of sorting and recycling

### Guiding questions **Building Materials**

- What have been the most effective waste policies so far in reducing waste (externalities) and promoting recycling?  
Restricted landfilling with high costs, restrictions on incineration, take-back obligation, mandatory quotes of usage
- What options exist to enhance capacity investment in recycling facilities?  
CCFD, simplified regulatory framework, upgrade of infrastructure (centralized and local, electricity, heat, gas, CO<sub>2</sub> networks)
- To what extent do recycling and incineration facilities compete for waste feedstock, and would an incineration tax encourage more recycling  
Very specific for each product; Therefore a tax on most plastics might be helpful, but highly complicated implementation. I would like to hold the producer accountable

# Further Questions

Important partly competing objectives of protection.

- According to which principles should the different effects be weighted? (Water, Air Quality (Health), GHG, Natural Resources (Raw Material, Landscape, Social)?
- Sorting <> Separation <> Chemical Partitioning: How can we prevent the built up of pollutants in internal circuits? Today the concentration of harmful wastes is economically unfavourable