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What can concrete contribute to net zero?

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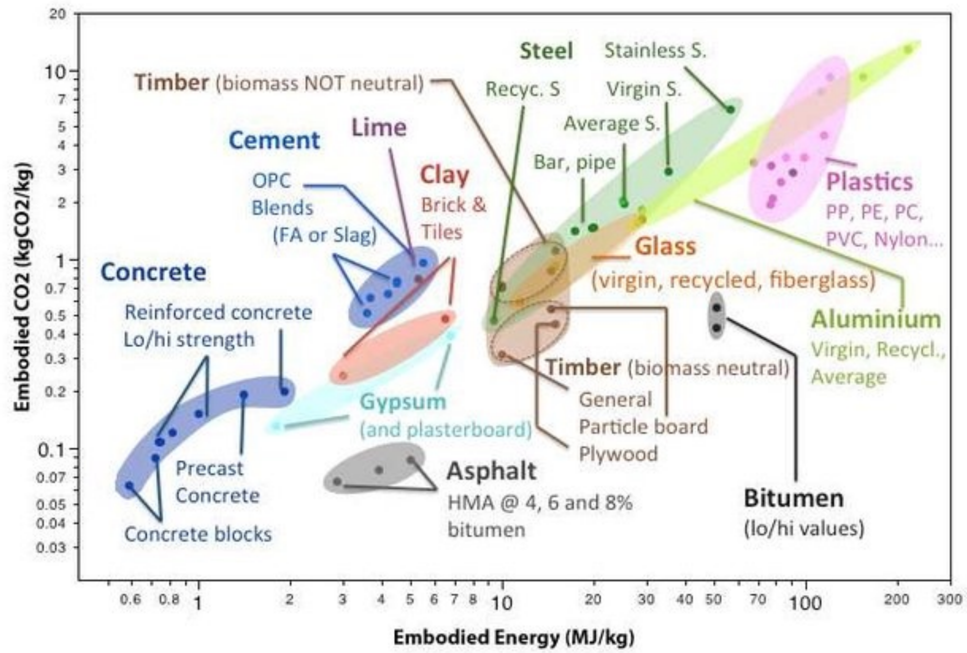
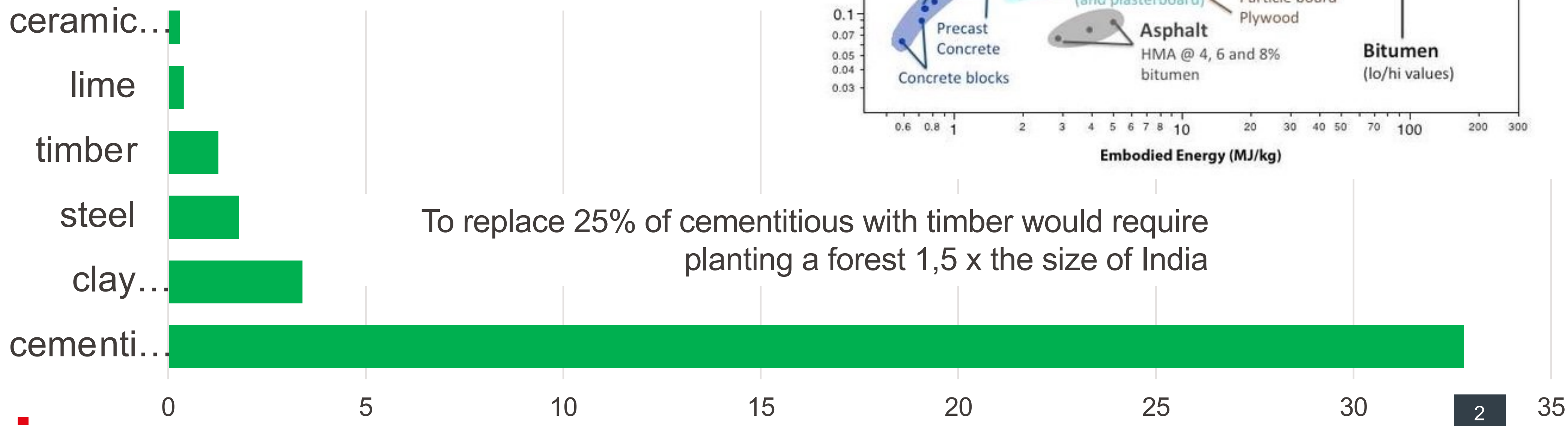
Concrete + Mortar are irreplaceable

Cementitious materials make up >50% of everything we produce.

It is only for this reason they account for 8% of CO_2 annually.

Low intrinsic environmental impact





To replace 25% of cementitious with timber would require planting a forest 1,5 x the size of India

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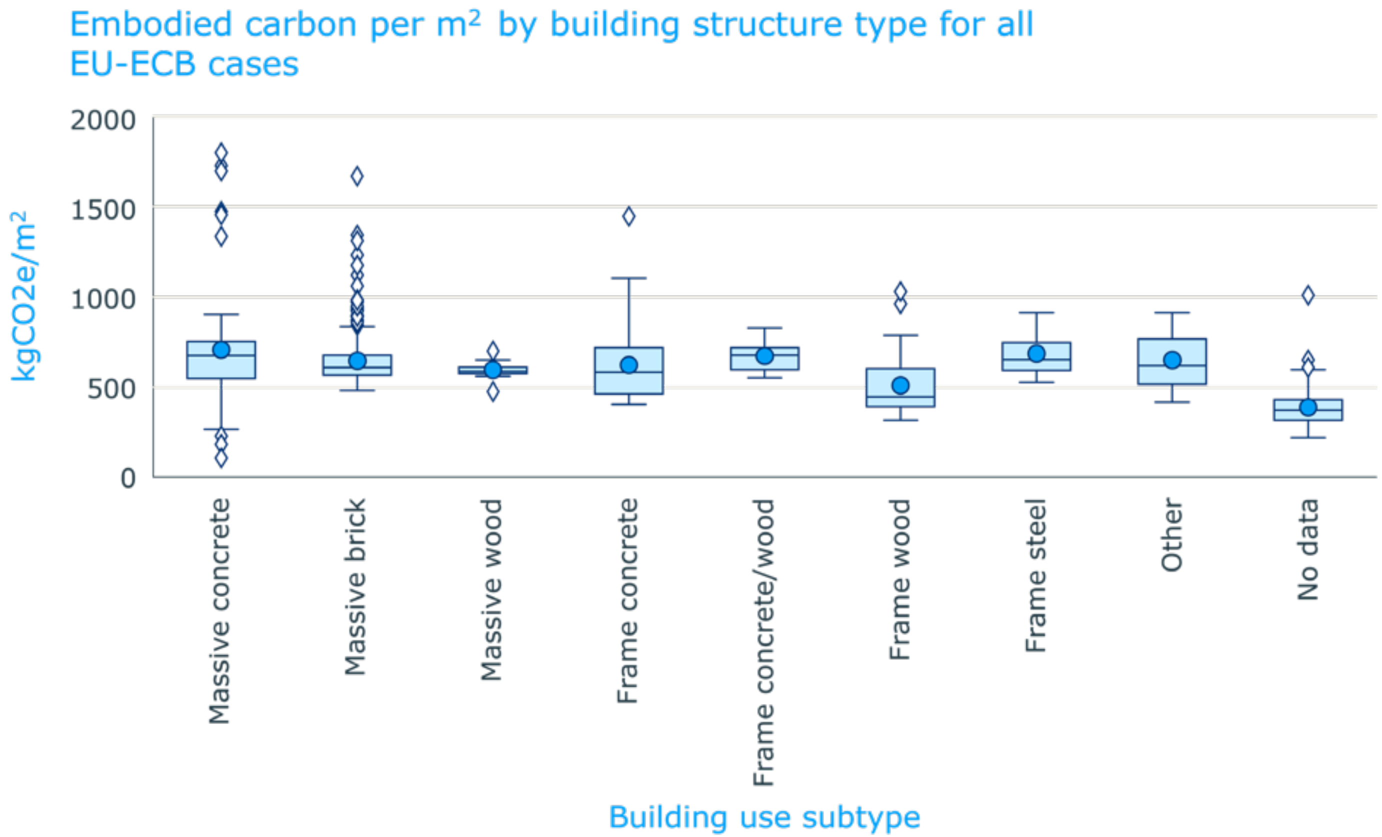
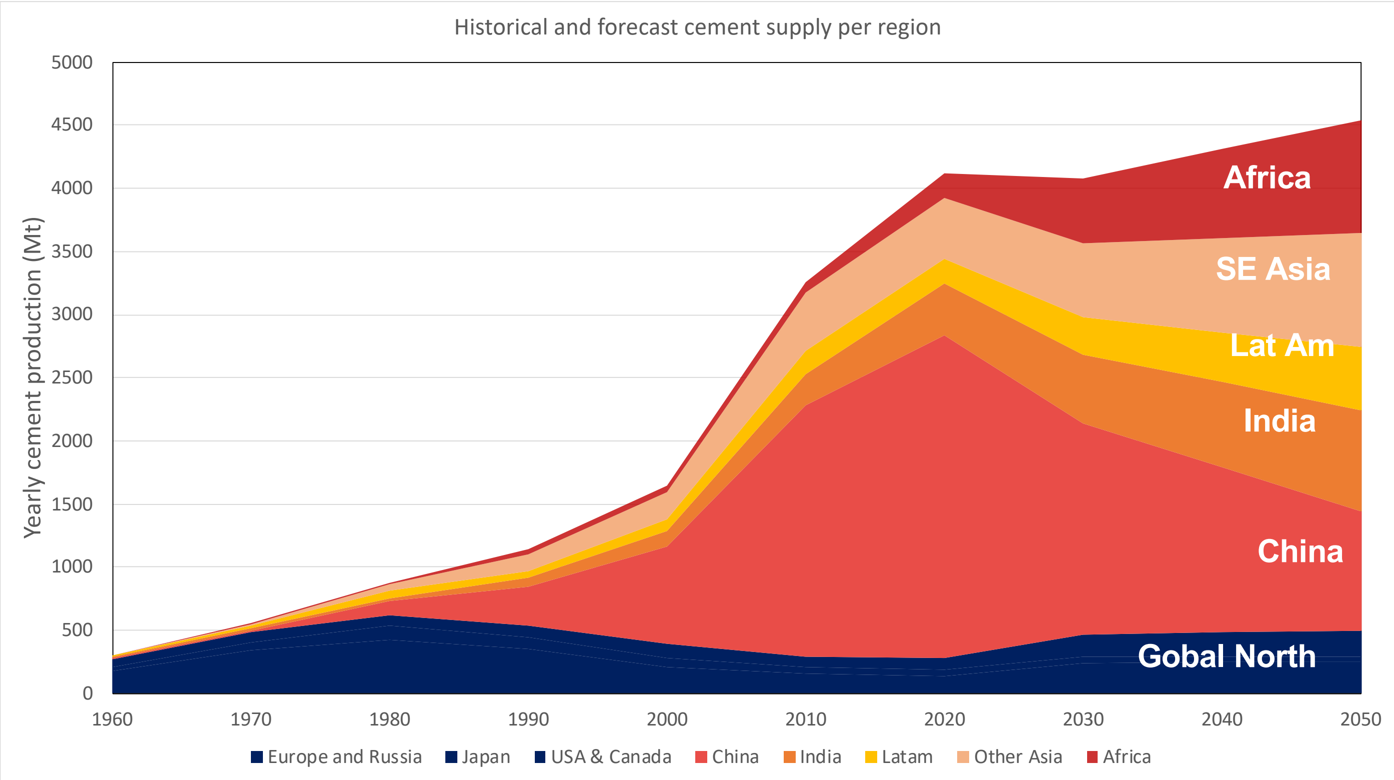
Would it help to replace concrete by other materials?



- Röck M, Sørensen A, Tozan B, Steinmann J, Le Den X, Horup L H, Birgisdottir H, Towards EU embodied carbon benchmarks for buildings – Setting the baseline: A bottom-up approach, 2022, https://doi.org/10.5281/zenodo.5895051.

Demand in global south



We need solutions for people in developing countries

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Report for European Climate Foundation 2017

Reduce CO_2 from clinker production → Reduce clinker in cement → Reduce cement in concrete → Reduce concrete in building → More efficient (re)use of buildings

- Efficient plants
- Waste fuels
- Alternate raw materials

- SCMs

- Aggregate grading
- Good admixtures
- Use filler

Substantial reductions in emissions > 80% can be achieved by working through the whole value chain

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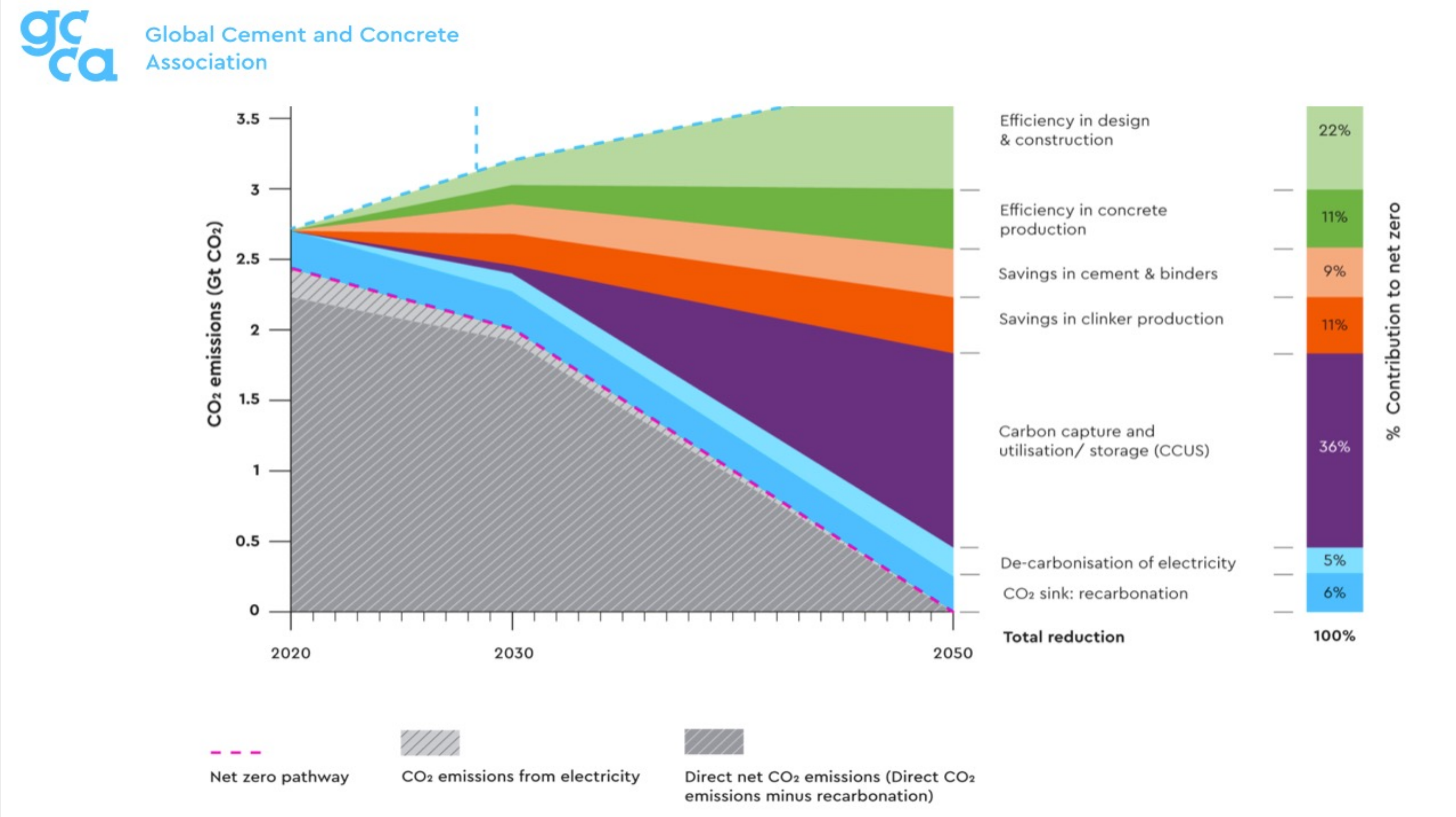
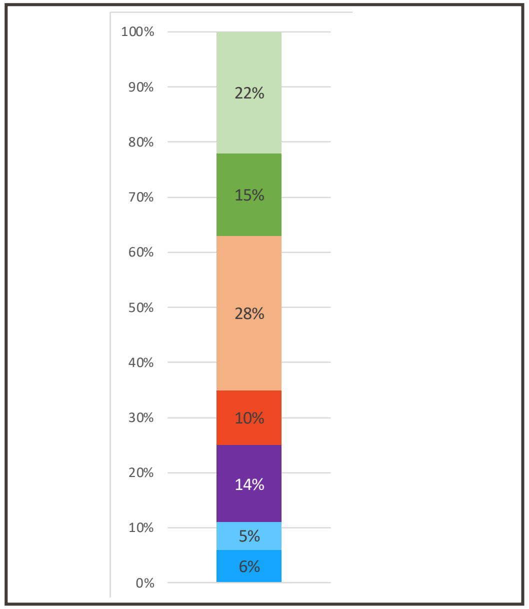
Drivers for CO_2 reductions: multiple approaches necessary



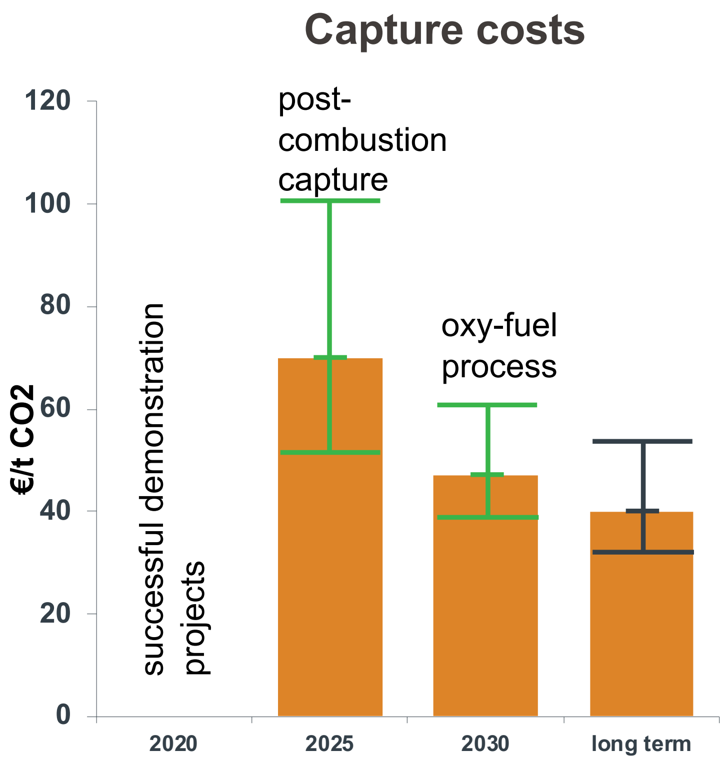
Expectation by LC3-project

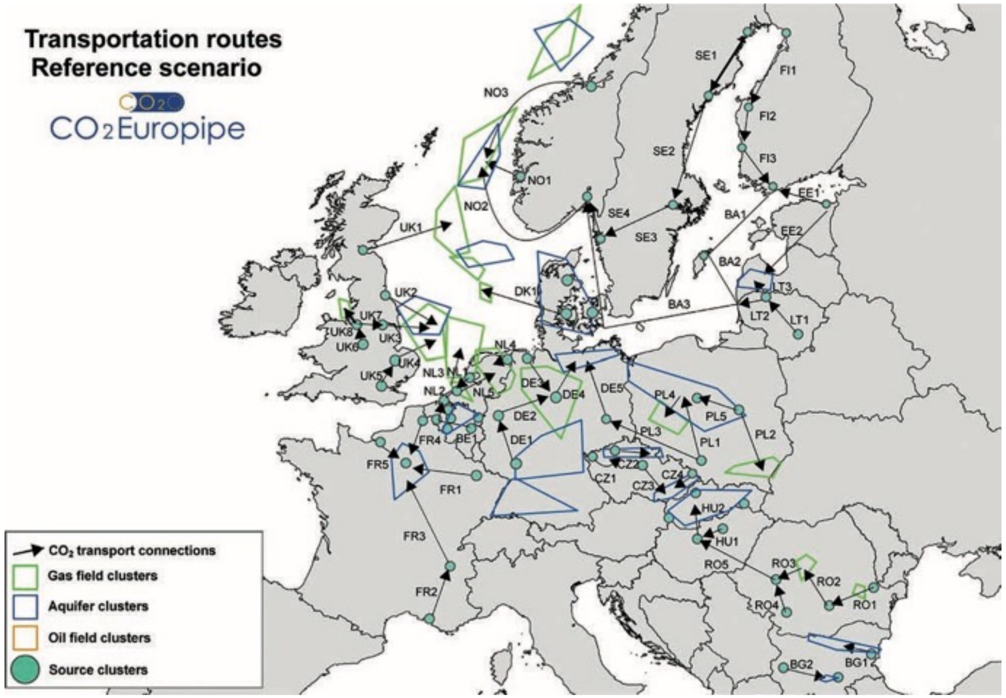


Slag and fly ash will disappear, but calcined clay allows high levels of substitution.

We believe higher potential from SCMs

Carbon Capture and Storage





At the very least it will be expensive
Reducing now will be a very sound investment

Scale of production >>> any "use" scenario
Need to build network to transport to storage sites

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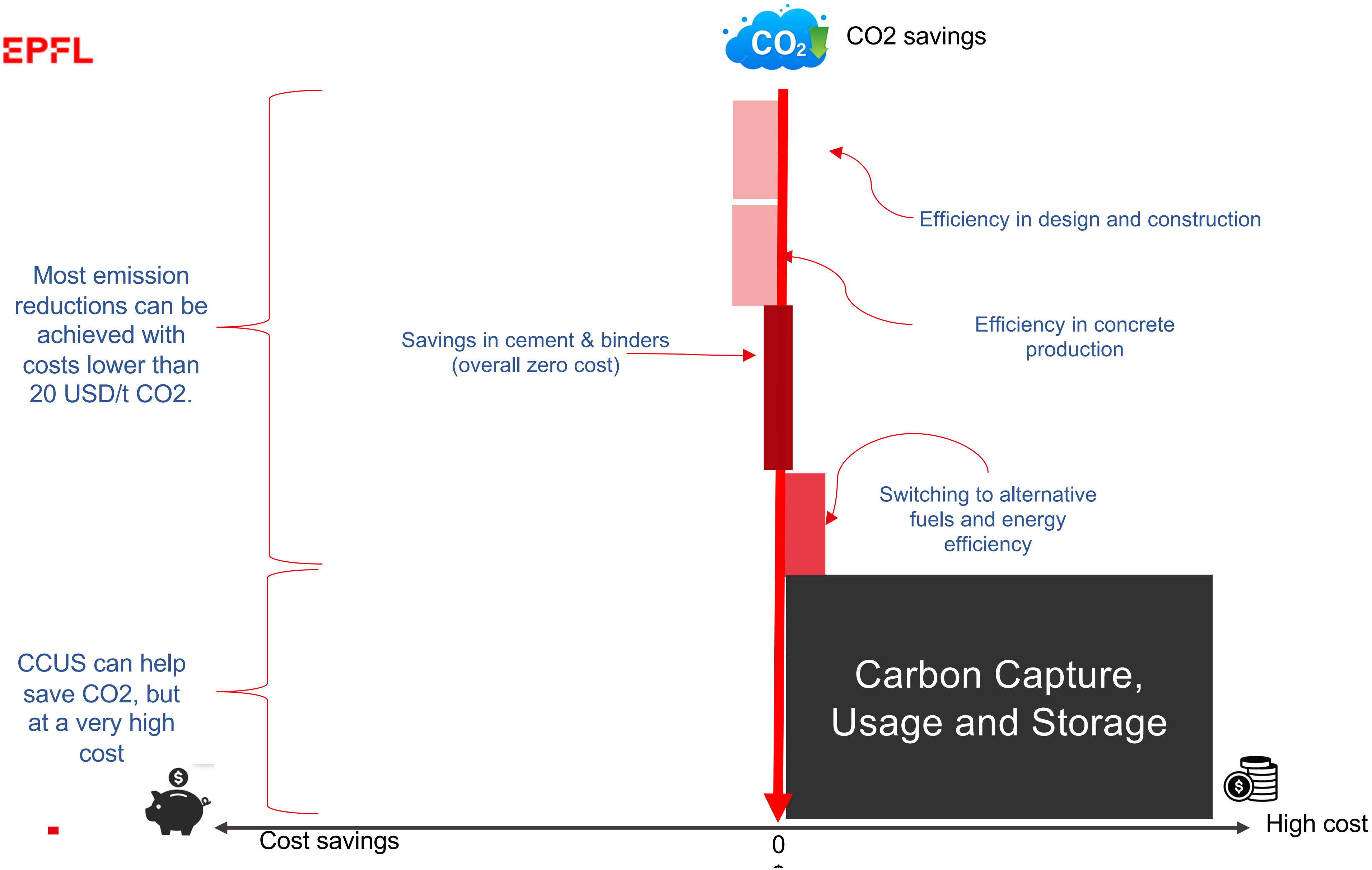
CO2 savings
Most emission reductions can be achieved with costs lower than 20 USD/t CO2.
CCUS can help save CO2, but at a very high cost
Efficiency in design and construction
Efficiency in concrete production
Savings in cement & binders (overall zero cost)
Switching to alternative fuels and energy efficiency
Carbon Capture, Usage and Storage
Cost savings
0
High cost

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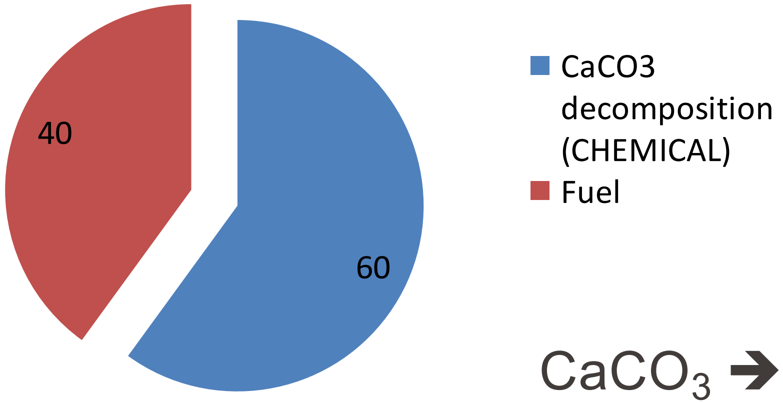
Origins of CO_2 emissions in clinker production: CO_2 from the clinker remains around 90% through to the Concrete

The production process is highly optimised up to around 80% of thermodynamic limit.

It is estimated that **< 2%** further savings can be made here

Use of waste fuels, which can be **> 80%** reduces the demand for fossil fuels



1 tonne of clinker leads to the emission of 750 – 900 kg CO_2 Average 850kg/t

$$CaCO_3 \rightarrow CaO + CO_2$$

Limestone 80% of raw material

Can we make cement with a different chemistry?

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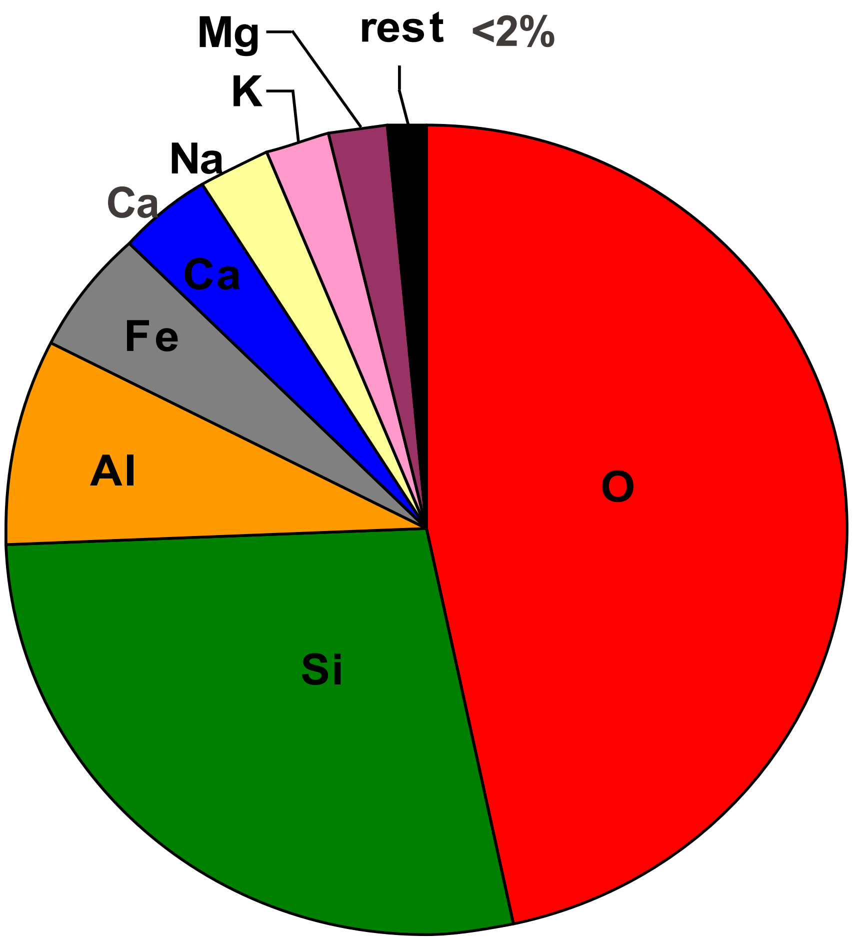
What is available on earth?



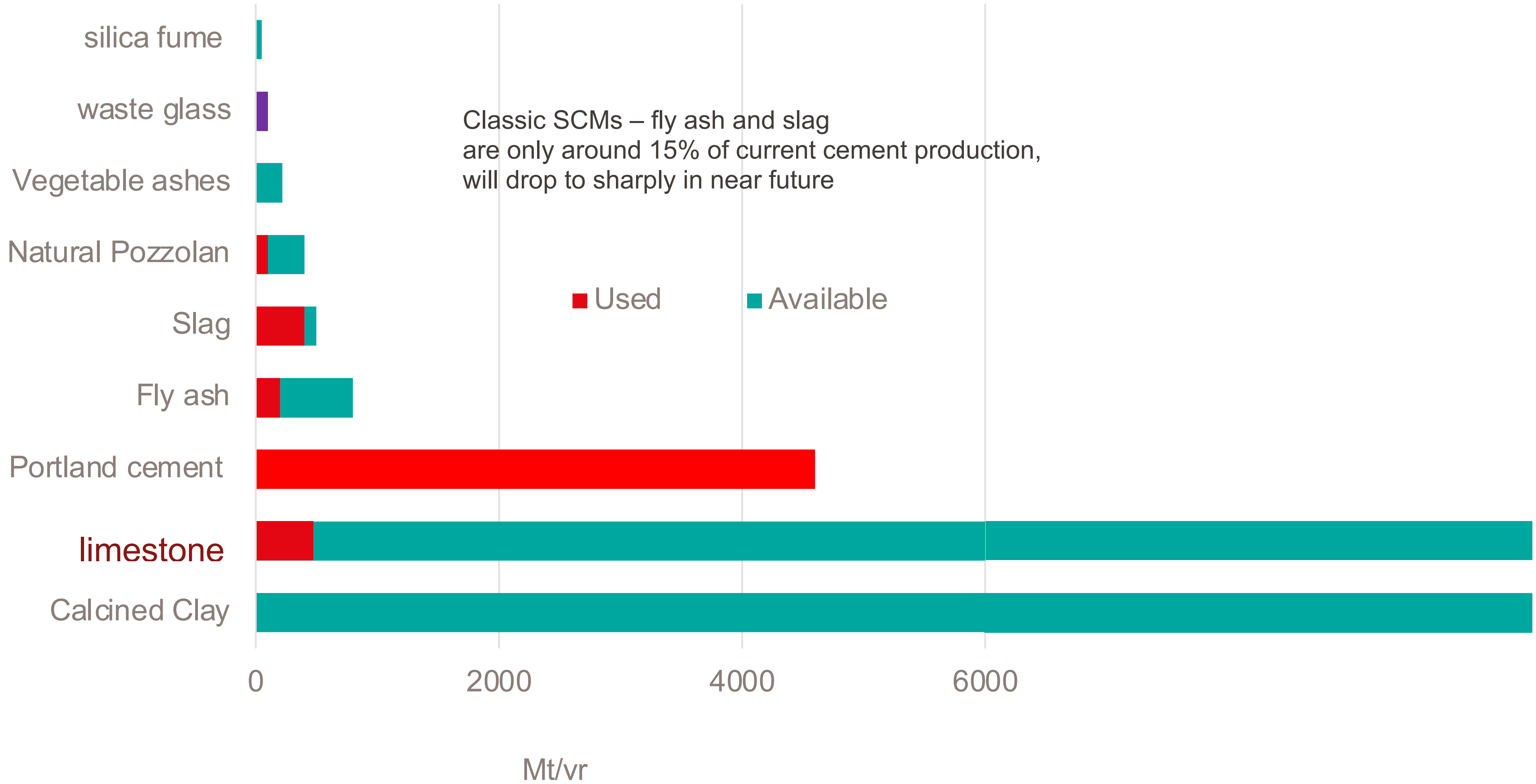
8 elements make up more than **98%** of the earth's crust

"Portland" cement is an inevitable consequence of the chemistry and geology of the earth

No alternative can be produced in quantities needed:

But a large fraction can be substituted with less reactive materials (SCMs)

Availability of SCMs



Classic SCMs – fly ash and slag
are only around 15% of current cement production,
will drop to sharply in near future

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There is no magic solution

- **Blended with SCMs will be best solution for sustainable cements for foreseeable future**

- **Only material potentially available in viable quantities is calcined clay.**

- **Synergetic reaction of calcined clay and limestone allows high levels of substitution:**
  EPFL led LC^3 project supported by SDC. Started 2013

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development
and Cooperation SDC

Limestone
Calcined
Clay
Cement
LC^3

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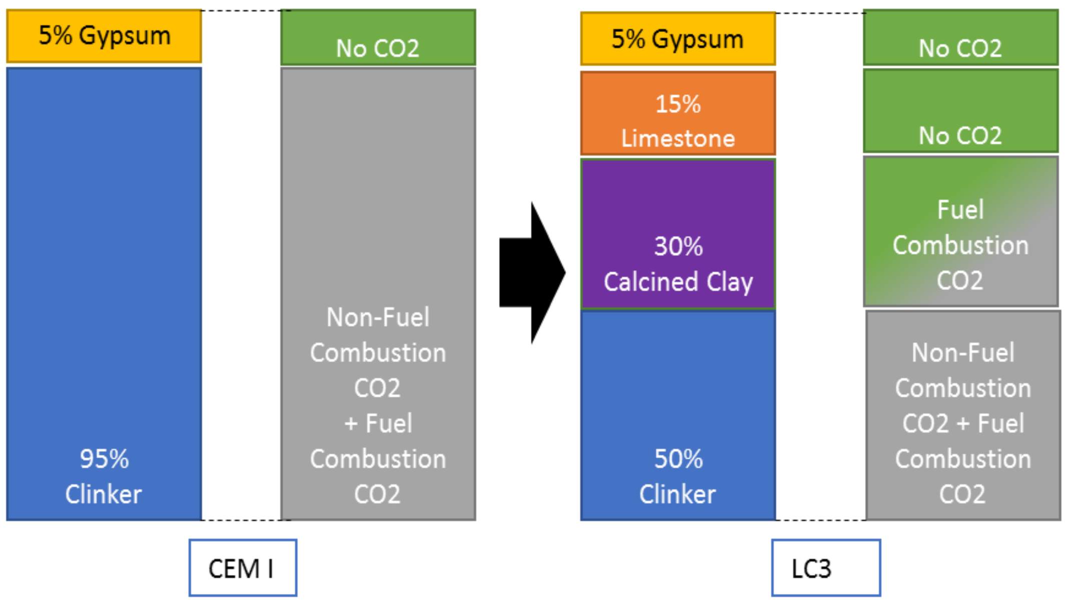
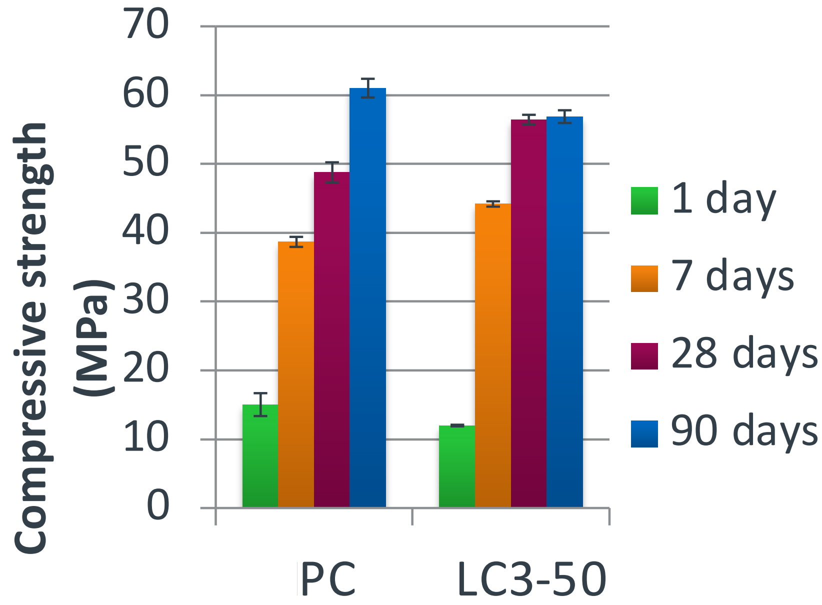
What is LC^3



LC^3 is a family of cements, the figure refers to the **clinker** content



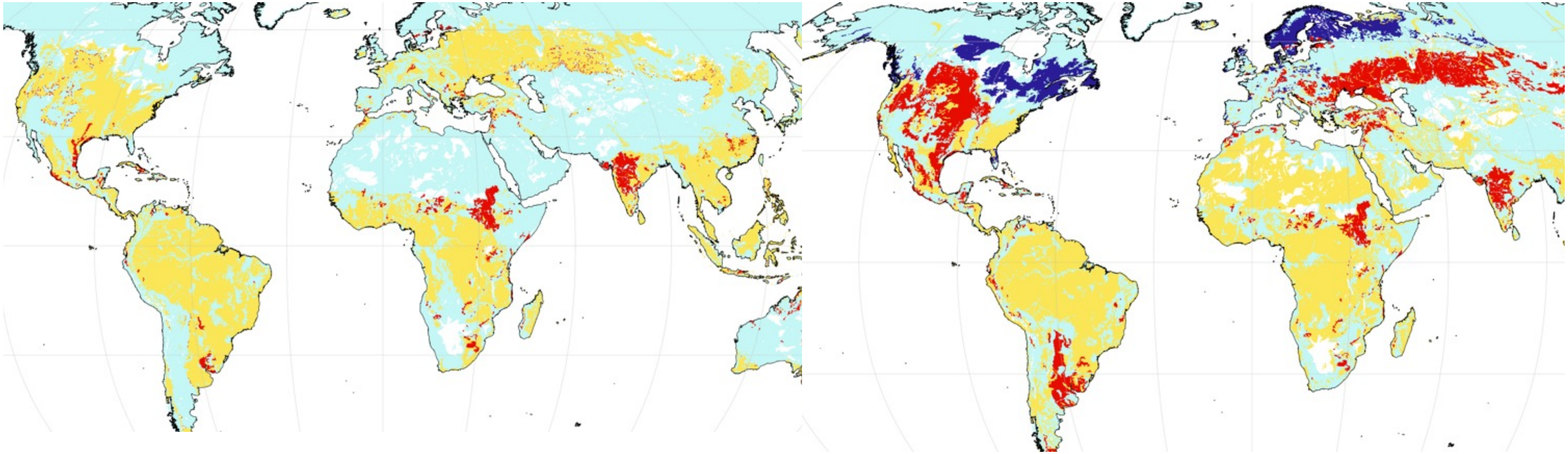
- 50% less clinker
- 40% less CO_2
- Similar strength
- Better chloride resistance
- Resistant to alkali silica reaction

Distribution of Kaolinitic clays

Ito and Wagai, Scientific data 2017

0-5m

>5m



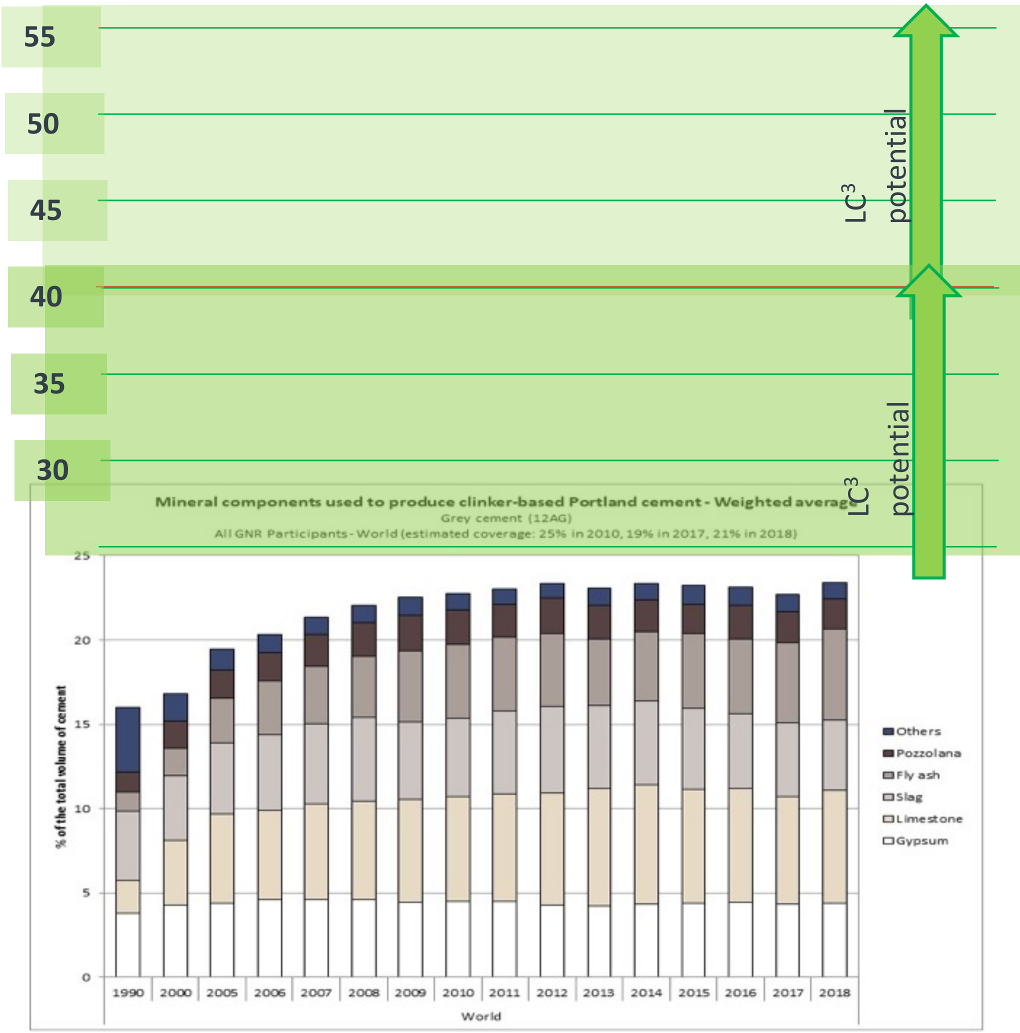
Ilite/mica

Kaolinite

Smectite

Vermiculite

Calcined Clay only SCM which can expand substitution



> 800 million Tonnes CO_2/yr

> 400 million Tonnes CO_2/yr

Demonstration structure, India

Around 14 tonnes of CO_2 saved
Compared to existing solutions

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New Calcination plant Ivory Coast

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Colour control at Ivory Coast plant

Financial Feasibility

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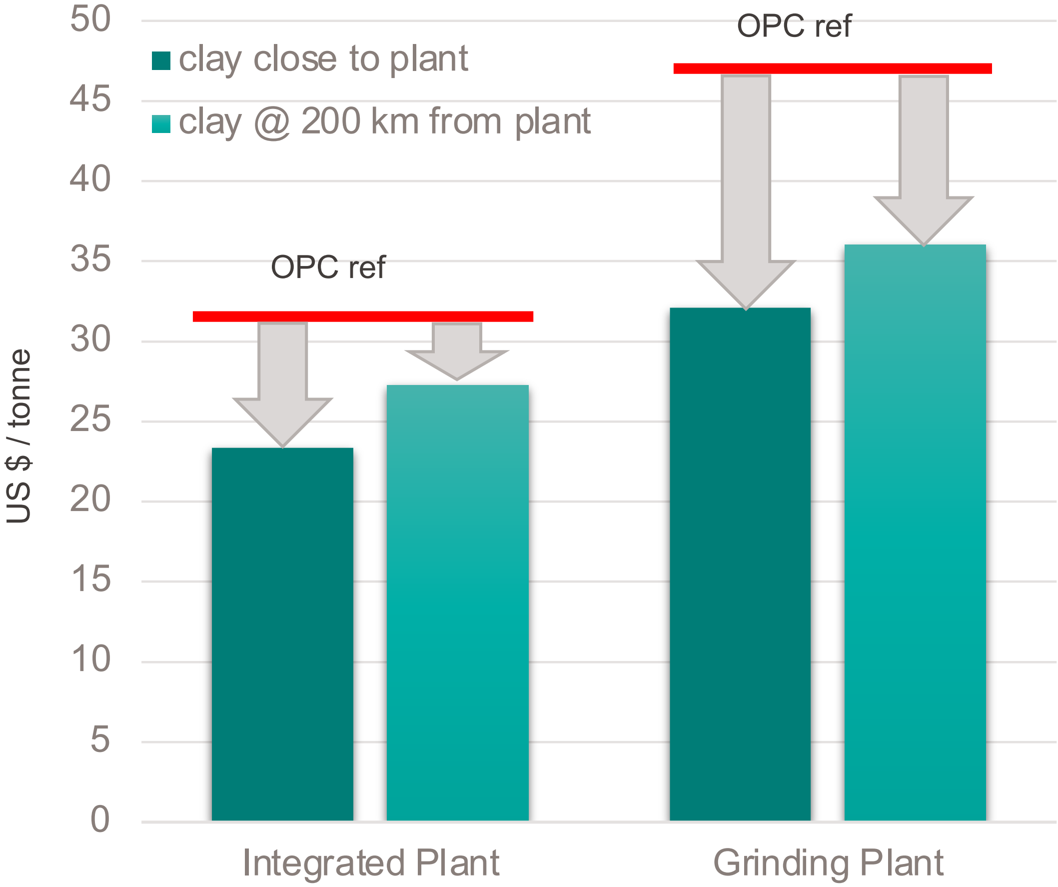
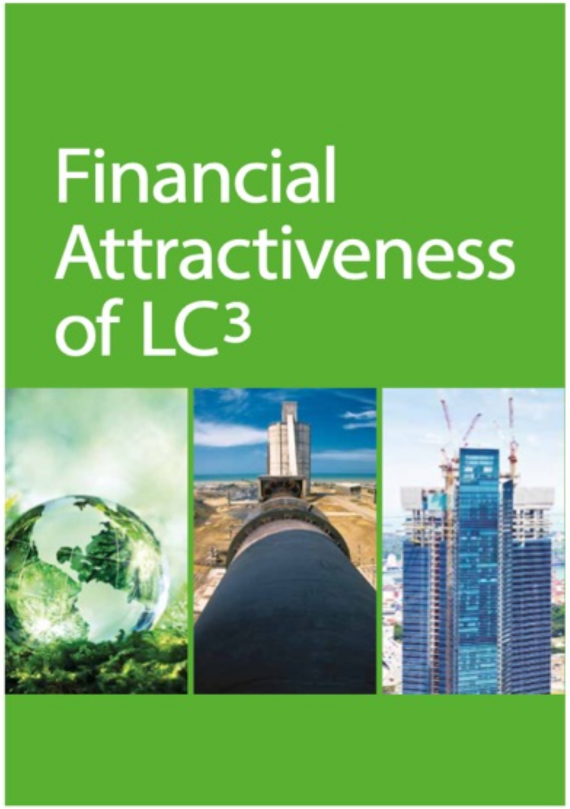
Lower cost: Cementis study





Report available:
https://lc3.ch/wp-content/uploads/2020/10/2019-LC3FinancialAttractiveness-WEB.pdf

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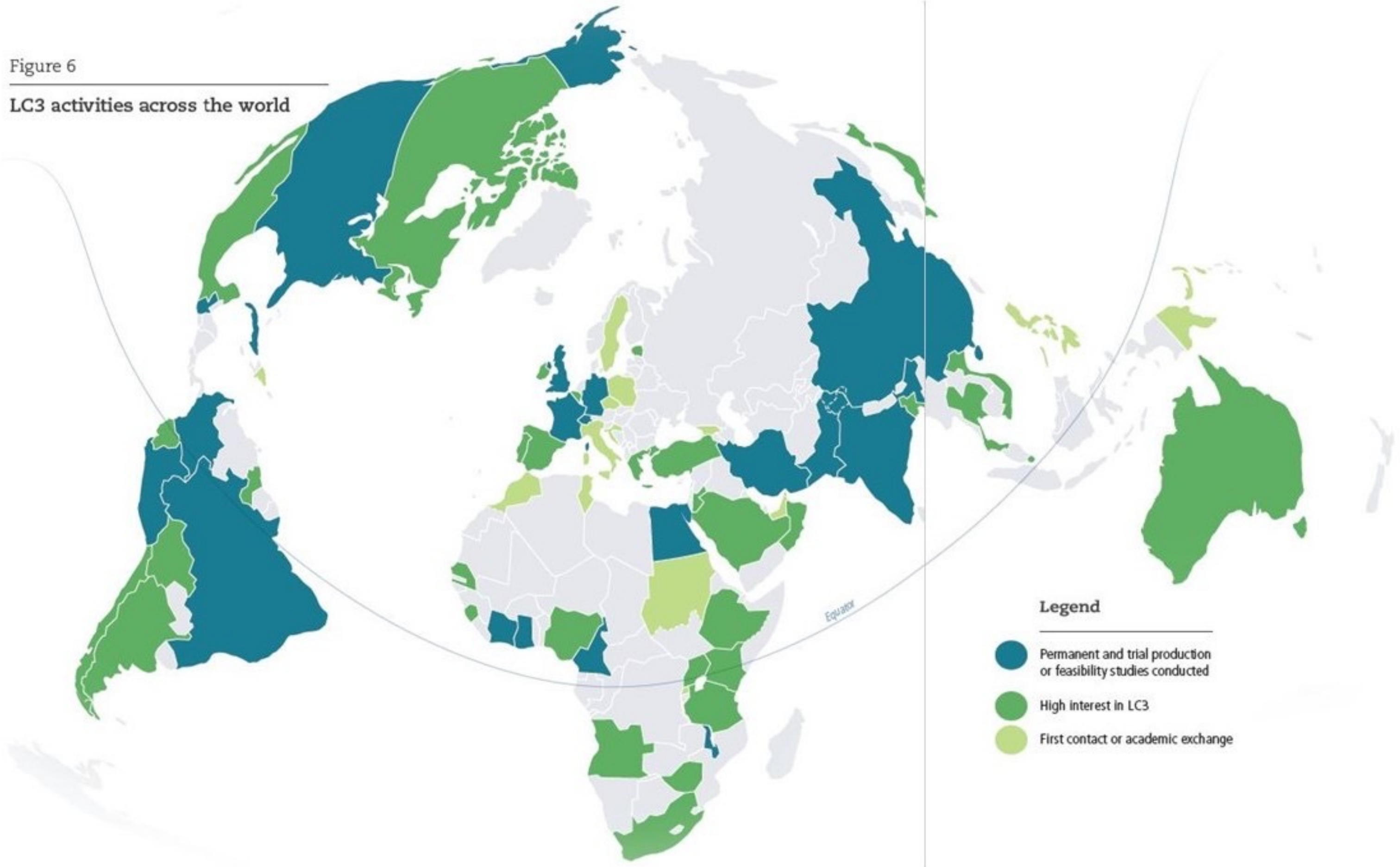
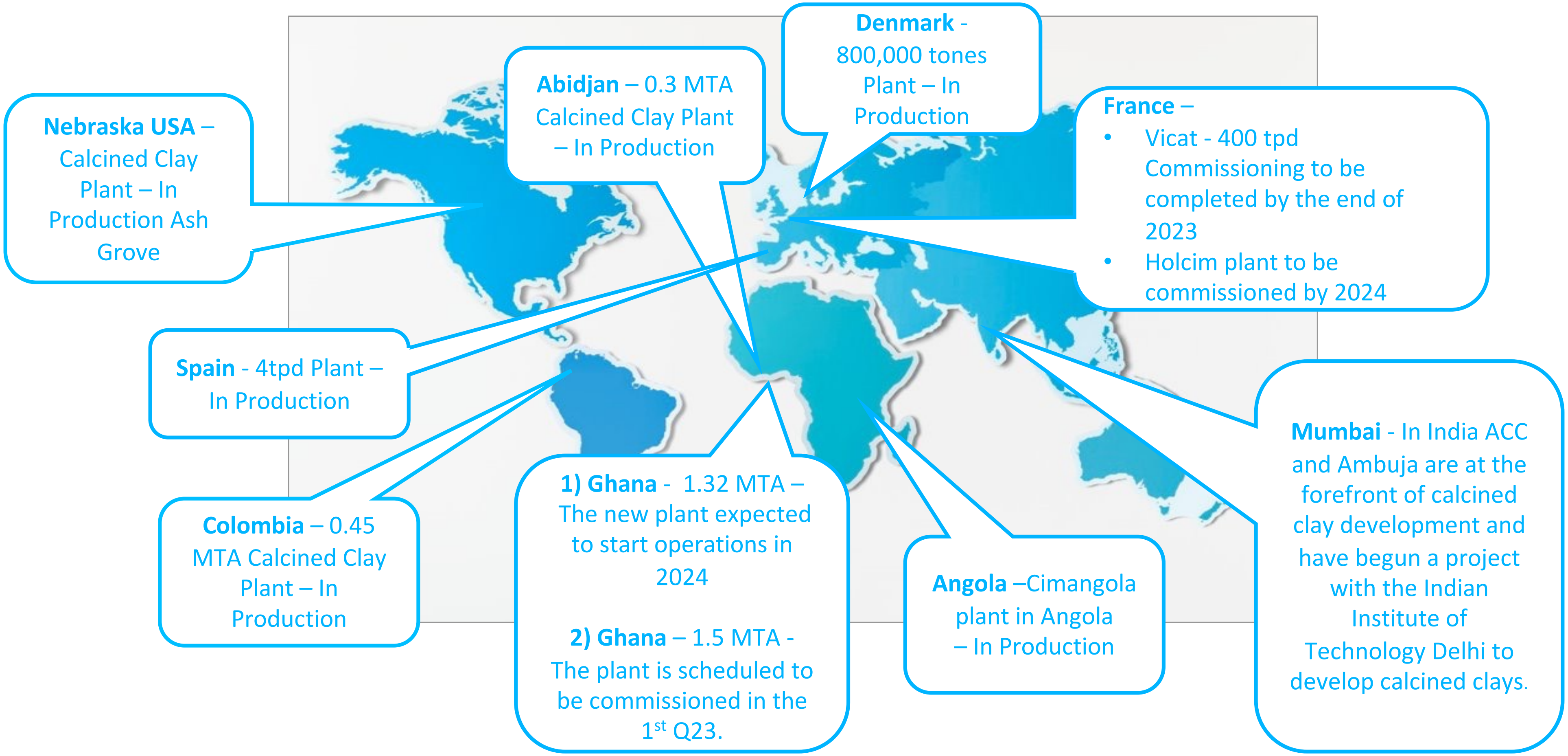
LC3 activities across the world




Nebraska USA – Calcined Clay Plant – In Production Ash Grove
Abidjan – 0.3 MTA Calcined Clay Plant – In Production
Denmark - 800,000 tones Plant – In Production
France –
Vicat - 400 tpd Commissioning to be completed by the end of 2023
Holcim plant to be commissioned by 2024
Spain - 4tpd Plant – In Production
Colombia – 0.45 MTA Calcined Clay Plant – In Production
1) Ghana - 1.32 MTA – The new plant expected to start operations in 2024
2) Ghana – 1.5 MTA - The plant is scheduled to be commissioned in the 1st Q23.
Angola –Cimangola plant in Angola – In Production
Mumbai - In India ACC and Ambuja are at the forefront of calcined clay development and have begun a project with the Indian Institute of Technology Delhi to develop calcined clays.

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Substantial reductions in emissions ~80% could be achieved by working through the whole value chain

Few producers Quick wins implemented	Few producers Large remaining potential	Many producers Implementation very difficult	Chain of deciders Implementation very difficult	Big changes in mindset needed
Reduce CO_2 from clinker production	Reduce clinker in cement	Reduce cement in concrete	Reduce concrete in building	More efficient (re)use of buildings
• Efficient plants • Waste fuels • Alternate raw materials	• SCMs	• Aggregate grading • Good admixtures • Use filler		

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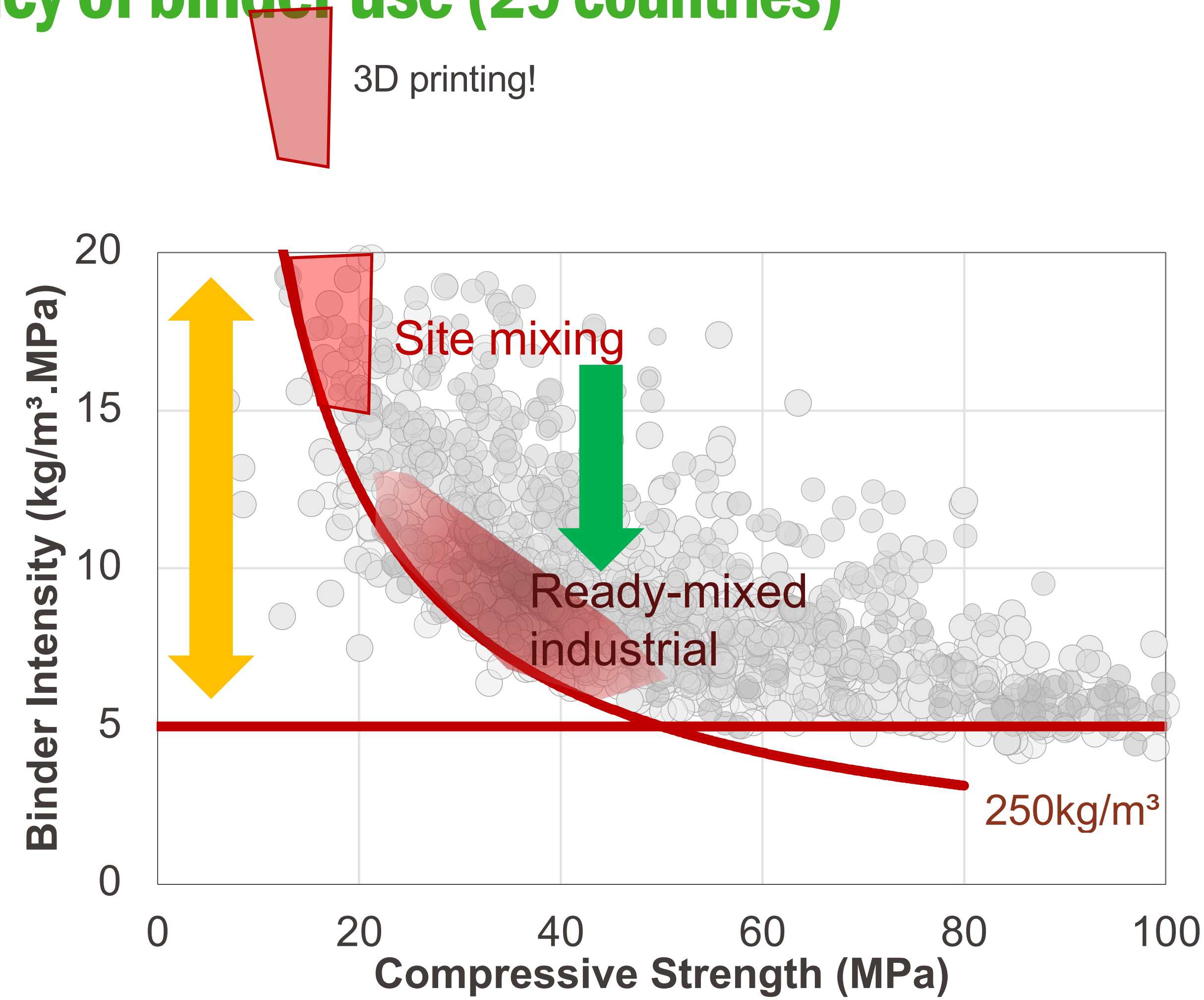
Efficiency of binder use (29 countries)



DAMINELI, et al. Measuring the eco-efficiency of cement use. **Cement and Concrete Composites**, 32, p. 555-562, 2010

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What are the blockages?

- **We have solutions:**
  - At cement level: LC3
  - At concrete level: use admixtures, aggregate grading
  - At structure level: lean design, stick to codes, do not over design

- **What are the barriers to implementation?**

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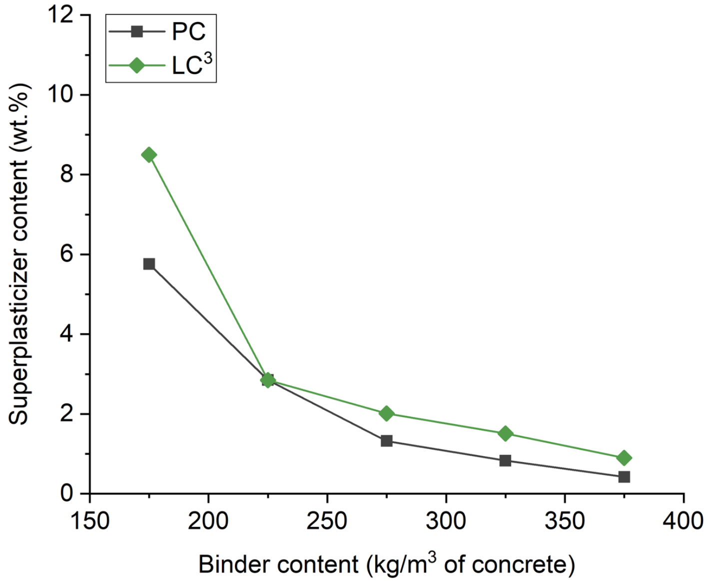
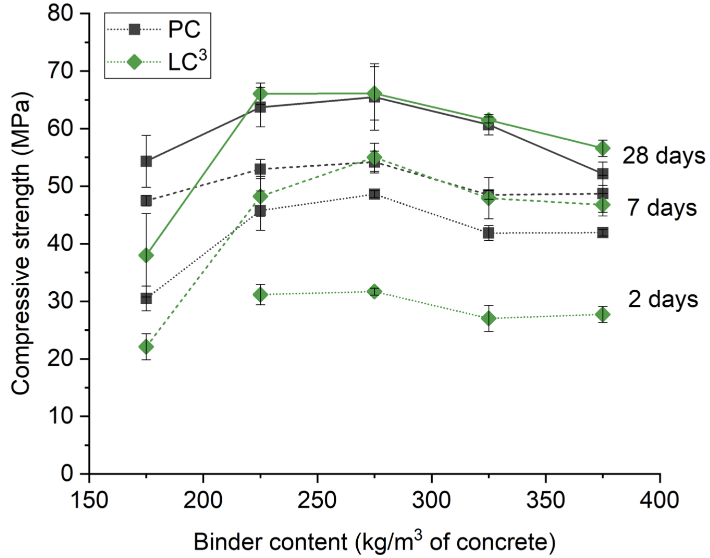
Cement level

- No time to do anything new
- Cannot find clays
- Need to some investment
- Lack of awareness: largest companies only make up 30% of market
- Allowed in codes and standards

Concrete level

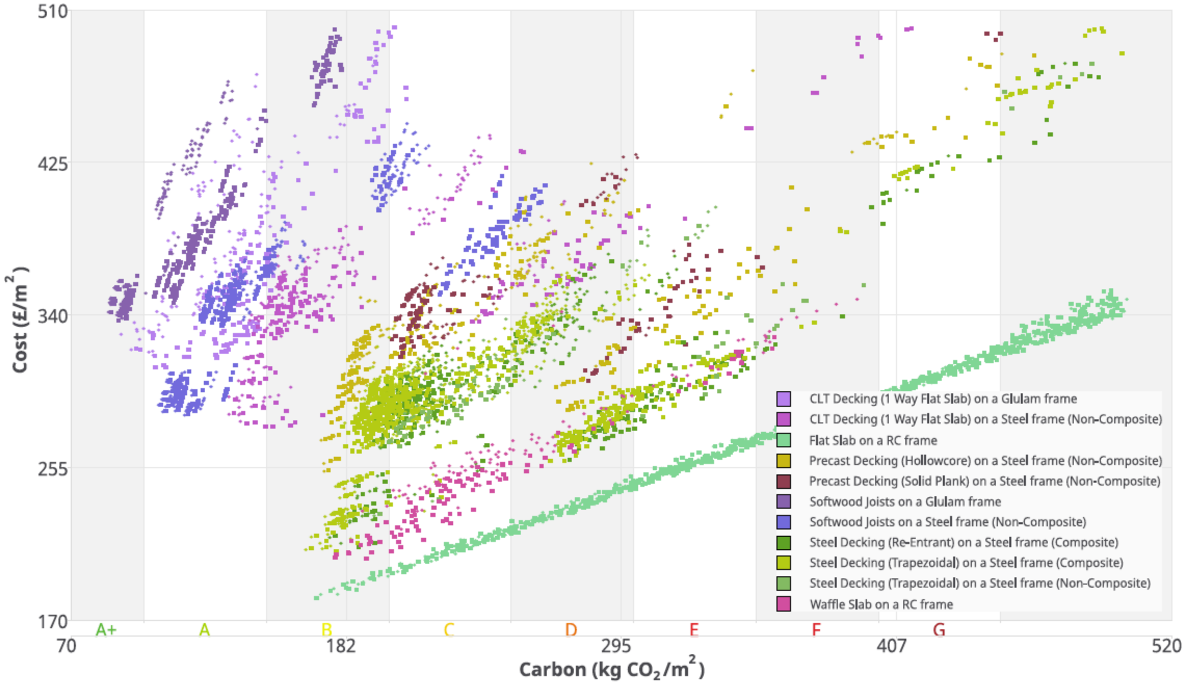
- Difficult to incentivise the v.large number of companies
- "we've always done it like that"
- Minimum cement content in codes from days before admixtures





Structure level

- An engineer's time costs more than extra concrete
- Paranoia about safety
- Difficulty to calculate and compare possibilities



Output of Panda software from Cyrille Dunant, University Cambridge

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Overall

- Thinking there are miracle alternatives
- Wasting time, effort and money on unscalable or ideas of dubious honesty

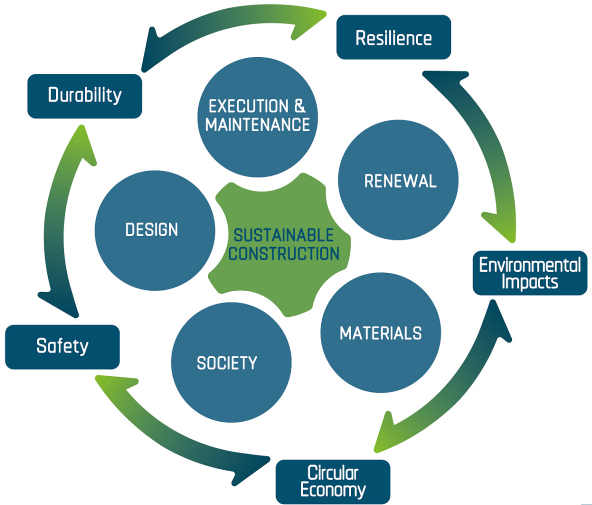
- Getting the different parts of the industry to work together

Recommending a new paradigm for the built environment

GLOBE

Global consensus on sustainability in the built environment

- High level policy advice
- More than 150 nations
- 5000+ experts
- 50+ years of expert networks
- Standards and guidelines
- Research and education
- Innovation



www.globe-consensus.com

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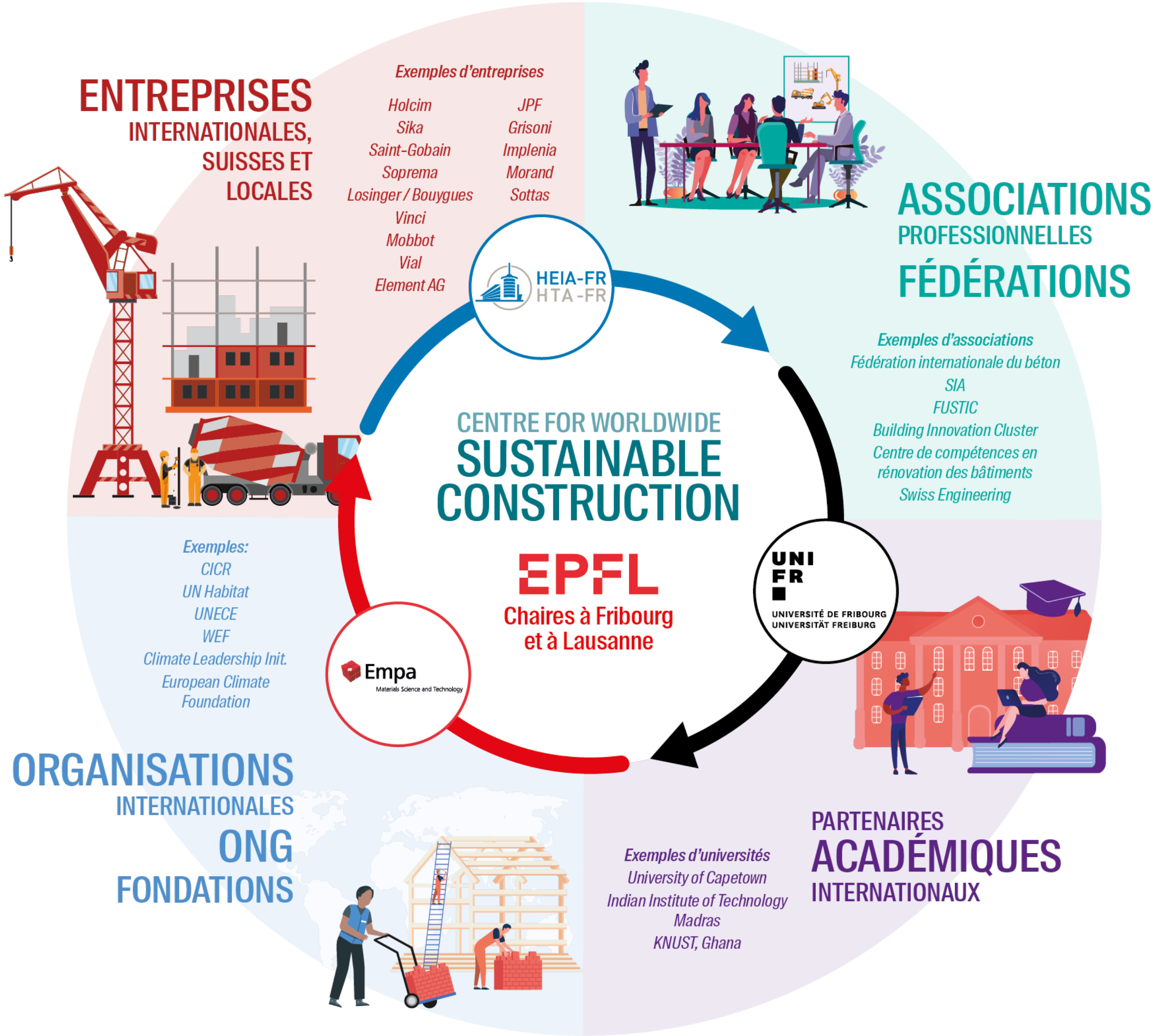
iass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Thank You

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