Pathways to Decarbonising Cement Manufacturing in SA

KAUST Research Conference

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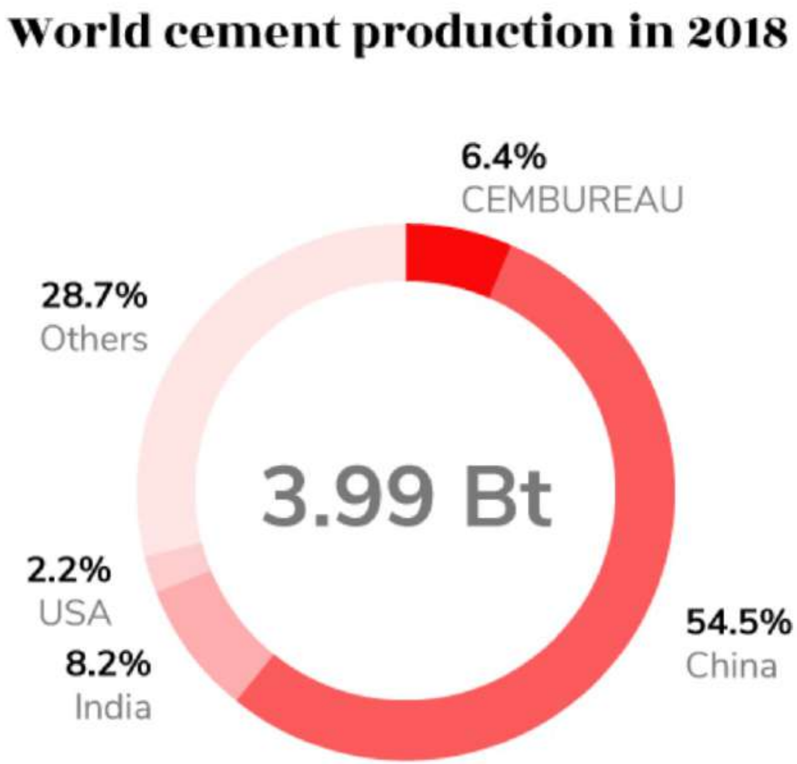
World cement production is 4 billion tons in 2018



- More than half is produced in China.
- KSA cement production is around 50 Mt (1.25%)
- Cement is responsible of 7% of worldwide GHG emissions.

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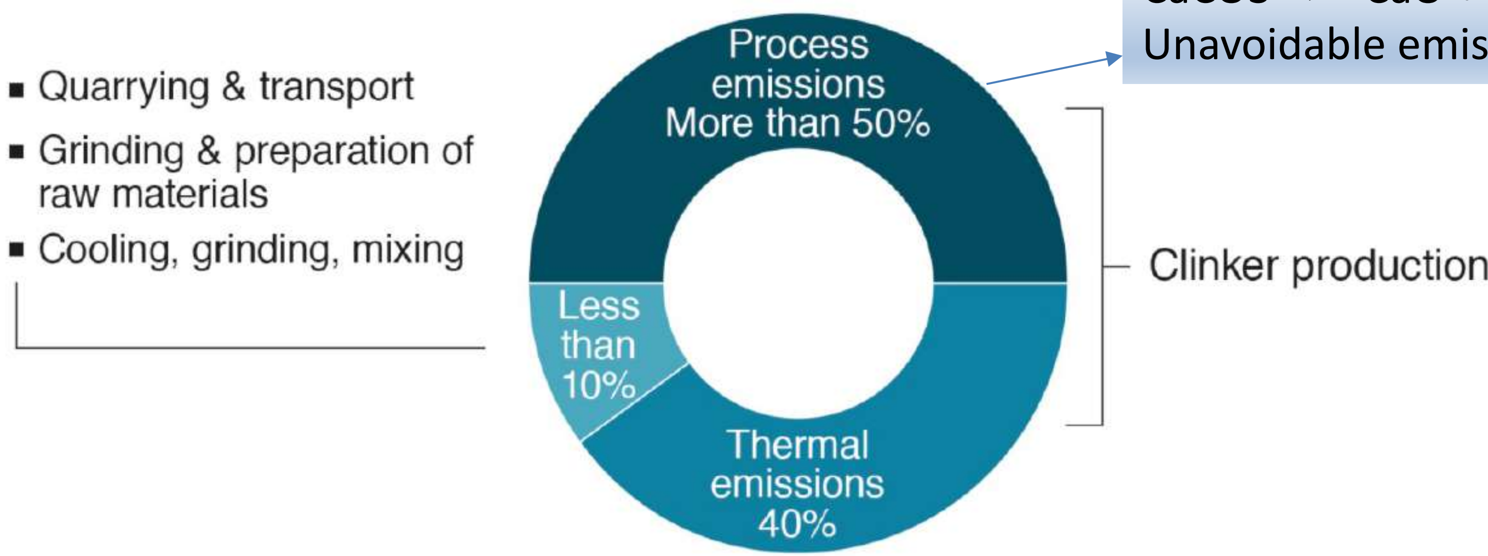
Origin of CO2 from cement industry

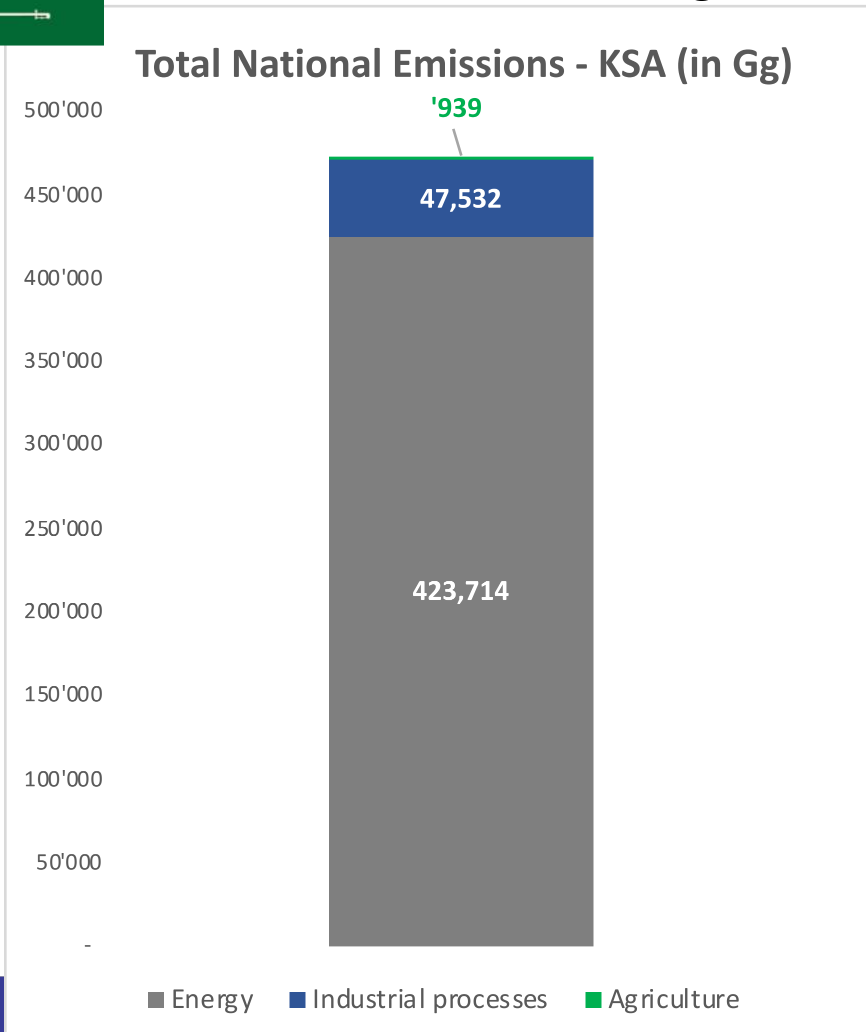
The production of "clinker" accounts for most of the CO2 emissions of cement production

$CaCO_3 \Rightarrow CaO + CO_2$
Unavoidable emissions



Cement represents 8% of the total KSA CO2 (based on UNFCCC 3rd NC)

Total= 472'186 Gg

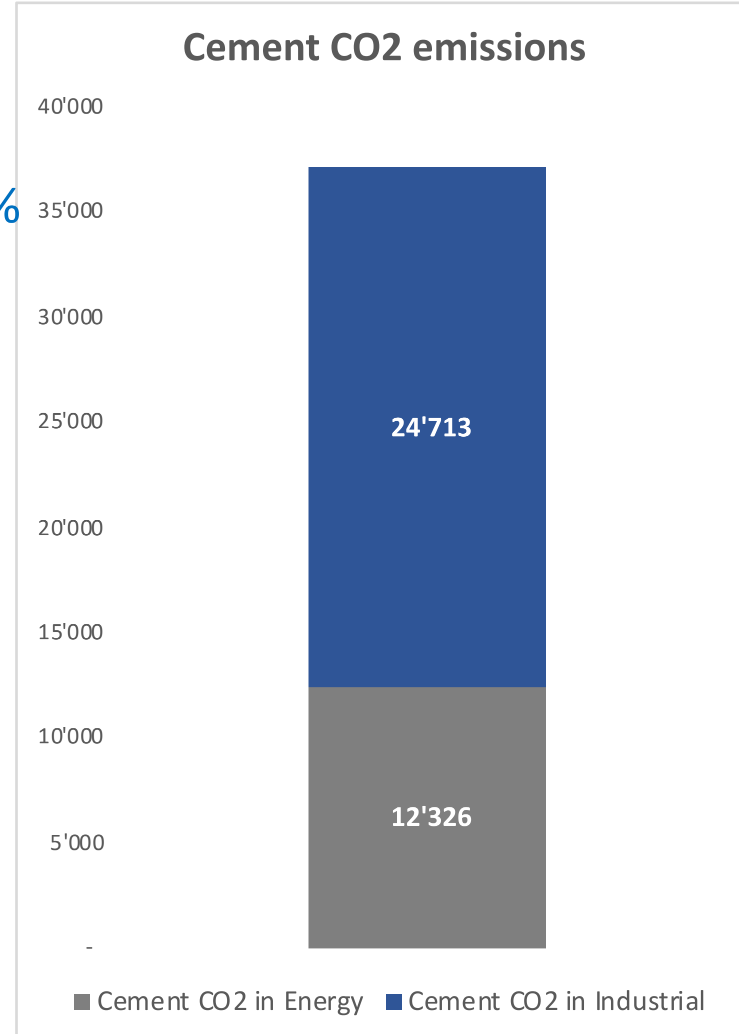


8%

52%

3%

Total= 37'039 Gg



The 4 levers to reduce CO2 in cement industry

Short term | Medium term (2021-2030) | Long term (2030-2050)

Improve Energy Efficiency

- State of the art kilns
- No more wet or semi wet kilns

Reduce the clinker to cement ratio

- Introduce blended cement with local available minerals
- Huge potential of CO2 reduction

Increase Alternative Fuel

- Replacing fossil fuel by waste answers 2 issues (reduce import of coal if applicable, respond to local waste issue)
- Reduction of CO2 (CO2 of fossil fuel vs waste)

Use of CCUS

- Still not economic viable
- Implementations target 2030
- Will represent 55% of the reduction vs today

State of the art kilns

Improve Energy Efficiency

- State of the art kilns
- No more wet or semi wet kilns

- Kilns in KSA are all dry kilns and modern

Kiln Type	Heat Input (MJ/ton of clinker)
Wet	5,860–6,280
Long Dry	4,600
1-Stage Cyclone Suspension Preheater	4,180
2-Stage Cyclone Suspension Preheater	3,770
4-Stage Cyclone Suspension Preheater	3,550
4-Stage Cyclone Suspension Preheater plus Calciner	3,140
5-Stage Cyclone Suspension Preheater plus Calciner plus High-Efficiency Cooler	3,010
6-Stage Cyclone Suspension Preheater plus Calciner plus High-Efficiency Cooler	<2,930

Source: Based on N. A. Madlool et al., "A Critical Review on Energy Use and Savings in the Cement Industries," Renewable and Sustainable Energy Reviews 15, no. 4 (2011): 2,042–60.

Most of them, 4 &5 stage

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Reducing the clinker to cement ratio

Reduce the clinker to cement ratio

- Introduce blended cement with local available minerals
- Huge potential of CO_2 reduction

- Reduce the process emissions (> 50% of total CO_2 emissions)
- Reduce the energy needed to calcine the limestone at 1450°C
- Use locally available cementitious material
- Reduce production cost
- KSA has: 
  - Limestone
  - Pouzzolana
  - Clay

IEA clinker to cement ratio targets
With Limestone and calcined clay

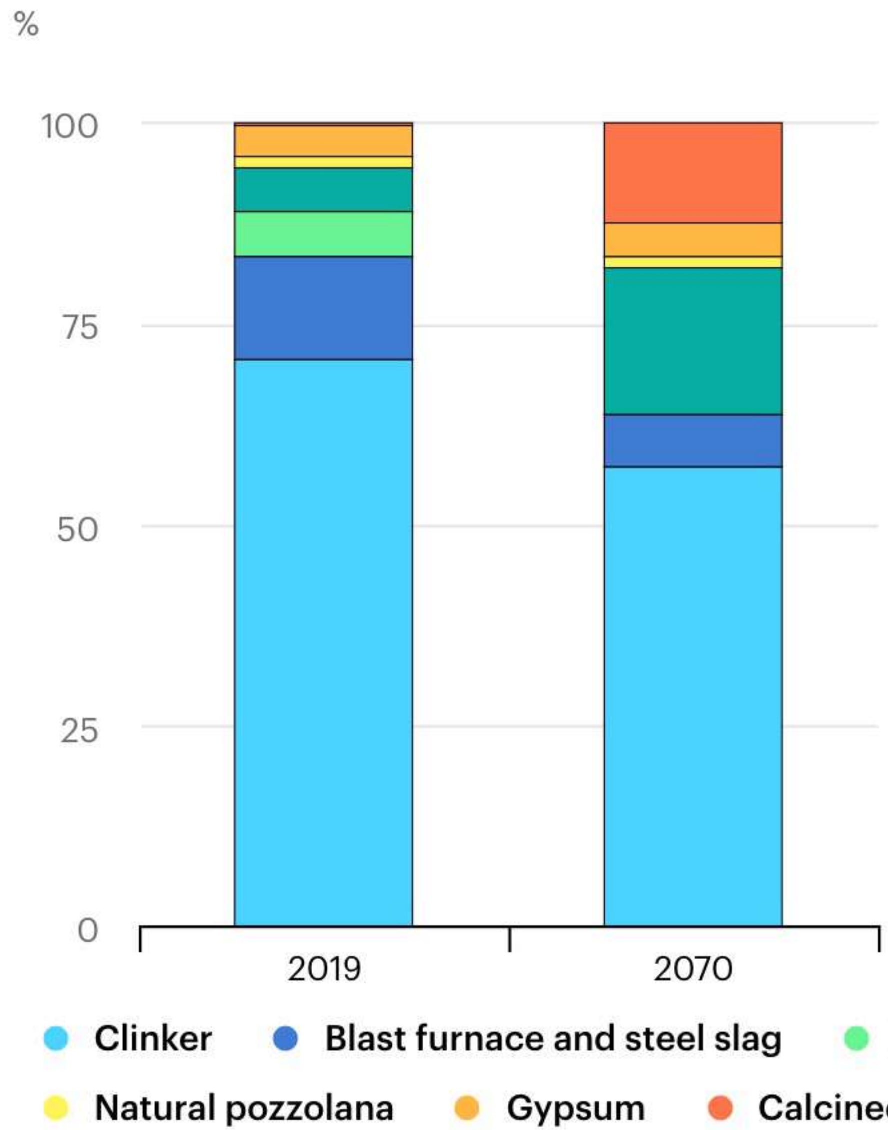
2020	2030	2050
71%	65%	57%

Global cement production by material composition in the Sustainable Development Scenario, 2019 and 2070 (IEA 2021)

Limestone

Fly ash

Slag



Natural pozzolan

Calcined clay (kaolinite)

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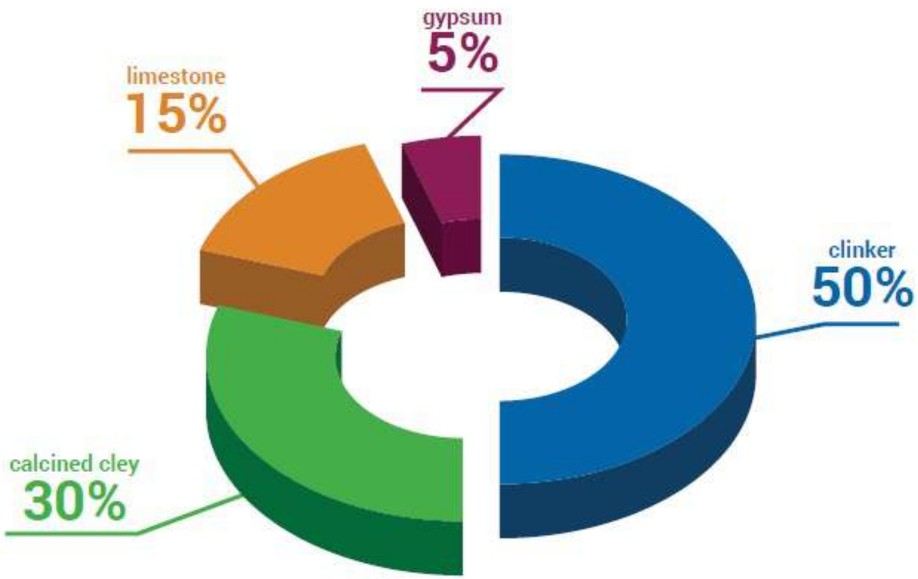
New LC3 cement developed by Swiss university & financed by Swiss government

- LC3 is not just a blended cement like the others



- 50% less clinker
- 39% less CO_2
- Similar compression strength as OPC
- Better chloride and Alkali Silica Resistant (important in KSA)

- Capex : 10 million USD
- Production cost: -7 USD/t vs CEM I

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

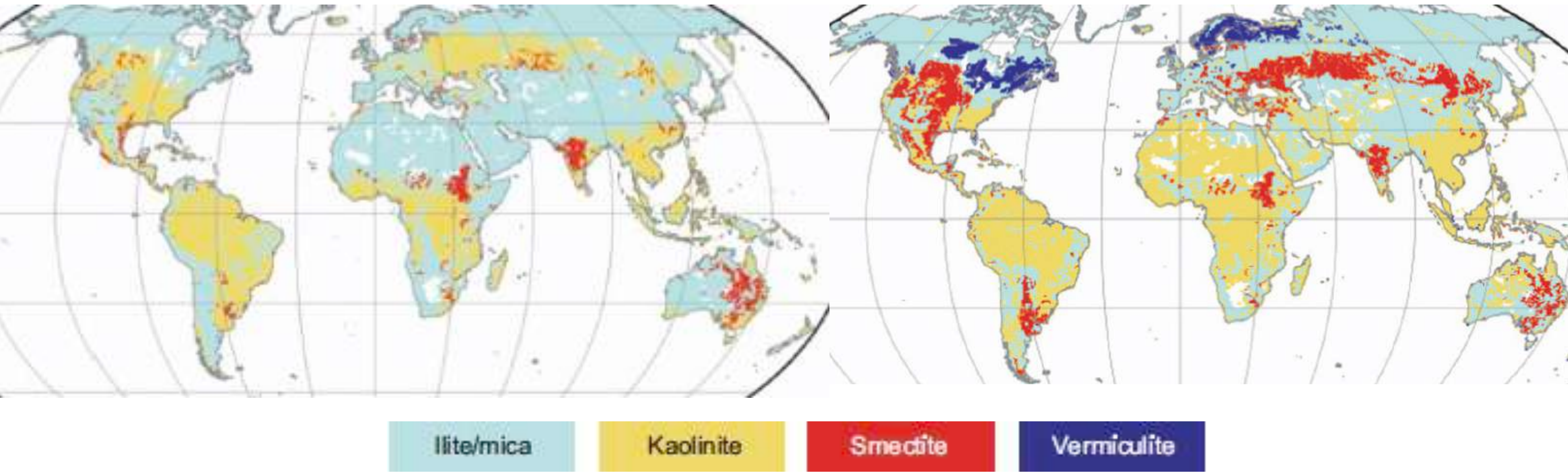
Swiss Agency for Development and Cooperation SDC

EPFL
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Distribution of Kaolinitic clays

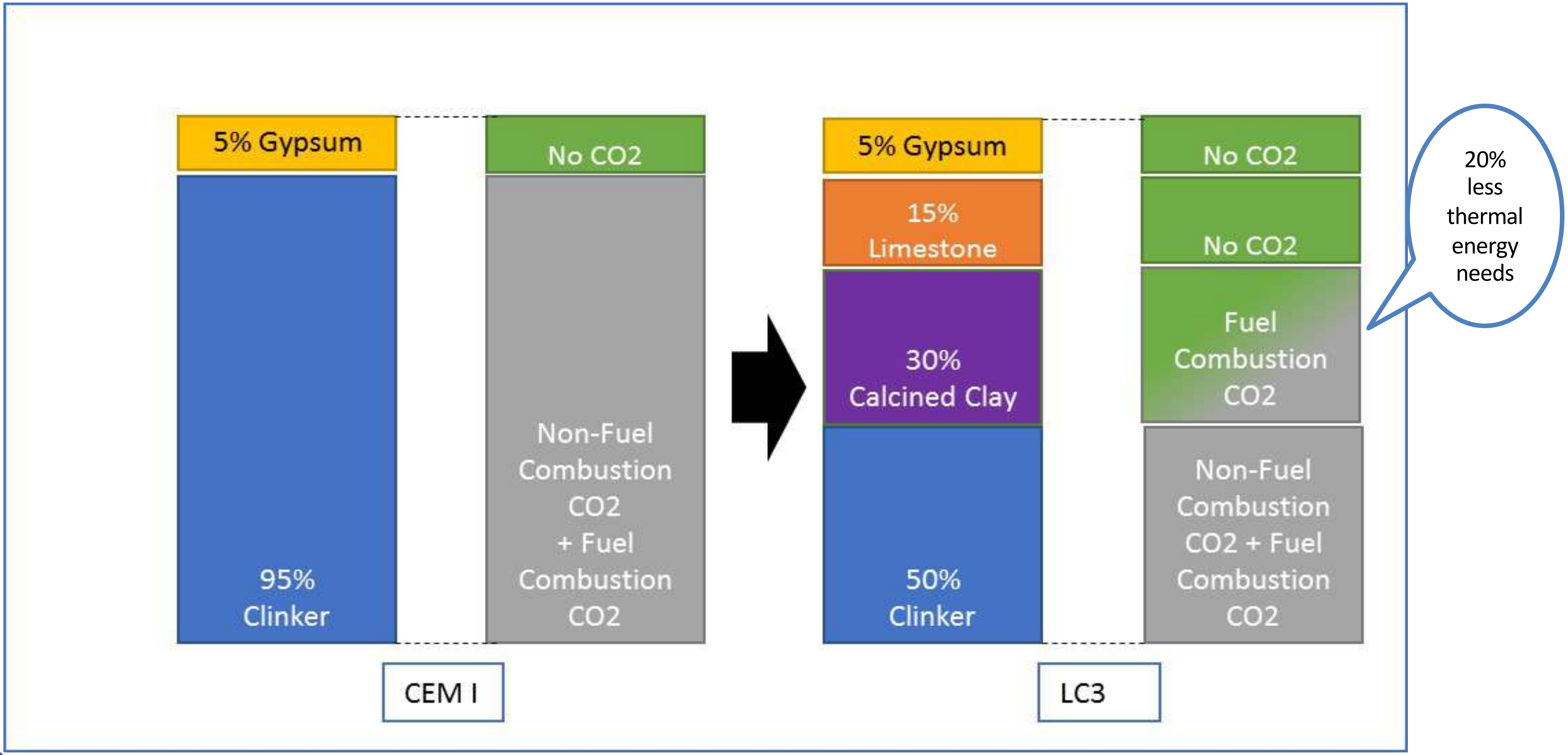
Ito and Wagai, Scientific data 2017

topsoil subsoil



LC3 can reduce up to 39% of CO_2 vs OPC

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



Using of alternative fuel to replace fossil fuel in KSA

Increase Alternative Fuel

- Replacing fossil fuel by waste answers 2 issues (reduce import of coal if applicable, respond to local waste issue)
- Reduction of CO_2 (CO_2 of fossil fuel vs waste)

- Waste is used in cement kiln to replace fossil fuel since many years
- There's **no** technical barrier to reaching 100% substitution rate!
- It solves local waste problem
- It reduces cost (if polluters pay principle is applied)
- But non biomass waste have CO_2 content

Fuel	CO_2 content	Waste	CO_2 content
Coal	96 kg CO_2/GJ	Waste oil	74 kg CO_2/GJ
Natural gas	56 kg CO_2/GJ	Tyres	85 kg CO_2/GJ
Petcoke	93 kg CO_2/GJ	Plastic	75 kg CO_2/GJ
Heavy Fuel	77 kg CO_2/GJ	Solvents	74 kg CO_2/GJ
		Biomass	0

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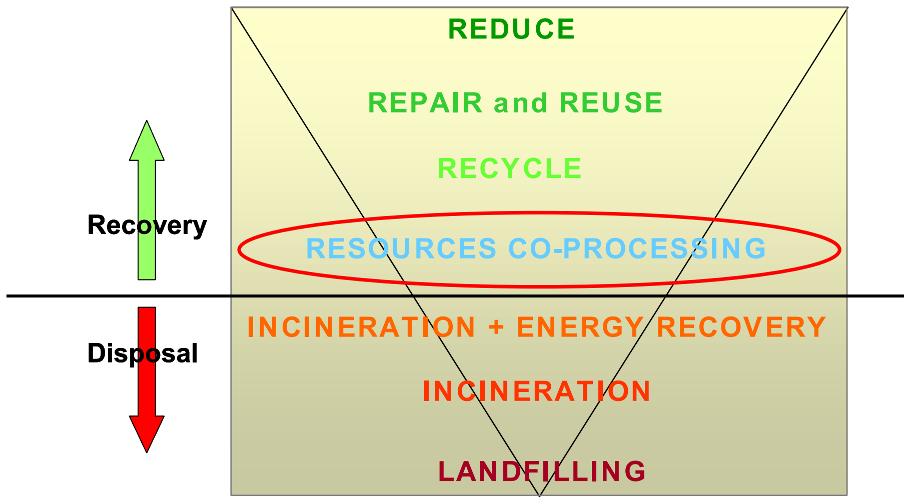
Waste taken as an opportunity

- The energy content of

1 ton of  = 1 ton of 

- and those tires also include raw materials such as iron and aluminum that are required for cement production!



KSA waste according to Ecomena

- KSA produces around 15 million tons of municipal solid waste (MSW) each year. The major portion of collected waste ends up in landfills untreated: risk of major pollution of ground water.

- Recycling rate ranges from 10-15%, mainly due to the existence of the informal sector which extracts recyclables from municipal waste stream.

- Non-hazardous and hazardous industrial waste also need to be tackled. Especially the non recyclable one.

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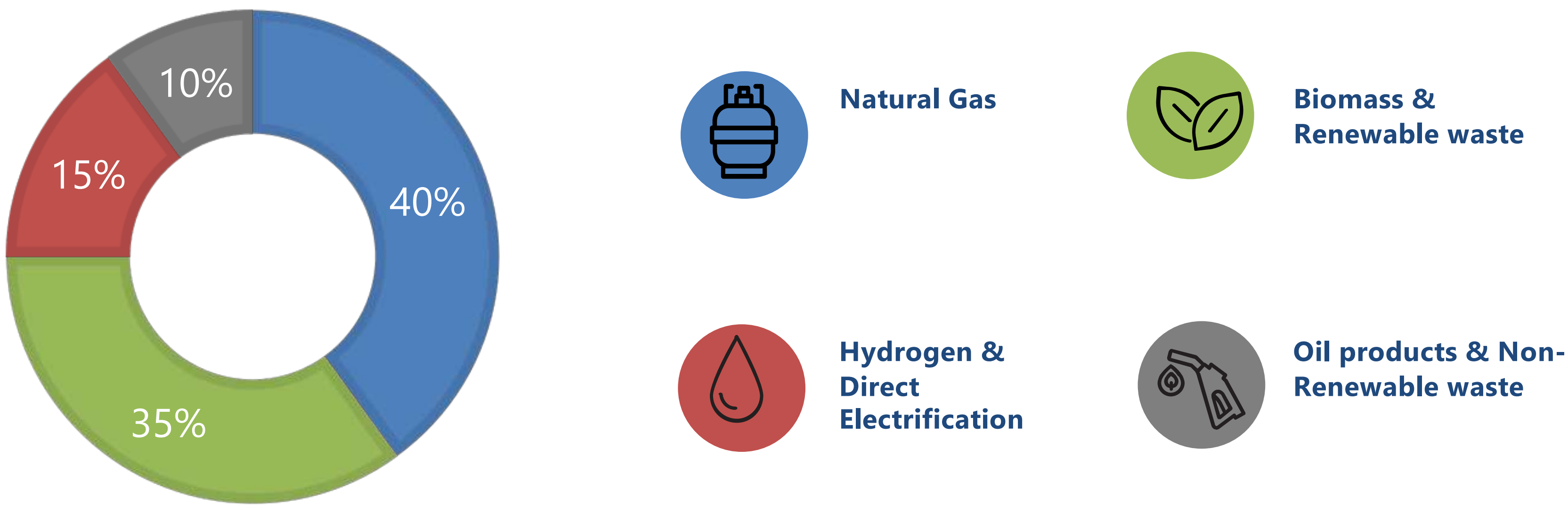
Future energy source for cement industry according to IEA

- According to IEA: Coal will be eliminated from cement production by 2050
- New expected mix:



CCUS in the cement industry is a necessity, not an option

Use of CCUS

- Still not economic viable
- Implementations target 2030

- CC technologies: all are still at the demonstration or prototype stage.
- 3 technologies are known to capture CO2 (ECRA):
  - Direct separation/indirect calcination (Leilac) *(TRL 6-7)*
  - Oxyfuel *(TRL 6)*
  - Post-combustion capture (Brevik) *(TRL 8)*
- But.
  - Begin of commercial use (2028- 2035)
  - Currently not economic feasible: need a CO2 cost of min €40/tonne of CO2.
- Issues for majority of cement plants: far from storage capacities.

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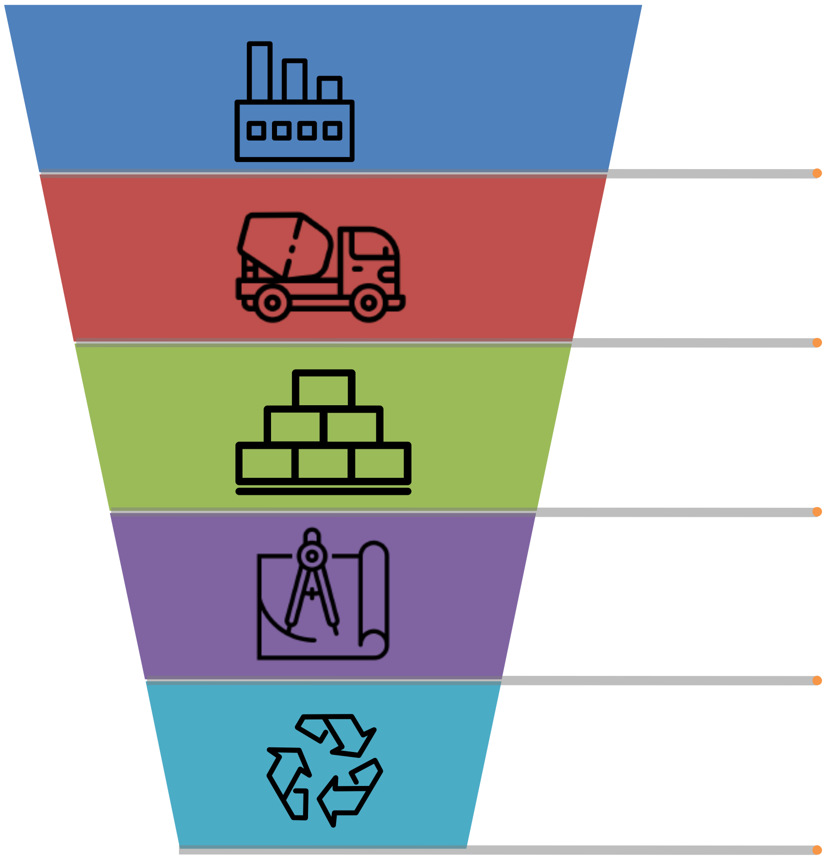
CO2 reduction beyond cement production down the supply chain



Cement Plant
Less clinker in Cement.

Concrete plants
Less Cement in concrete (optimized recipes)

Construction Companies
Optimizing concrete in structures

Architects
Optimized design.

Recycling End of Life
Recycling concrete.

Summary

- Cement emits huge volume of CO_2 but we will always need this construction material.
- The industry needs to take action NOW to reduce emissions through lever 1, 2 and 3.
- The lever 4, CCUS, will be needed but will be commercialized after 2030 only. Cement industry needs to act now.
- Actions have to be taken down the value chain.
- NEOM would be the ideal project to showcase all the possibilities to build a sustainable city with low CO_2 material.

- Start replacing OPC/CEM I in any construction.
- Geological survey to identify deposits of kaolinite clay.
- Increase use of waste replacing coal/fuel by making it cost effective (polluters pay principle + stop subsidies on HFO)
- Begin Feasibility studies on CCUS

Thank you !

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Back-up: Co-processing of waste in cement kiln recovers energy and/or material.

Co-Processing refers to the use of waste materials in industrial processes, such as cement, lime, or steel production and power stations. It is **a recovery of energy or material from waste**. The cement industry is the only industry which does both at the same time

Characteristics	Temperature and time
Temperature at main burner	>1450°C: material >1800°C: flame temperature.
Residence time at main burner	>12-15 sec and >1200°C >5-6 sec and >1800°C
Temperature at precalciner	>850°C: material >1000°C: flame temperature
Residence time at precalciner	>2 - 6 sec and >800°C

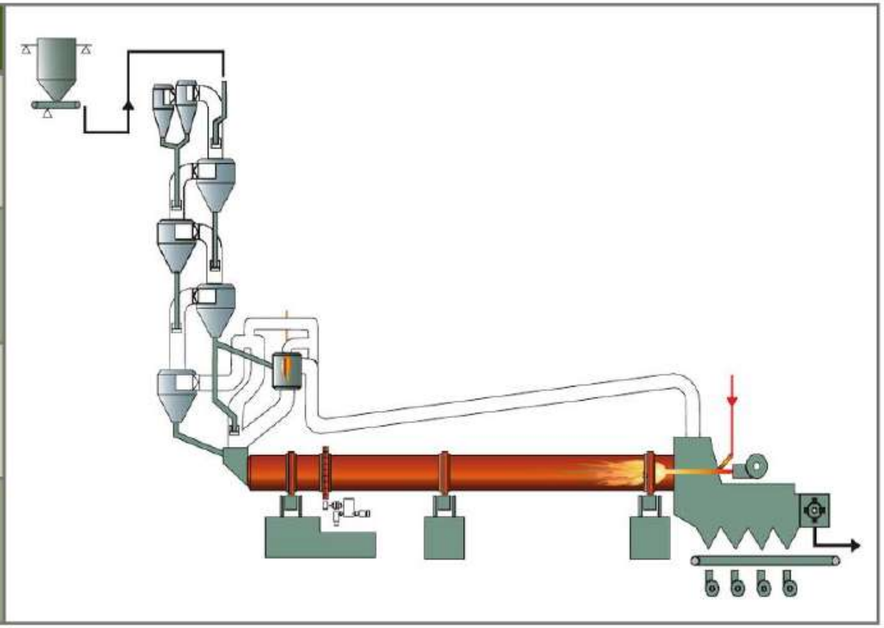

Table 2: Temperature and residence time during cement production

Back-up: Examples of Waste used as Alternatives fuels …

Non-exhaustive lists

- Diaper trimmings
- Expired & contaminated seeds
- Damaged beans
- Plastics
- Expired products
- Expired food/ health products
- Packaging materials
- Rubber wastes
- Textile waste
- Refinery wastes
- Bleaching earth
- Herbicides
- Insecticides

- Paint wastes
- Used oil & grease
- Scrap tyres
- Wood chips
- Solvents
- Carbon fines
- Oil filter fluffs
- Coking wastes
- Shipping wastes
- RDF fluff & pellets
- Surfactants
- Pharmaceuticals
- Sorted municipal solid waste

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Back-up: Calorific value of fossil fuel and waste

Natural resources

- Coal = 28 MJ/kg
- Heavy oil = 40 MJ/kg
- Petcoke = 33 MJ/kg

Alternative resources

- Animal Fat = 37 MJ/kg
- Waste oil = 30 - 40 MJ/kg
- Waste tires = 30 MJ/kg
- Palm nut shells = 19 MJ/kg
- Car shredded waste = 15 MJ/kg
- Dried sewage sludge = 10 MJ/kg

Oxyfuel technology to be build in Germany