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Towards CO_2-neutral concrete

Industrial scale-up of a closed-loop recycling process of end-of-life concrete (CIRCO$_2$BETON® project)

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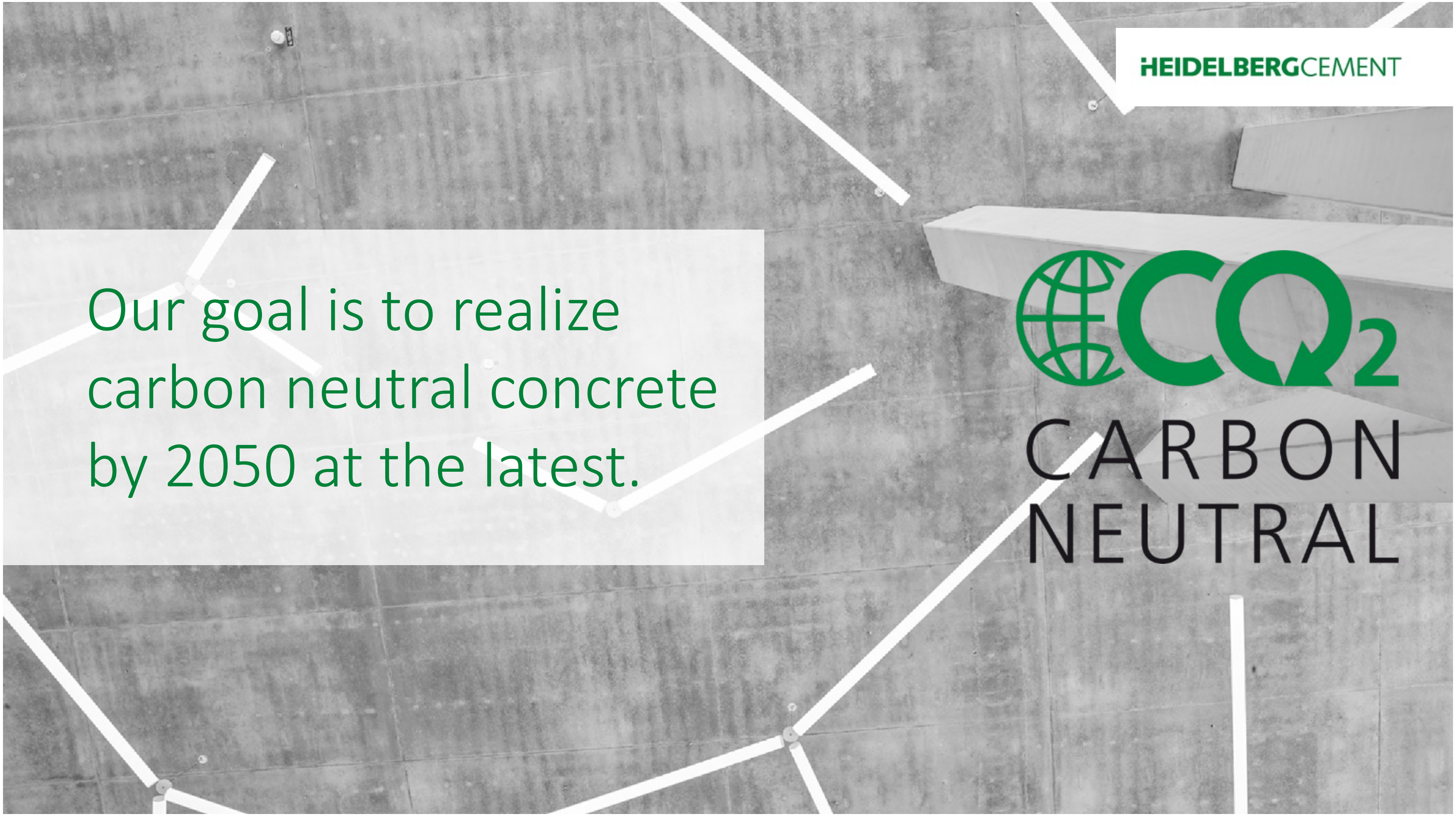
(Jan Skocek, HeidelbergCement, Global R&D)

ECEEE summer study, Hyères, June 8th 2022

MATERIAL TO BUILD OUR FUTURE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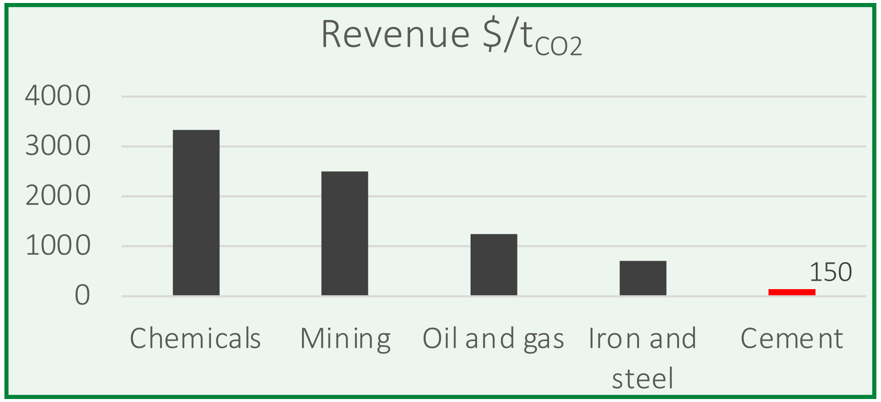
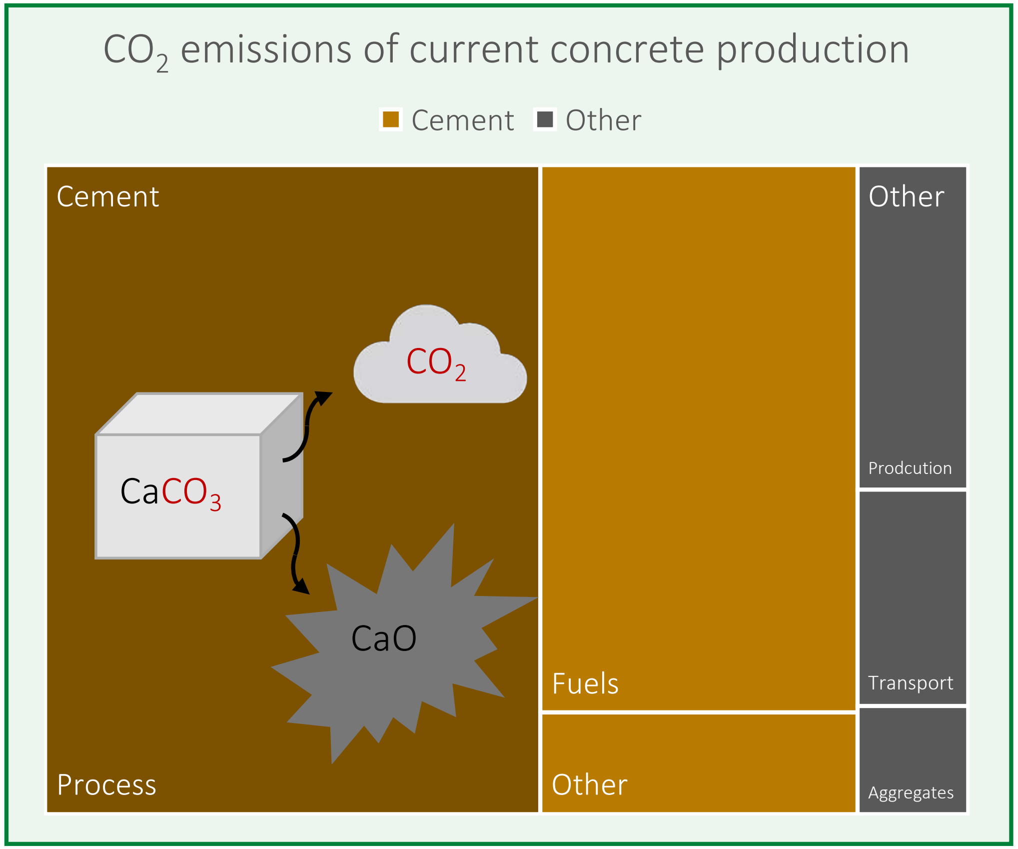
Our goal is to realize
carbon neutral concrete
by 2050 at the latest.
CO_2
CARBON
NEUTRAL

Huge economical and technical challenges to reduce CO_2 emissions

- Most of concrete CO_2 emissions originate from cement, resp. clinker production
- About 500 kg $CO_2/t_{clinker}$ originate from limestone (=process emissions)
- Process emissions cannot be avoided at scale for reasonable costs





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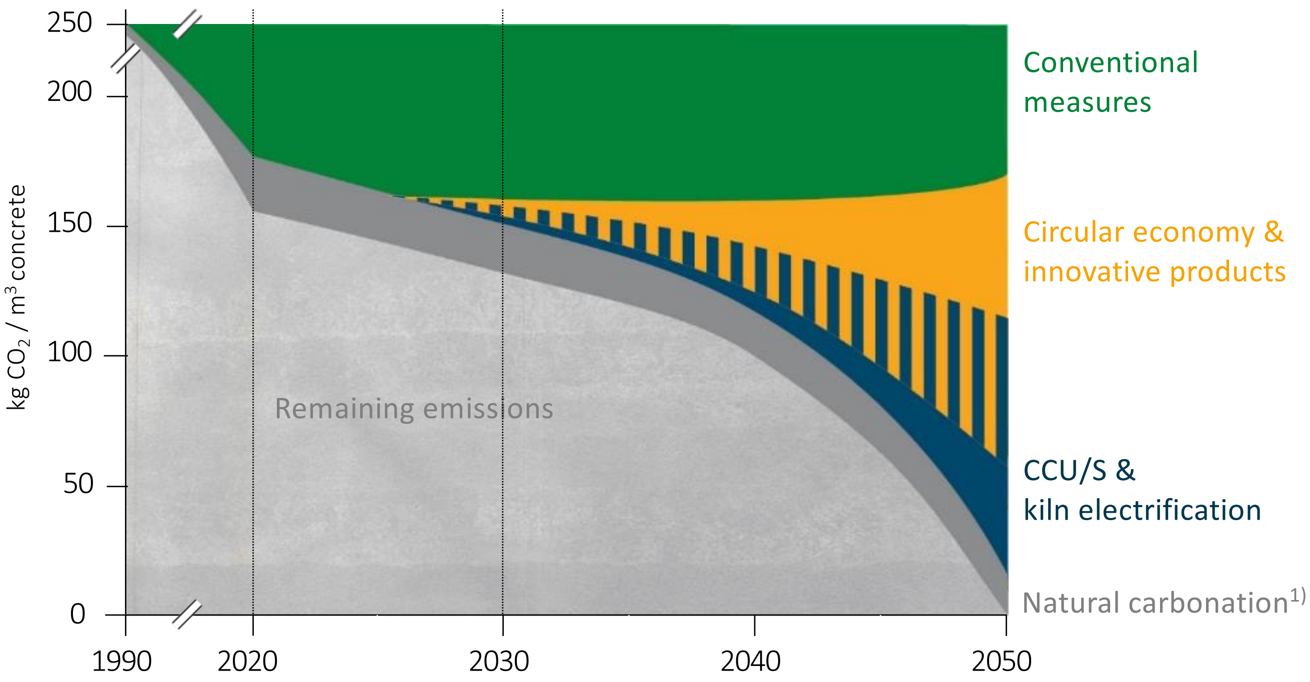
Carbon neutrality by 2050 requires a variety of different approaches

Our approach to carbon neutrality



1) Natural carbonation is the absorption of CO_2 from the atmosphere during the lifetime of a concrete construction

Circular economy & innovative products

- Recycled materials (recycled aggregates, recycled concrete paste as raw material)
- Alternative cementitious materials (e.g. calcined clay, carbonated recycled concrete paste)
- Low carbon clinker types (example: Ternocem, CSA)
- Low carbon cement types (example: MultiComponentCement – CEMII/C-M)

CCU/S & kiln electrification

- Carbon Capture & Usage (high protein animal feed, manufacture of fuels, carbonates and chemicals)
- Carbon Capture & Storage (amine scrubbing, Oxyfuel technology, LEILAC)
- Hydrogen & kiln electrification projects

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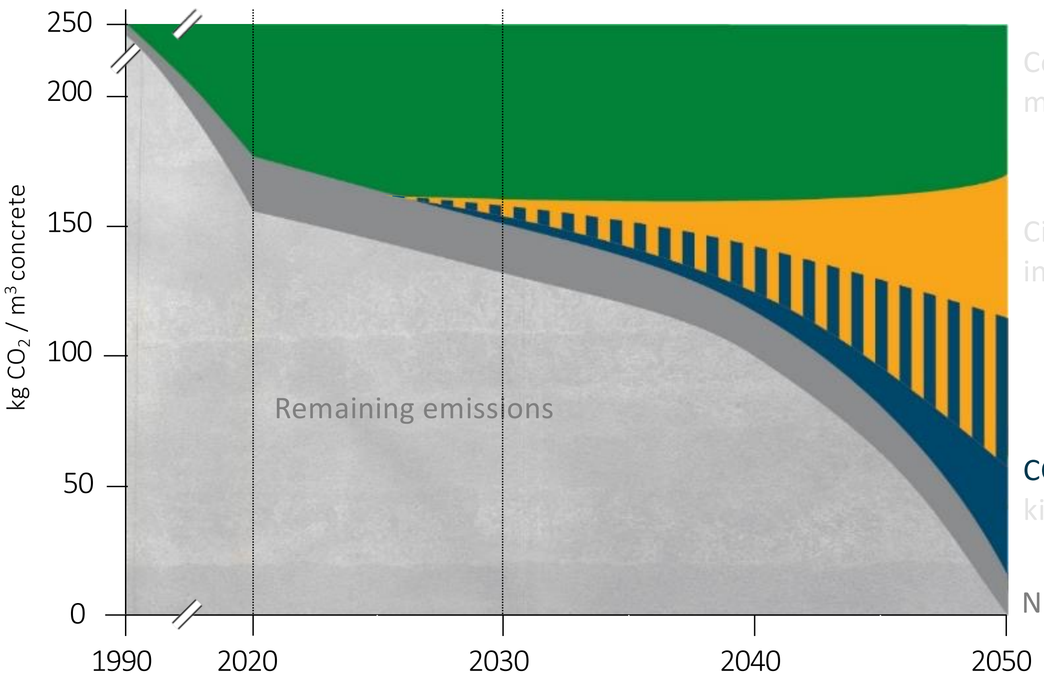

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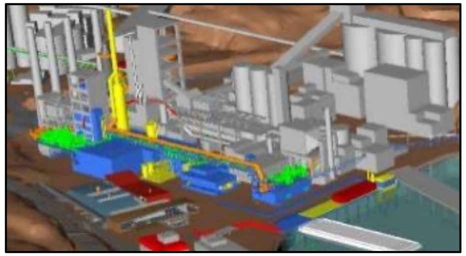
TECHNOLOGY DEVELOPMENTS

Capture technology needs to be robust and resource/energy efficient

TRL 8	**TRL 5**	**TRL 6**
Post combustion (Amine)	Oxyfuel	Direct separation (LEILAC)

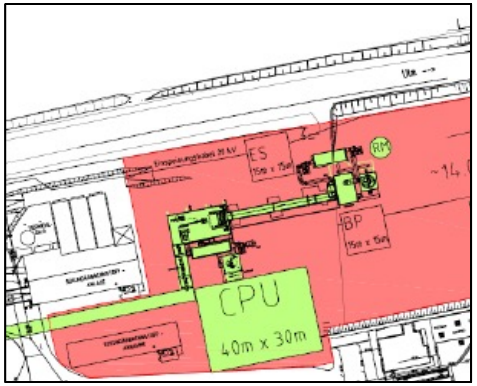
Post combustion (Amine) — *TRL 8*

Industrial/commercial:
Brevik, Norway



Oxyfuel — *TRL 5*

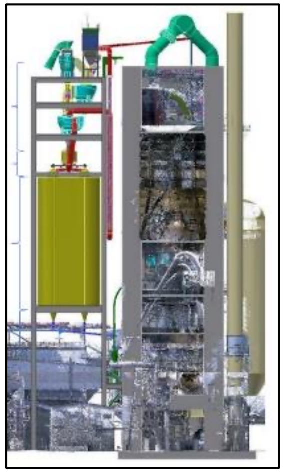
Pre-industrial:
CI4C, Germany



Direct separation (LEILAC) — *TRL 6*

Pilot:
LEILAC-1, Belgium
EU-funds 12 m€

Pre-industrial:
LEILAC-2, Germany
EU-funds 16 m€



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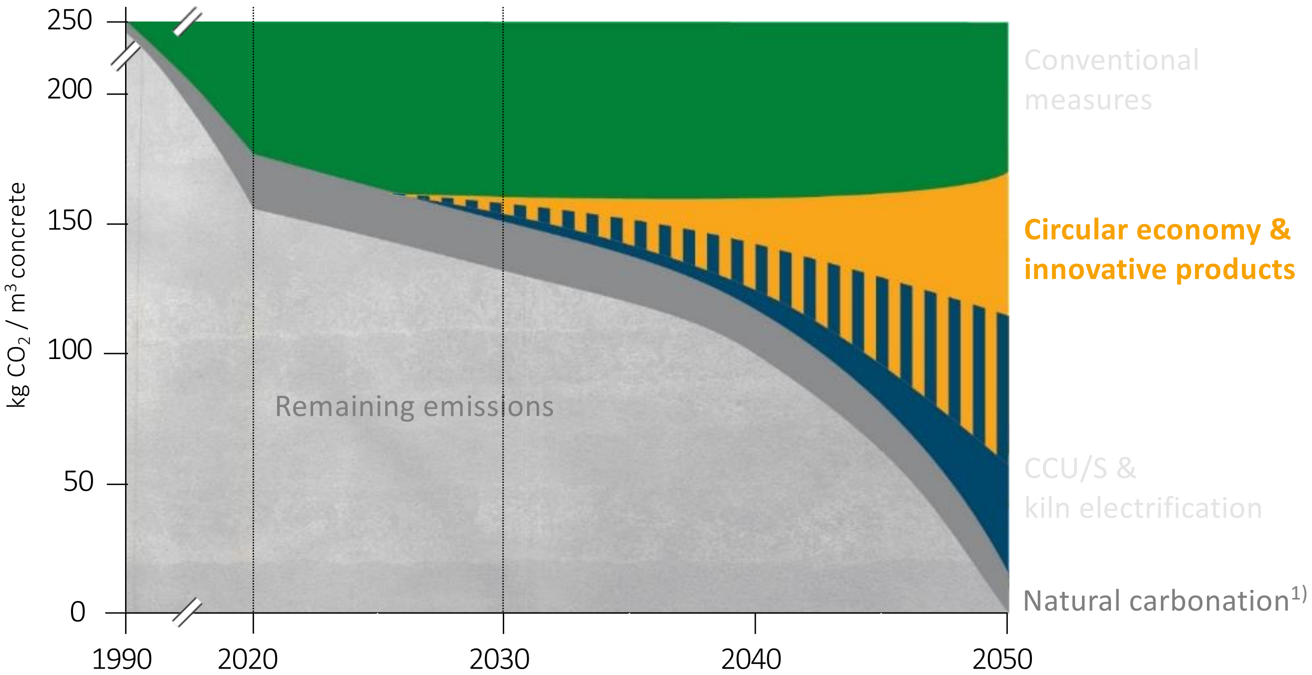

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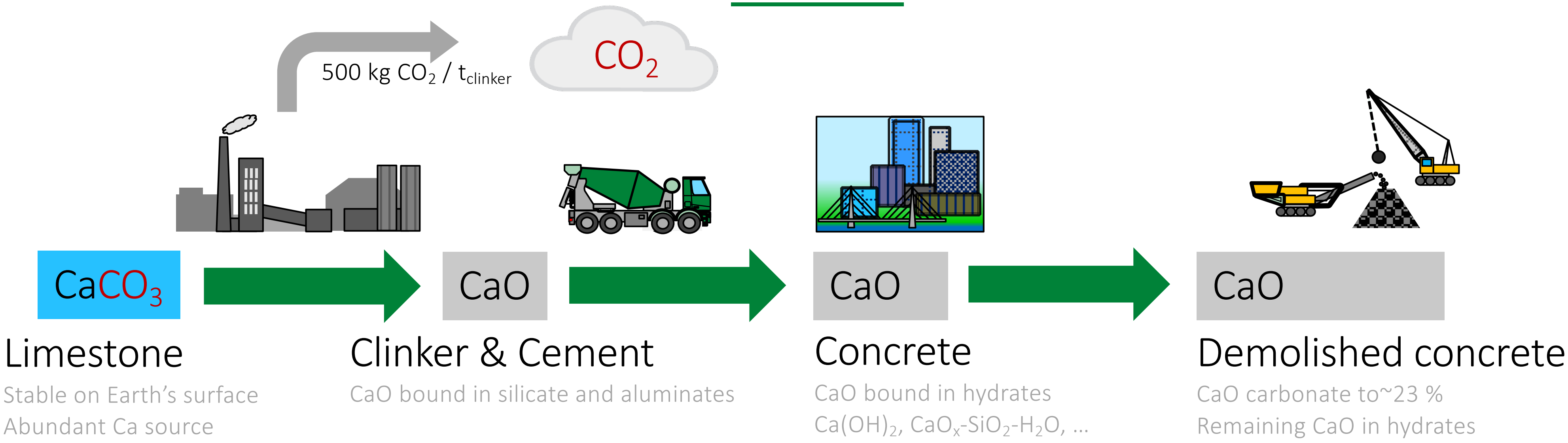
Concrete at end of its service life is a large source of decarbonated CaO



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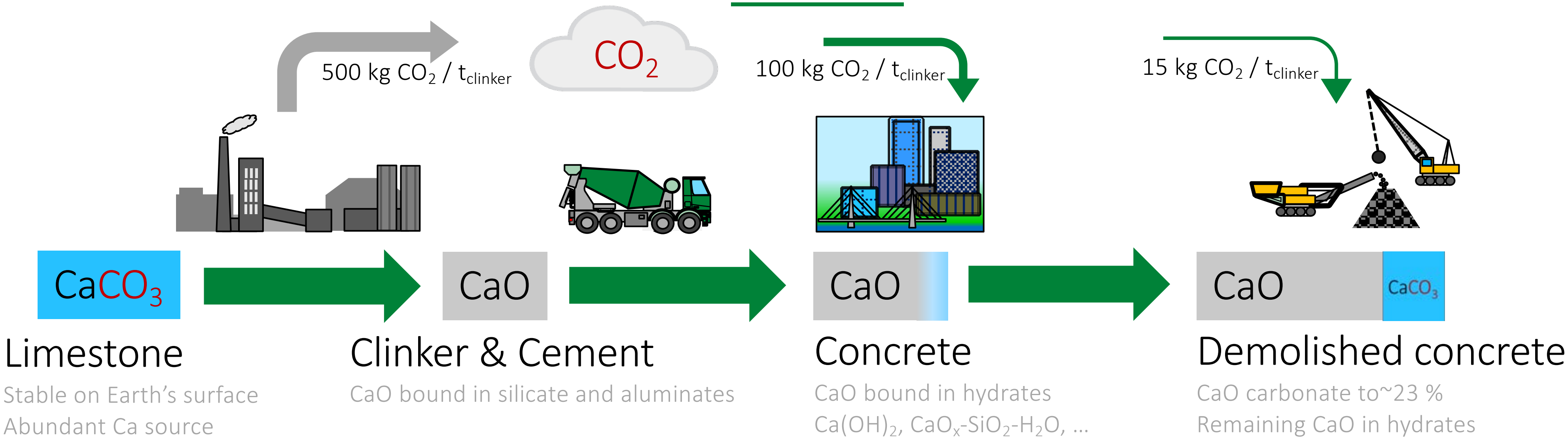
CaO in concrete spontaneously binds CO_2 when in contact with air



CO2 EMISSIONS REDUCTION BY CONCRETE RECYCLING

About 80 % of CaO remains available for CO_2 reduction

$CaCO_3$

Limestone

Stable on Earth's surface
Abundant Ca source

CaO

Clinker & Cement

CaO bound in silicate and aluminates

CaO

Concrete

CaO bound in hydrates
$Ca(OH)_2$, CaO_x-SiO_2-H_2O, …

CaO $CaCO_3$

Demolished concrete

CaO carbonate to~23 %
Remaining CaO in hydrates

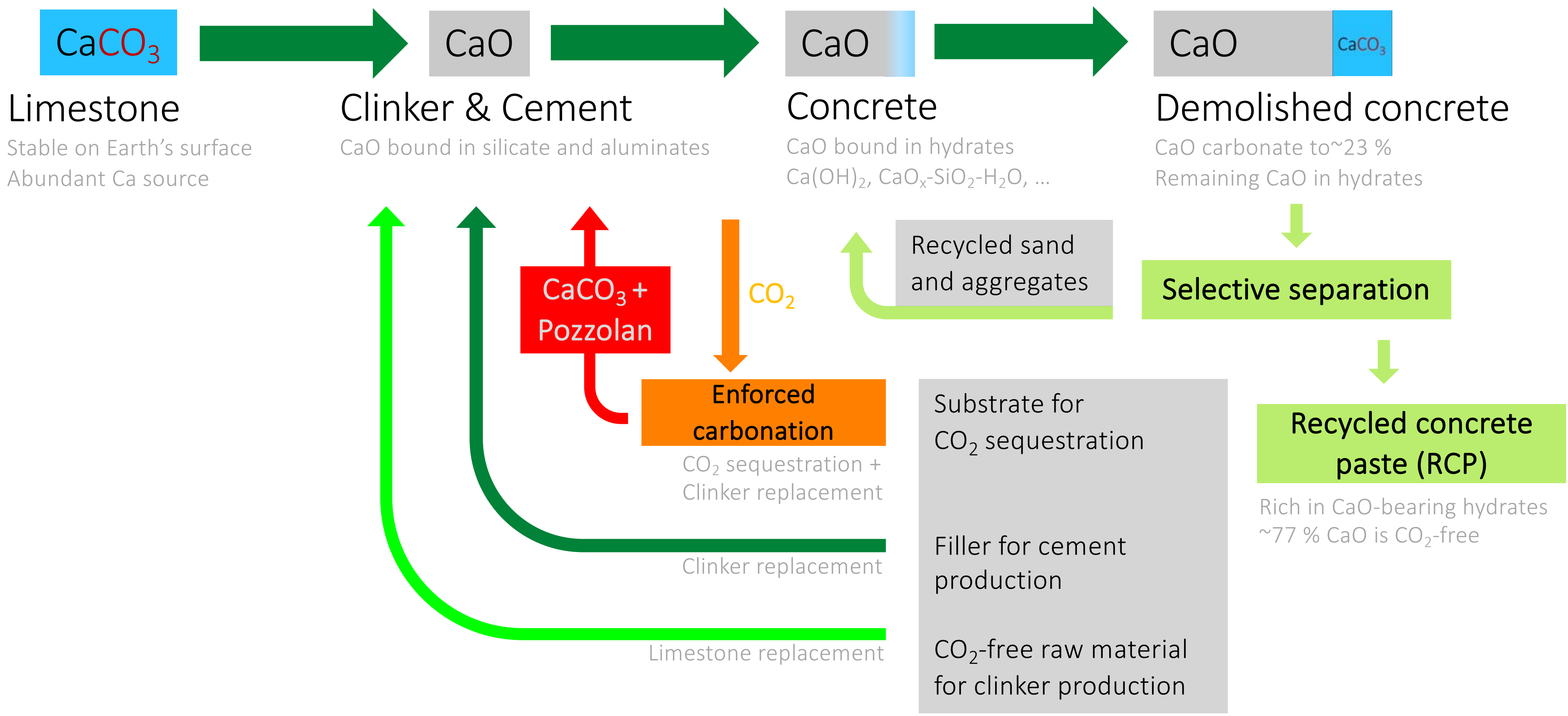
Recycled sand and aggregates

Selective separation

Recycled concrete paste (RCP)

Rich in CaO-bearing hydrates
~77 % CaO is CO_2-free

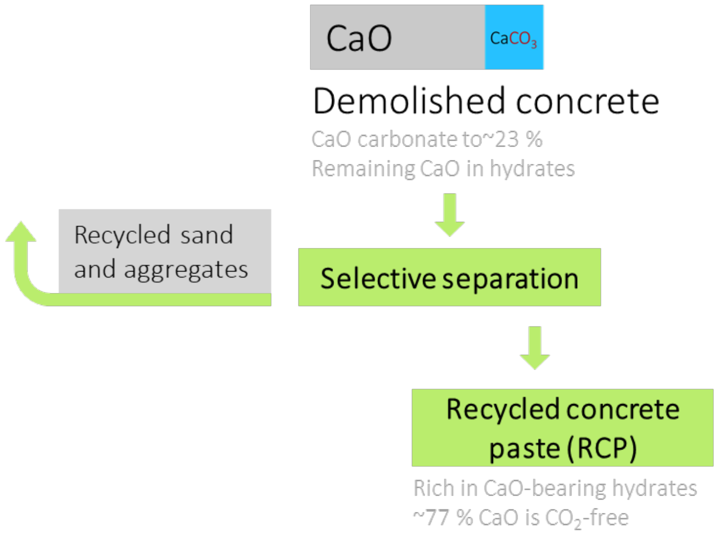
Recycled concrete paste can be used in clinker and cement production



Selective separation

- ✓ Mechanical treatment with low energy demand suitable
  → Low-pressure attrition-driven in-bed comminution highly effective
- ✓ RCP yield of up to 80 % and purity of up to 80 % possible
- ✓ Removing RCP improves quality of recycled aggregates and sand
  → RA and RS can replacement of up to 100 % without changing mix design and compromising concrete workability and strength
- ✓ Further technology developments in project C^2inCO_2 funded by German government

Bundesministerium
für Bildung
und Forschung



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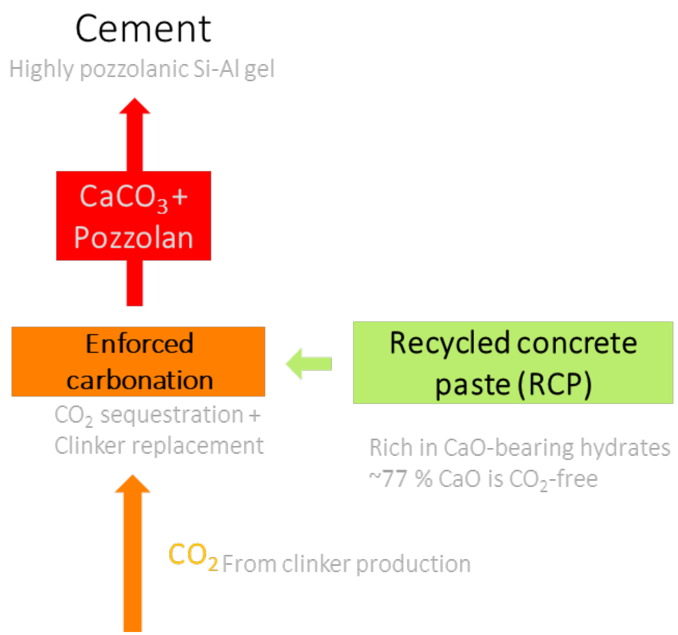
Enforced carbonation = Carbon Capture and Utilization using RCP

- ✓ **Thermodynamically feasible CO_2 mineralization into calcite**
  - → Fast kinetics, exothermic, ambient pressure and T suitable
  - → 80 % of process emissions mineralized in 30 minutes

- ✓ **Robust to reaction and material conditions**
  - → Raw kiln gas can be directly used
  - → Demonstrated at full scale in HC plant in Brevik

https://blog.heidelbergcement.com/en/ccu-brevik-norcem-recycled-concrete

- ☒ **Large scale experience to be developed**



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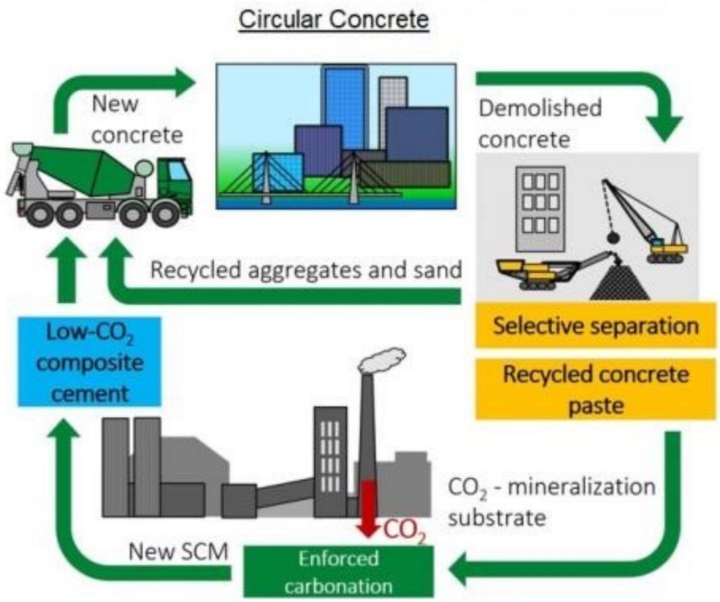
CIRCO_2BETON project

Industrialialize then demonstrate environmental and economical benefits of the closed loop recycling of concrete

Direct technological challenges (industrialization):
- Selective separation
- Continuous enforced carbonation process

Indirect challenges :
- Large-scale roll-out of selective deconstruction to improve the quality and homogeneity of demolished concrete
- Easier access to the resource
- Traceability throughout the value chain

The CIRCO_2BETON® project is supported by the Investments for the Future program operated by ADEME and Ile de France Region



SCM = Supplementary Cementitious Material

- ✓ Recycling platform to be located near Paris (Yvelines, 78)
- ✓ CO2 reactor to be implement in the Ranville Cement plant (Calvados, 14)

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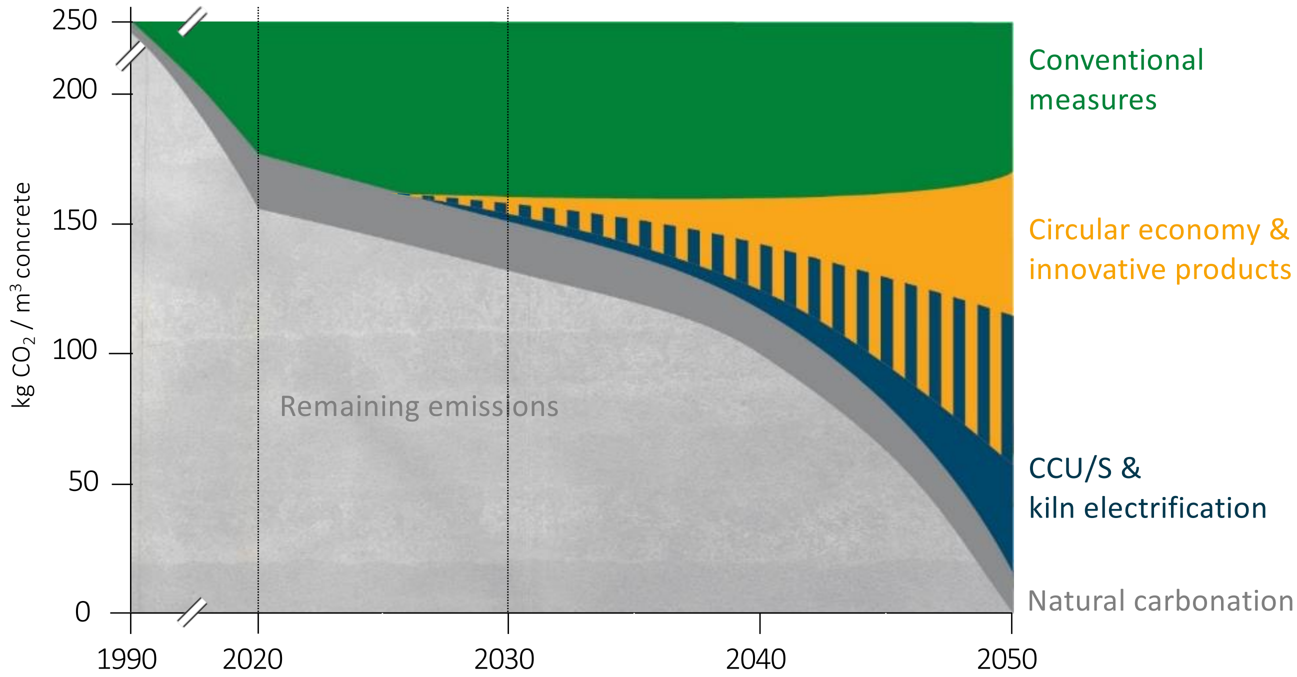
Concrete recycling is one of the key pillars of HeidelbergCement's way to carbon neutral concrete as it is



- ✓ Promoting circular economy
- ✓ Independent of other industries
- ✓ Cost-competitive to other CCUS
- ☒ Technology not available
- ☒ New materials

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