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29 & 30 AUGUST 2023 www.cemcon-sa.org.za/conpavestruc2023

ADMIXTURES AND ADDITIVES OF THE FUTURE CEMENT AND CONCRETE

SAINT-GOBAIN

The « not so fun » part

CONTENT

- **The situation and metrics**
- Response from the cement & concrete industry
- The implications
  a) Changing cement landscapes / new binders
  b) Changing concrete requirements
- The role of admixtures in helping the response
- The future admixture

WHERE WE ARE..
GLOBAL WARMING

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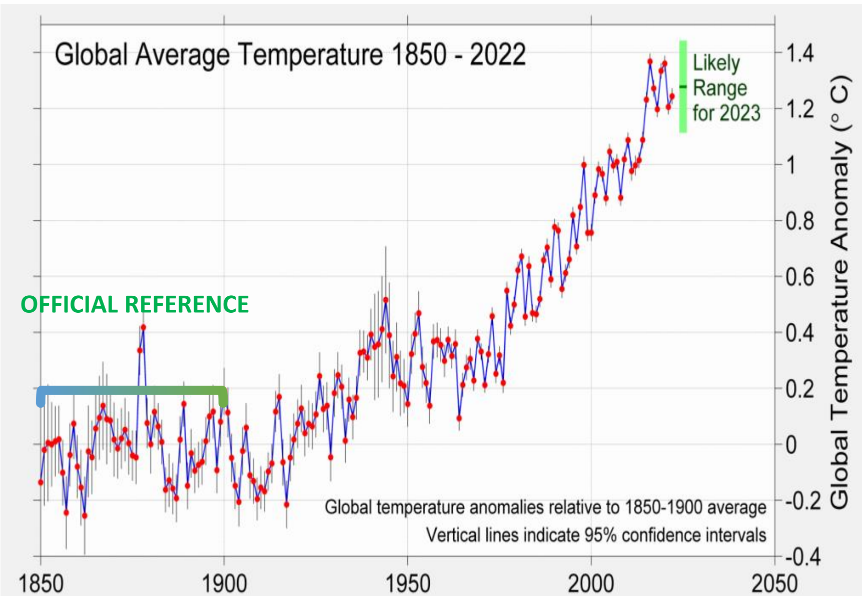
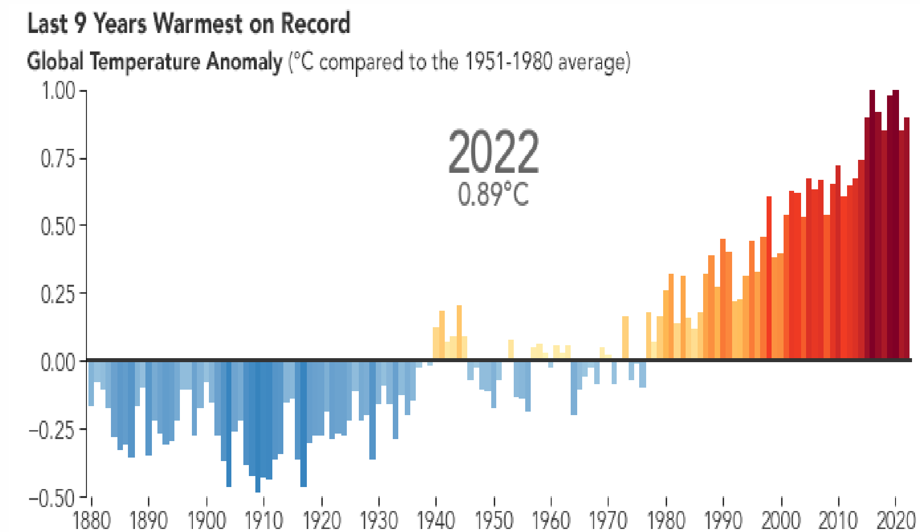
~+1,3° C vs. 1850 – 1900 (OFFICIAL REFERENCE PERIOD)

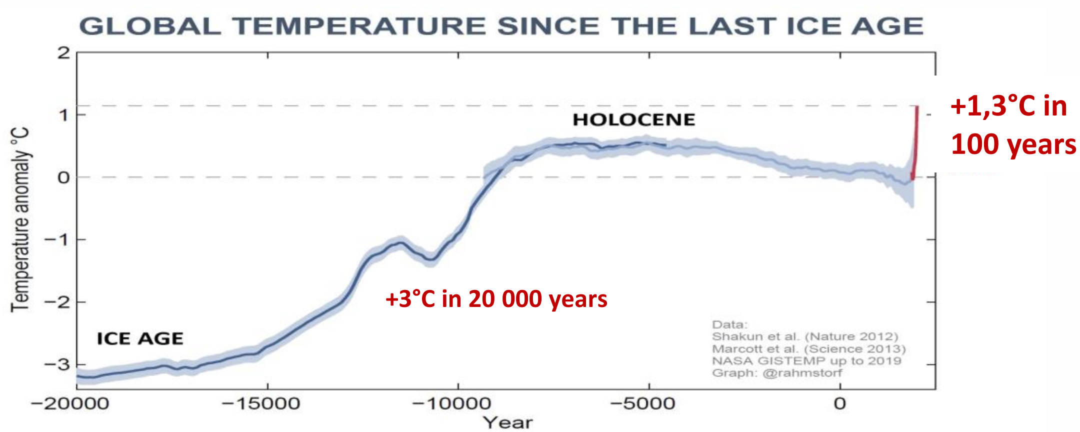
❖ **Getting closer to the Paris Agreement + 1,5°C target …**



Sources : Berkeley Earth



Sources : NASA



Sources : NASA

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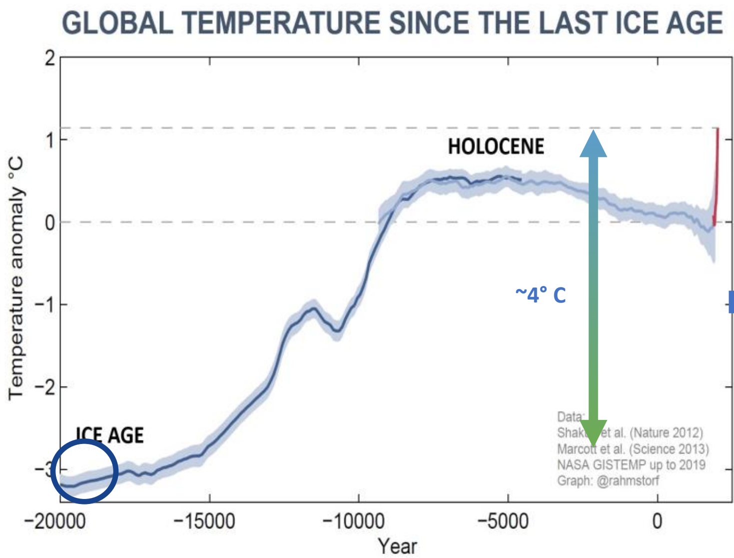
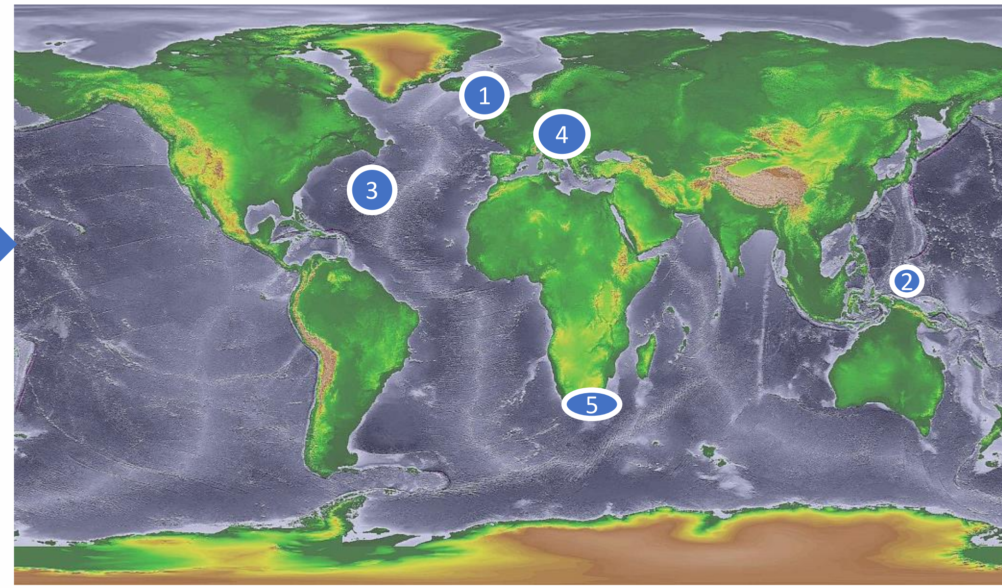
IT DOESN'T SOUND LIKE MUCH

- Our world at ~- 4°C vs today (ICE AGE)





1. Northern Europe & UK are covered by a 3 km layer of ice : you can walk from Paris to London !

2. You can also walk from Australia to New Zealand !

3. The Oceans are 120 m lower.

4. Most of todays fertile areas are desertic (dry toundra …)

5. SAF area is 2/3 temperatedesert surrounded by some tropical grass land.

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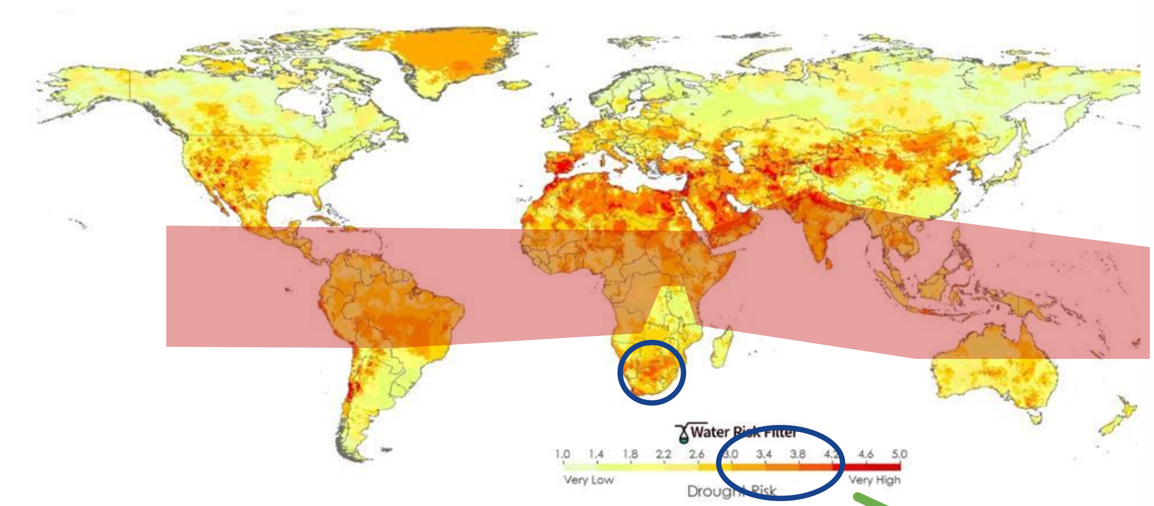
What if we hit the 4°C limit ?

MOST LIKELY CONSEQUENCES FOR SOUTH AFRICA

Global drought and temperature risk



Source: WWF 2018

Region where outdoor temperature and humidity would not be survivable more than 150 days per year

- Disastrous harvests : Famine
- Lack of water makes some regions almost inhabitable
- Massive population migration : local territorial conflicts

GWP AND ENERGY

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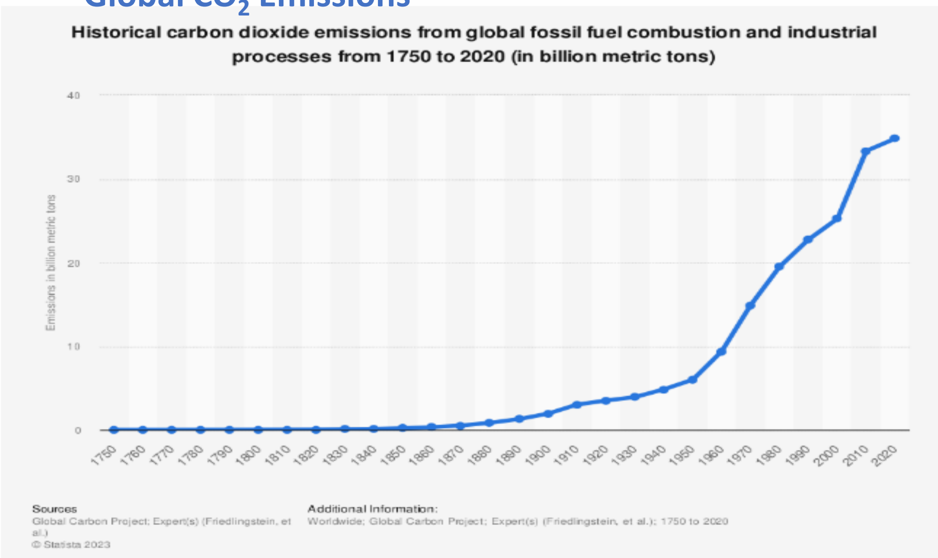
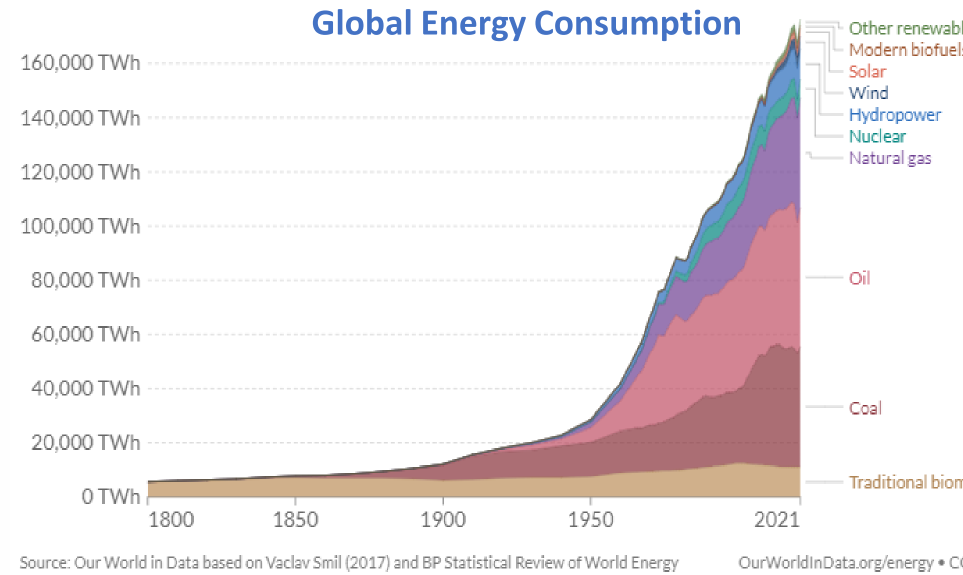
OUR ENERGY CONSUMPTION AND CO2 EMISSIONS ARE STILL INCREASING

Global CO_2 Emissions

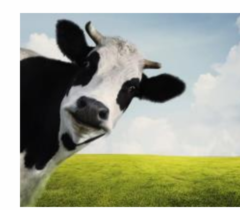




*Energy Returned On Energy Invested (kWh)

Energy Source	EROEI*
Saudi oil in the 40s	100
Shale Oil	4
Hydropower	50
Nuclear	50
Wind turbine	10
Wind turbine + storage (batteries)	5
Solar panels + storage (batteries)	5

Greenhouse Gas		Global Warming Potential (GWP)
1.	Carbon dioxide (CO_2)	1
2.	Methane (CH_4)	25
3.	Nitrous oxide(N_2O)	298
4.	Hydrofluorocarbons (HFCs)	124 – 14,800
5.	Perfluorocarbons (PFCs)	7,390 – 12,200
6.	Sulfur hexafluoride (SF_6)	22,800
7.	Nitrogen trifluoride (NF_3)[3]	17,200



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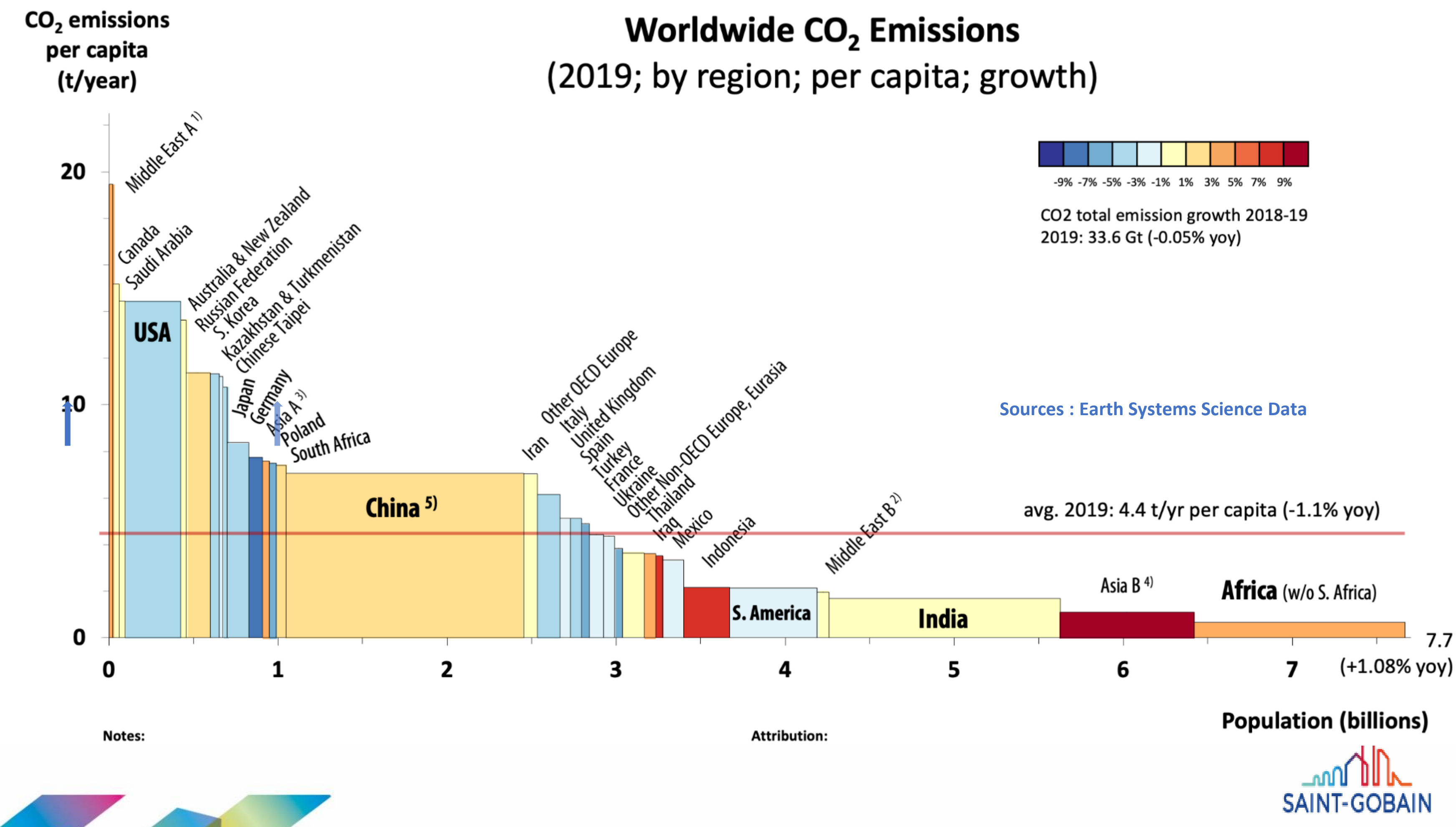
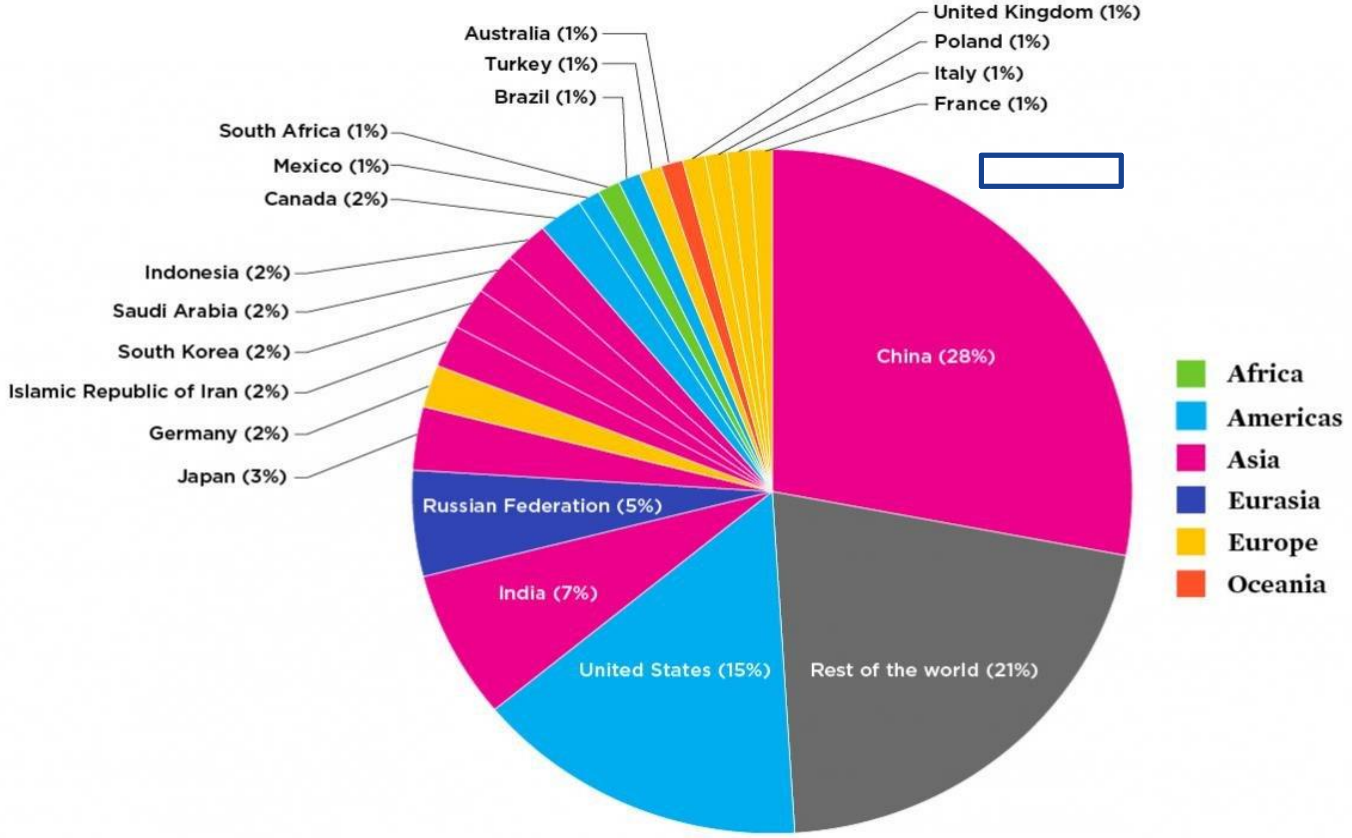
GHG EMISSIONS SNAPSHOT



GHG EMISSIONS SNAPSHOT

South AFRICA : ~1% of total emissions in 2020



Data: Earth Systems Science Data 11, 1783-1838, 2019

Sources : Earth Systems Science Data

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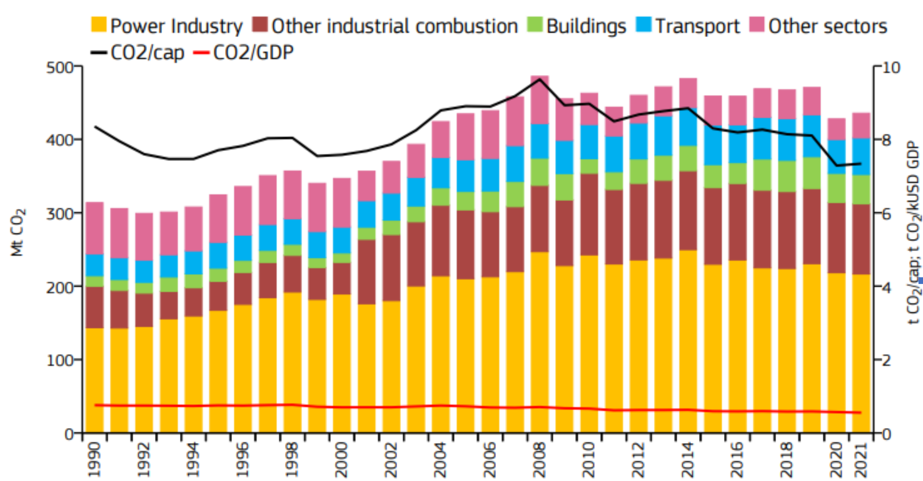
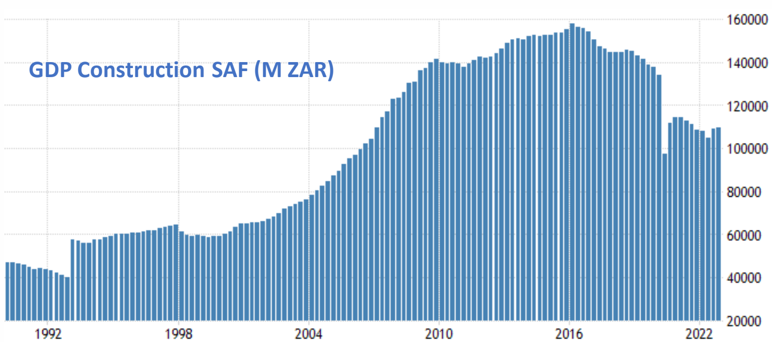
GHG EMISSIONS SNAPSHOT

SOUTH AFRICA



	CAGR 3,4% 2021 vs 1990	CAGR 3,0% 2021 vs 2005	2021 vs 2020
Power Industry	+51%	+3%	-1%
Other industrial combustion	+69%	+2%	0%
Buildings	+180%	+60%	+1%
Transport	+68%	+15%	+8%
Other sectors	-52%	-46%	+20%
All sectors	+39%	0%	+2%

Sources : IPCC



	2021 vs 1990	2021 vs 2005	2021 vs 2020
GDP Construction SAF	+118 %	+68 %	-3%

- THE SITUATION AND METRICS
- **RESPONSE FROM THE CEMENT & CONCRETE INDUSTRY**
- THE IMPLICATIONS

a) Changing cement landscapes / new binders

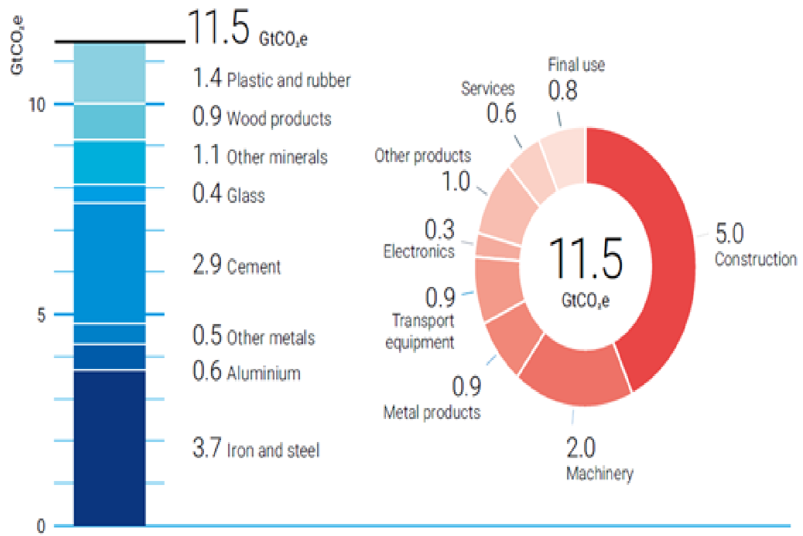
b) Changing concrete requirements

- THE ROLE OF ADMIXTURES IN HELPING THE RESPONSE
- THE FUTURE ADMIXTURE

CONSTRUCTION INDUSTRY

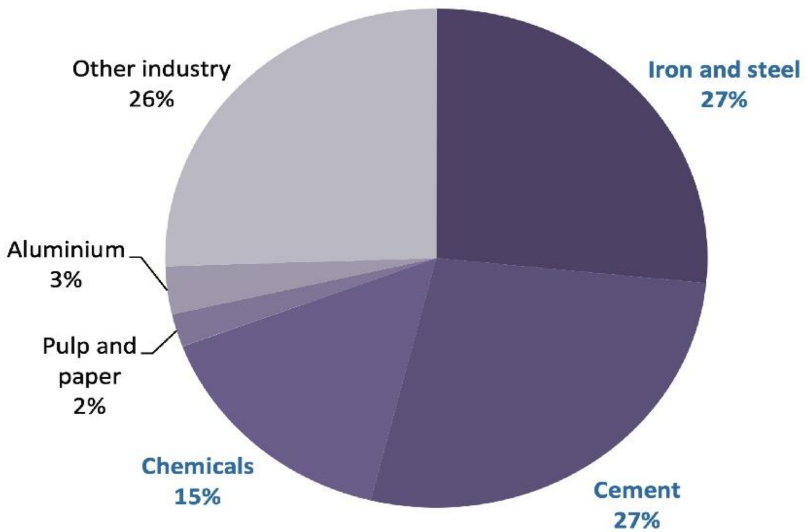
MATERIAL PRODUCTION: CONSTRUCTION IS THE MAIN EMITTER

Figure ES.6. GHG emissions in $GtCO_2e$ associated with materials production by material (left) and by the first use of materials in subsequent production processes or final consumption (right)



From: UN Environment Program. Emissions Gap. Report 2019. November 2019.

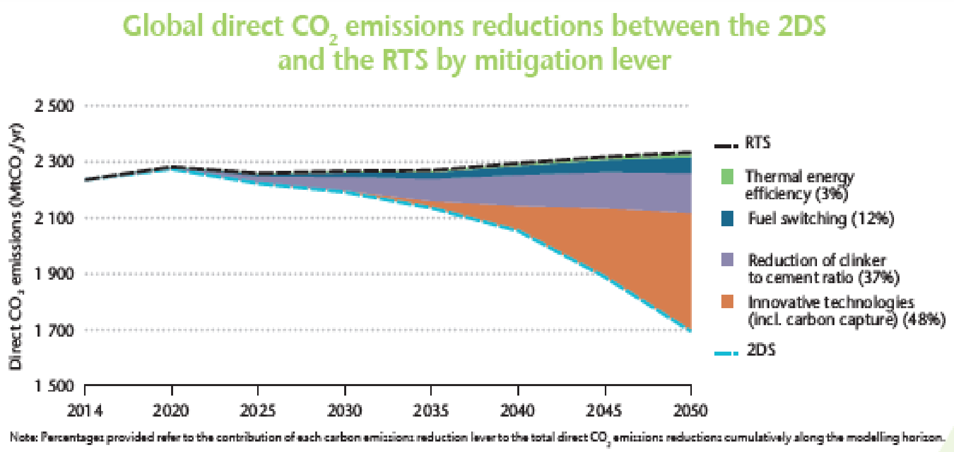
Share of Global Direct CO2 Emissions by Industry Subsector



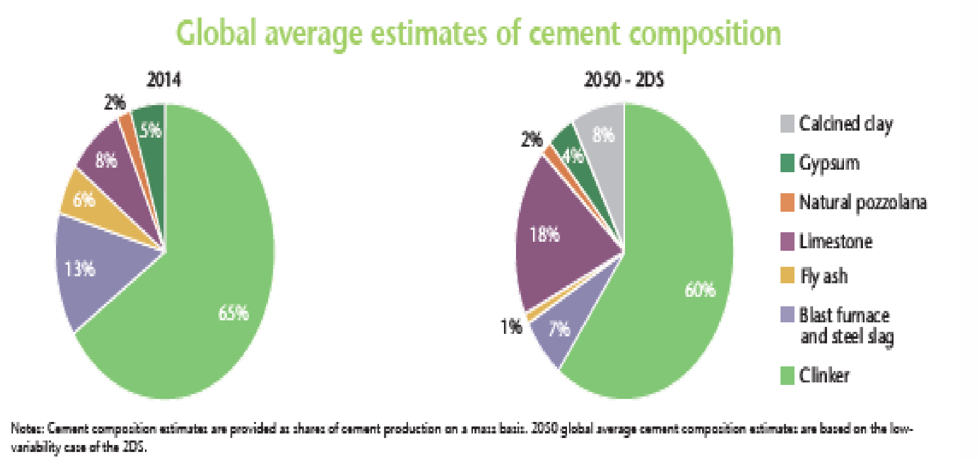
Source: Raimund Malischek, Adam Baylin-Stern, and Samantha McCulloch, Transforming Industry Through CCUS (Paris: International Energy Agency, 2019), https://www.iea.org/reports/transforming-industry-through-ccus.

MATERIAL PRODUCTION: CONSTRUCTION IS THE MAIN EMITTER

Production of 1 ton of cement emits ≅ 650kg of CO2



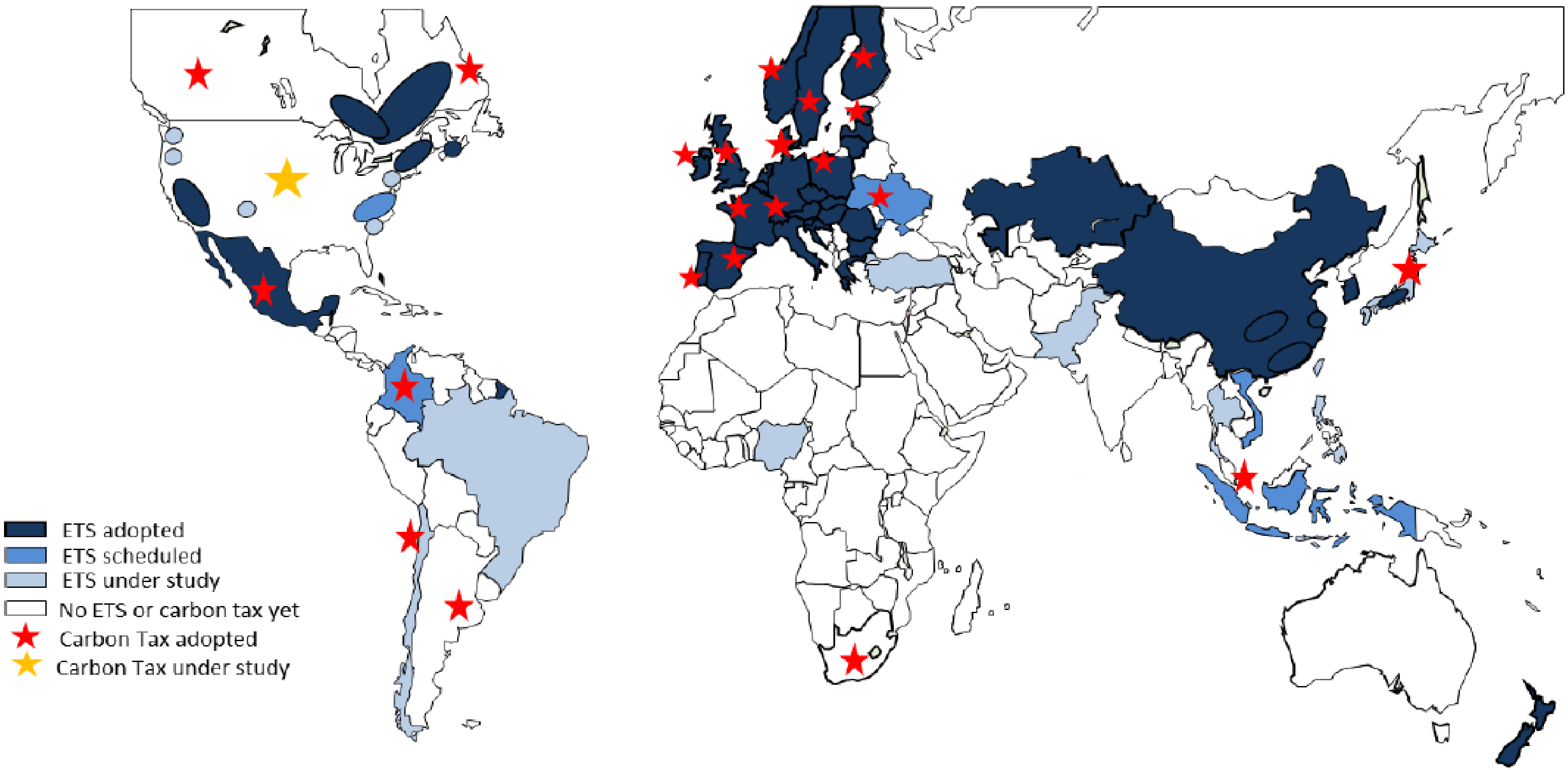
- **Decarbonization scenario shows action on four mitigation levers:**
  - **Energy efficiency (3%)**
  - **Fuel switching (12%)**
  - **Clinker substitution (37%)**
  - **Innovative technologies (48%) - including CCS (Carbon Capture and Storage)**



- **Clinker to cement ratio target is set at 0,60 by 2050**
  - **Reference 0,65 in 2014**
  - **Evolution of SCMs availability**

CARBON TAXES AND EMISSIONS TRADING SCHEME ARE RAMPING UP... LEADING TO AN INCREASE IN CO_2 FOCUS

2022 Worldwide ETS & Carbon Tax map



CONSTRUCTION MUTATION TOWARDS SUSTAINABILITY IS ACCELERATING

As a consequence, for most countries signing the COP 21 accords …

CORE ENVIRONMENTAL IMPACT INDICATORS: 1 tonne Cement CEM I

Parameter	Unit	production A1 - A3
Global warming potential total (GWP total)	kg CO_2 eq.	803
Global warming potential fossil (GWP fossil)	kg CO_2 eq.	803[*1)]
Global warming potential biogenic (GWP biogenic)	kg CO_2 eq.	0.22[*2)]
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC 11 eq.	1.8E-7
Acidification potential, accumulated exceedance (AP)	mol H+ eq.	1.82
Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-freshwater)	kg PO_4 eq.	0.000324
Eutrophication potential, fraction of nutrients reaching marine end compartment (EP-marine)	kg N eq.	0.51
Eutrophication potential, accumulated exceedance (EP-terrestrial)	mol N eq.	6.01
Formation potential of tropospheric ozone (POCP)	kg NMVOC eq.	2.33
Abiotic depletion potential for non-fossil resources (ADP-minerals and metals)	kg Sb eq.	1.82E-5[*3)]
Abiotic depletion potential for fossil resources (ADP-fossil fuels)	MJ, net calorific value	3130[*3)]
Water (user) deprivation potential, deprivation weighted water consumption	m^3 world eq. deprived	14.1[*3)]

focus on Global Warming Potential (CO2 footprint)

Emission Trading System

Sources : CEMBUREAU & Trading Economics

EFFICIENCY IN DESIGN AND CONSTRUCTION: THE IMPACT OF REGULATION

French RE 2020, an 18 years journey towards sustainable construction regulation :

2004	2013	2016	2022
CERTIFICATION HQE BÂTIMENT DURABLE	RT 2012	E+ C- Bâtiment à Énergie Positive & Réduction Carbone	RE 2020 RÉGLEMENTATION ENVIRONNEMENTALE
High Environmental Quality	**Energy Savings**	**Energy Savings and Low Carbon**	**Energy Savings & Low Carbon**
Private Label	**French official Standard**	**French Official Label**	**French official Standard**
VOLUNTARY	**MANDATORY**	**VOLUNTARY**	**MANDATORY**

EFFICIENCY IN DESIGN AND CONSTRUCTION: THE IMPACT OF REGULATION

The French concrete industry is already developing a full range of LCC

Cemex

"Circle" program rolled out through RMX range Vertua - 3 levels of CO_2 footprint reduction

Eqiom/CRH

Launch of EQIOM (R) - 3 levels of CO_2 footprint reduction

Holcim

360 approach rolled out with EcoPact range *(4 levels of CO_2 reduction)* + launch of Ecolabel

Vicat

Launch of RMX range Deca 2 levels of CO_2 footprint reduction

Vinci Construction

Launch of own low carbon range, Exegy

...

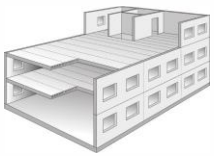
A MUTATION BOOSTED BY KEY MARKET DRIVERS AND NEW MATERIALS

Trend is to reduce environmental footprint of buildings

Leading towards the development of new concrete substitutes ...

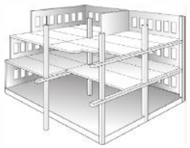
- URBANIZATION & VERTICAL CONSTRUCTION
- RAW MATERIALS SCARCITY
- SKILLED LABOR SCARCITY
- COST & TIME REDUCTION REQUIREMENTS
- SUSTAINABILITY

LOAD BEARING WALLS



SOLID WALLS

PILLAR-BEAM STRUCTURE



LIGHT FRAME

PRECAST FAVORABLE

EXAMPLE : ENGINEERED WOOD PRODUCTS (CLT, GLT ...)

- Credible load Bearing substitutes to concrete
- Lighter : Reducing load on foundations
- Precast business model = Fast assembly / construction
- Carbon sink

NGO's AND FINANCIAL INSTITUTIONS

COMPANY ACTION EXPECTED

Coming from NGOs with an international credit
Most cement companies publishing their targets and auditing progress

CDP DISCLOSURE INSIGHT ACTION

The universe of companies has on average reduced their emissions intensity by 1% p.a. over the last 4 years but this is not enough for a 2-degrees trajectory and would need to more than double to meet a 2-degrees target.

CCS is an important technology for this sector's decarbonization but remains at pilot stage. HeidelbergCement leads the main projects in this space, with only limited R&D spend on CCS outside Europe.

Carbon regulation for the sector remains benign, with the sector in Europe continuing to benefit from surplus free allowances within the EU ETS – carbon prices need to rise by three to six times to provide incentives to deploy technologies such as CCS.

11 of the 13 companies in our sample have emission reduction targets, **but only three of these meet a 2-degrees goal[2].**

Strong regional trends are found with Indian companies outperforming international peers with process emissions measured by the clinker ratio[1] of 69% vs 78%. This is driven by better access to alternative materials such as fly ash and slag coming from other carbon intensive sectors, such as thermal power generation and steel production.

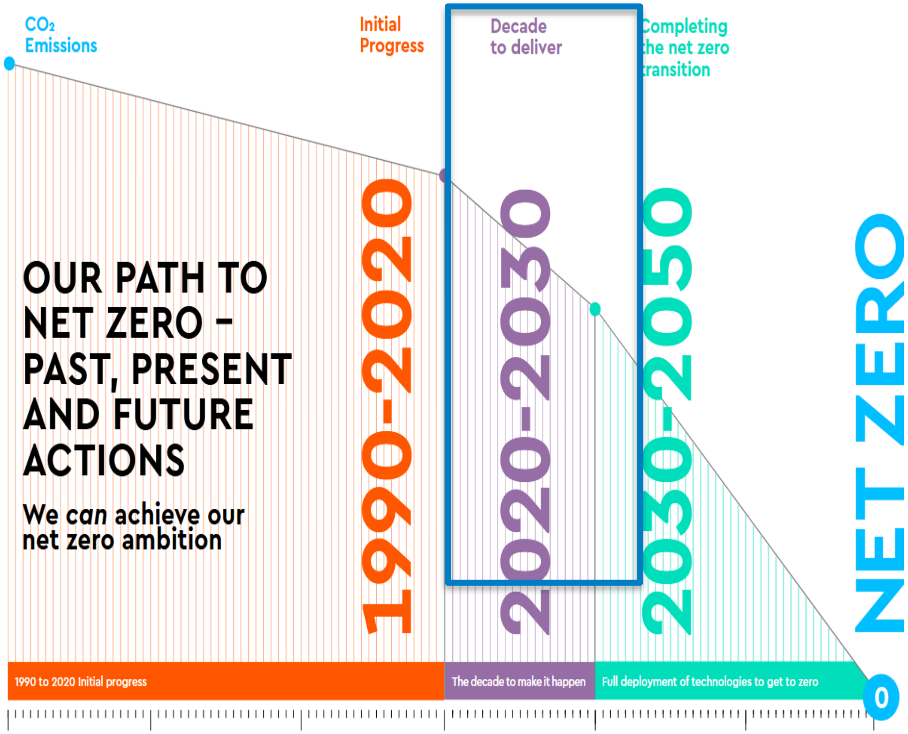
Use of alternative materials in developed markets is facing constrained supply. European companies will need to find scalable and sustainable alternatives to fly ash and slag or develop low-carbon technologies to be able to improve current emission intensity levels.

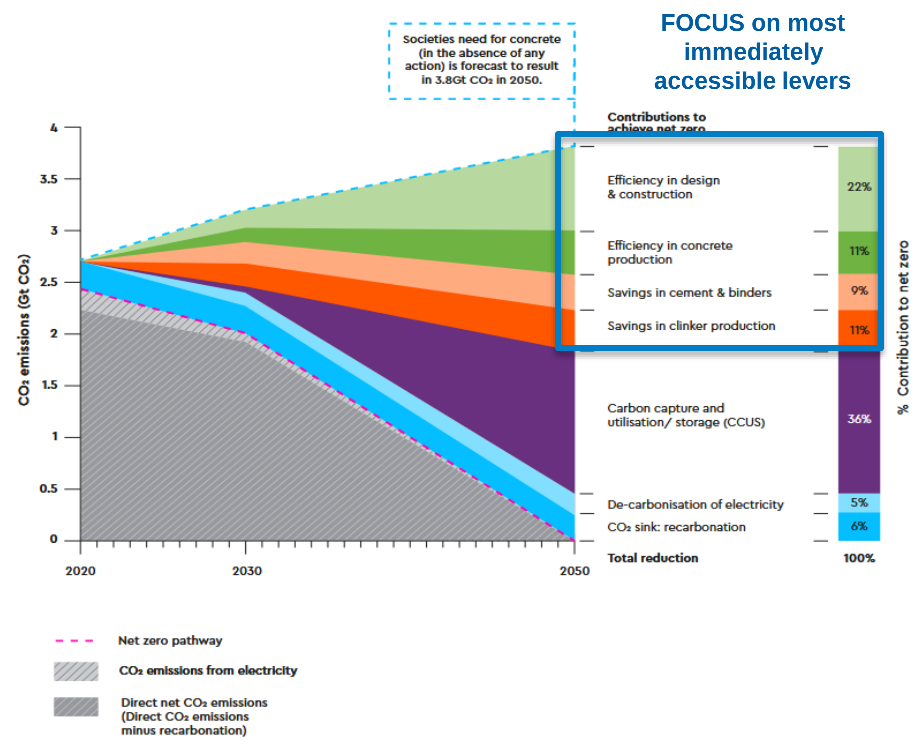
- **From Financial institutions**
- **IIGCC recommendations (July 2019)**
  - **Implement a strong governance framework**
  - **Take action to reduce greenhouse gas emissions across the value chain**
  - **Provide enhanced corporate disclosure**

SAINT-GOBAIN

CEMENT AND CONCRETE INDUSTRY ON THE MOVE…
LOW CARBON CONCRETE IN ACTION

Published ambitions for a net zero footprint in 2050.





Sources : GCCA

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  a) **Changing cement landscapes / new binders**
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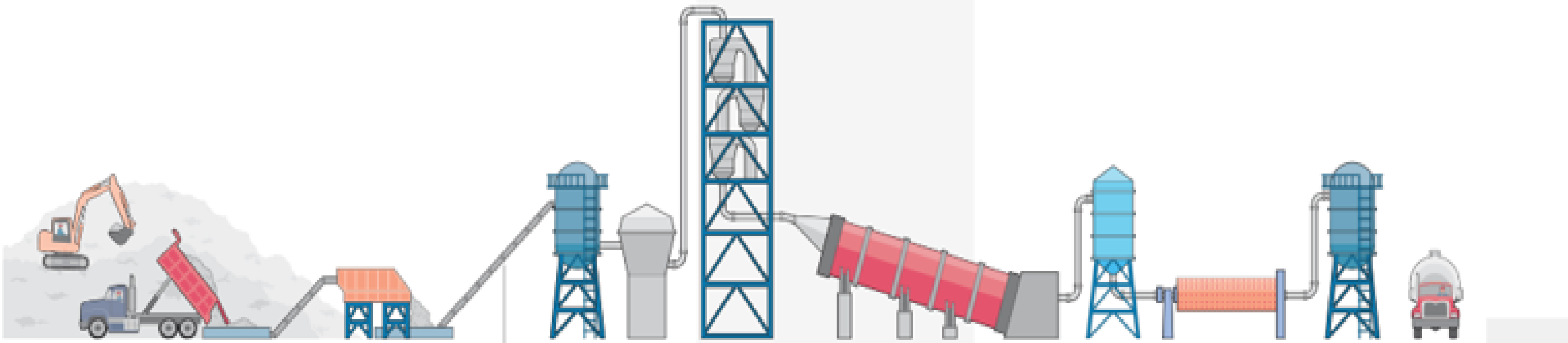
CEMENT MANUFACTURING PROCESS CHANGES…

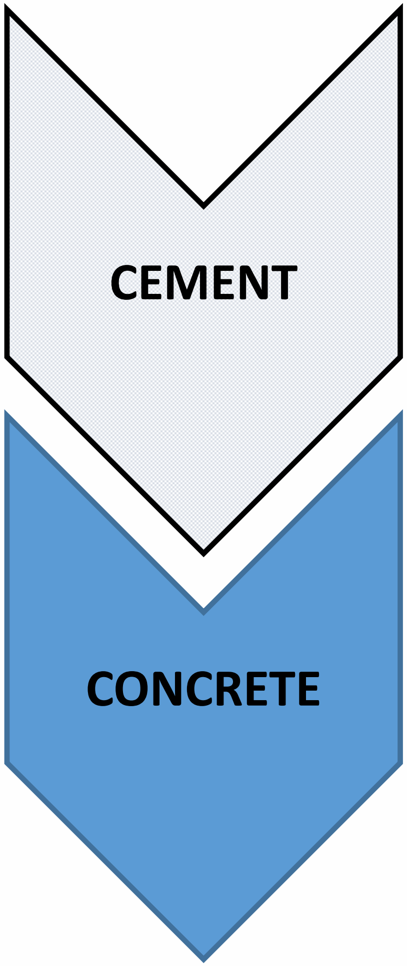
Raw materials, energy, and resources | **Clinker and cement manufacturing**



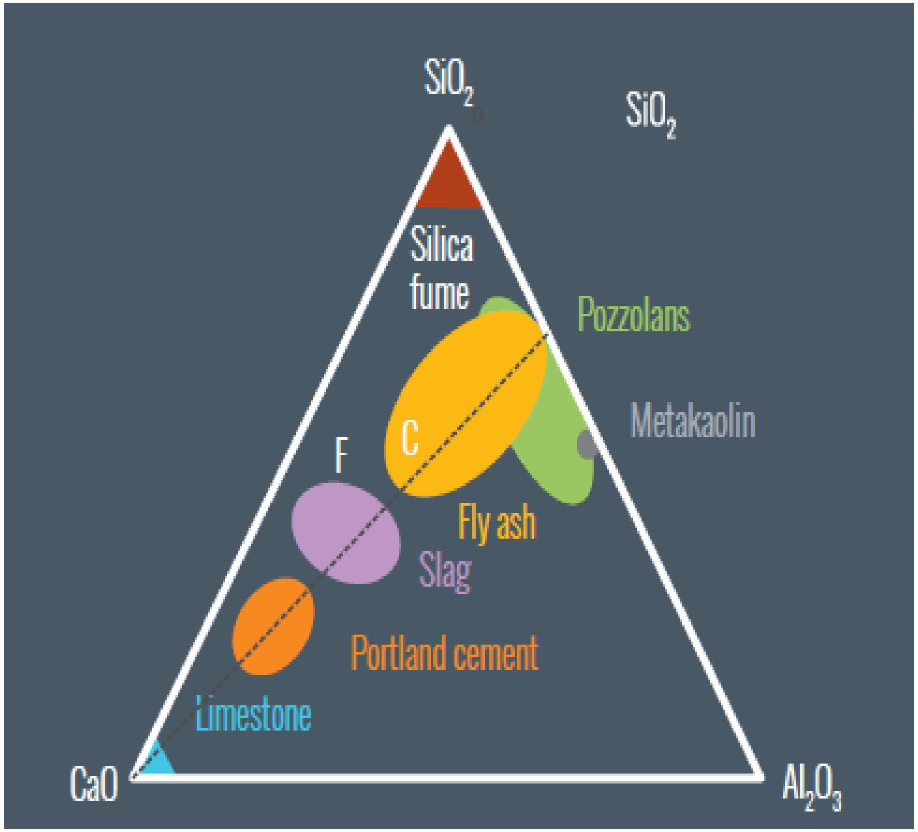
	Quarry	Crusher	Transport[1]	Raw mill	Kiln and preheater/ precalcinator[2]	Cooler[3]	Cement mill	Logis-tics[4]	**Total**
Energy, mega-joule/ton	40	5	40	100	3,150	160	285	115	3,895
CO_2, kilogram/ton	3	1	7	17	479 Calcination process; 319 Fossil fuels	28	49	22	925

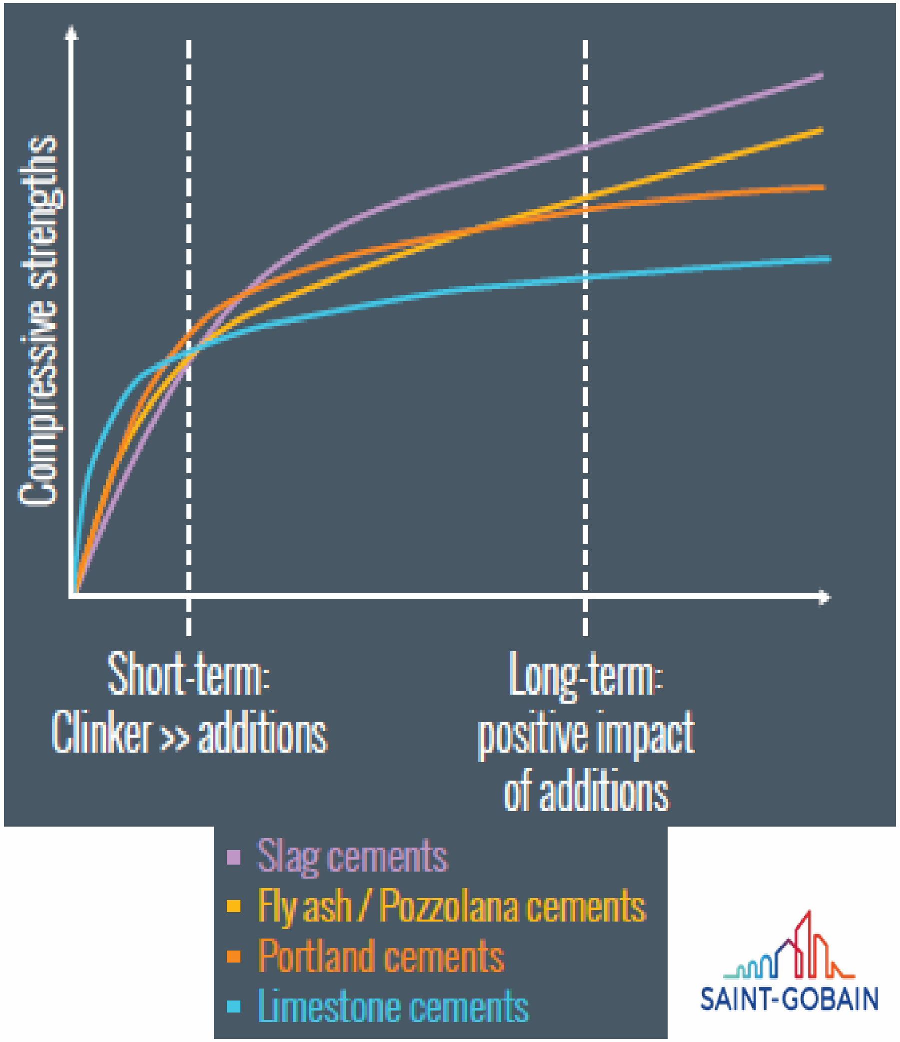
NEW TECHNOLOGIES ARISING

- ❑ Carbon Capture and storage
- ❑ Pushing up clinker substitution
  - Intensifying usage of existing
  - Supplementary Cementitious Materials (SCMs)
  - Implentating use of new SCMs
- ❑ Alternative Clinkers
  - Belitic clinkers
  - Magnesium based cements
  - Carbonation hardening cements
- ❑ Alkali activated materials
- ❑ CO_2 mitigation through better efficiency of cement in concrete
- ❑ Careful selection of aggregate grading and more sophisticated admixturization necessary to ensure workable concrete mixes.



SCM IMPACT AND LIMITATIONS





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ADMIXTURE EVOLUTION

7000 BC

- Fifth El, Galilee, Israel

3000 BC

- Egyptians use of straw to bind clay bricks

300 BC to 476 AD

- Animal fat, milk, and blood used as admixtures

1932 – 1941

- Patent for SNF as plasticizer.
- Air-entraining for freeze thaw

1963 - 1970

- SNF commercially available
- SMF patented
- Fibers introduced

1980 – 1999

- Super plasticizers introduced as admixtures
- Fibers introduced

2023

- **Dynamic performa**
- **Sustainab**
- **SCOPE**

ADMIXTURES ARE ENABLERS OF THE FUTURE!

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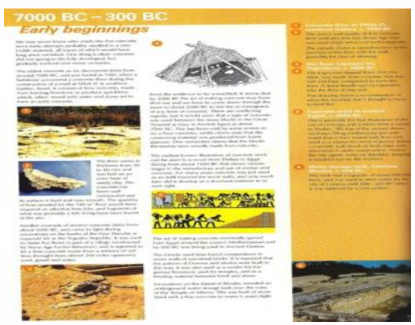
- Today we see changing materials, customer needs are fixed
- The admixture formulation to contend with dynamics

TODAY	→	TOMORROW
Formulation Tools	Customer needs	Formulation Tools


7000 BC – 300 BC
Early beginnings

Customer needs

- Workability retention
- Early strengths

- Placeability
- Low viscosity

- Robustness

- Low viscosity
- Pumpability

- Savings

intel inside

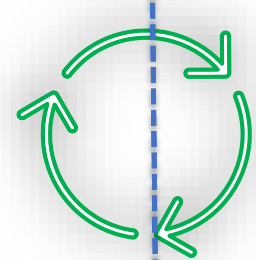
CEMENT AND CONCRETE

SAINT-GOBAIN

CEMENT ADDITIVES AND CONCRETE ADMIXTURES PLAY A CRITICAL ROLE

Blended Cement and new binders production enablers

- NEW MINERAL BLENDS
- GRINDING and CO-GRINDING
- EARLY STRENGTHS ACTIVATION

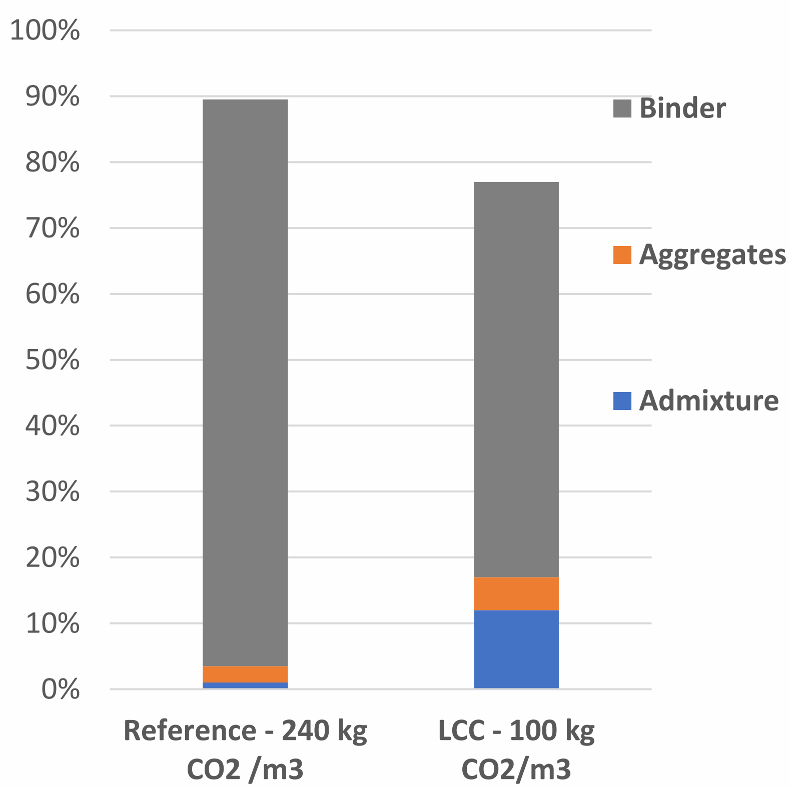


Low Environmental Impact Concrete production enablers

- NEW BINDERS / CONCRETE
- WORKABILITY & RHEOLOGY
- SETTING & HARDENING DYNAMICS
- DURABILITY
- LOCAL MATERIALS USE & RECYCLING

LOW CARBON CONCRETE NEXT STEPS

Contribution to concrete total CO_2 footprint (%)



ADDITIONAL LEVERS	POTENTIAL ASSOCIATED CHALLENGES
USE OF LOCAL and RECYCLED AGGREGATES	▪ Water absorption ▪ Shape and packing density
REDUCE CONCRETE REINFORCEMENT FOOTPRINT	▪ Use of micro & macro-fiber ▪ Use of eco-friendly fibers
LOWER CO2 FOOTPRINT ADDITIVES	▪ Locally bio-sourced or recyc raw materials (Scope 1) ▪ Eco-friendly transportation (Scopes 1 & 3) ▪ Reduced industrial CO2 footprint (Scope 2)

SAINT-GOBAIN

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FUTURE ADMIXTURES IMPROVING THE SUSTAINABILITY PROFILE

Performance and Efficiency

- Mix Design Optimisation
- Reduction of Grinding Time
- Reduction of Curing Time

- Shrinkage resistance
- Freeze Thaw
- Reduce Porosity

Green

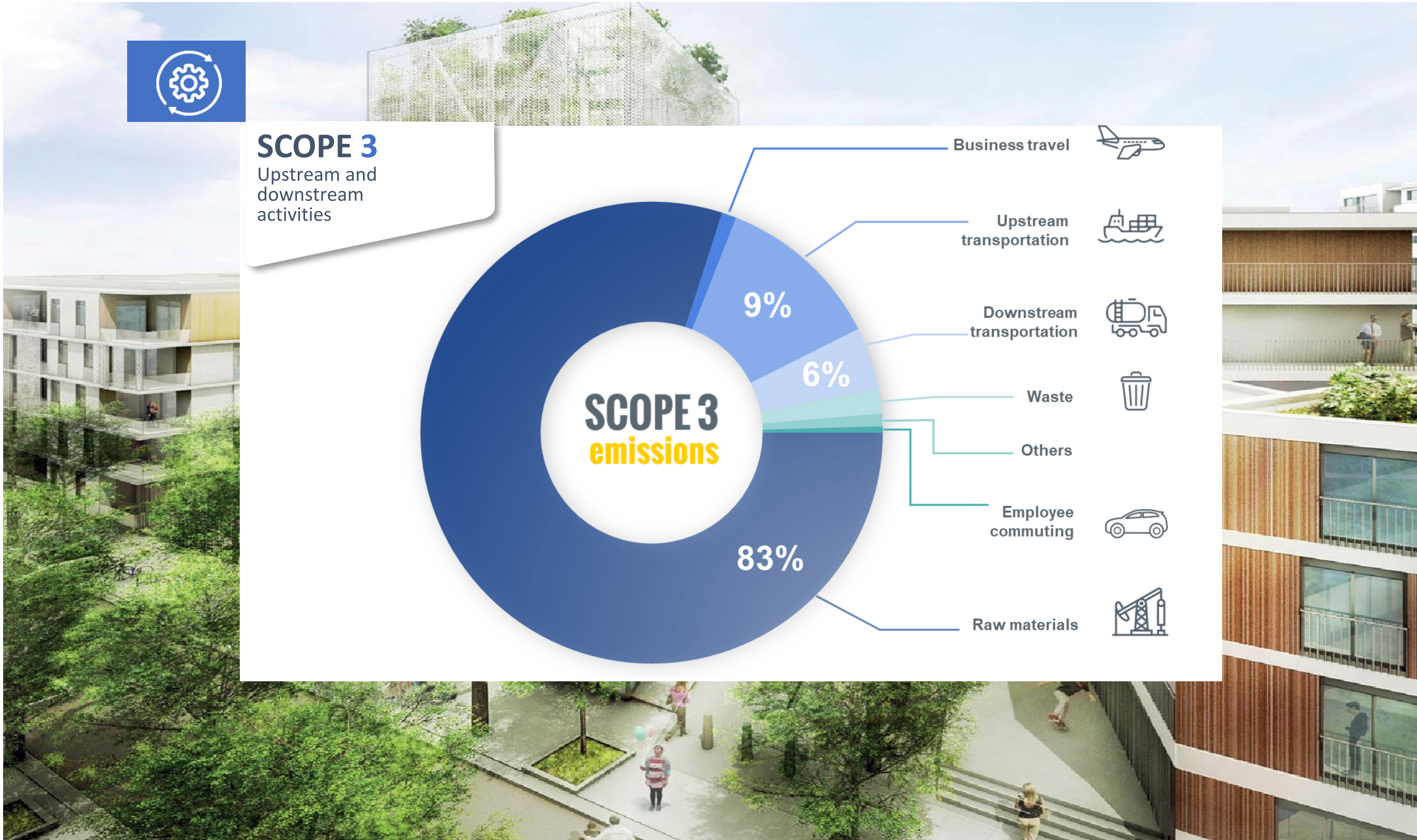
Sustainable Admixture

- Recycling Aggregates
- Safe formulation
- SMC

- Structural slabs and roofs
- Tilt Up
- Pervious Concrete
- 3D Concrete

Durability and Energy


SCOPE
1,2,3
Direct emissions
Indirect emissions
Indirect emissions
GAS + FUEL
ELECTRICITY
UPSTREAM AND DOWNSTREAM ACTIVITIES
1 scope
2 scope
3 scope
CHRYSO
4 ktCO2eq
3 ktCO2eq
660 ktCO2eq
Saint-Gobain
8000 ktCO2eq
2700 ktCO2eq
25000 ktCO2eq


SCOPE 3
Upstream and downstream activities
SCOPE 3 emissions
9%
6%
83%
Business travel
Upstream transportation
Downstream transportation
Waste
Others
Employee commuting
Raw materials

ACKNOWLEDGEMENT
CHRYSO SA AND FRANCE TEAM
ESPECIALLY
MARC PLANCON
BRUNO PELLERIN