

The complexity of introducing a novel cement in the context of Climate Change mitigation

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Universidad Central de las Villas

Global Partnership for Sustainable Construction and Resource Efficiency



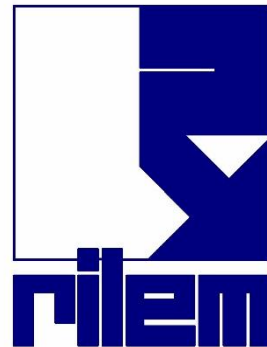
Affiliation



Professor and Director of CIDEM
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Chair of the Technical Committee
TC 282-CCL – Calcined Clays as
Supplementary Cementitious Materials

Collaboration with Prof. Karen Scrivener and LC3 Project

2005-2008
SDC-SNSF Project
*Calcined clays for
pozzolans*



2009-2012
SDC-SNSF Project
*Ternary blend cement
calcined clay-limestone*



2013-2022
SDC-Climate Change
Low Carbon Cement

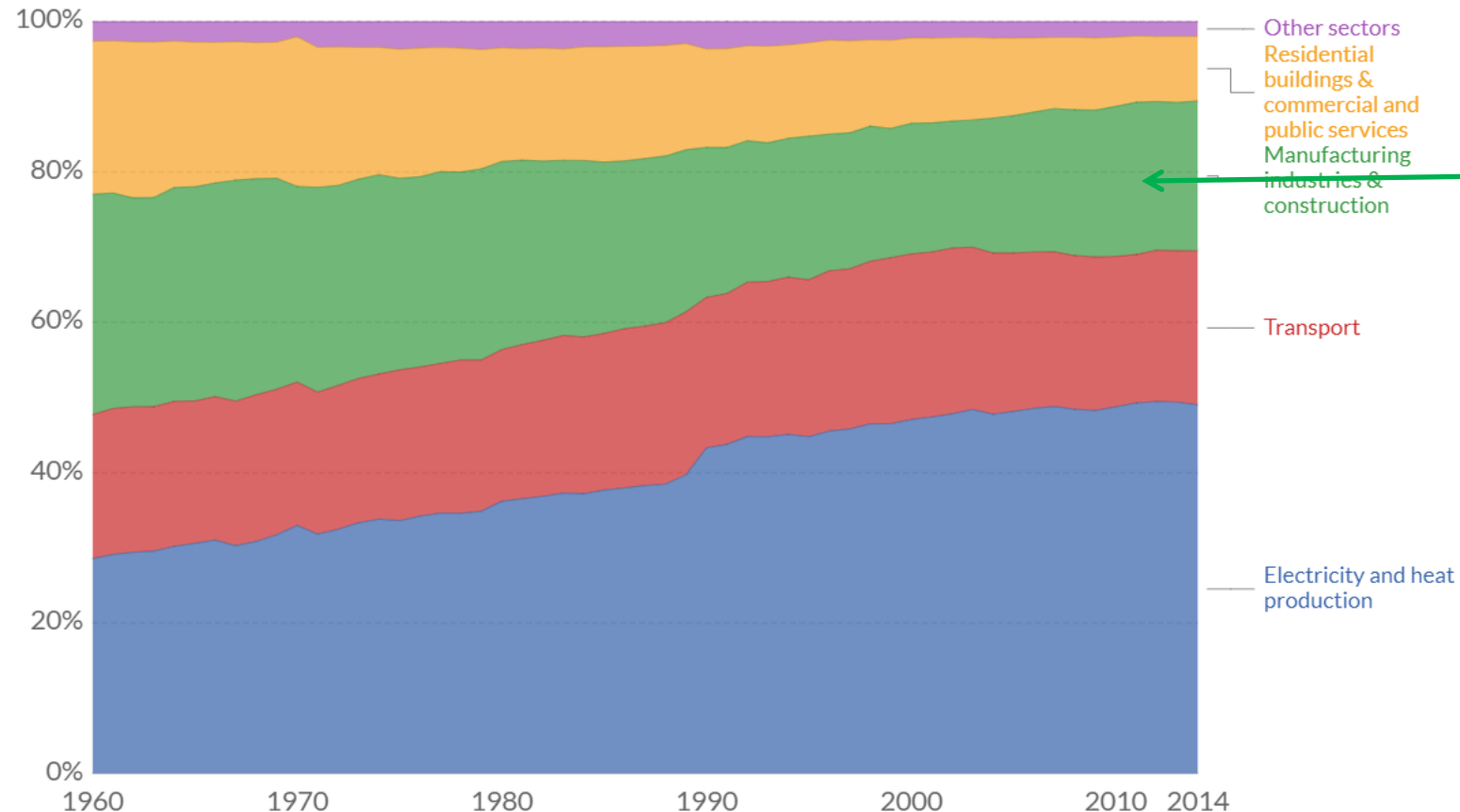


The pursuit of sustainable alternatives to replace Clinker with Supplementary cementitious Materials

Industry associated CO₂ emissions

Carbon dioxide (CO₂) emissions by sector or source, World
Share of carbon dioxide (CO₂) emissions from fuel combustion by sector or source.

Our World
in Data

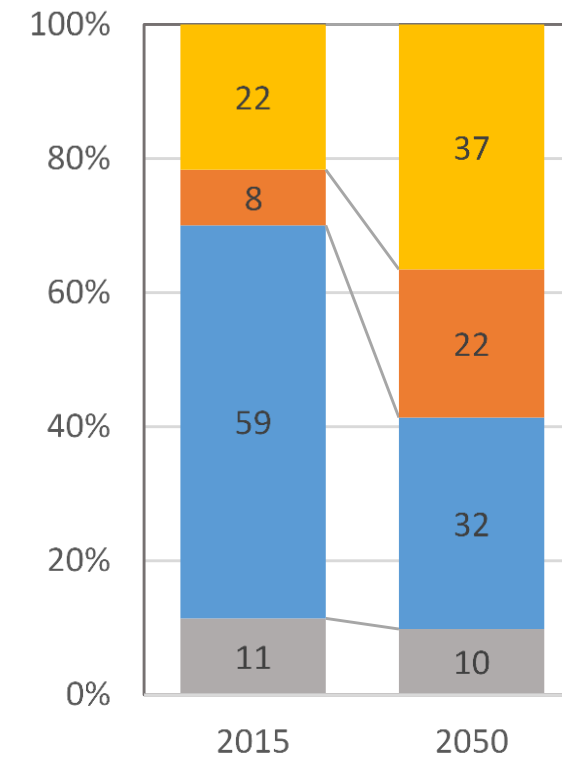
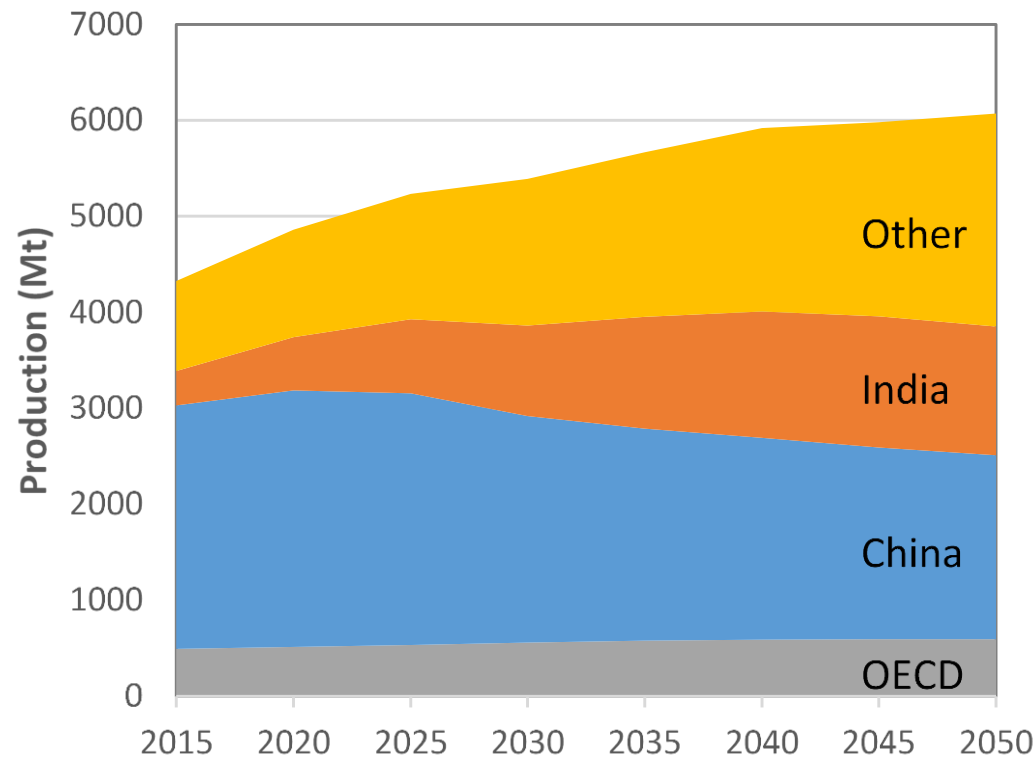


More than half of these emissions are associated with cement!!

Source: International Energy Agency (IEA) via The World Bank

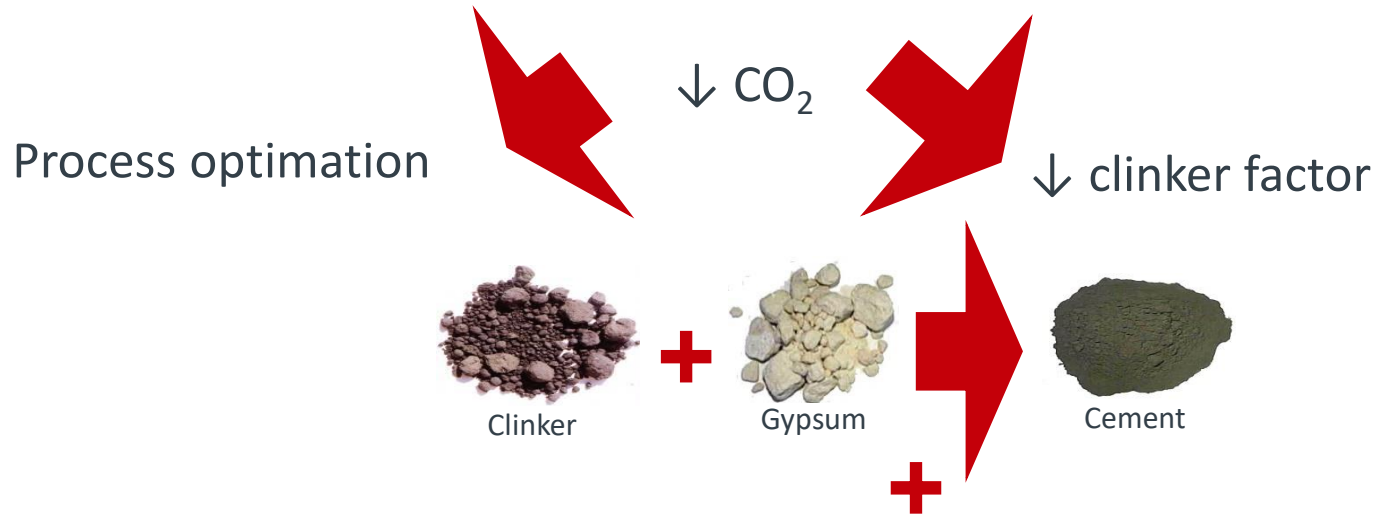
CC BY

Forecast growth cement production



U.N. Environment, K.L. Scrivener, V.M. John, E.M. Gartner, Cement and Concrete Research Eco-efficient cements : Potential economically viable solutions for a low-CO₂ cement-based materials industry ☆, (2018).

Way towards sustainability: reducing clinker factor



SCMs – Supplementary Cementitious Materials



Limestone



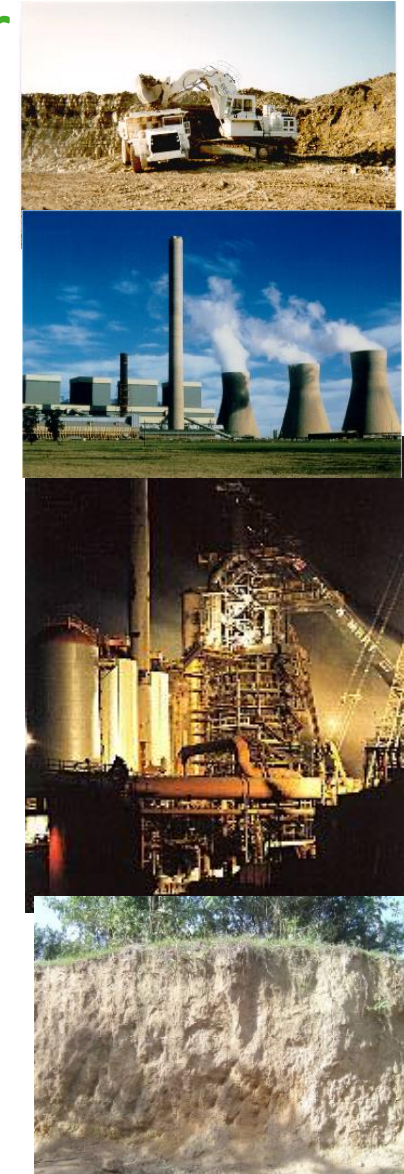
Fly ash



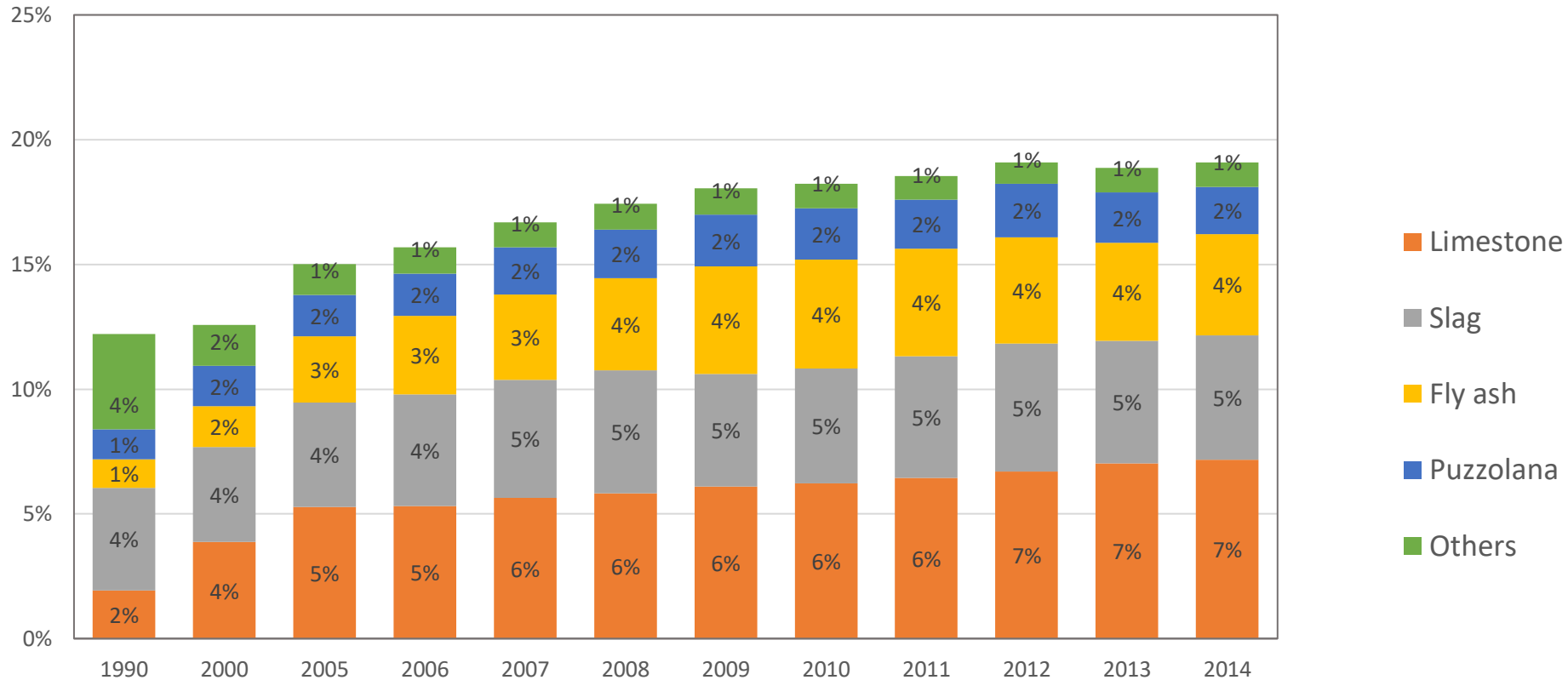
Slag



Natural pozzolan



Global trend in clinker substitution



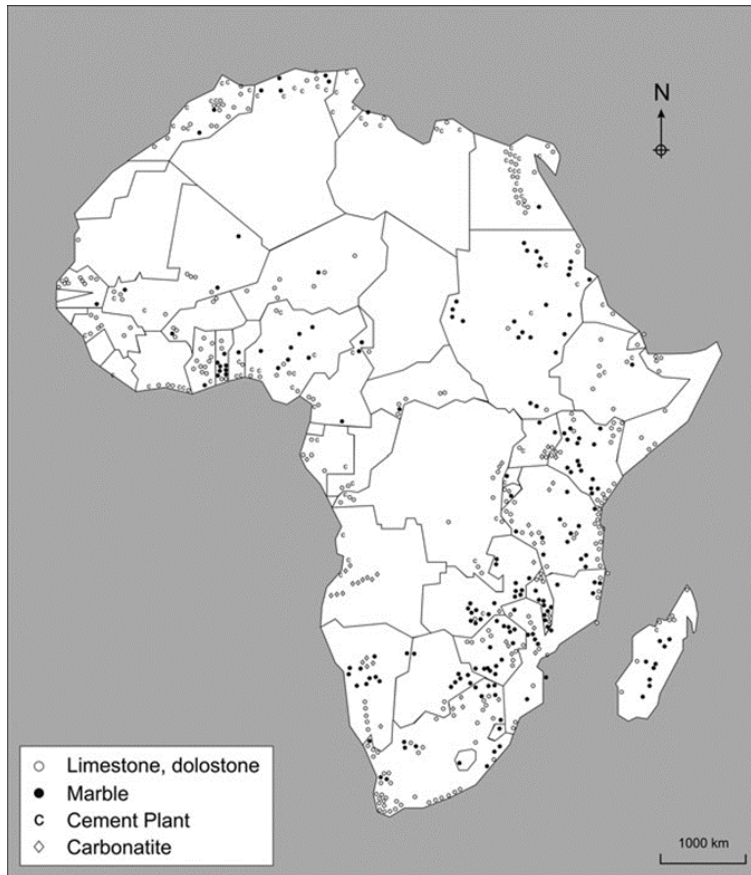
- Almost no progress in last 5 years
- Only 3 substitutes used in quantity

U.N. Environment, K.L. Scrivener, V.M. John, E.M. Gartner, Cement and Concrete Research Eco-efficient cements : Potential economically viable solutions for a low-CO₂ cement-based materials industry ☆, (2018).

Availability of SCMs



Limestone and clinker in Africa



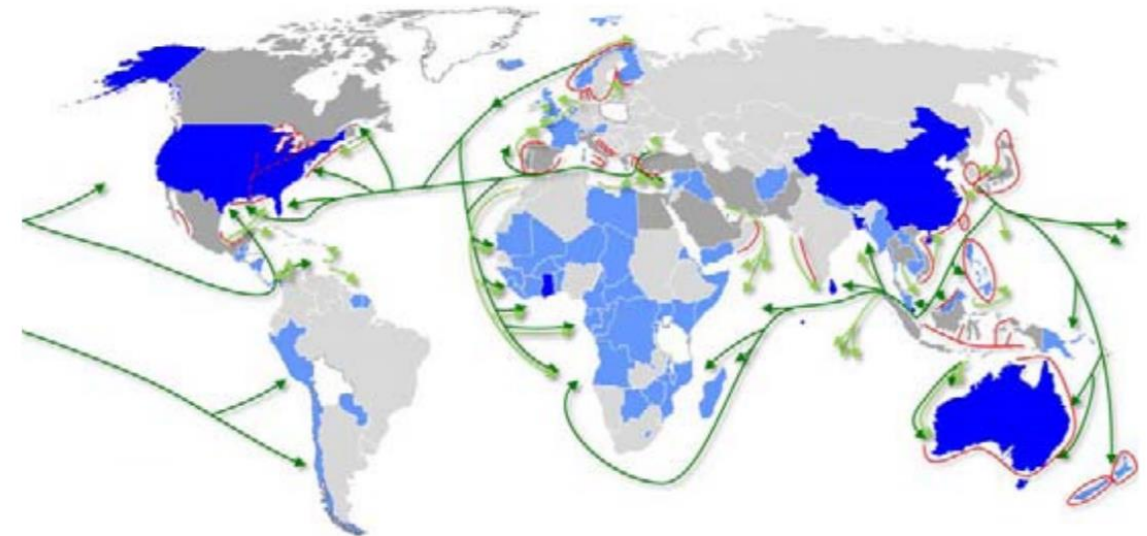
Right - Figure 1: Cement and clinker trade flows in 2018.

Imports

- >5Mt
- 1-5Mt
- In balance

Available clinker & cement

- 1-5Mt
- >5Mt



Clinker flow

8 **Global Cement Magazine** March 2020

The scarcity of limestone prompts African countries to import clinker and grind locally, with locally added mineral extensions

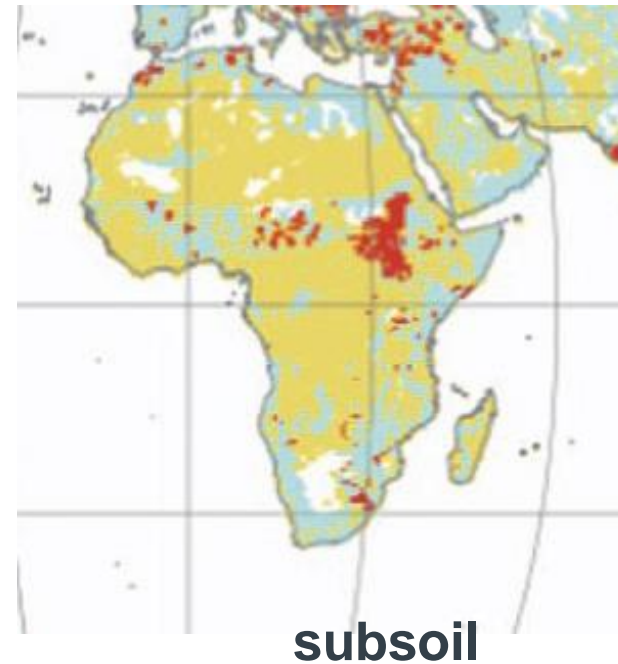
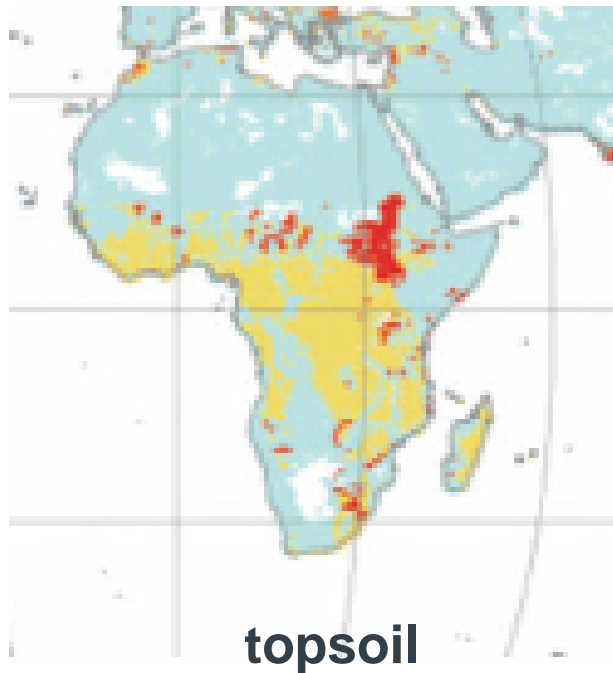
Clay availability Africa

Illite/mica

Kaolinite

Smectite

Vermiculite



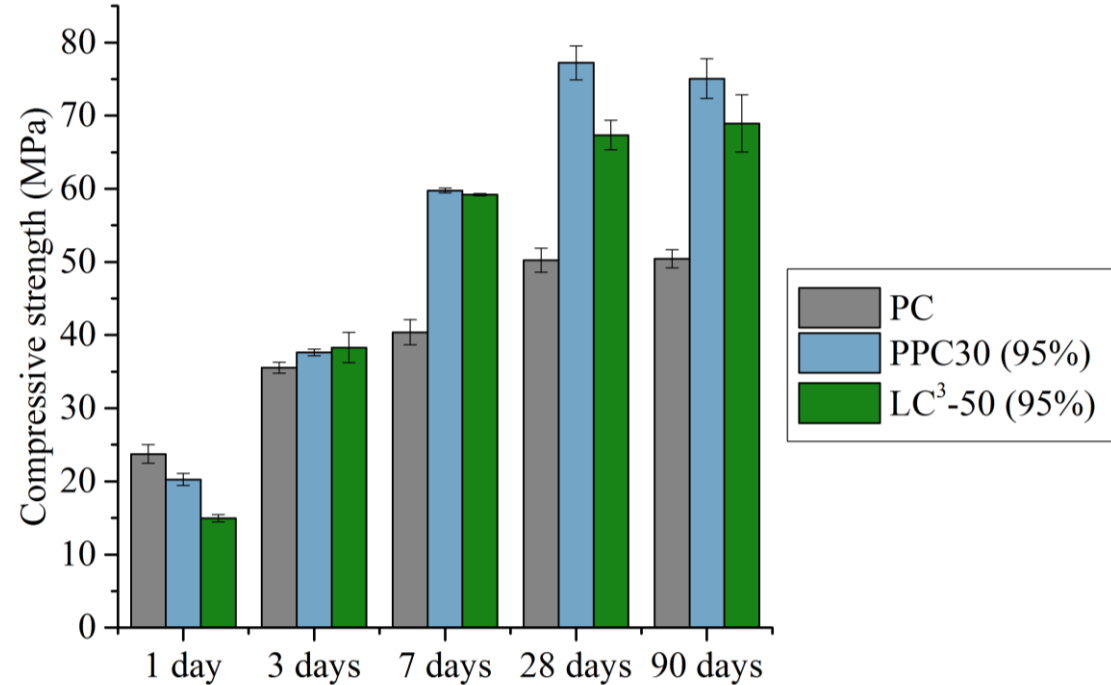
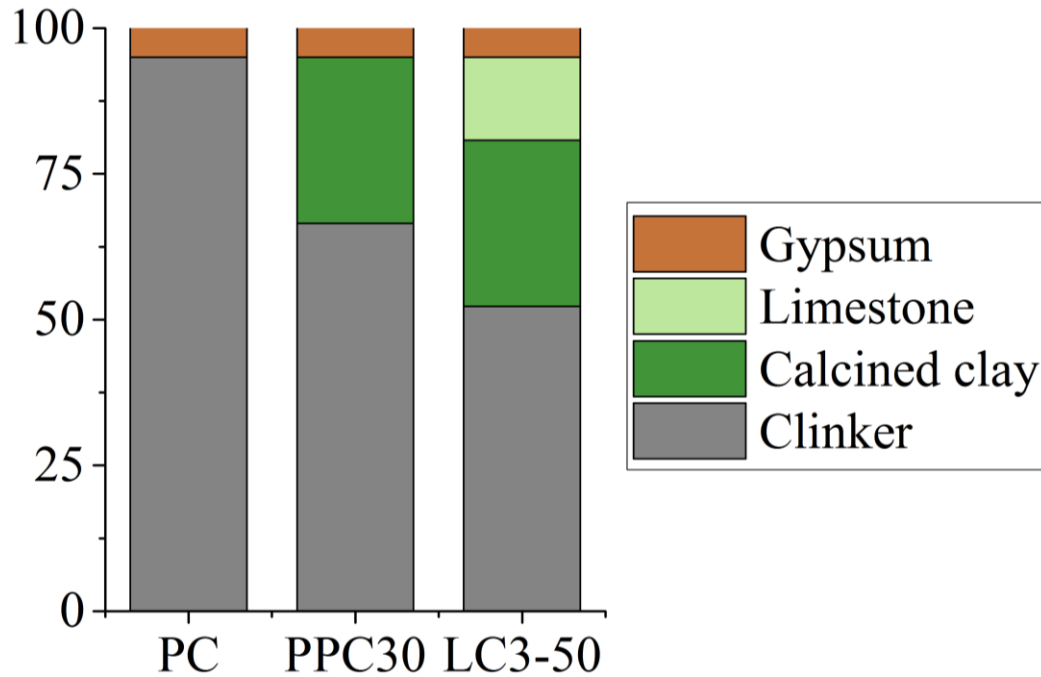
Ito and Wagai, Scientific data 2017

The presence of kaolinitic clay is reported for most African countries; some of them have large reserves of these materials

Challenges for most African countries

- » Reduce clinker content in cement due to high cost of imports
- » Introduce locally available Supplementary Cementitious Materials, SCM
- » Lower transportation costs of cement

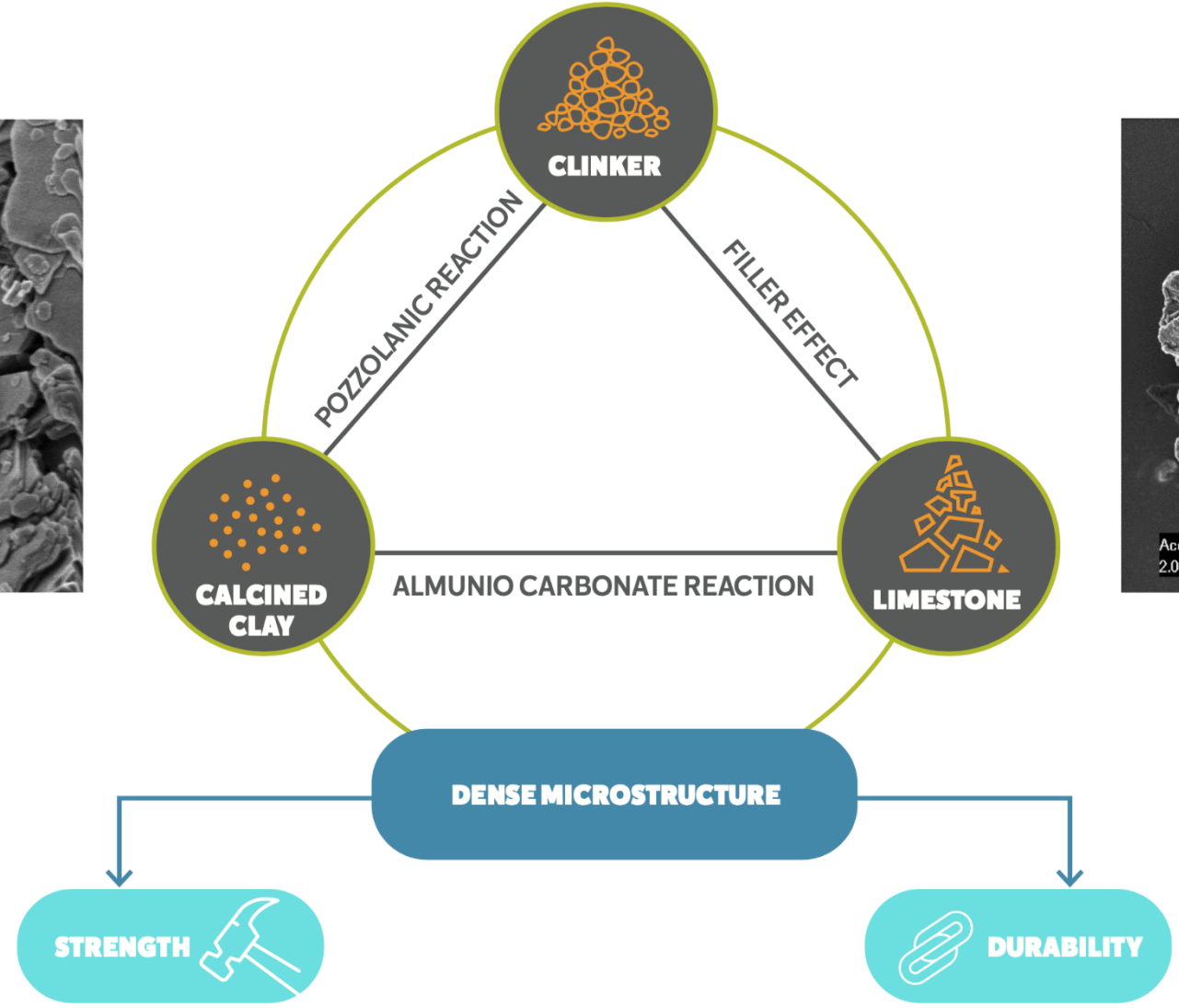
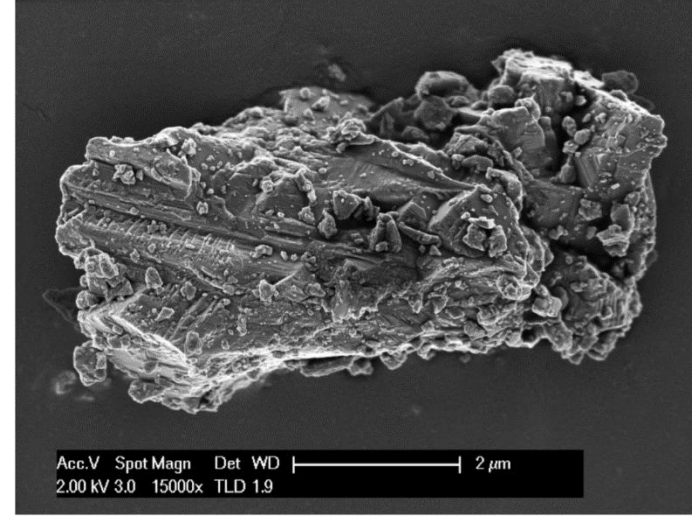
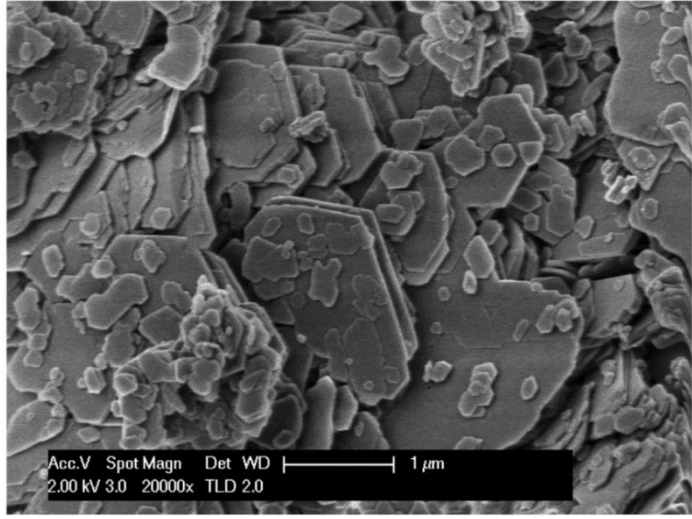
Low carbon cement LC3



Slide Prof. Karen Scrivener

Similar strength to Portland cement
50% Clinker
35%+ reduction CO₂
High resistance to chlorides
Lower production cost

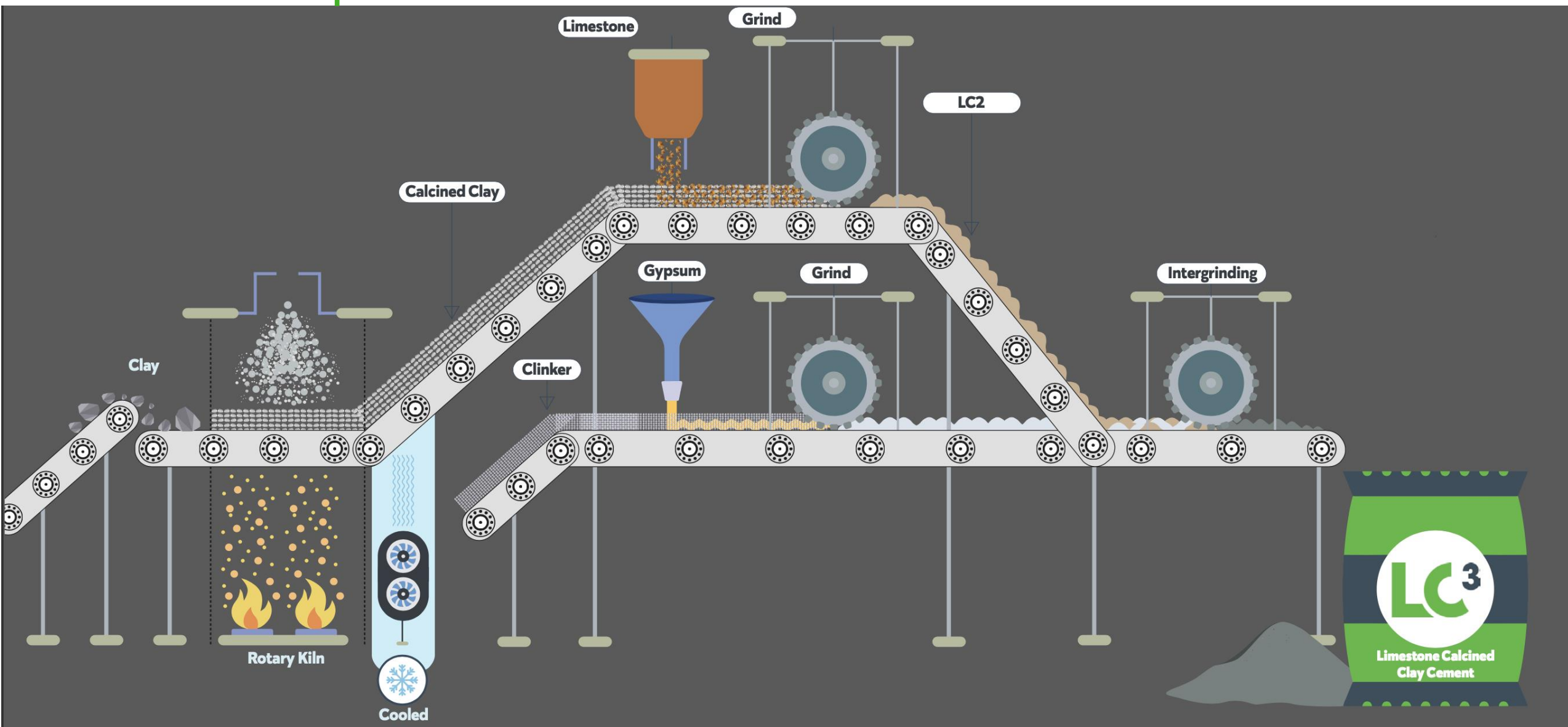
The science behind LC³



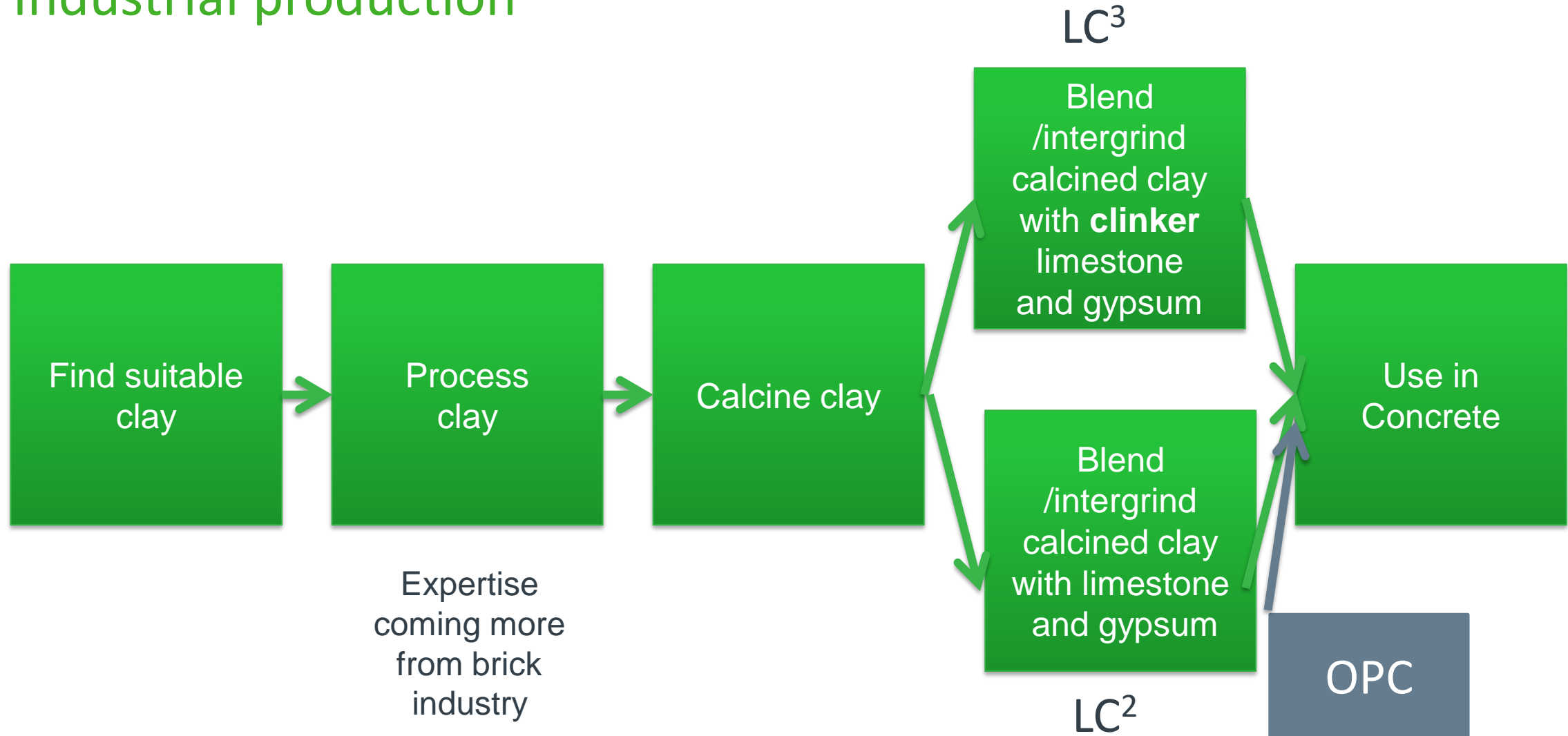
Alternatives to produce LC3

- » Industrial production
 - » Large clay calcination units
 - » Coupled to existing integrated cement plants or grinders
- » Local production
 - » Crushing fired clay bricks for calcined clay
 - » Local grinding units (ball mills)

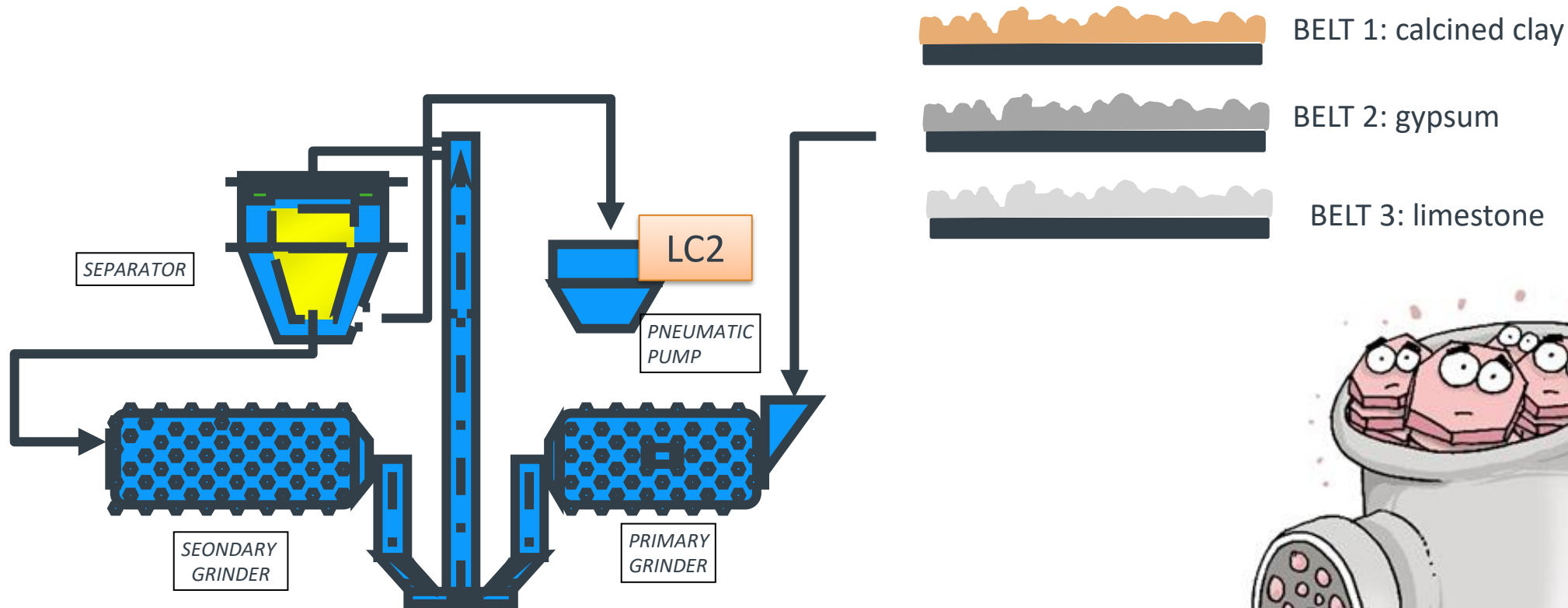
Industrial production of LC³



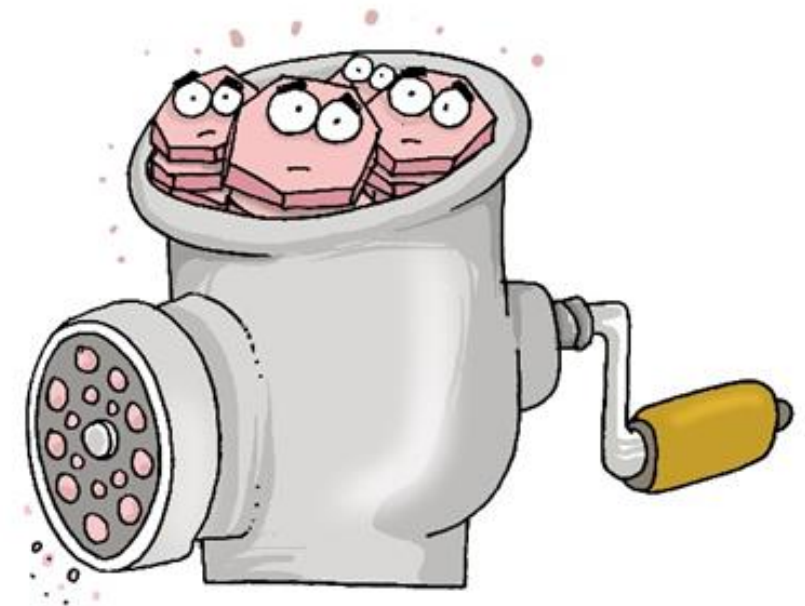
Industrial production



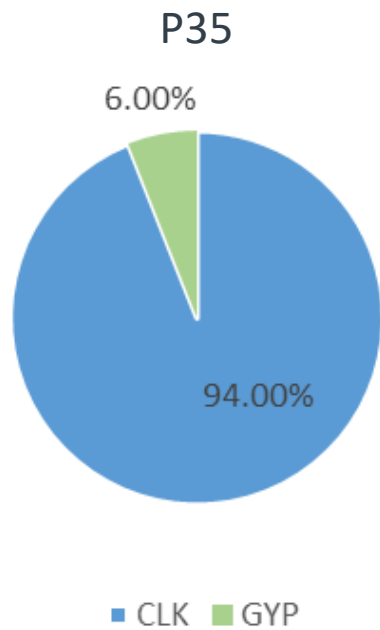
Mineral addition (LC2)



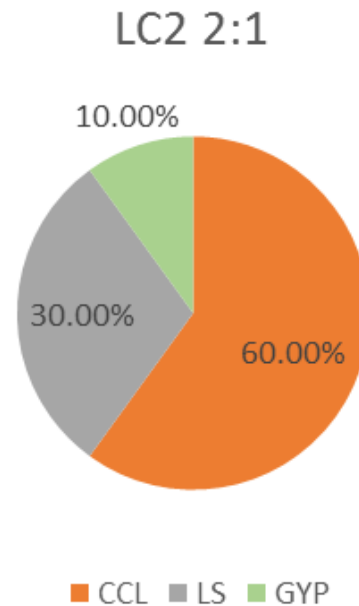
	CLK	CCL	LS	GYP	Total	SO3
LC2 2:1	0.00%	63.00%	30.00%	7.00%	100.00%	2.80%



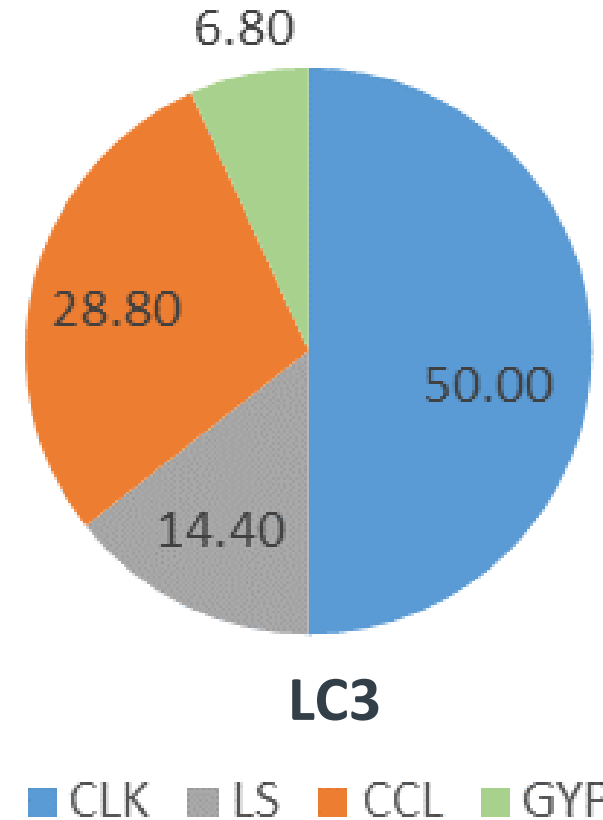
Use of LC2 blended with Portland cement in concrete



+



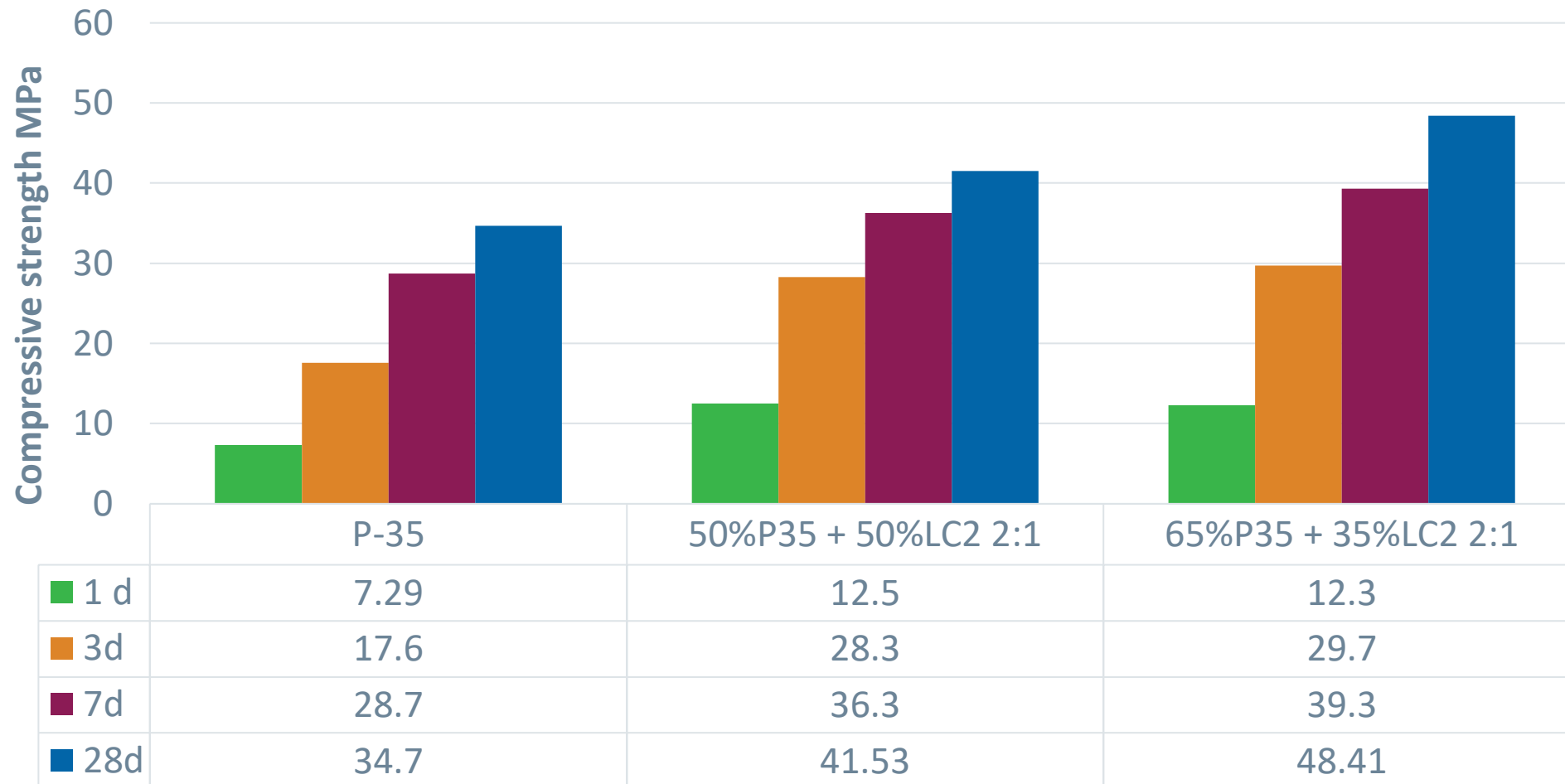
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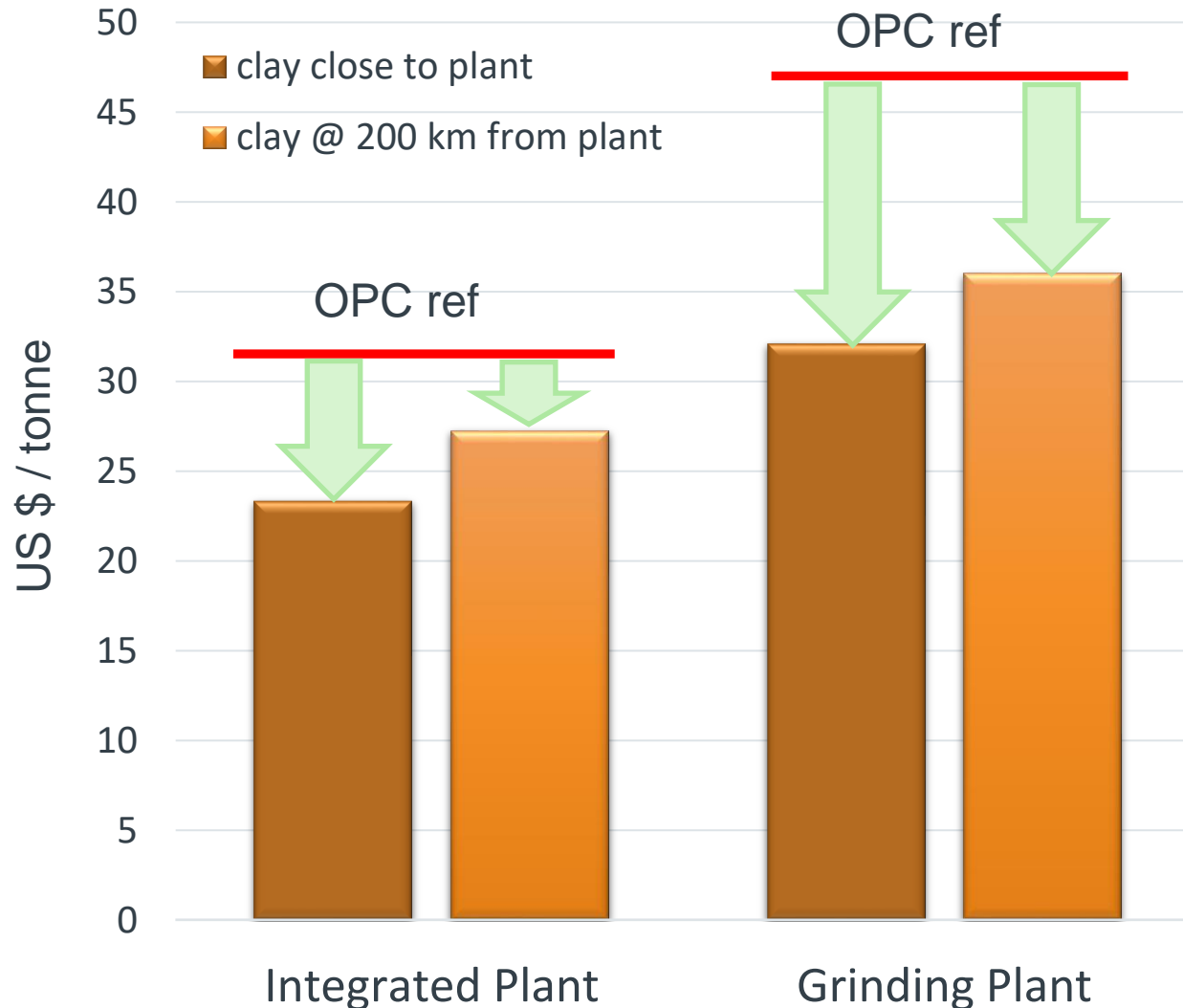
CLK: Clinker
GYP: gypsum
CCL: calcined clay
LS: limestone

The GREAT advantage of LC2 is that it can be added flexibly based on final use; it also has a long shelf life


Standard mortars 50%LC2 + 50%PC (EN-197)



Cost analysis



Financial Attractiveness of LC3




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

New EN 197 cement Standard

Recent developments of TC 51 “cement” have enabled the production of Portland composite cements (CEM II/C-M) with the following composition:

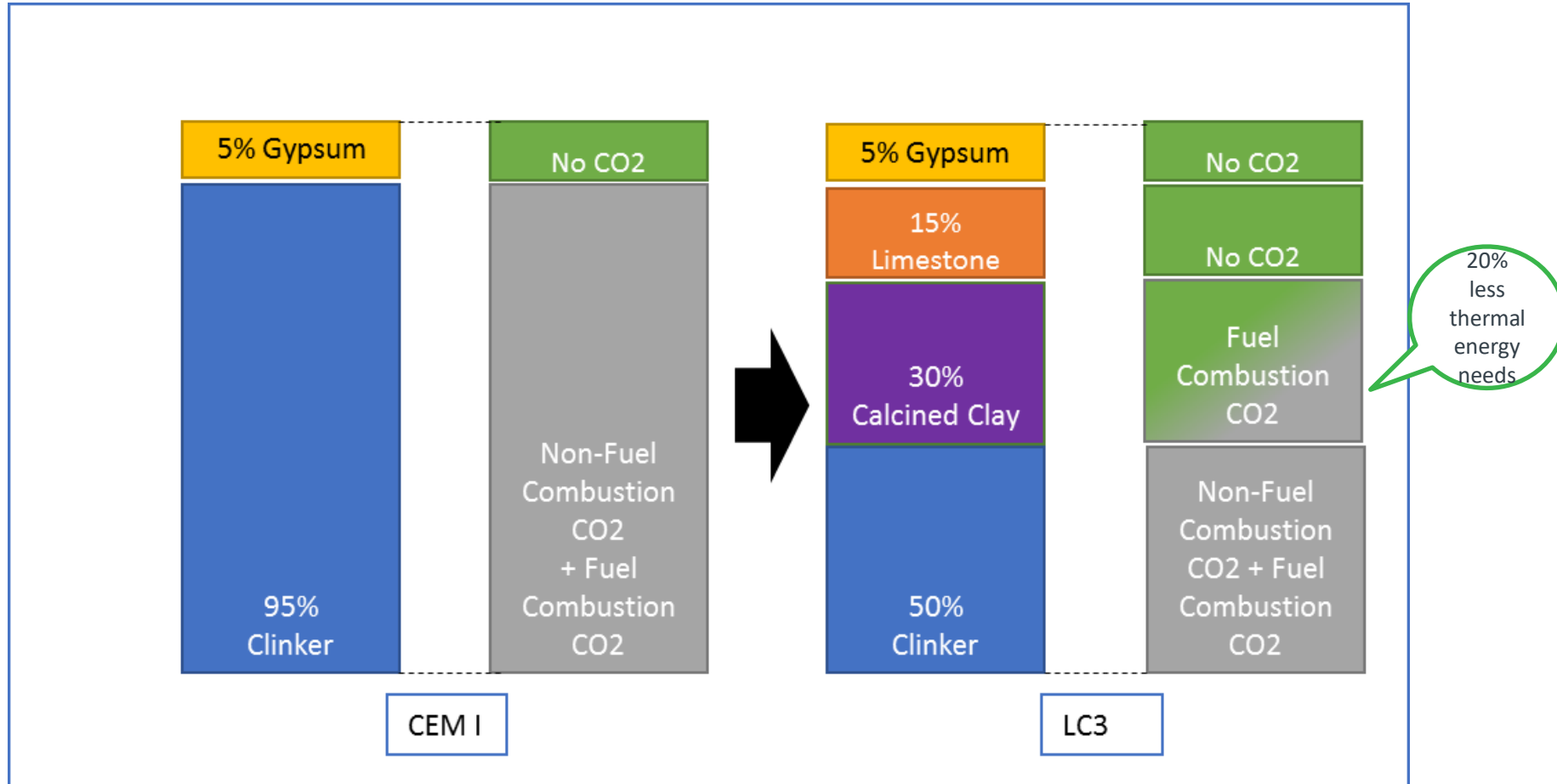
- Calcined pozzolan (Q) + Limestone (Lc) ~ 36-50%
- Clinker content ~ 50-64%

This new standard is **yet** to be ratified locally in each UE country

Main types	Notation of the products (types of cement)		Composition (percentage by mass ^a)									Minor additional constituents	
			Main constituents										
			Clinker	Blast-furnace slag	Silica fume	Pozzolana		Fly ash		Burnt shale	Limestone		
						natural	natural calcined	siliceous	calcareous				
Type name	Type notation	K	S	D ^b	P	Q	V	W	T	L ^c			
CEM II	Portland-composite cement ^d	CEM II/C-M	50-64	←----- 36-50 -----→									0-5
CEM VI	Composite cement	CEM VI (S-P)	35-49	31-59	-	6-20	-	-	-	-	-	0-5	
		CEM VI (S-V)	35-49	31-59	-	-	-	6-20	-	-	-	0-5	
		CEM VI (S-L)	35-49	31-59	-	-	-	-	-	-	6-20	-	0-5
		CEM VI (S-LL)	35-49	31-59	-	-	-	-	-	-	-	6-20	0-5

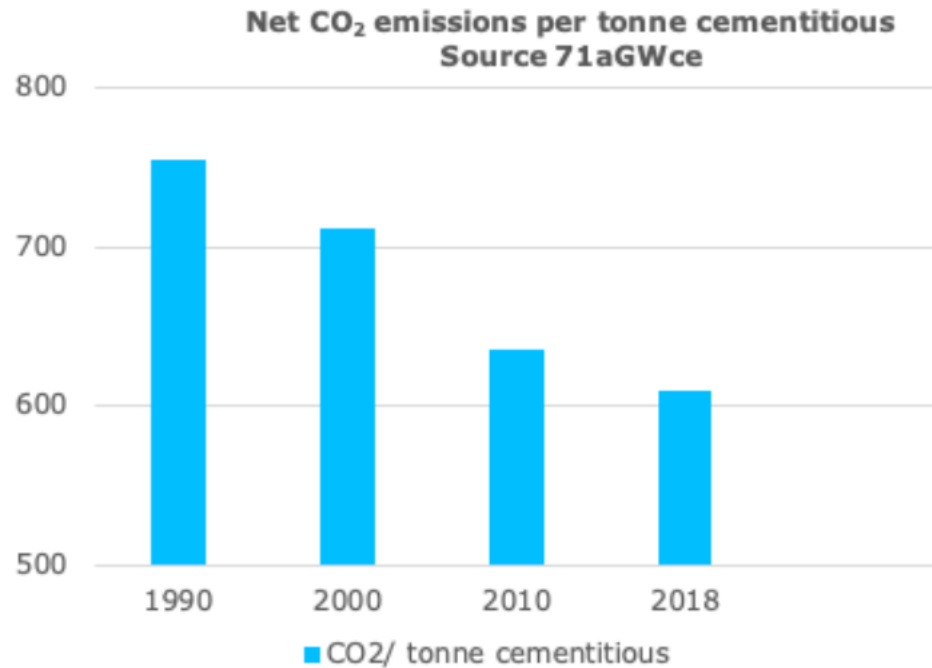
^a The values in the table refer to the sum of the main and minor additional constituents.
^b In case of the use of silica fume, the proportion of silica fume is limited to 6-10%.
^c In case of the use of limestone, the proportion of limestone (sum of L, LL).
^d The number of main constituents other than clinker is limited to two and shall be declared by designation of the cement (for examples, see Clause 6).

CO₂ reduction using LC³



calcined clay only needs to be heated until 850 °C
thus, only 2'600 MJ per ton of calcined clay is needed

CO₂ referring to benchmark (GCCA)



- 19.2%
CO₂ reduction per tonne
cementitious

x 9.5
Fossil Fuel substitution

- 18 %
energy efficiency
improvement

CO₂ emissions released per
1 ton of cement produced

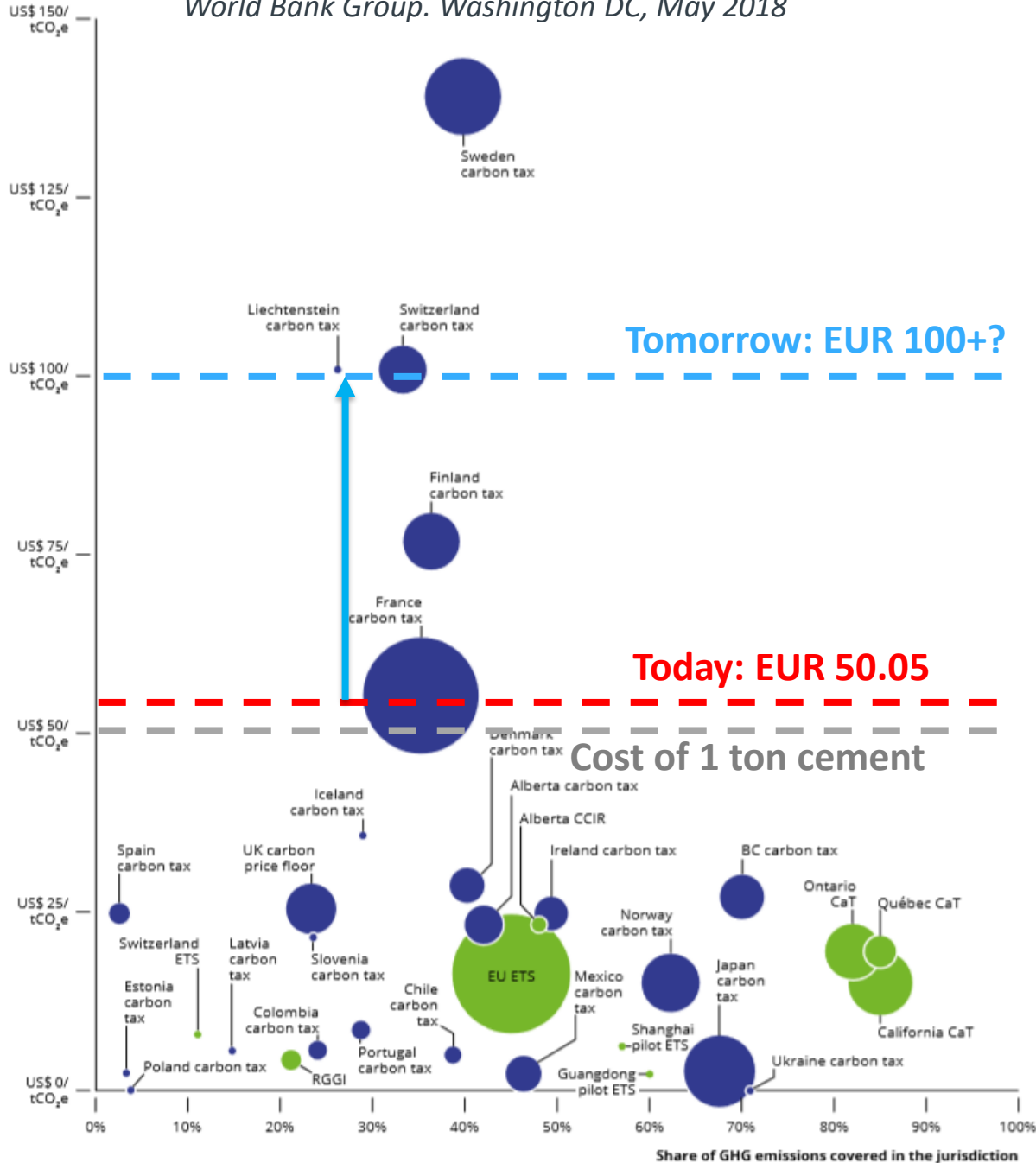
PC	CCL	50%PC +50%LC2
750	250	450

CO₂ saved:

- 40% related to Cem I 42.5R
- 25% related to Cem II 42.5N
- 18% related to Cem II 42.5R

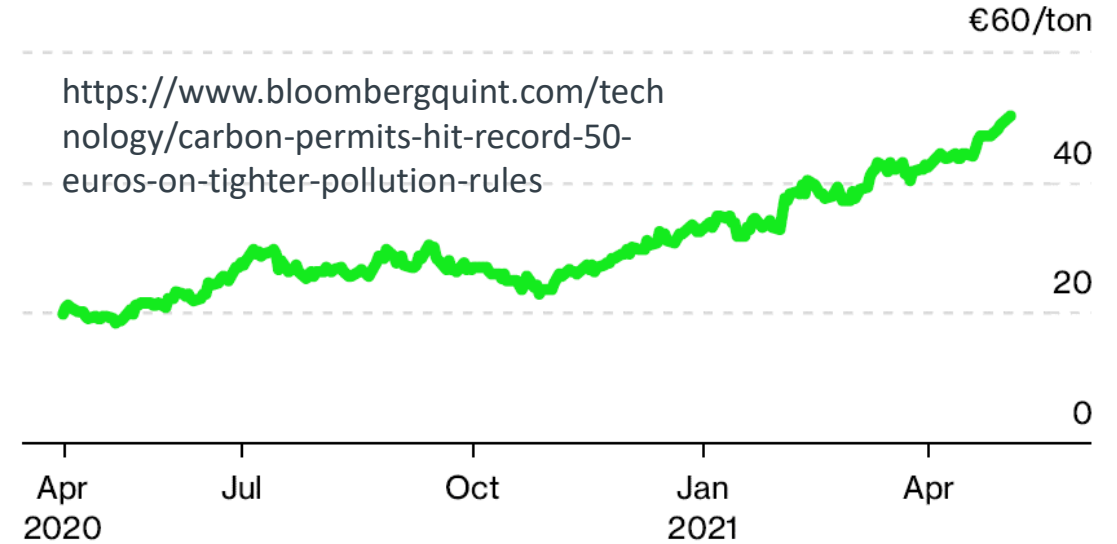
<https://gccassociation.org/sustainability-innovation/gnr-gcca-in-numbers/>

LC3-50 achieves mechanical
properties similar to Cem I
42.5 at all ages



Opportunities: CO2 incentives

EU carbon price

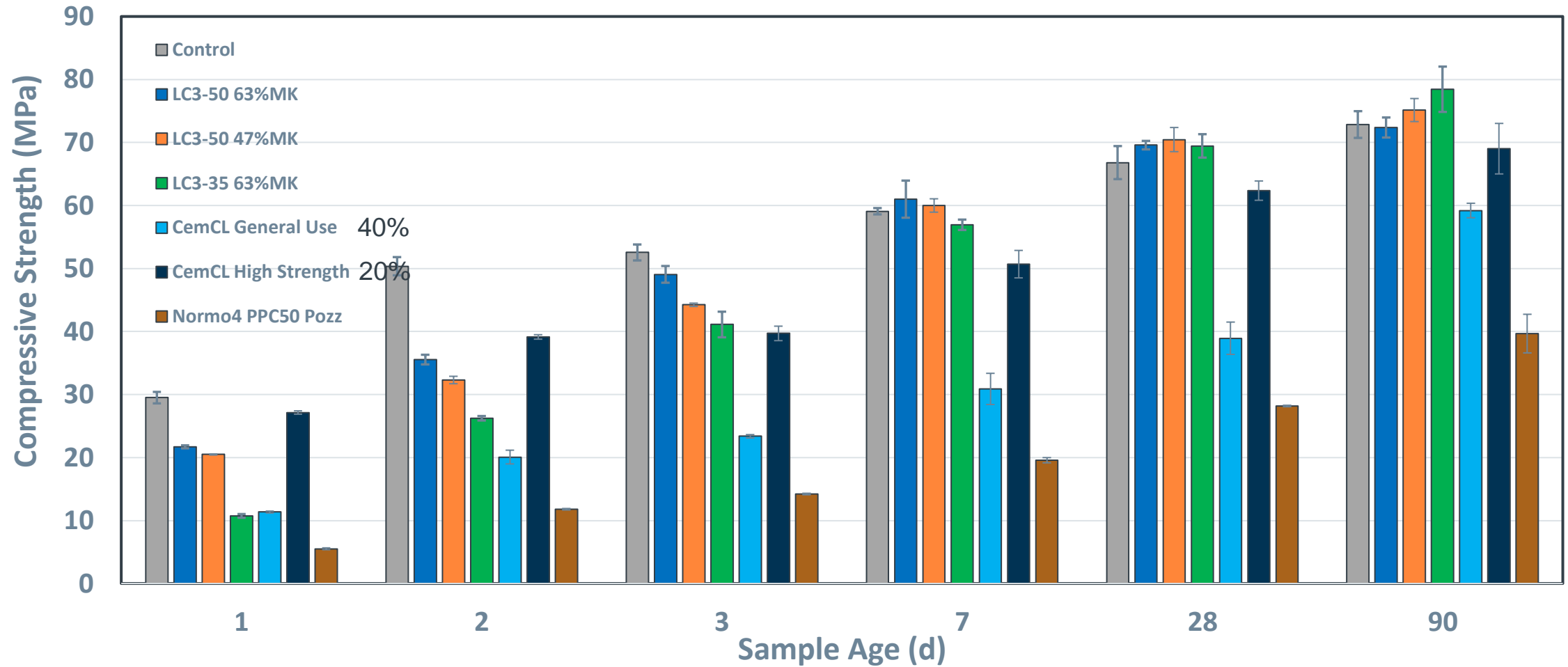


<https://www.bloombergquint.com/technology/carbon-permits-hit-record-50-euros-on-tighter-pollution-rules>

Source: ICE

“The 50 euro-mark has some significance since it has been a target price for some investors for a number of years by now,” Ek said by email. “Fundamentally, we believe prices can go higher than that, but also expect some tough political discussions on our way to 100+ prices which may turn sentiment at some point.”

Opportunities: very low clinker cements



CIMPOR, DeOHclay Blended Cement, Ivory Coast



The LC3 project team



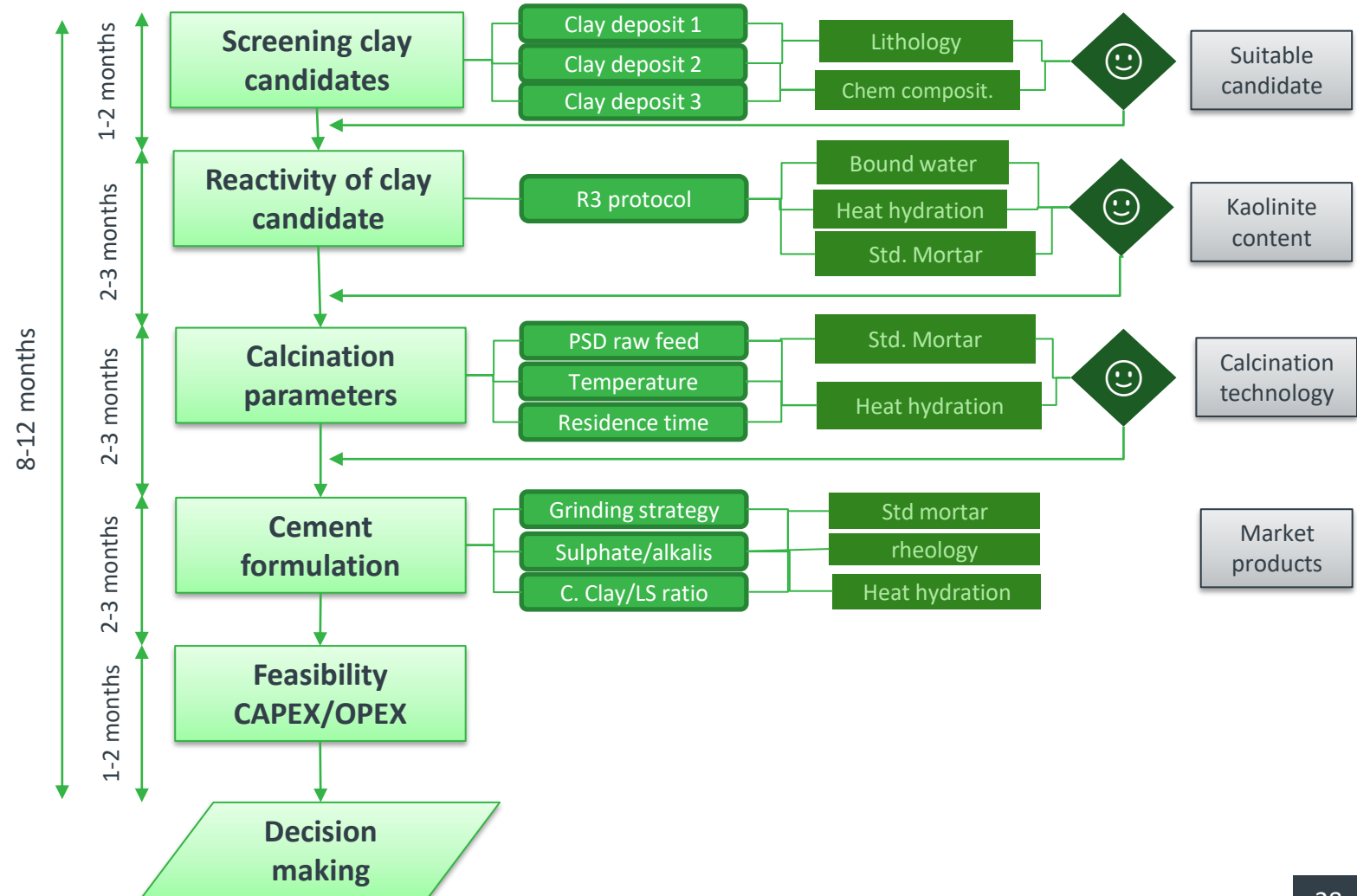
2 not for profit Technical Resource Centres (TRCs):



Protocol to assist companies introduce LC3



Non-profit company registered in Switzerland, with the goal of providing advisory service to companies in the cement sector (www.ecosolutions.gl)



LC3 plant Cuba



CIDEN • UCLV
PLANTA GENERAL

Molino: Automático, Manual
Horno: Automático, Manual

MOLINO HORNO

123 % 123 % 123 % 123 % 123 % 123 % 123 % 123 %

General Horno Molino Parametros Contagens Graficos

CIDEN • UCLV
HORNO ROTATIVO

Automático Manual

Consigna 123 %
Velocidade 123 %

123 % 123 % 123 %

Parada Invalido

Tiempo trabajo
Parcial 12345 H 12 M
Total 12345 H 12 M

General Horno Molino Parametros Contagens Graficos

CIDEN • UCLV
MOLINO DE BOLAS

Parada Invalido

Consigna 123 %
Velocidade 123 %

123 % 123 %

Parada Invalido

Tiempo trabajo
Parcial 12345 H 12 M
Total 12345 H 12 M

General Horno Molino Parametros Contagens Graficos

Vjeco-Designer Runtime 6.2.4.1070

Producción de
Cemento
Bajo Carbono

Planta Experimental

LC³

General Horno Molino Parametros Contagens Graficos

Fully sensor-equipped calcined clay calciner and grinding facilities

Concluding remarks

- » Sustainability of cement in Africa prompts for lowering clinker content further
- » Good clays available almost at the entire continent
- » LC3 cement is a good choice: 50% clinker, strength similar to Cem I, 40% CO2 reduction, lower cost.
- » First of a kind cement plant using calcined clay in commercial operation in West Africa
- » Emerging opportunities for the introduction of the technology in Africa.
- » Need for the creation of an LC3 Technology Resource Center in Africa, to accompany local dissemination of technology

Thank you!!

José Fernando Martirena Hernández (Prof. Dr.Sc. Ing.)

Director CIDEM

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