Sustainable Construction Summit
Lausanne 2025

Prof.

Karen Scrivener

Laboratory of Construction Materials, LMC, EPFL

Decarbonising construction

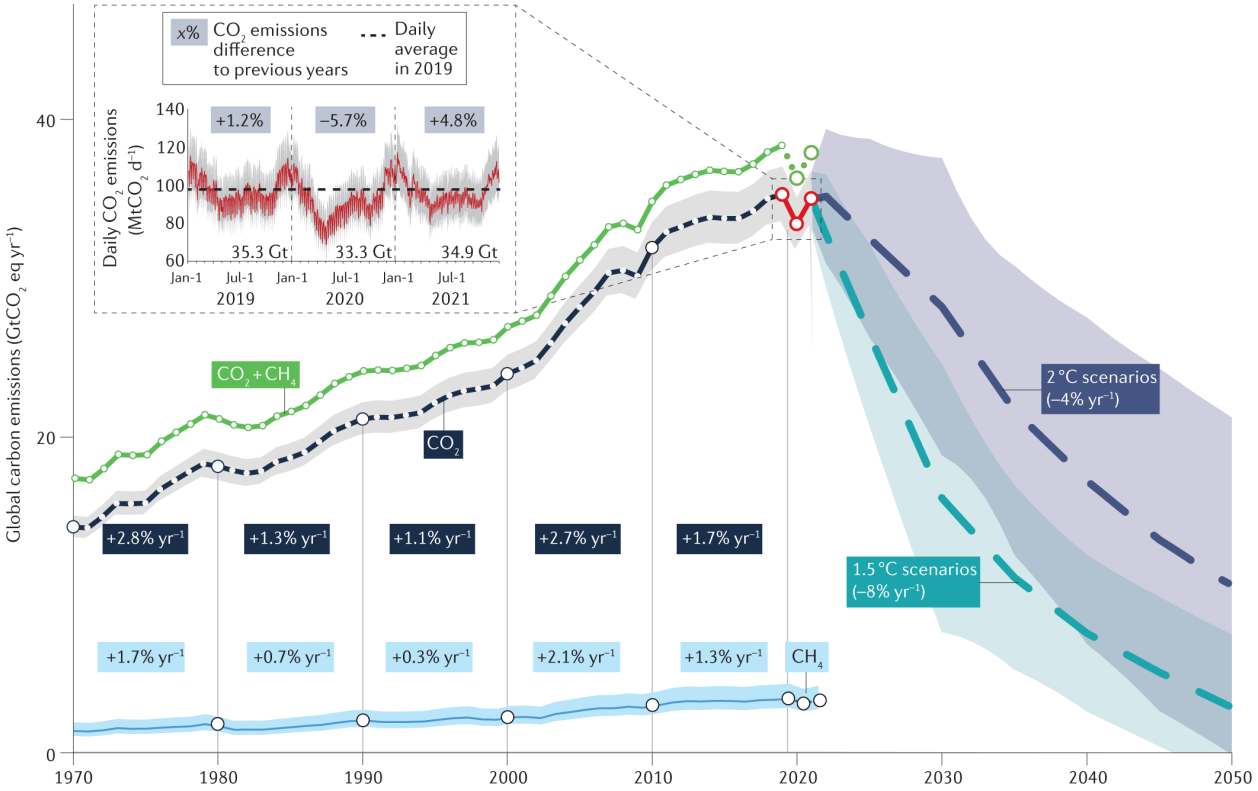
Karen Scrivener, FREng
EPFL
Switzerland

École
polytechnique
fédérale
de Lausanne

Putting effort where there are most potential gains

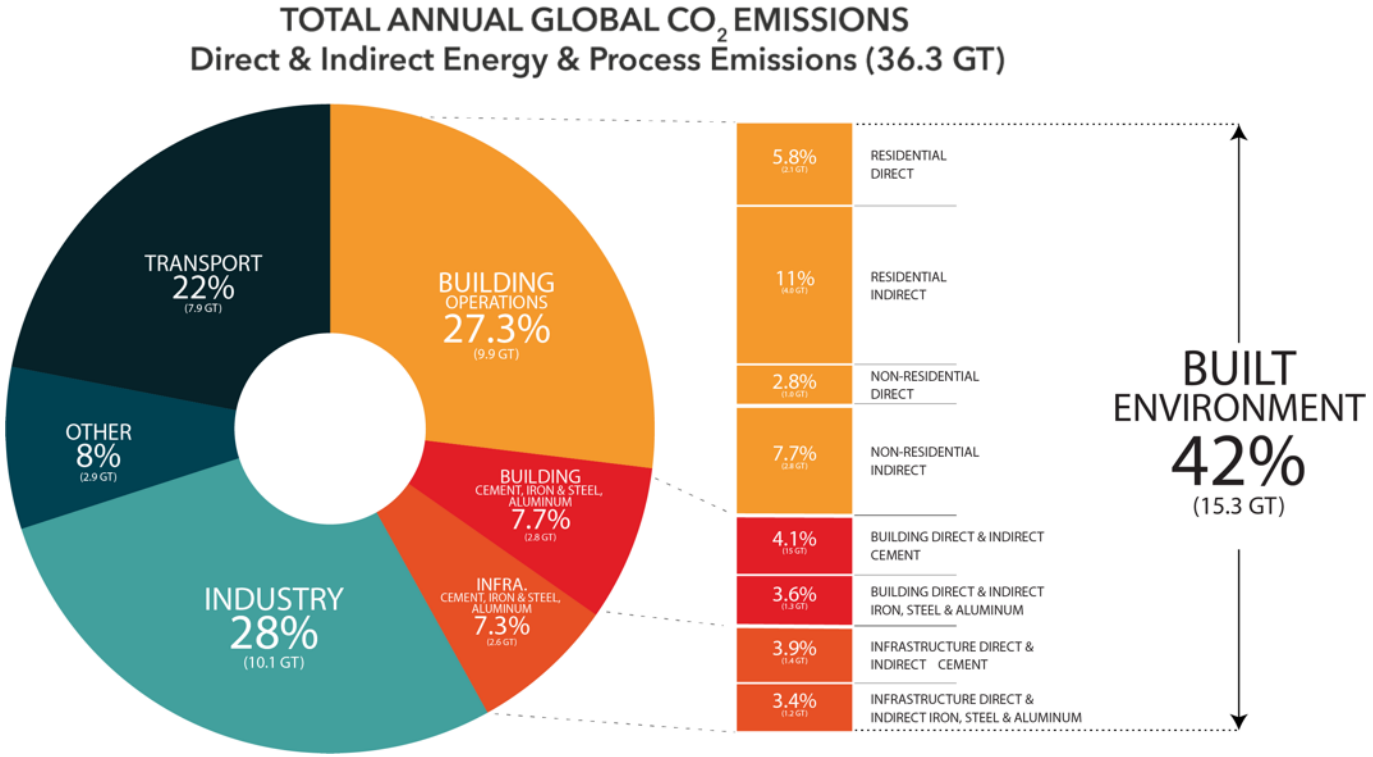
80/20 rule

Need to act fast

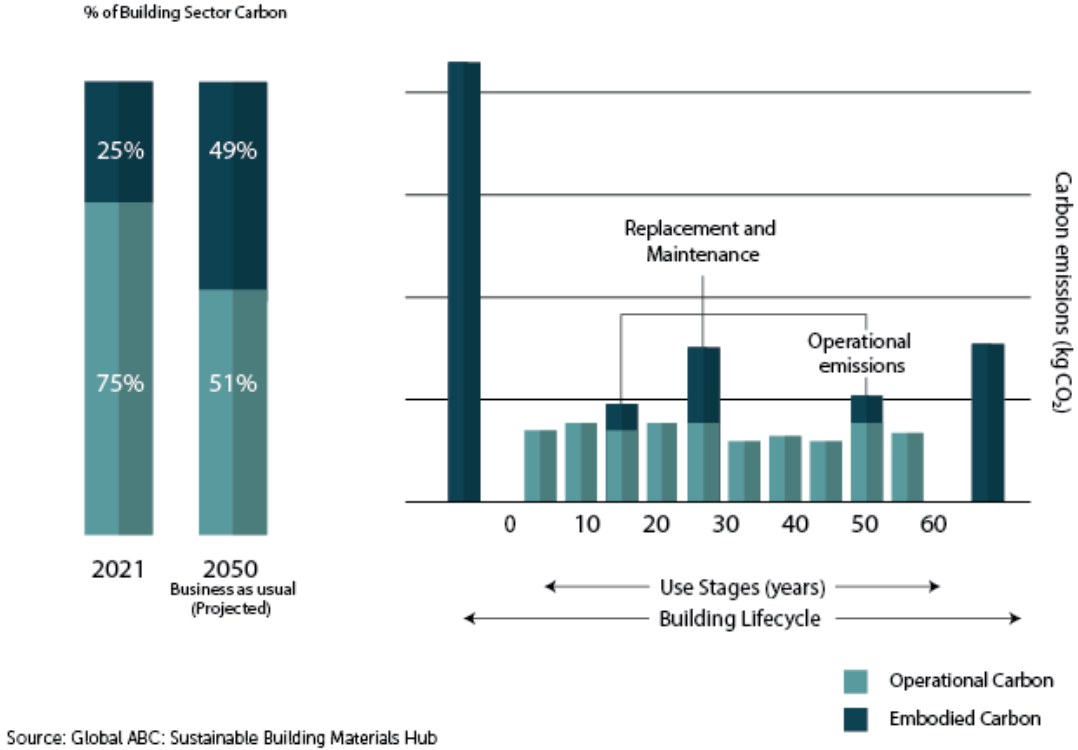


Liu et al. 2022. Nature Reviews Earth & Environment 3, 217-219

Embodied Carbon emissions is becoming the primary source of Carbon impact from buildings



Contribution from Emboddied is the most important to 2050



Source: Global ABC: Sustainable Building Materials Hub

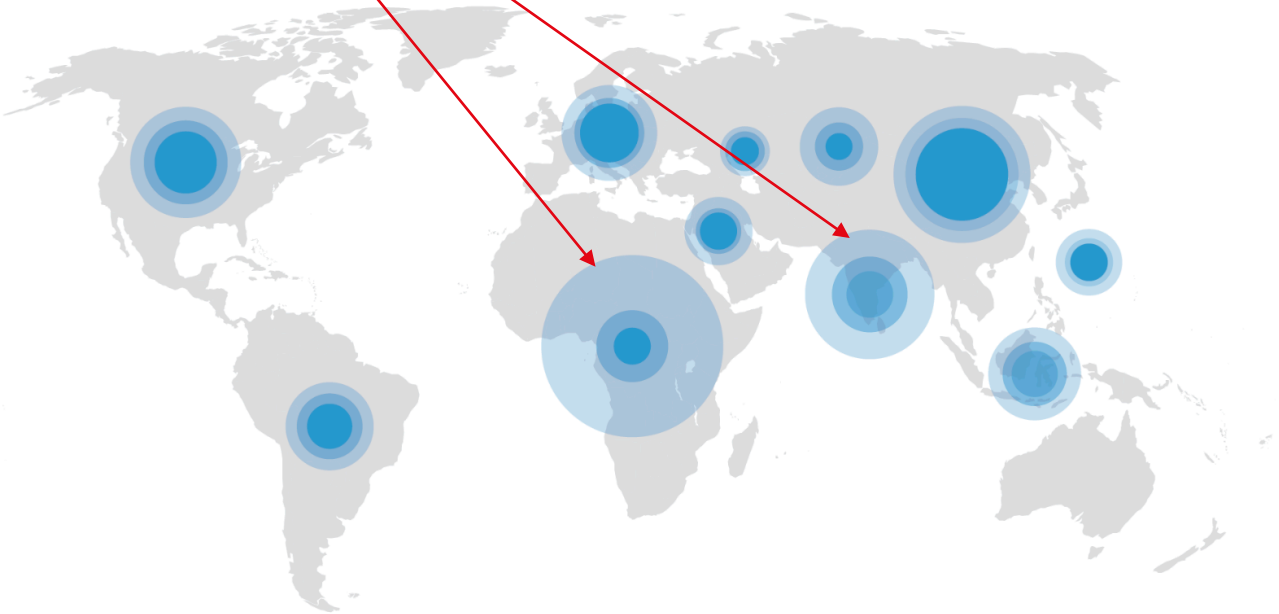
For NEW construction > 80% of emissions before 2050 will be from embodied: materials

Tomorrow....

This will **NOT HAPPEN** in the Global North

It will happen HERE:
>80% construction in global south

Global building floor area
is expected to **double** by 2060.

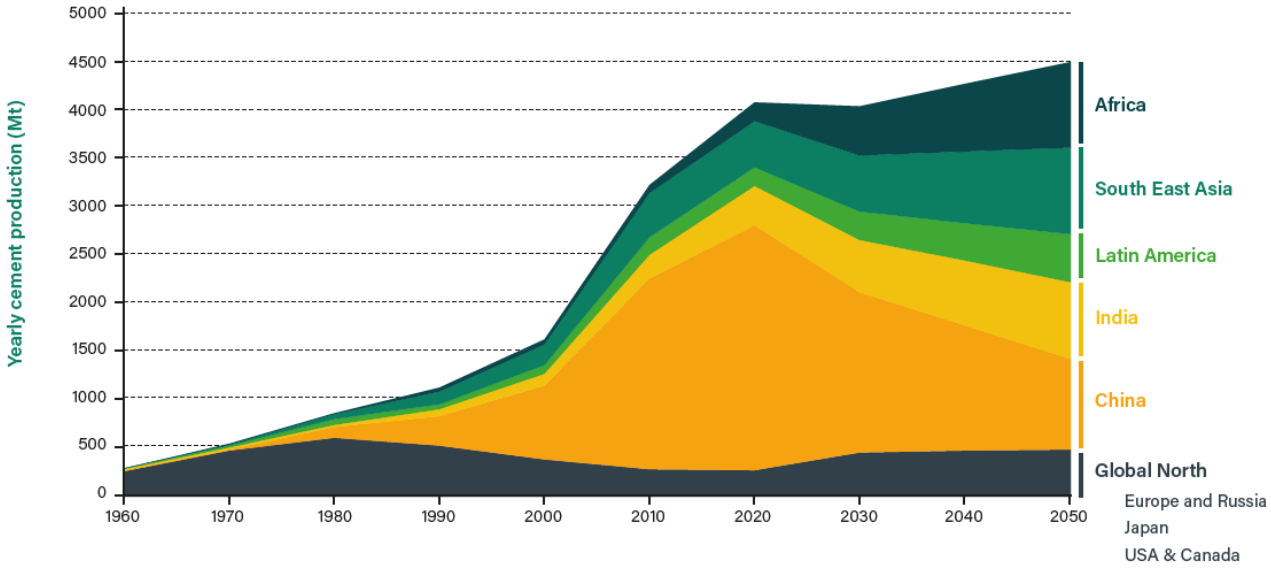


Data Sources: Global ABC, Global Status Report 2017

Changing pattern of cement use:

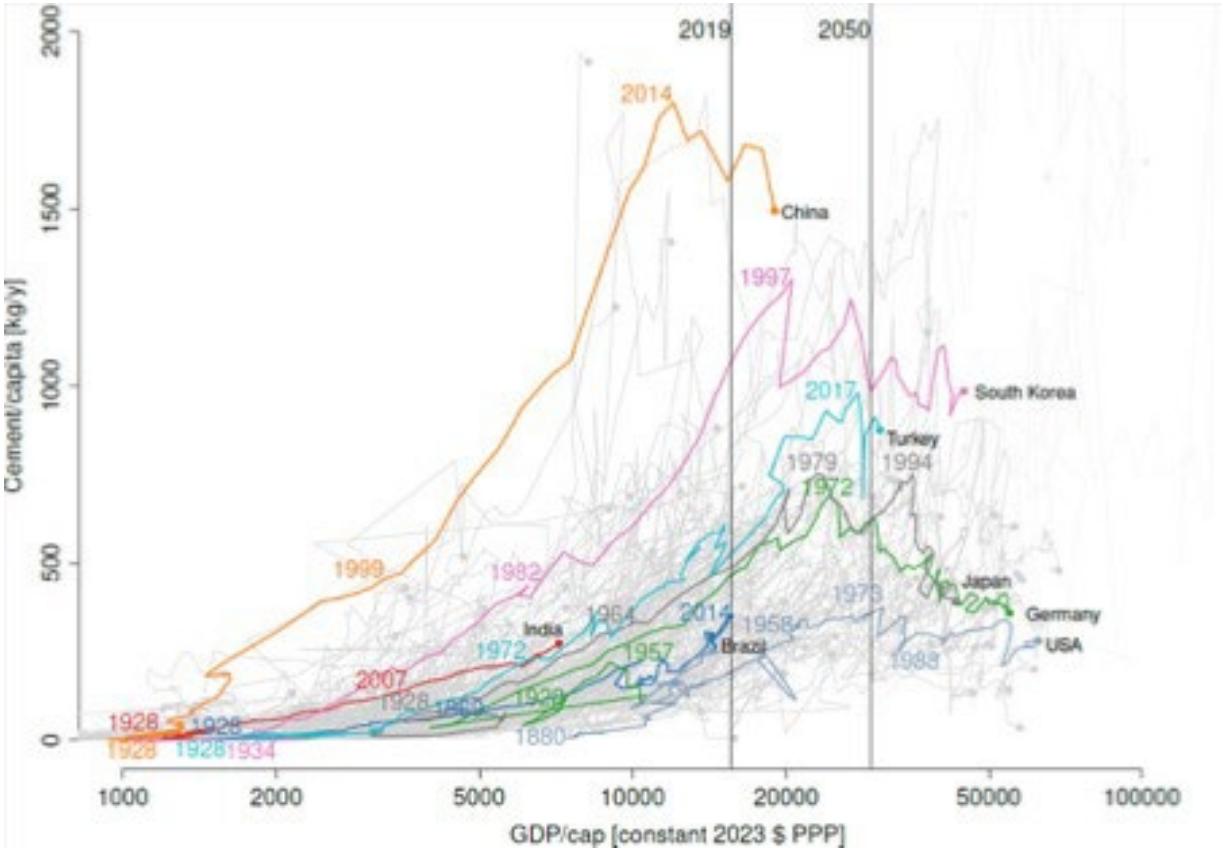
Cement based materials are more than two thirds of all construction

Historical and forecast cement supply per region



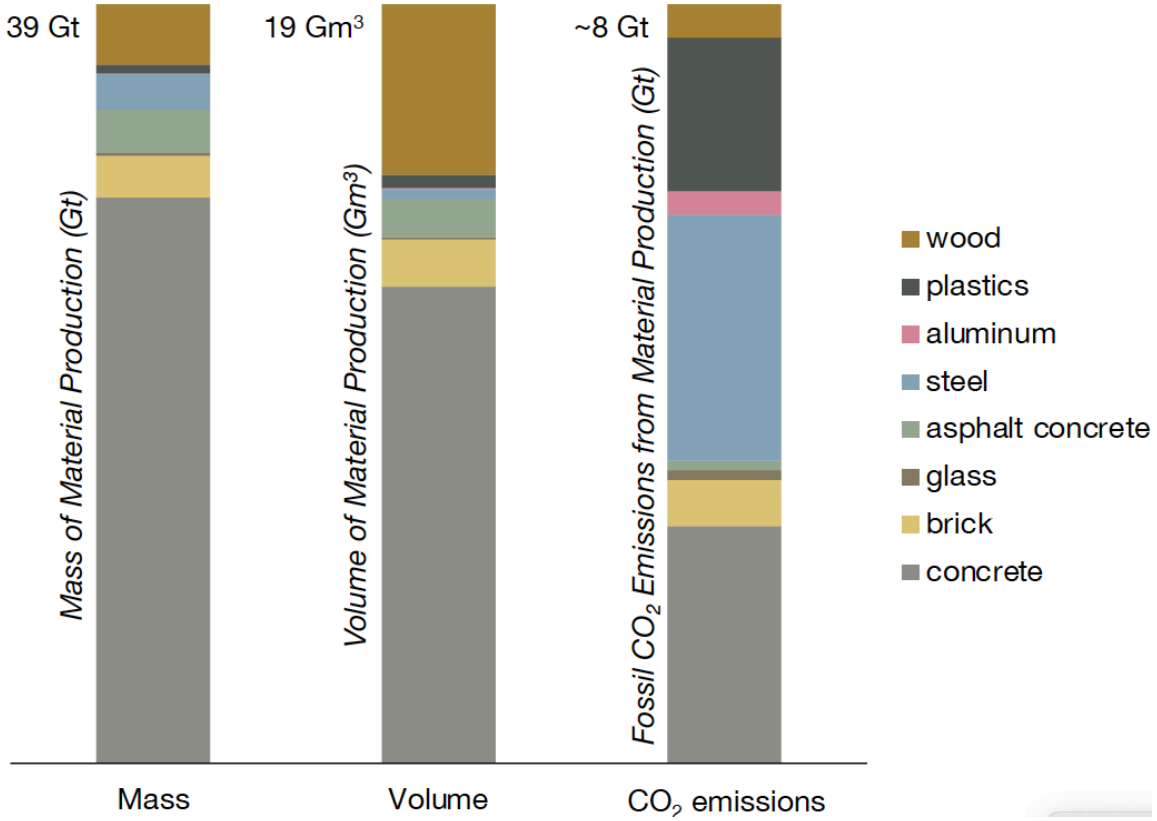
We need solutions for people in developing countries

Concrete "Hump" a normal phenomenon of growth



In China maybe 1000 out 1500 cement plants will close

World Use of materials:
about 90% by mass is in construction



Nearly **80%** of materals are based on cement

- > 80% of emissions from new buildings before 2050 will be ***emboddied***
- > 80% in global south
- ~ 80% materials based on cement

- No realistic alternative

- But 80% of reduction possible at low or negative cost

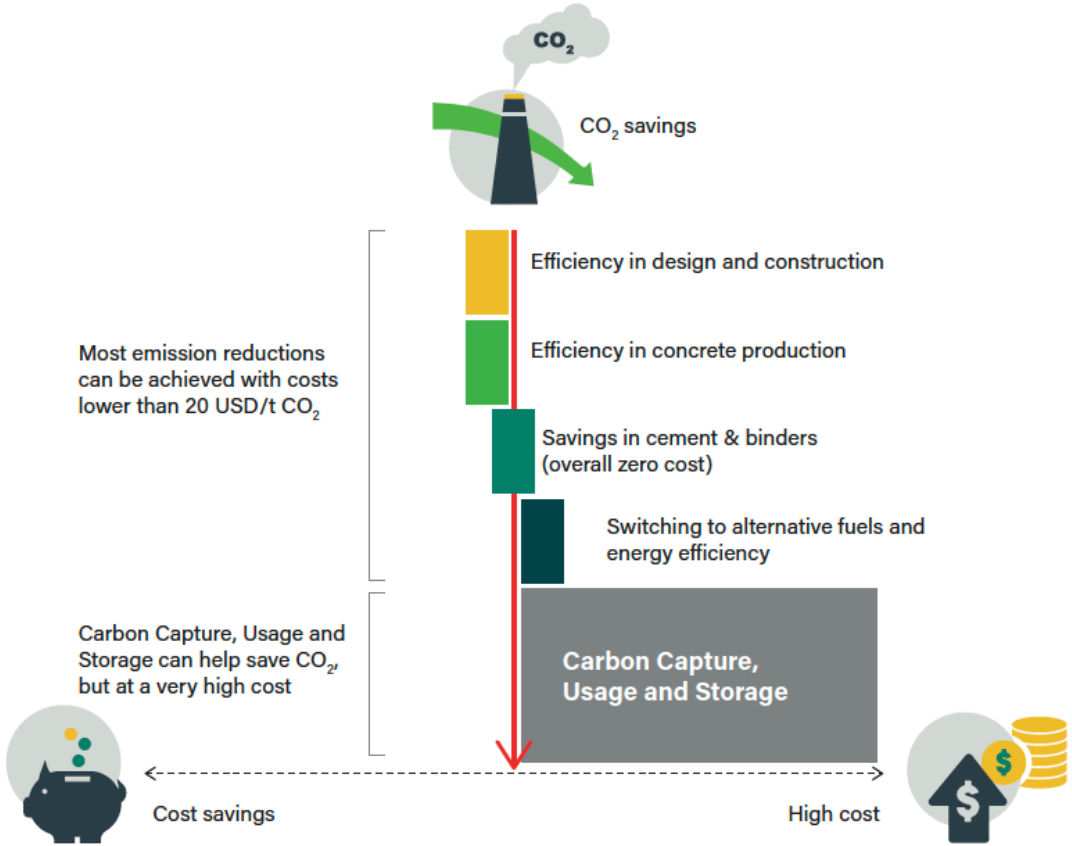
No silver bullet

Despite the media interest they attract, most niche technologies – such as alkali activated materials, cement from algae, etc are:

- impractical,
- costly,
- unscalable,
- will take too long to mature

so have little to no possibility of delivering any significant impact.

Much of the path to net zero is low cost



We can do a lot if we act through the value chain

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		RECYCLE!

nature communications

Article

https://doi.org/10.1038/s41467-023-40302-0

Near-term pathways for decarbonizing global concrete production

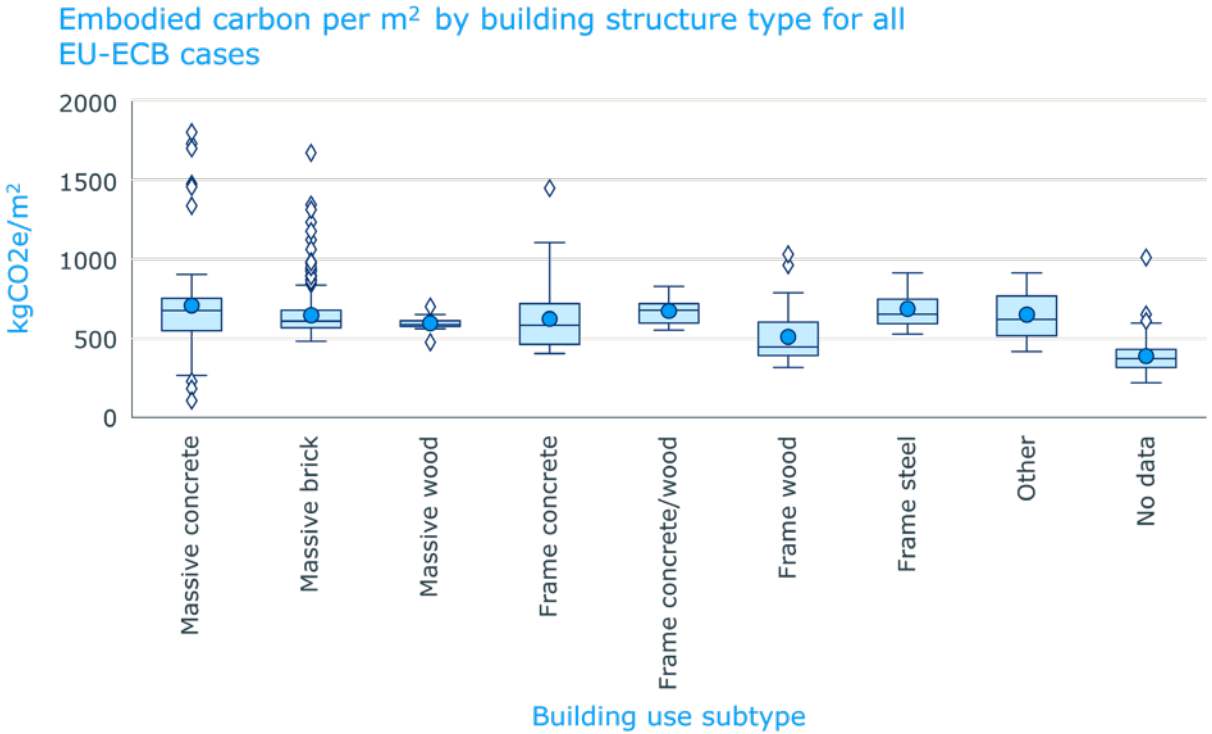
Received: 27 January 2023

Accepted: 21 July 2023

Josefine A. Olsson [1], Sabbie A. Miller [1] ✉ & Mark G. Alexander [2]

Calculated **76%** with these strategies

Need for metrics in applications: GBDI



Global Building Data Initiaive

GBDI

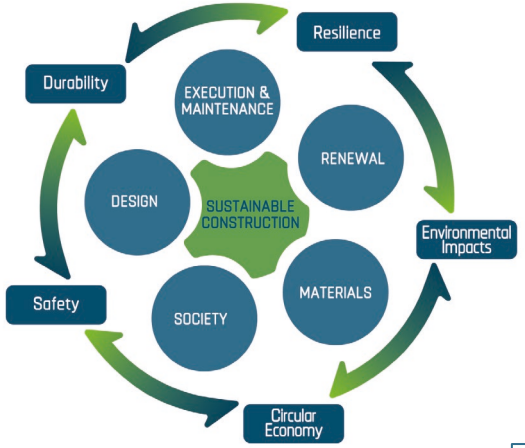
- Röck M, Sørensen A, Tozan B, Steinmann J, Le Den X, Horup L H, Birgisdottir H, Towards EU embodied carbon benchmarks for buildings – Setting the baseline: A bottom-up approach, 2022, https://doi.org/10.5281/zenodo.5895051.

To realise these gains the industry needs to work together

GLOBE

Global consensus on sustainability in the built environment

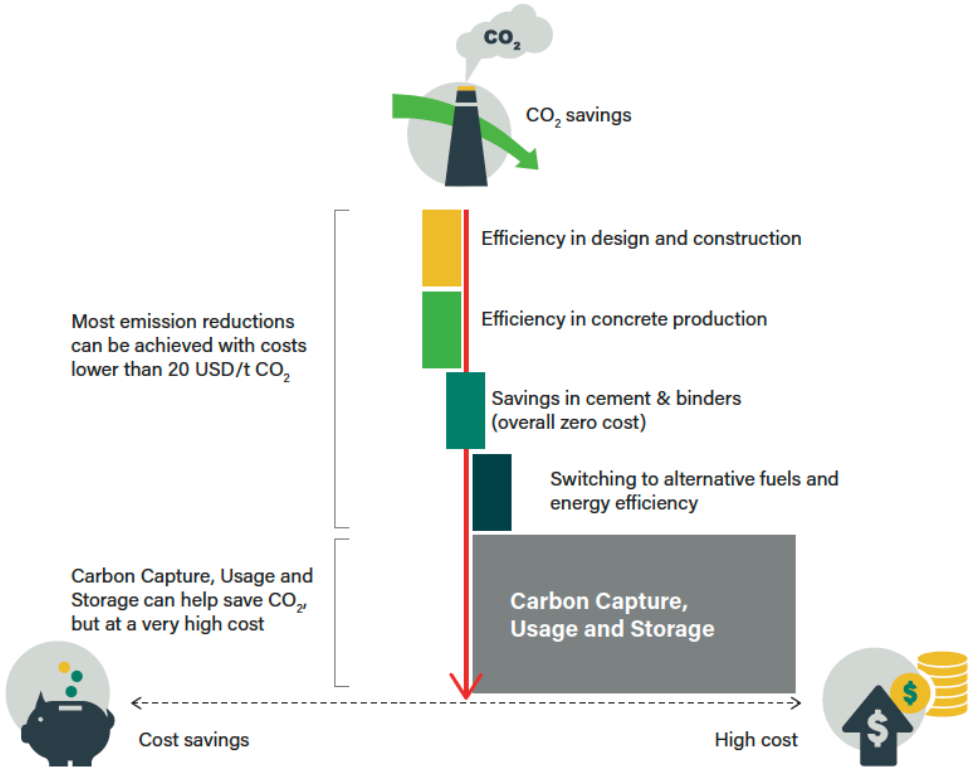
- High level policy advice
- More than 150 nations
- 5000+ experts
- 50+ years of expert networks
- Standards and guidelines
- Research and education
- Innovation



www.globe-consensus.com

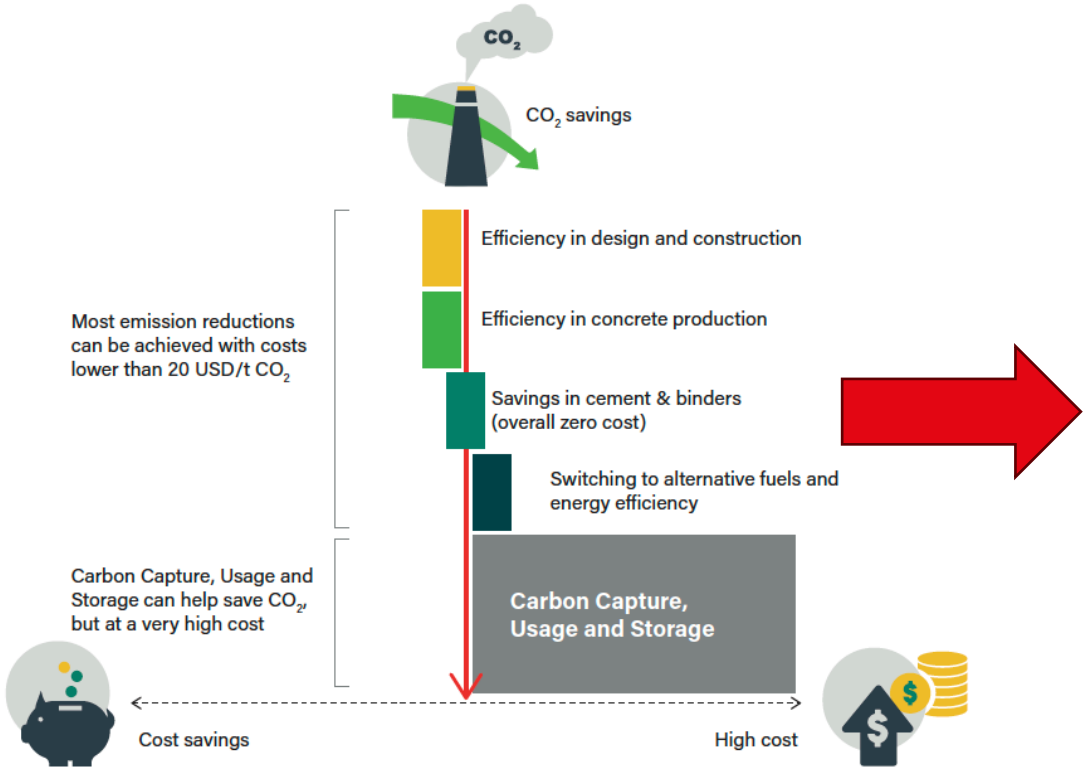
See on-line presentation from COP28 for more details

70-80% possible at low or negative cost. Remainder will need CCUS



CCUS will increase cost of producing clinker 2-4 times

Reducing clinker factor is the most practical to implement



Roadmaps in Africa

Tanzania first roadmap

PRESENTATION

The cement industry is at a turning point in its history, with a common vision of achieving carbon neutrality by 2050 and continuing to contribute to the development and climate resilience required in our countries. This document expresses the contribution of the Tanzanian

This Roadmap for the Tanzanian Cement Industry is aligned with the global cement and concrete decarbonization trajectories developed by GCCA and represents the sector's contribution to preventing the Earth's temperature from rising by more than 1.5°C compared to the pre-

The Road to Net Zero 2050 for the Tanzanian cement industry

This Roadmap, as indicated above, was developed based on the GCCA Net Zero Cement & Concrete 2050 Roadmap Accelerator Program.

Total CO_2 emissions from the Tanzanian cement industry reached 4.9 $mTCO_2$ in 2022. It is expected to increase 4.2 x (17.8 $mTCO_2$) by 2050 following increased cement consumption if no mitigation actions are taken.

Reduction of clinker content in cement, the most significant mitigation lever, can reduce up to 4.4 $mTCO_2$ by 2050 which represents 25% of the total emissions to be abated.. But achieving this target will depend on a certain number of Policy Enablers to be implemented by the Tanzanian Authorities.

The emissions that could not be abated through immediately available measures will represent 9.2 $mTCO_2$ by 2050 (51% of the total emissions). This number is in line with most Global Soth countries. Potential mitigation levers to abate these remaining emissions could be for example:

- Higher impact of traditional levers
- New technology improvement like electrification of kilns, use of green hydrogen, etc.
- Carbon Capture Usage or Storage (CCUS).

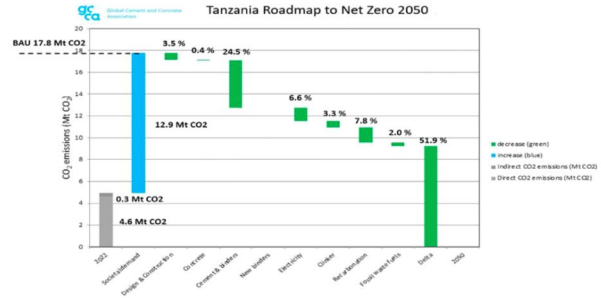
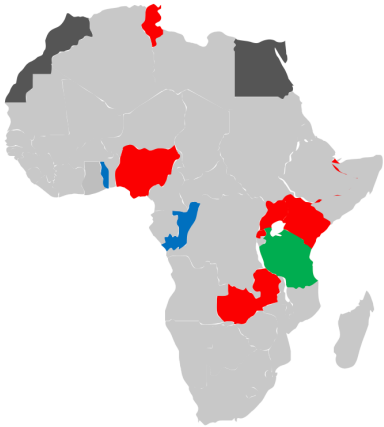


Figure 7: Impact of the different levers to 2050

Tanzania Net Zero Accelerator Roadmap 16

More to come



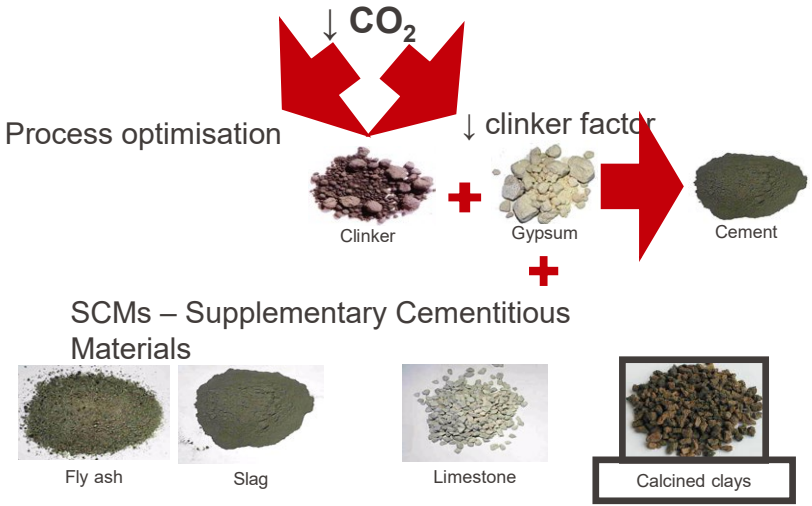
Finished and published Roadmaps

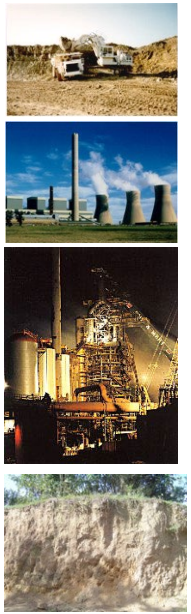
Initiated Roadmaps

Roadmaps U Discussion

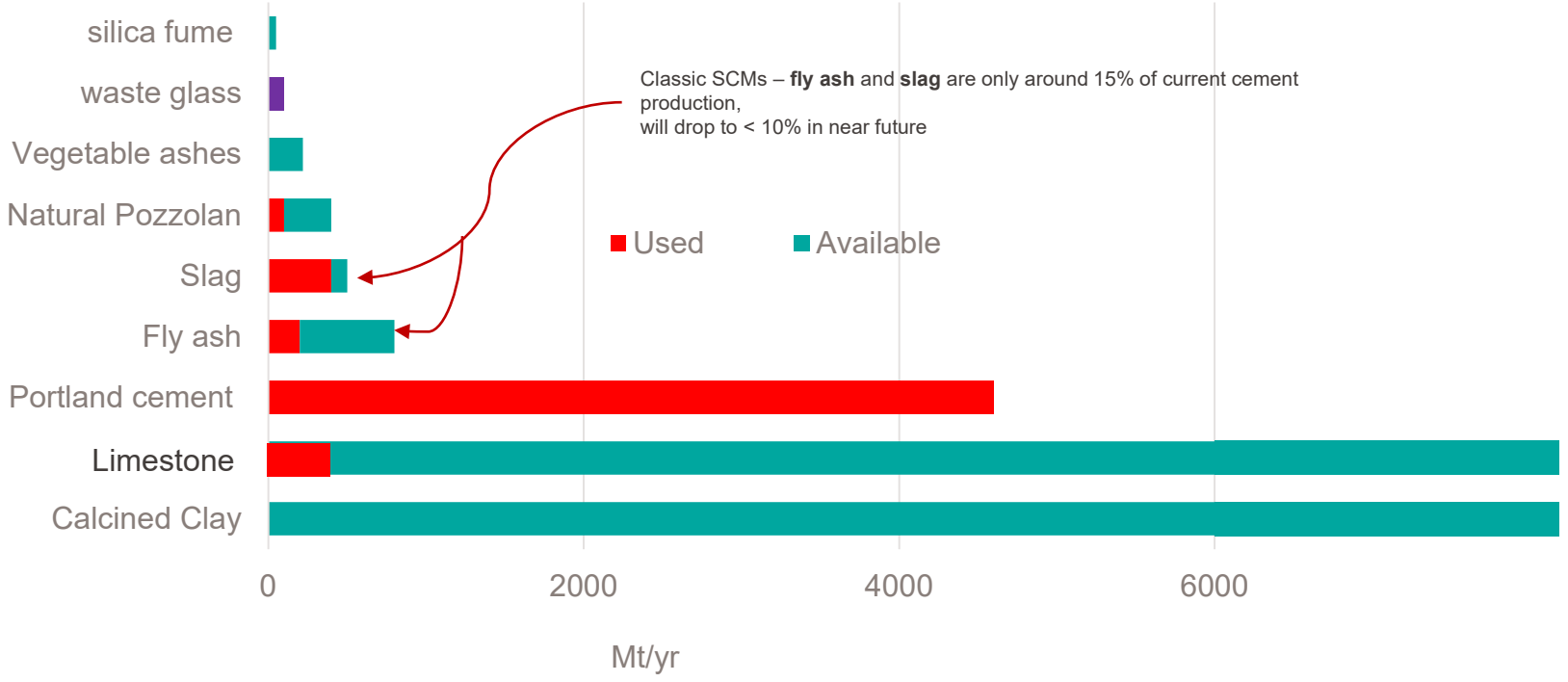
~80% of accessible reduction from clinker substitution

Most promising approach – reducing the clinker factor

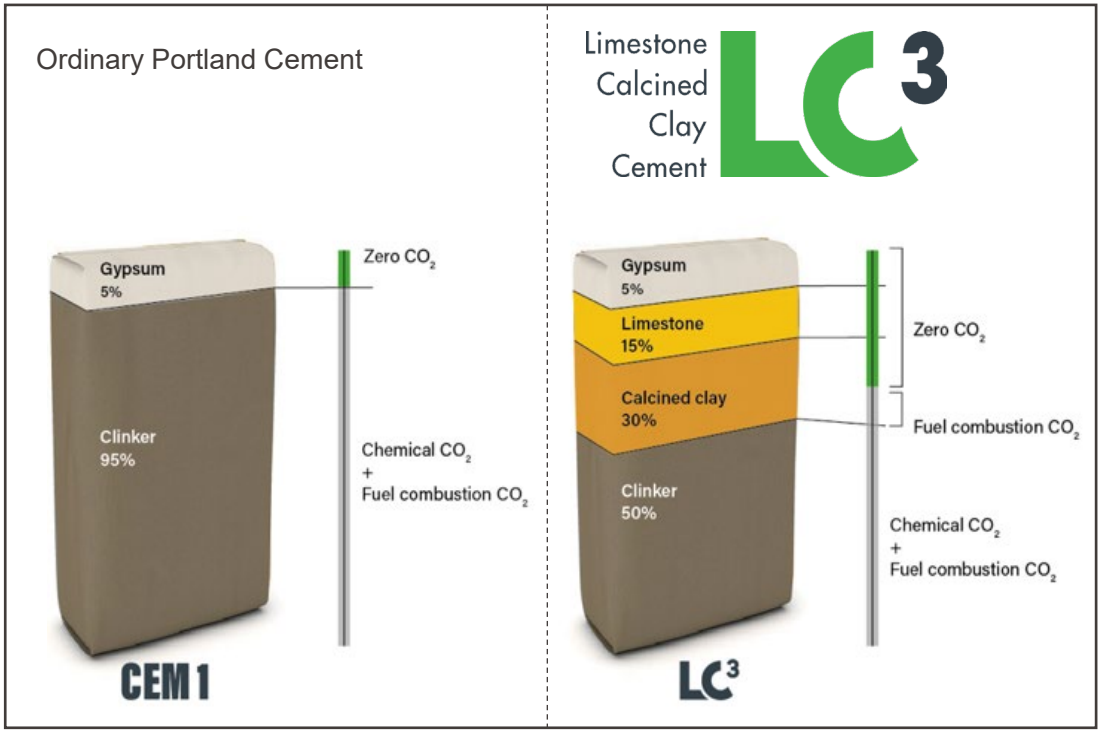




Availability of SCMs

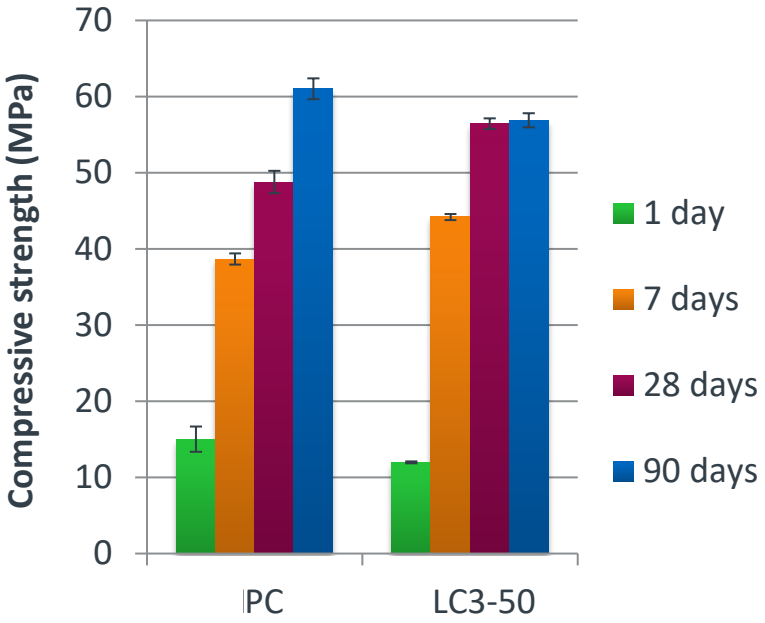


LC^3 – Limestone Calcined Clay Cement



- LC^3 is a **low-carbon** blended cement type
- **Reduces CO_2 emissions in cement by 40%**

LC^3 has comparable strength to OPC

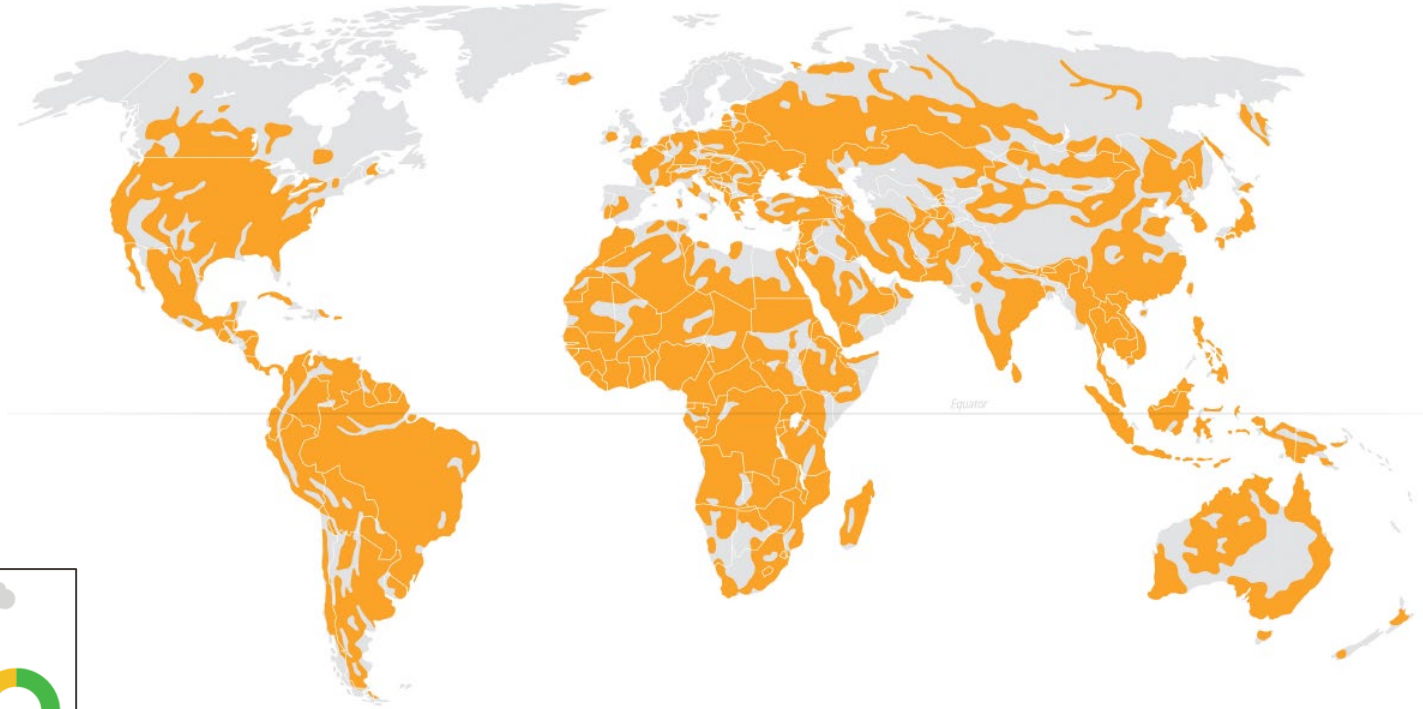


LC3-50 = 50% clinker.

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

HIGH PERFORMANCE

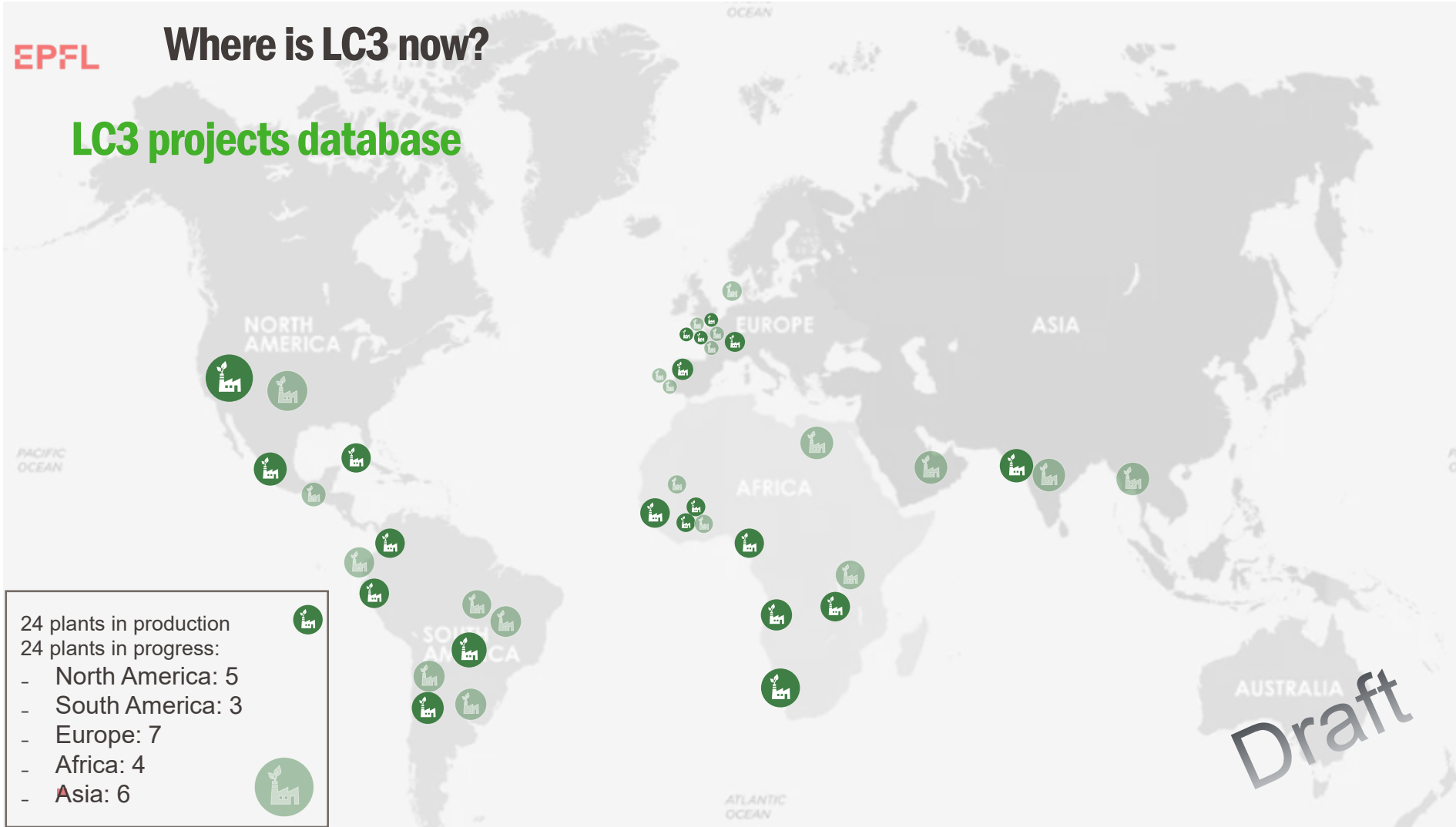
World distribution of kaolinitic clays



Source: Ito and Wagai, Scientific data 2017

Where is LC3 now?

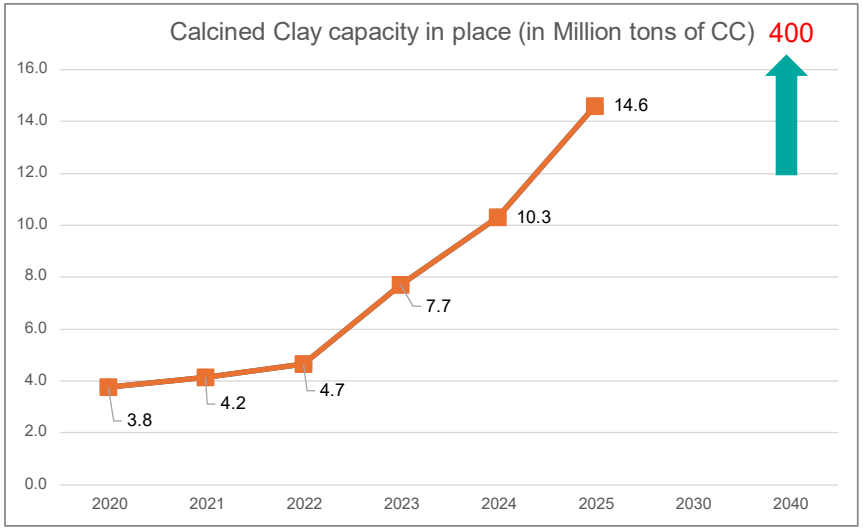
LC3 projects database

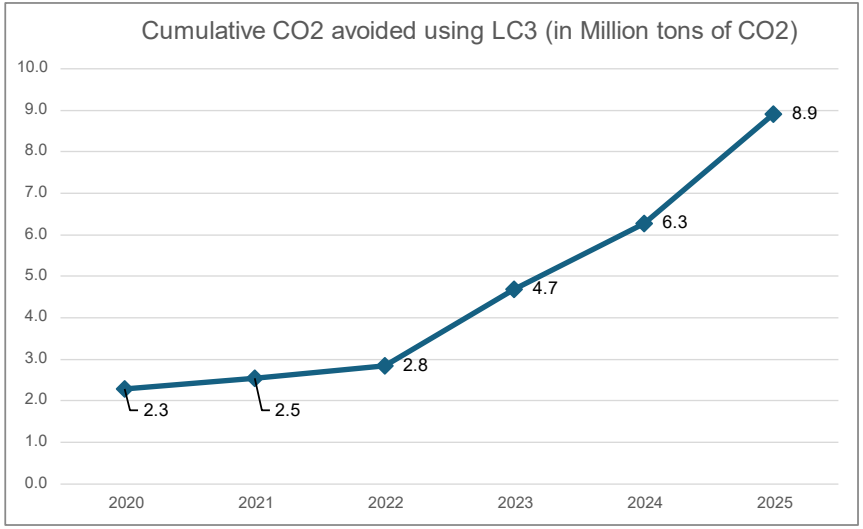


24 plants in production
24 plants in progress:

- North America: 5
- South America: 3
- Europe: 7
- Africa: 4
- Asia: 6

Capacity development and cumulative Co2 savings





By 2040, the goal of achieving one-third of global cement production with LC3 would require reaching a calcined clay production capacity of 400 million tons, which means an increase of 25 million tons annually.

Constructions with LC3 materials

2014 ⟹ 2024

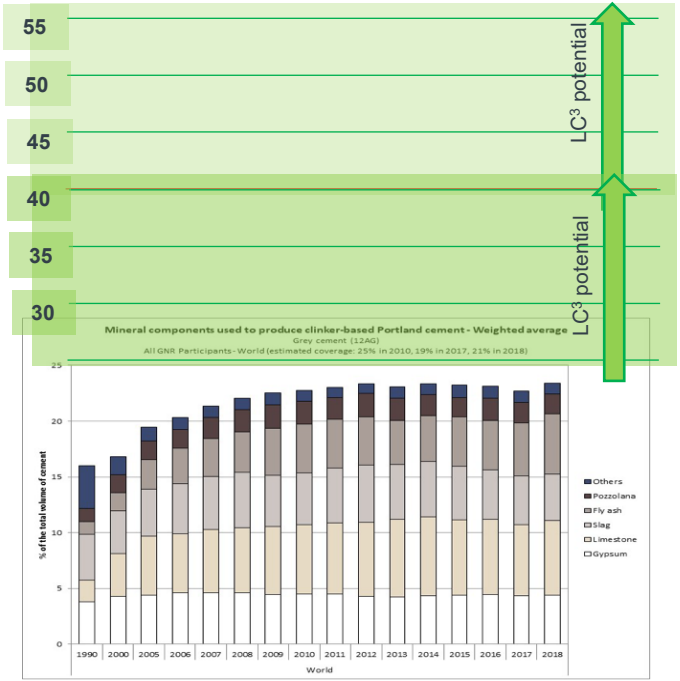
Colombia

Switzerland

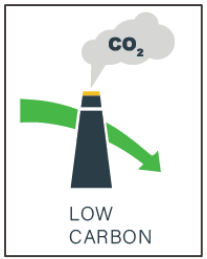
Rolex campus in planning

World Potential?

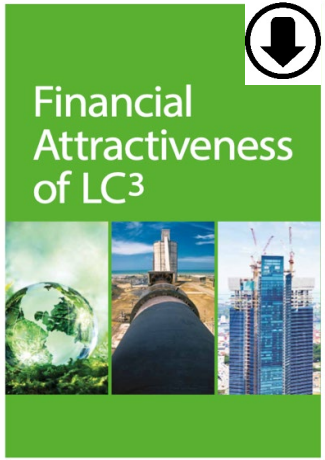
Calcined Clay only SCM which can expand substitution



- ✓ 800 million tonnes CO_2/yr
- ✓ 400 million tonnes CO_2/yr



Financial Feasibility

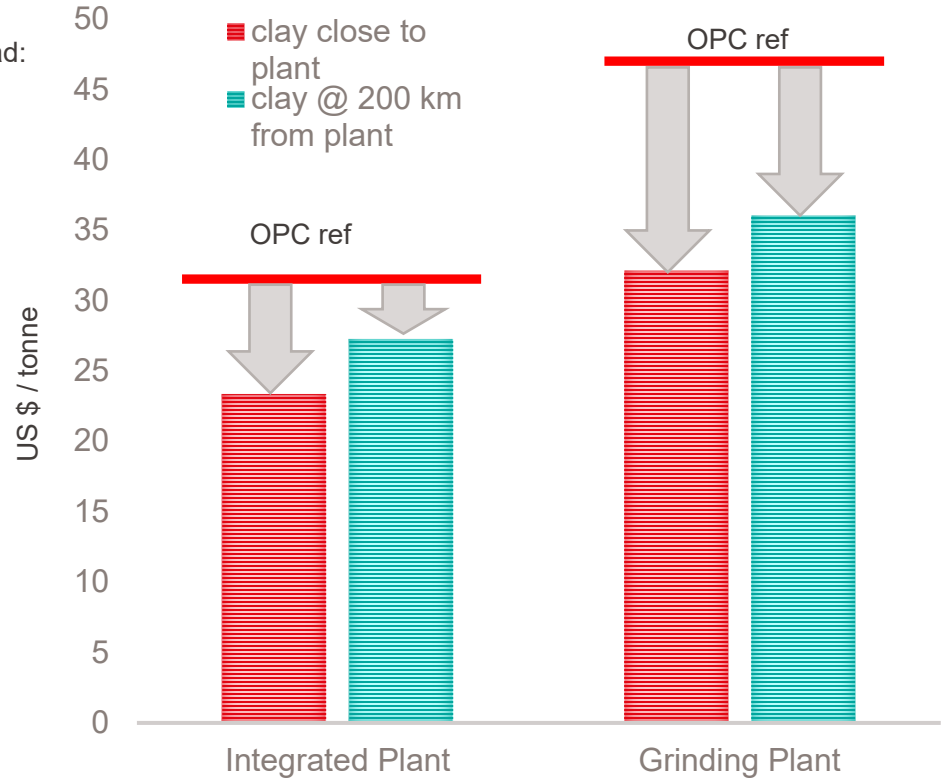


Report available to download:
www.lc3.ch

Study by LC3 Project partner

CEMENTIS

LOW CAPITAL

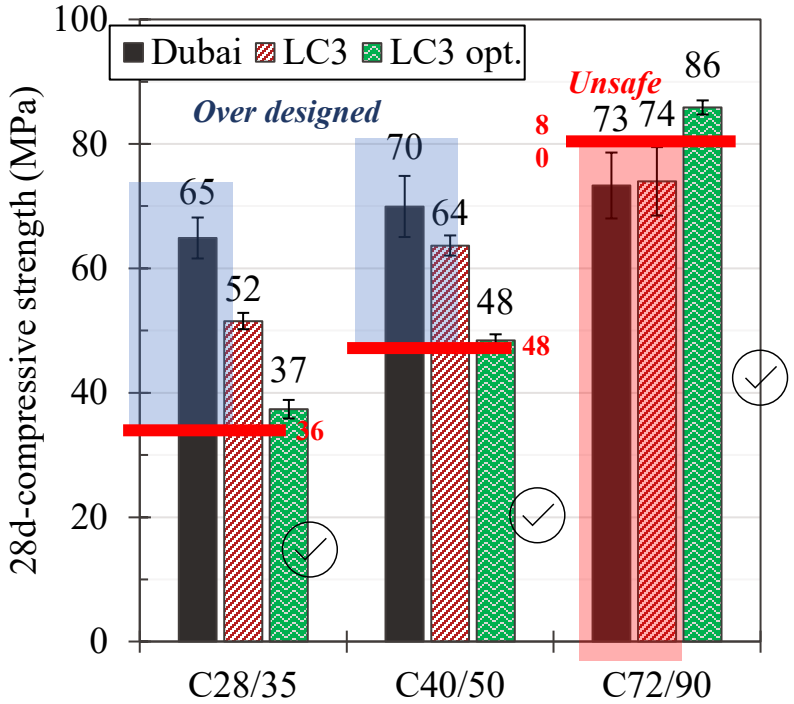


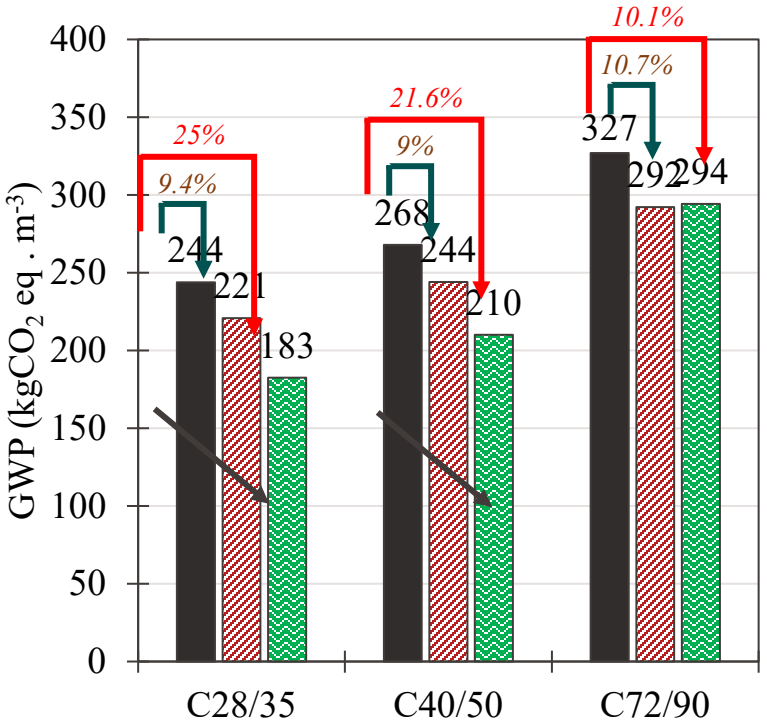
High performance:

Comparison of LC^3 concrete with concretes prescribed in Dubai

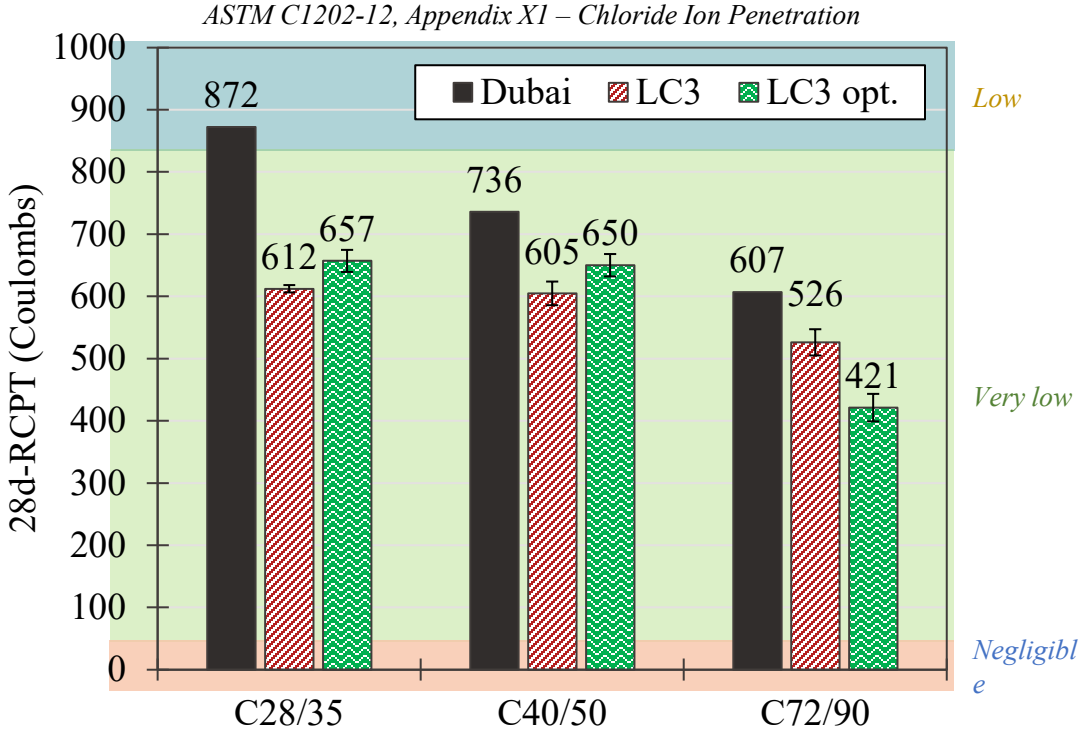
Strength class	C28/35			C40/50			C72/90		
Materials (kg/m³)	Dubai	LC^3	LC^3 opt.	Dubai	LC^3	LC^3 opt.	Dubai	LC^3	LC^3 opt.
Total binder	**380**	**380**	**325**	**420**	**420**	**375**	**510**	**510**	**510**
GGBS ratio	36%			36%			26%		
SF ratio		55kg (*15%*)			45kg (*11%*)		8%		
w/b ratio	**0.42**	**0.42**	**0.61**	**0.36**	**0.36**	**0.48**	**0.29**	**0.29**	**0.26**
SP (%)	0.50	1.56	0.20	0.50	1.97	0.50	0.75	1.97	2.50
Slump test (mm)	10	-	**100**	10	-	**75**	10	-	**10**

Compressive strength and GWP





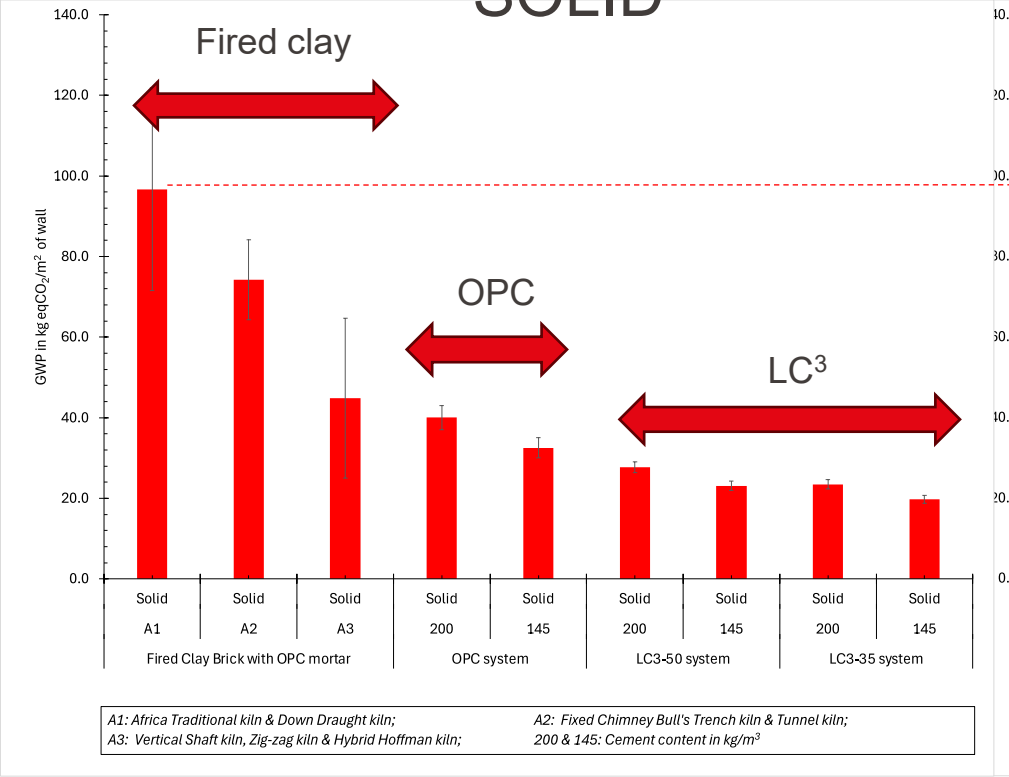
Chloride transport



Materials for the informal sector

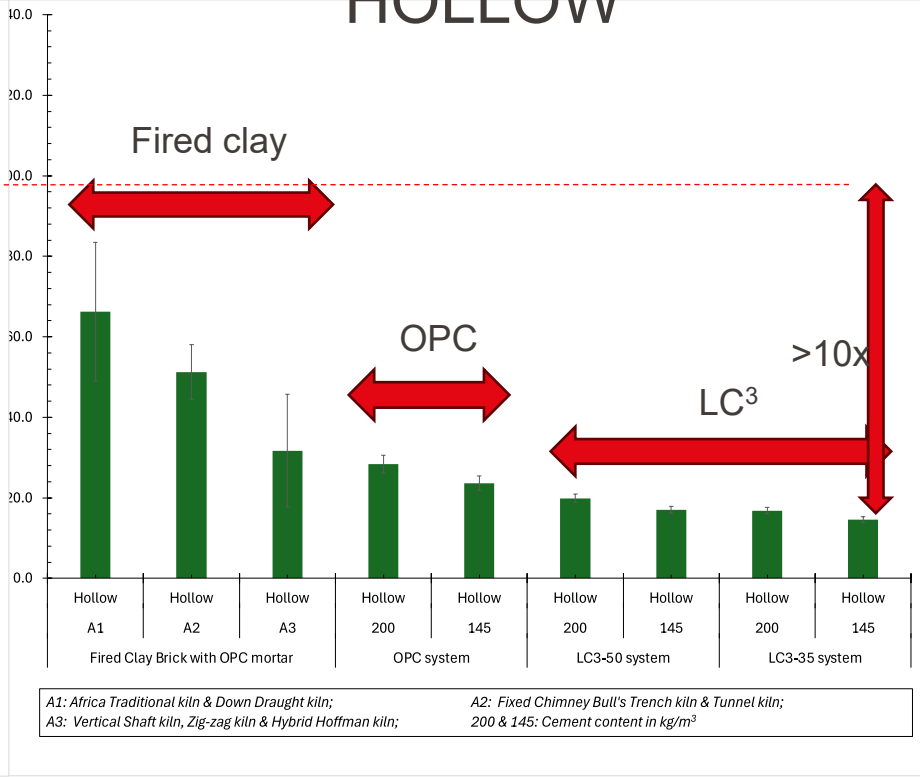
Concrete blocks

SOLID



A1: Africa Traditional kiln & Down Draught kiln; *A2: Fixed Chimney Bull's Trench kiln & Tunnel kiln;*
A3: Vertical Shaft kiln, Zig-zag kiln & Hybrid Hoffman kiln; *200 & 145: Cement content in kg/m³*

HOLLOW



A1: Africa Traditional kiln & Down Draught kiln; *A2: Fixed Chimney Bull's Trench kiln & Tunnel kiln;*
A3: Vertical Shaft kiln, Zig-zag kiln & Hybrid Hoffman kiln; *200 & 145: Cement content in kg/m³*

Concluding remarks

- ✓ Substantial reductions – **up to 80%** - in CO_2 are possible
  - ✓ At cement level by increasing SCM substitution
  - ✓ At concrete level by minimising cement content
  - ✓ At structure level

- ✓ All of the above will also lower cost

- ✓ Remainder CO_2 can only be dealt with by carbon capture and storage at a high cost, infrastructure not in place.

- ✓ Calcined clays are the only realistic option for extending the use SCMs

- ✓ Can be done FAST and at SCALE
- ✓ 500 million tonnes / year reduction by 2040

Thank You

Karen Scrivener

École
polytechnique
fédérale
de Lausanne