Limestone Calcined Clay Cement
LC3
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LOW CARBON LOW COST LOW CAPITAL HIGH PERFORMANCE

Environmental benefits of LC^3

International Conference on Building Materials
Cape Town, South Africa
19 November 2019

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TARA

INDIAN INSTITUTE OF TECHNOLOGY MADRAS

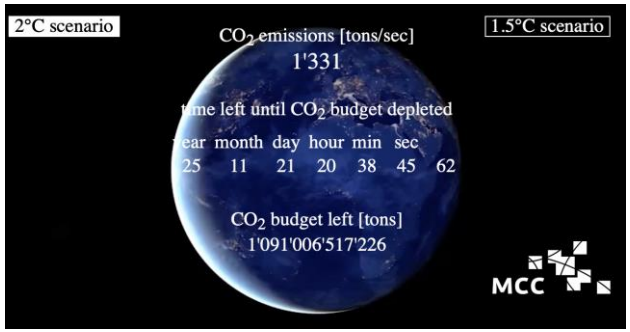
Outline of the presentation

1. Environmental impact of the cement sector
   - » Detect requirements for feasible technologies
   - » Industry that can have the largest savings of CO_2
   - » Realistic and large-scale solutions
2. Advantages of LC3 on CO_2
3. Resource efficiency of LC3
4. LC3 in the current policy frameworks
5. Forecast: LC3 as an opportunity in a changing political framework

1. Global challenge: global warming

Implications for the building sector

- Need to lower CO_2-emissions
- Running out of time

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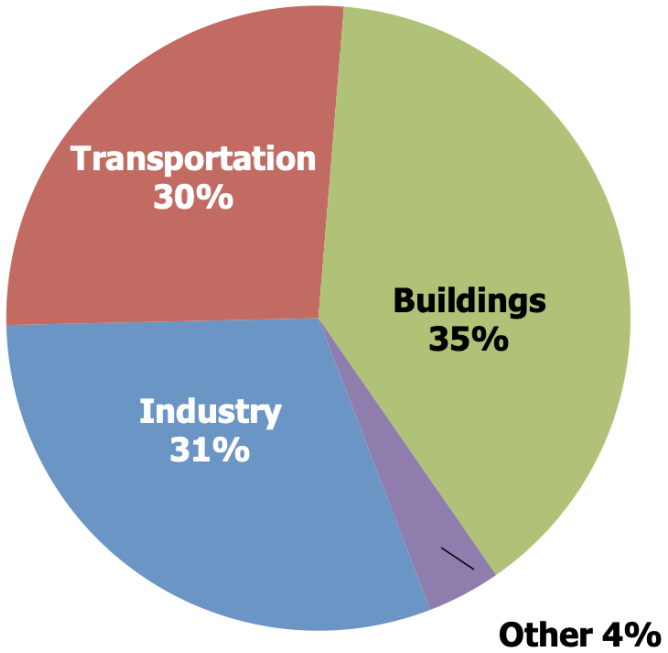
'Brutal news': global carbon emissions jump to all-time high in 2018

Rapid cuts needed to protect billions of people from rising emissions due to increase in use of cars and coal

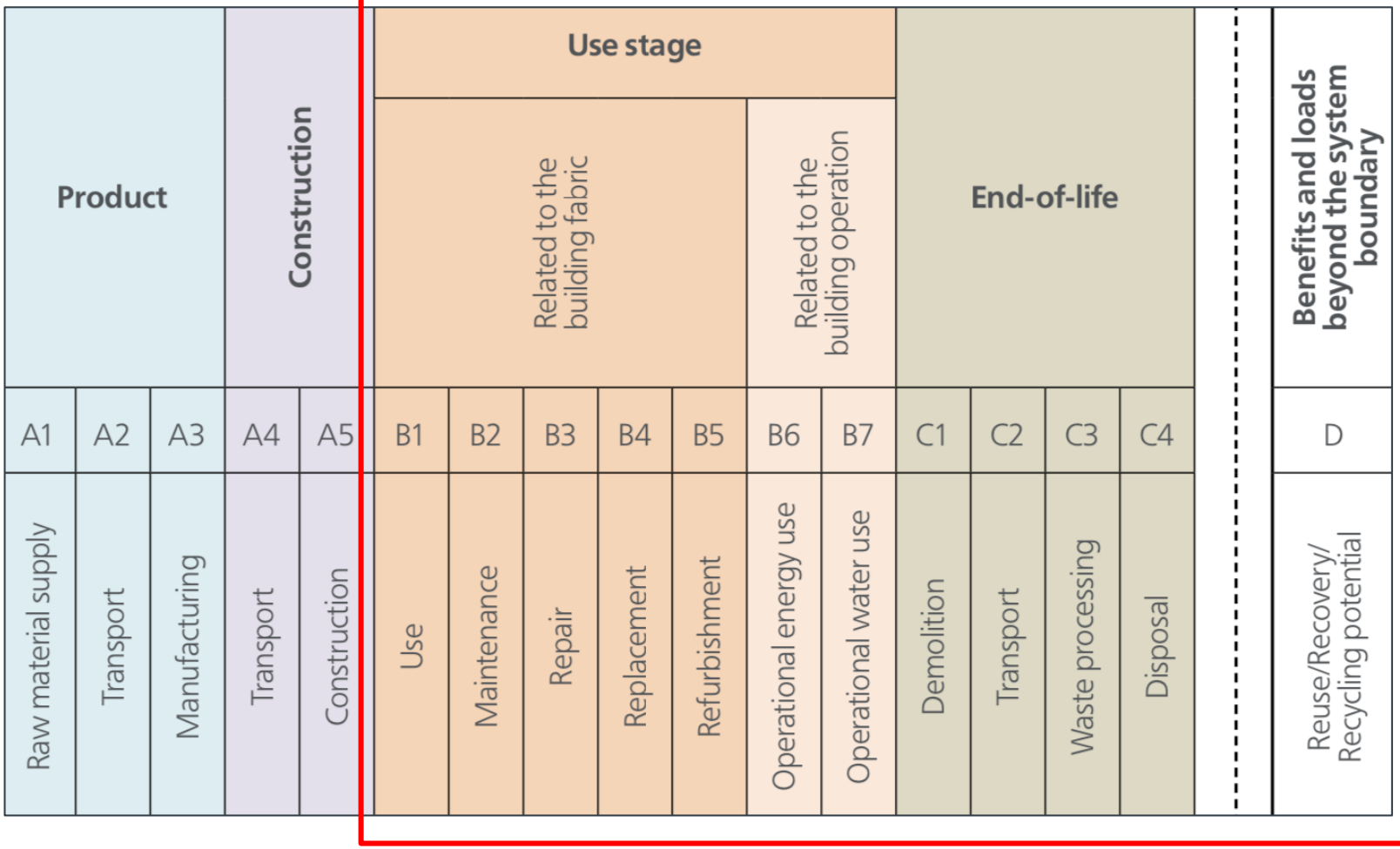


Source: US-EIA Monthly Energy Review, July 2015

- **Urgent need for green transformation and green technology**

1. Where to find green alternatives

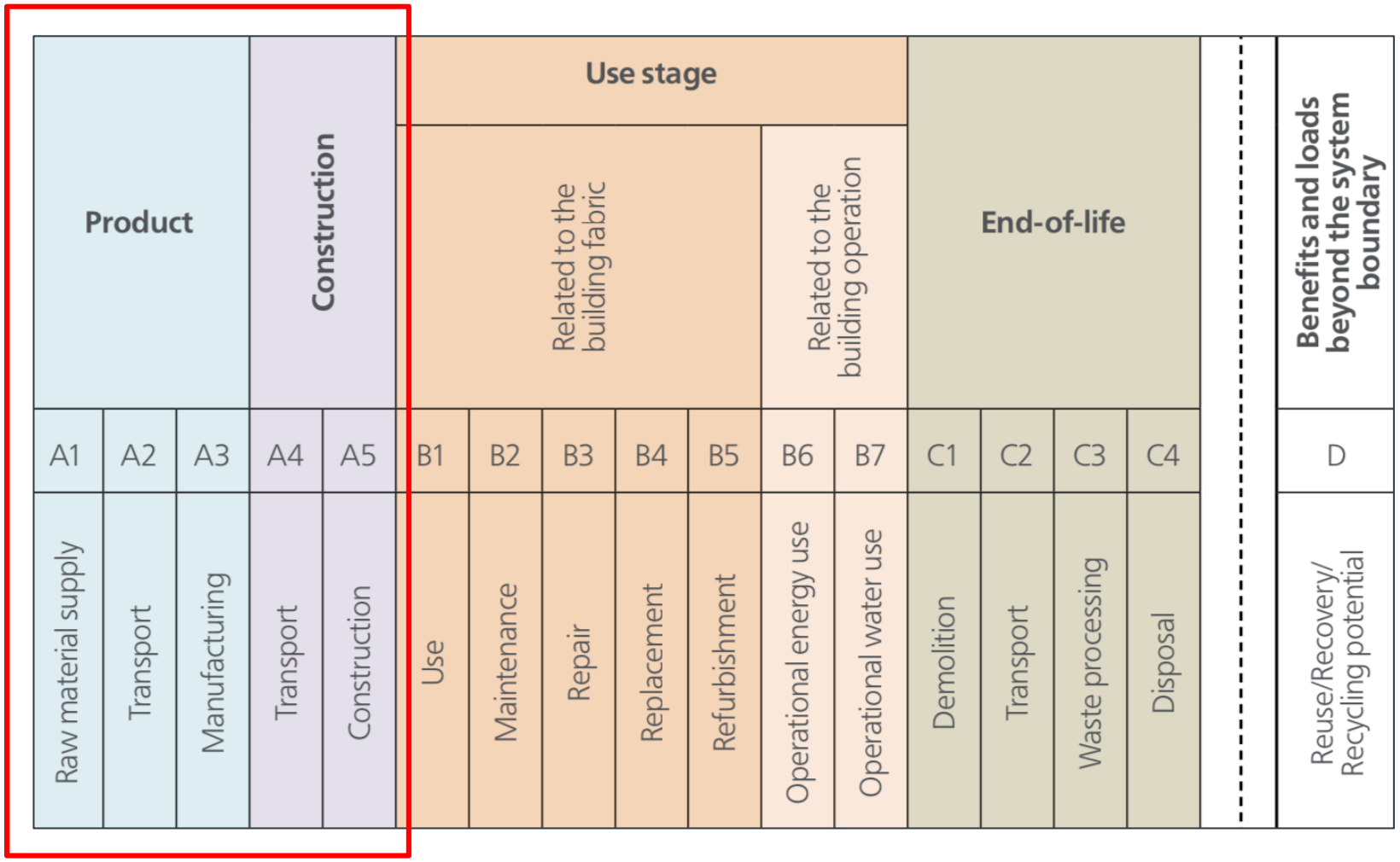
Current focus of public discussion for constructions



Source: Embodied and whole life carbon assessment for architects , RIBA architecture

1. Where to find green alternatives

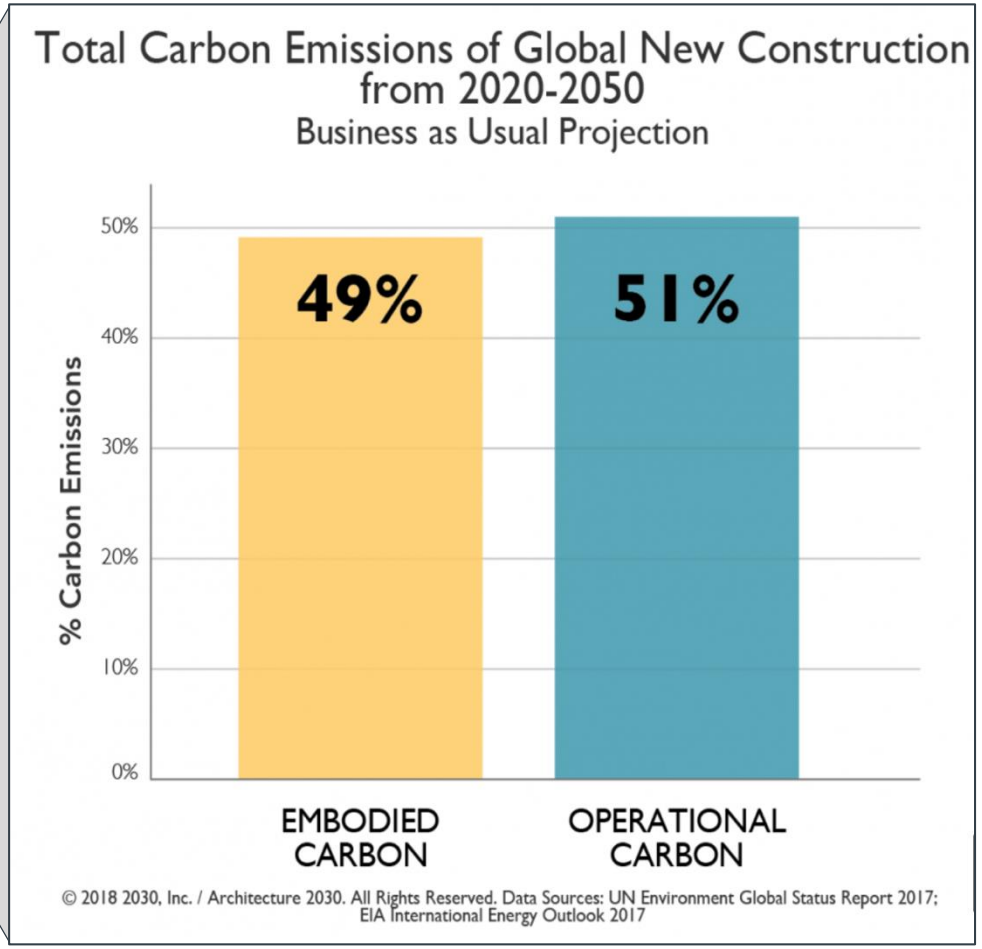
Enormous potentials in earlier stages



Source: Embodied and whole life carbon assessment for architects , RIBA architecture

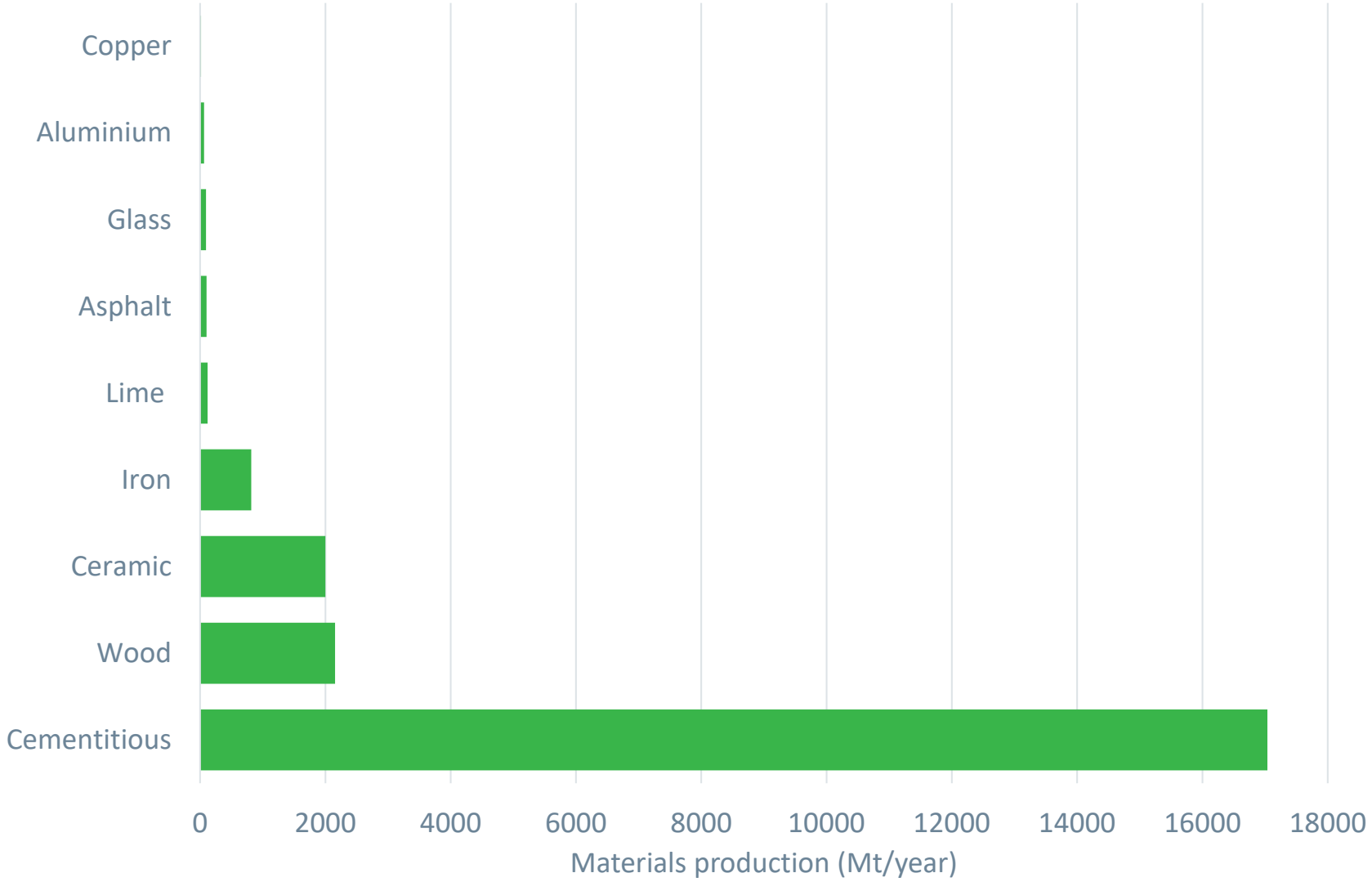
1. Where to find green alternatives

Product			Construction		Use stage							End-of-life				Benefits and loads beyond the system boundary
					Related to the building fabric					Related to the building operation						
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport	Construction	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Demolition	Transport	Waste processing	Disposal	Reuse/Recovery/ Recycling potential



- **Saving embodied carbon with feasible materials means saving CO_2 immediately**
- **Embodied carbon cannot be changed anymore over time**

1. Material consumption per year



1. Environmental impact of cement

Current worldwide consumption of cement

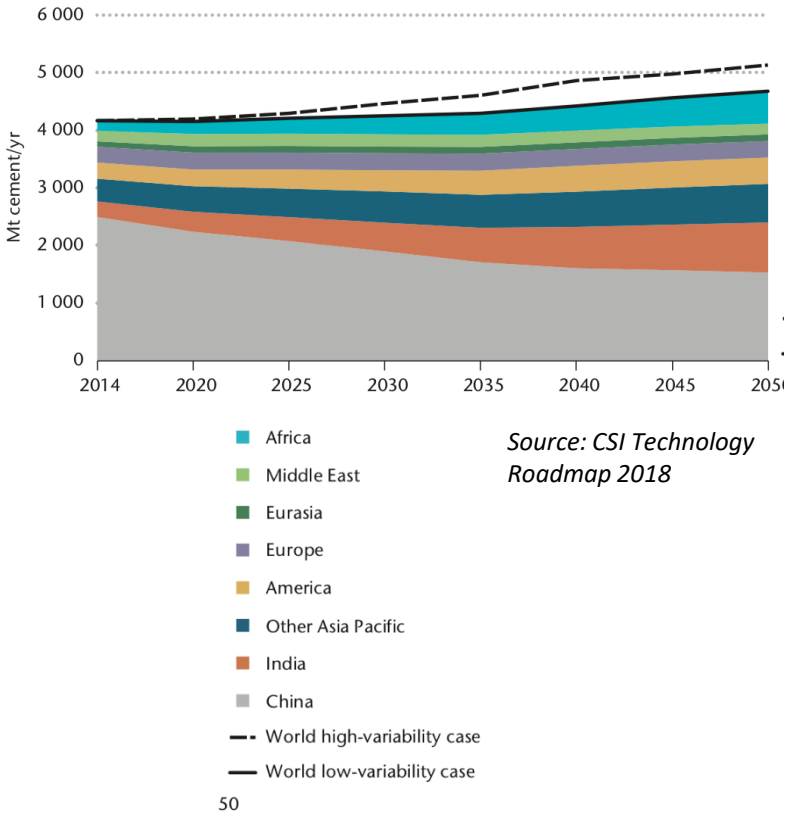
- Production: 4’199 million tons p.a.
- When used for concrete, this amount of cement equals
  - 2’542 times the mass of the building materials of the Great Pyramid of Giza
  - 35’000 times the concrete for the Petronas Twin Towers, Kuala Lumpur
  - 1.5 m^3 per person on earth per year

- **Cement is the most produced material in the world**

1. Conclusions from building material sector analysis

Forecast: main challenges for global building material market

Demand expected to increase up to 5'000 million tons p.a. in 2050



Source: CSI Technology Roadmap 2018

1. Conclusions from building material sector analysis

Forecast: main challenges for global building material market

Demand expected to increase up to 5'000 million tons p.a. in 2050

High extent of **resources** required for global construction material sector

Global cement industry one of the largest producers of **CO_2**

- Accounts for 5 to 10% of human-caused emissions

No alternative to cement!

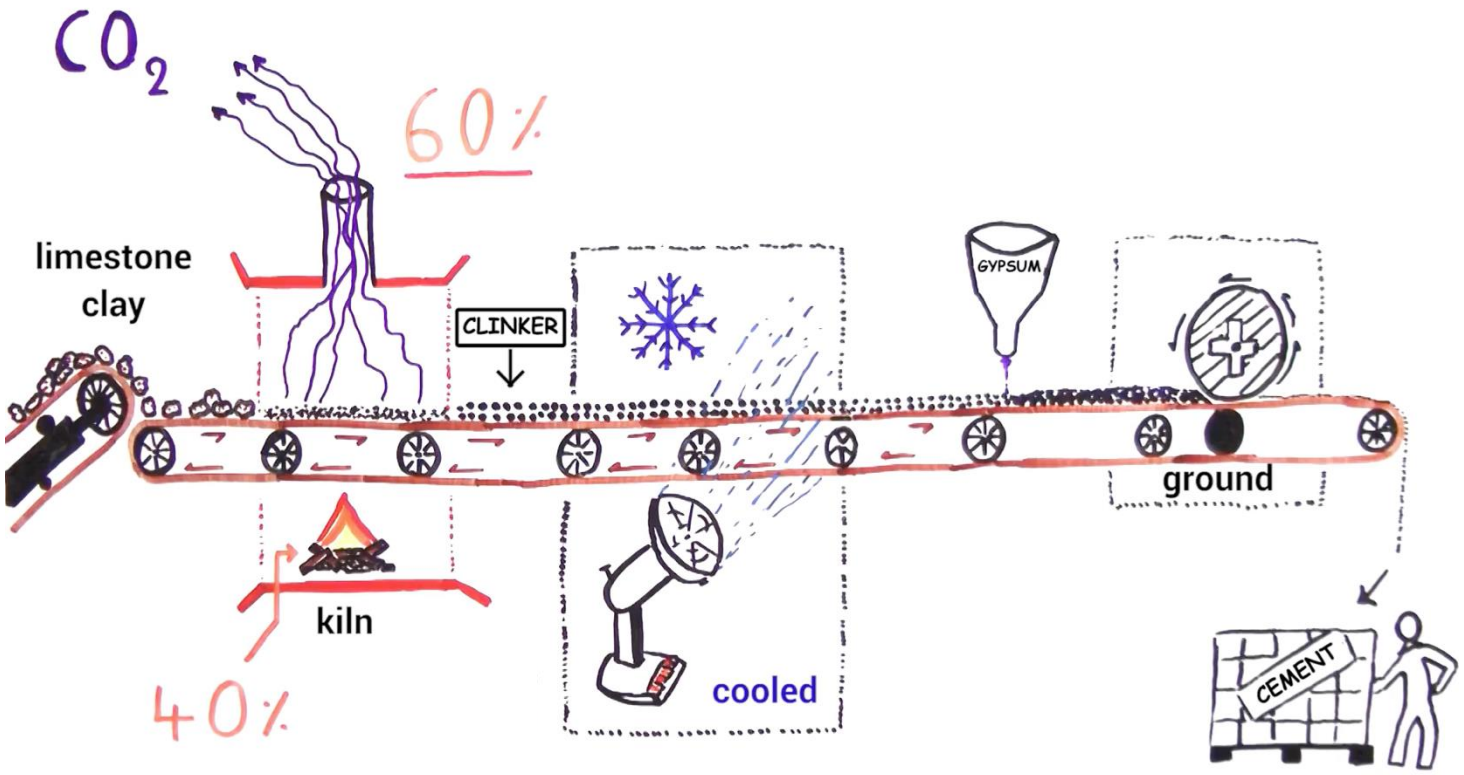
- Matching supply and demand
  - Available resources on earth (no miracle solution)
  - Global demand / development ambitions
- Relatively climate friendly compared to other building materials
  - 50% of everything we produce vs. CO2 emissions of 5-10%

- **Viable solutions to lower CO_2-emissions need focus on reducing the emissions of cement itself**

2. Advantages of LC3

a. Where does CO_2 in cement production come from?

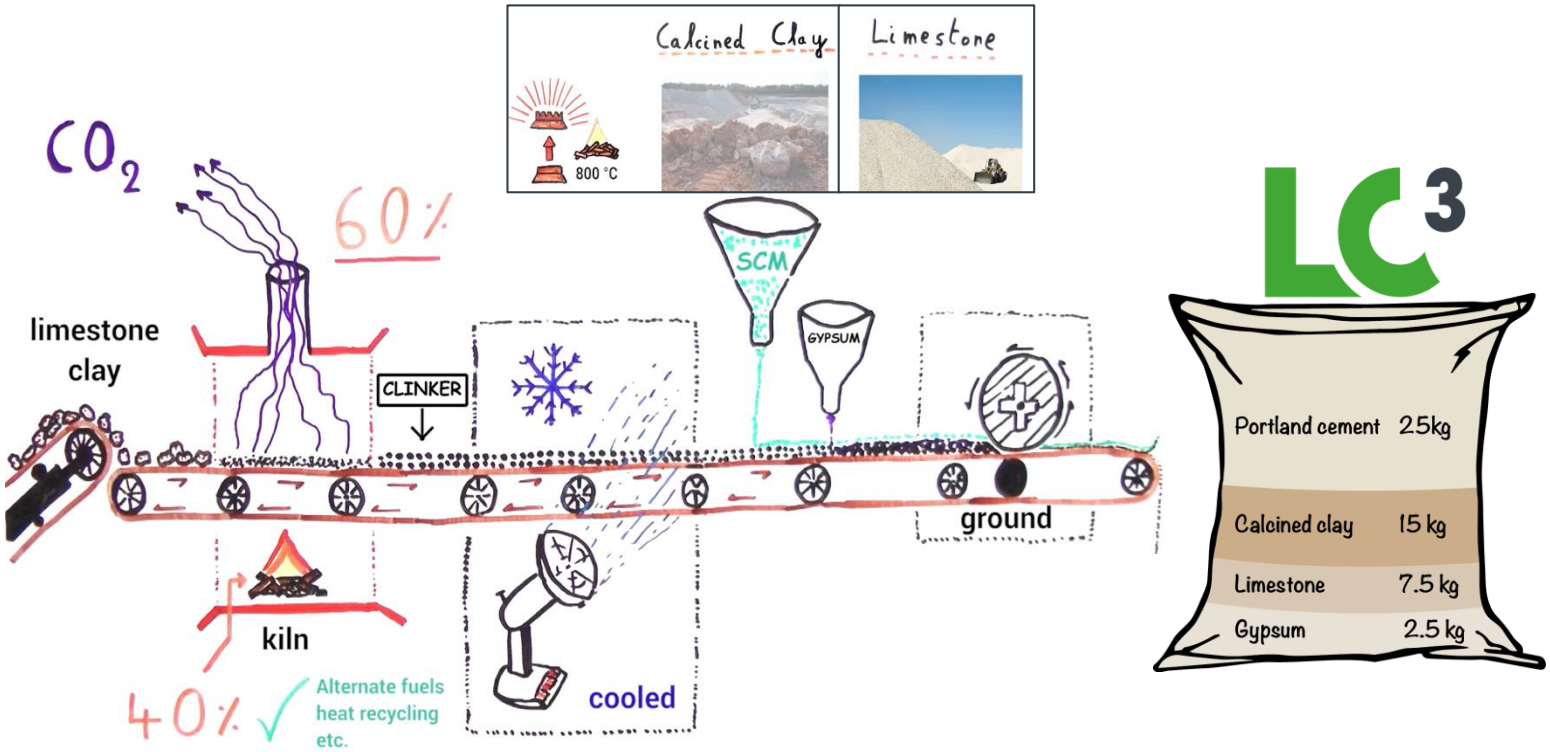
- Production of clinker is energy- and CO_2-intensive
  - 40% of CO_2 emissions from burning fuel to heat kiln to 1450°C / 2640°F
  - 60% due to decomposition of the limestone, $CaCO_3 \rightarrow CO_2 + CaO$



2. Advantages of LC3

b. How to change the cement production in order to lower CO_2?

- Change the composition of the cement
  - reduce clinker content → save CO_2

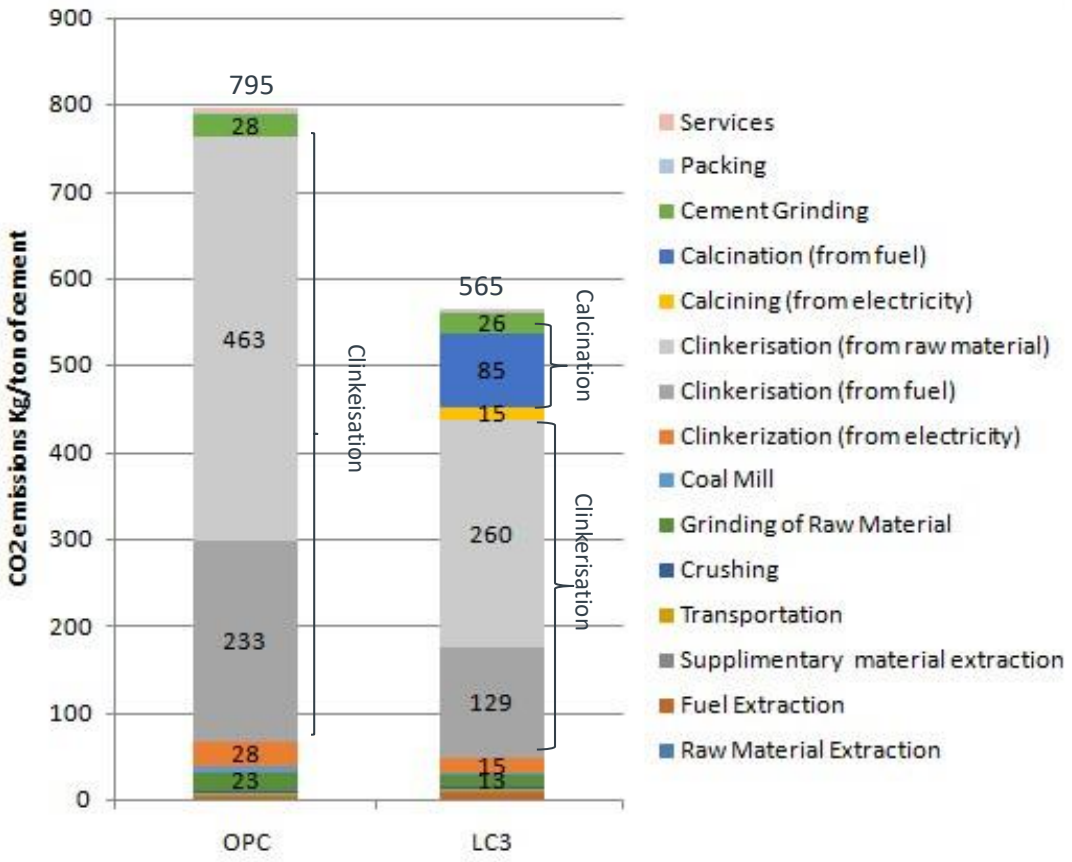


- **Minimize clinker content to reduce CO_2 from both energy and decomposition**

2. Advantages of LC3

c. Process-wise CO_2-emissions

- 30 - 40% of CO2-savings
- CO2-savings 400 million tonnes per year
  - 1 - 2% of global emissions
  - Equals to entire yearly emissions of France



- **LC3 saves between 30 and 40% of CO2 compared to conventional OPC**

2. Advantages of LC3

c. Case study, cements: Ground-to-Gate Calculations

- Break down of environmental impacts by production tiers to determine where emissions are occurring
- All processes from extraction of raw materials to their end use is accounted for in emissions and energy consumption.
- Emissions and energy from the extraction of fuels and the production of electricity are also attributed to cement production.

Impact	OPC	PPC (fly ash blended cement)	LC^3
Emission of CO_2 (kg/ton of cement)	**795**	**610**	**565**
Energy consumed or Embodied energy (MJ/ton of cement)	**3810**	**2980**	**3430**

*Energy consumption for **calcination of clay is taken as 2.6 MJ/kg***

2. Advantages of LC3

d. Case study, cements: CSI System Calculations

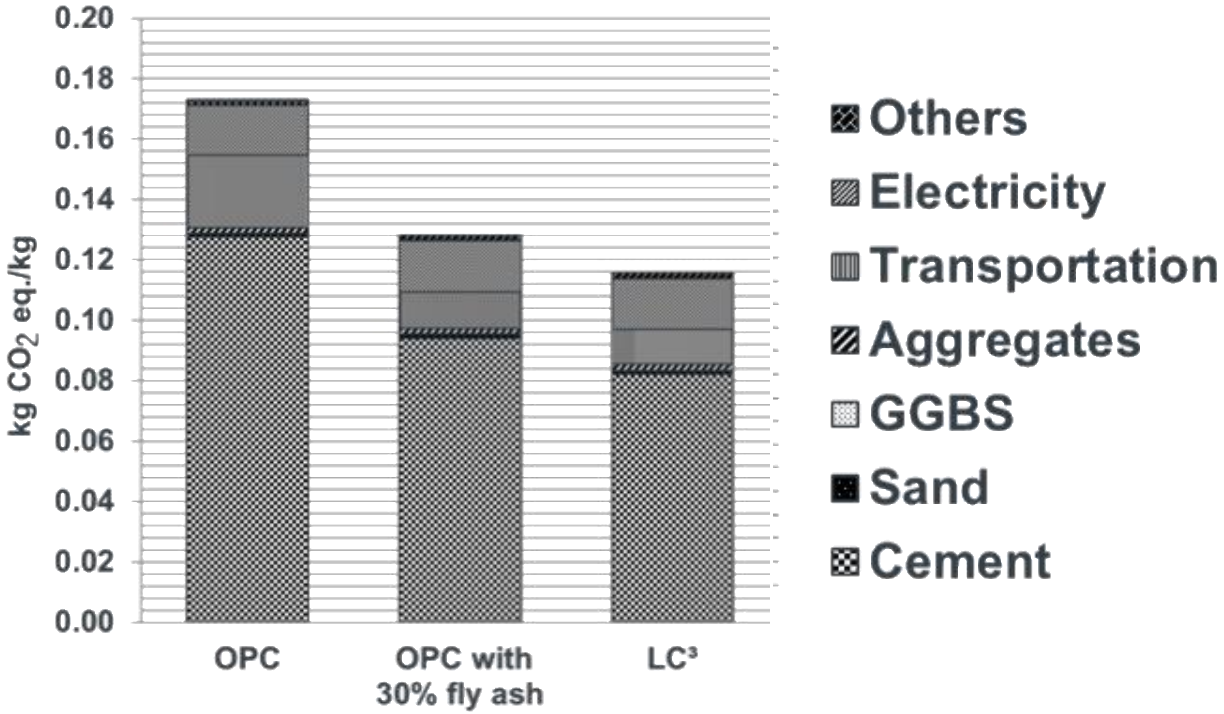
- Only direct emissions are considered.
- Emissions and energy consumption during extraction and transportation of raw materials and all fuels are excluded.
- Emissions and energy consumed due to the production of electricity (both purchased and produced) is excluded.
- *Provides data for comparison with CSI database*
- *Based on measurable quantities at the plant level and avoids almost all assumptions that are not relevant to local conditions and materials.*

Impact	OPC	PPC	LC^3	CSI (India, 2012): 70.5% clinker factor
Emission of CO_2 (kg/ton of cement)	**700**	**520**	**465**	580*
Energy consumed or Embodied energy (MJ/ton of cement)	**2630**	**1965**	**2350**	2400* *values shown for comparison

2. Advantages of LC3

e. Case study, concrete: LCA Ground-to-Gate Calculations

- 50 MPa design strengths
- Mixes typically used in RMC (in India), with similar workability and strength gain
- Concretes with OPC, OPC + 30% fly ash, and LC3 (50% clinker)



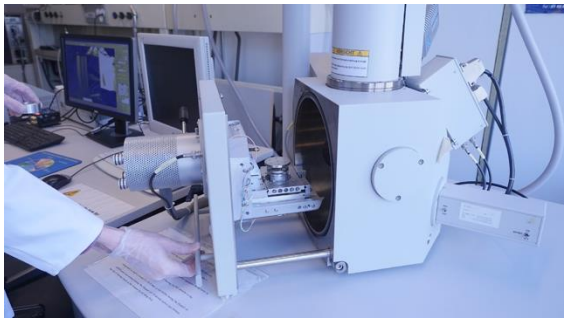
*Includes contribution of processes in cement production other than clinkerization

2. Advantages of LC3

f. Prefab material: LCA of Hollow Core Slab

2. Advantages of LC3

g. Testing and application in all different aspects, also real structures






» **In theory and practice, LC3 shows much lower CO2-emissions than ordinary OPC**

2. Advantages of LC3

h. Finalized applications of LC3

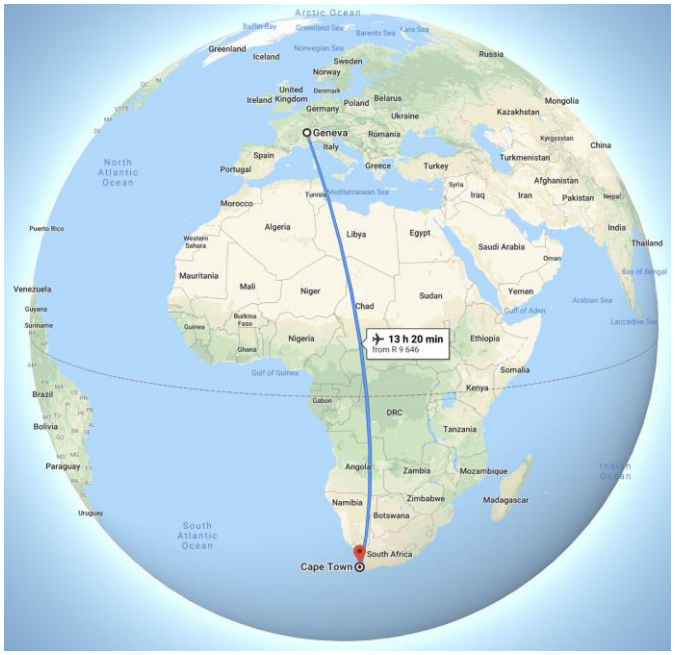
- 11 applications in Asia and 16 in Latin America
  - Roads, houses, pavements, damn
  - Including a Swiss embassy building in Delhi
  - And demo house with 98% of LC3

- **In theory and practice, LC3 performs similar or even better than ordinary OPC**

2. Advantages of LC3

h. Model house in India

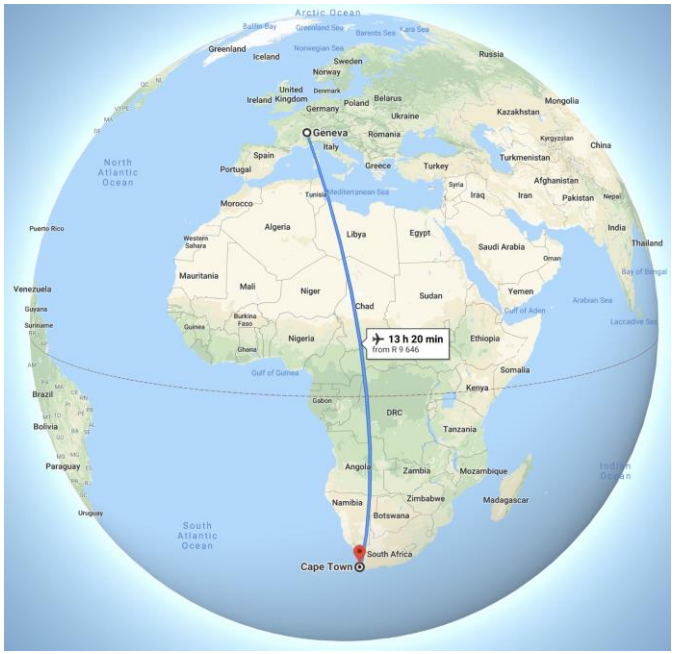
- Built as demonstration by the LC3-project
- This house is made 98% out of LC3 and it
  - Used 26.6 t of industrial waste (192 kg/sqm)
  - Saved 15.5 t of CO_2 (114 kg/sqm)
  - Equivalent CO_2-savings compared to 10 passengers from Geneva to Cape Town



2. Advantages of LC3

i. Hypothetical demonstration: example in Latin America

- Madre Laura bridge in Medellin
- Longest bridge in Colombia with 768 meters
- If built with LC3,
  - could have saved 9,240 tons of CO_2
  - Equivalent CO_2-savings compared to 6'200 passengers from Geneva to Cape Town



3. Resource efficiency of LC^3

- Utilization of lower grade material for LC^3
  - Clay waste e.g. ceramic or cosmetic industry
  - Less purity of limestone required, e.g. dolomite presence
- Using existing deposits of waste materials
  - Low prices for the raw materials
- Avoiding creating waste
  - Avoiding cost (e.g. for landfill taxes)

- **LC3 saves resources and can thereby even unlock further cost options**

3. Advantages of LC3 summarized

- LC3 achieves 30 - 40% of CO2-savings compared to conventional OPC
- LC3 saves scarce resources and use waste materials
- LC3 does not restrict ambitions for growth and development
  - Serves the global cement demand
  - While being “greener” than OPC

- **LC3 is a feasible solution for both climate protection and development efforts**

4. LC3 in the current policy framework

a. Strategic significance to gain CO_2-savings

- New policies provide incentives for lowering emissions and saving energy
  - Typically rewards, fees or subsidies

- The green incentives are an opportunity and mechanism
  - For Policy makers to favour low-carbon solutions
  - For industrials to access finance or lower costs
  - For academia to access finance for research

- Following categorization will help for the discussion between groups
  - Among these groups, not everybody is aware of the potentials of LC3

- **Increasing awareness among policy makers, academia and industrials to facilitate LC3**

4. LC3 in policy frameworks

1. LC3 receives increasing recognition from policy makers
   - » Project team at UN-COP, green city reports, UN-GSDR, UN-Habitat, etc.

2. SDGs:

3. NDCs
   - » Exemplary calculations from Latin America
   - » LC3 up to 11% contribution to achieving national target and >50% of industrial goal (commercial and industrial sector)

4. Urban planning and green cities
   - » LC3 an opportunity to use large amounts of materials to significantly lower CO_2

5. Forecast: CO2-pricing will make LC3 even more attractive

4. LC3 in the current policy framework

a. LC3 Contribution to the SDGs

Clean Technology Adoption (Alternative to OPC)

Limestone Calcined Clay Cement LC3

Sustainable Infrastructure (Green material infra and housing)

Sustainable Industries (Gives green alternative for users)

4. LC3 in the current policy framework

a. LC3 Contribution to the SDGs

Affordable Housing (Low Cost)

Resource Efficient Cities (Less resources use)

Built cities using local materials (Uses widely available Clay)

4. LC3 in the current policy framework

a. LC3 Contribution to the SDGs

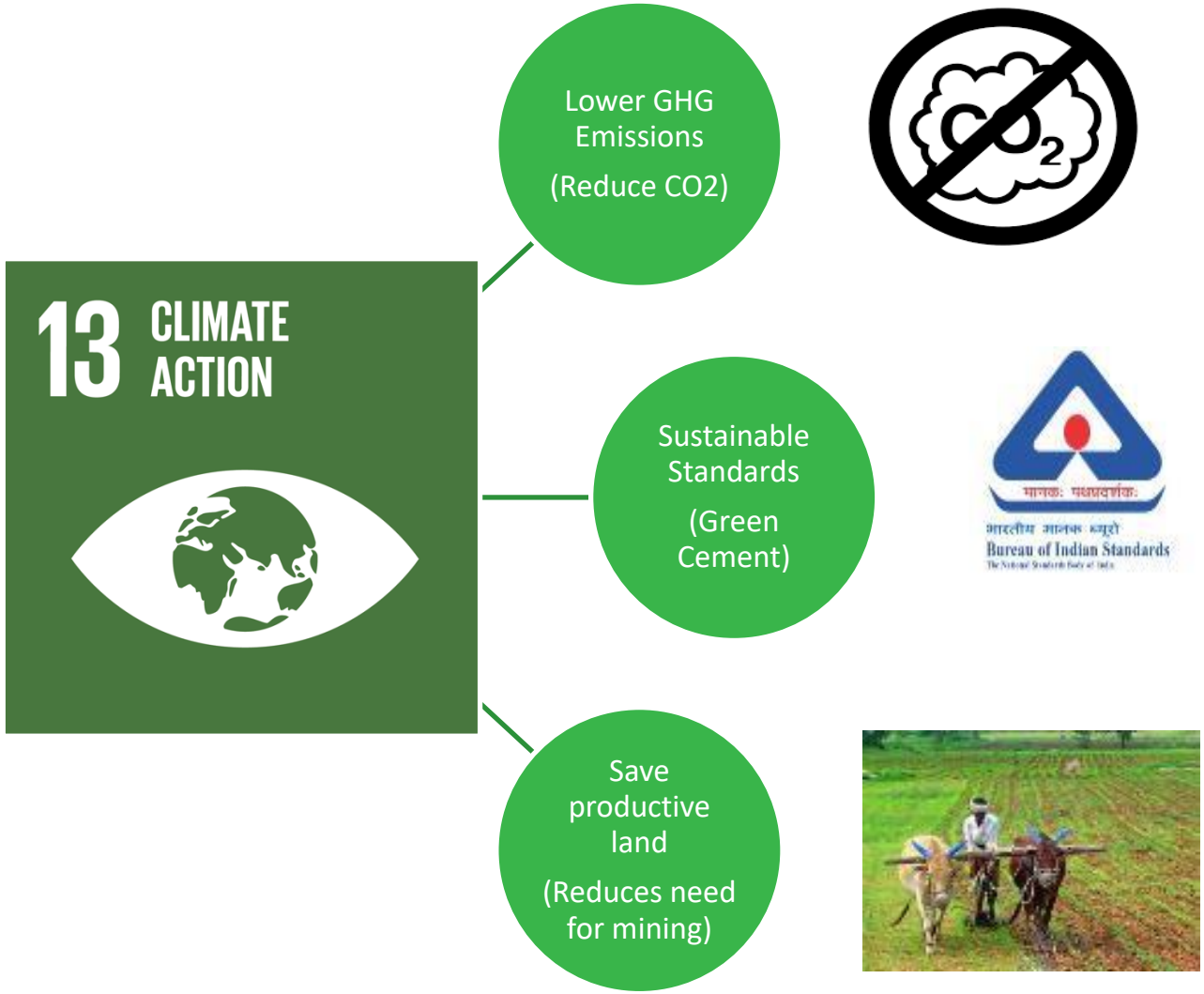
Sustainable Management of natural resources (Utilisation of mine waste)

Efficient use of natural resources (Limestone)

Efficient use of natural resources (Coal)

4. LC3 in the current policy framework

a. LC3 Contribution to the SDGs



4. LC3 in the current policy framework

a. LC3 Contribution to the SDGs

LC3-Project member and partners from **Academia**

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LC3-Project members and partners from **Policy**

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Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

LC3-Project members and partners from the **Industry**

TARA

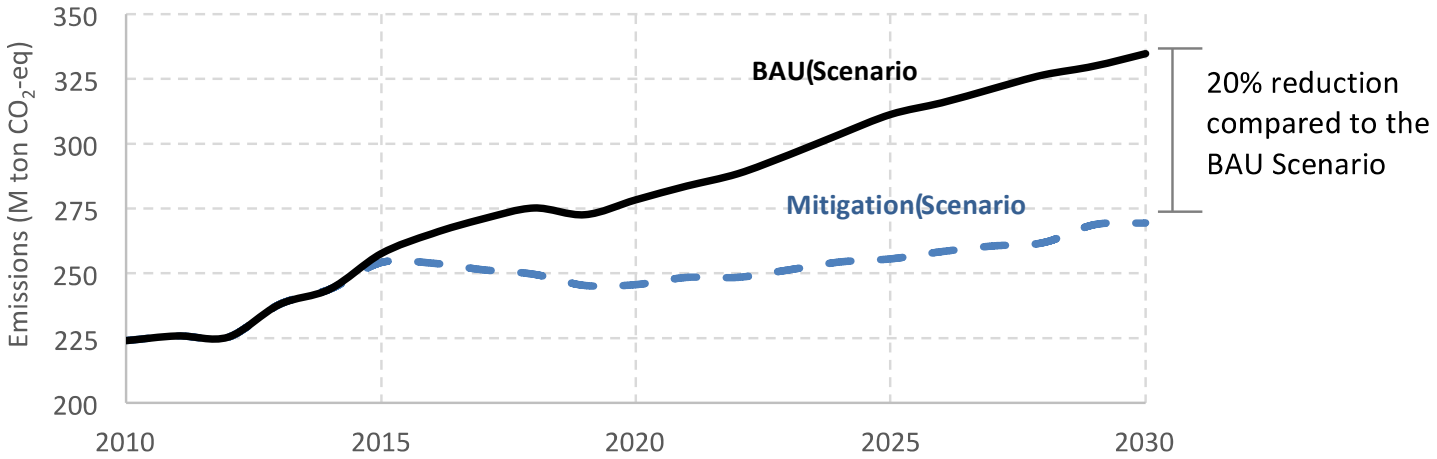
Numerous industrial project partners

4. LC3 in the current policy framework

b. NDCs, Case study: Colombia

- Colombian cement industry is the third biggest in Latin America
  - 12 million tons produced in 2015
  - 20 million tons expected by 2020
- CO2-emissions are expected to increase in a BAU-scenario

- Colombia committed to reduce 20% of its CO2-emissions by 2030 in the NDCs
- Goal: Reduction of 67 million tons (from 335 million t to 268 million t)
  - Approx. 9 million tons reduction target for commercial and industrial sector



Source: Gobierno de Colombia, 2015.

4. LC3 in the current policy framework

b. NDCs, Case study: Potentials of LC3 for NDCs in Colombia

- If Colombia produces 20 million tonnes of cement in 2020
  1. BAU-scenario: with OPC, 18 million tons of CO2 are expected
  2. Ideal scenario: with 100% LC3, around 11.3 million tons of CO2
  3. Realistic scenario: with 50% LC3, around 14.7 million tons of CO2
- Scenario 3: Reduction of 3.3 million tons of CO2 would make 5% of NDC total goal
  - LC3 could account for one third of the industry reduction goal (9.2 million tons)

LC3 impact on the NDCs in specific Latin American countries

Country	Total production of cement by 2020	Total commitment to reduce CO2 (NDCs*)	Savings If all cement was LC3	Savings if 50 % of all cement was LC3
Colombia	20 m tons	- 67 m tons	6.5 m tons or 10 %	3.25 m tons or 5 %
Peru	18 m tons	- 59 m tons	5.4 m tons or 9.1 %	2.7 m tons or 4.5 %
Ecuador	6 m tons	- 16 m tons	1.8 m tons or 11 %	0.9 m tons or 5.6 %
Mexico	41 m tons	-211 m tons	12.2 m tons or 5.8 %	6.1 m tons or 3 %

- **LC3 is can make a substantial contribution to achieve NDCs**

4. LC3 in the current policy framework

c. CO2-emissions in South Africa

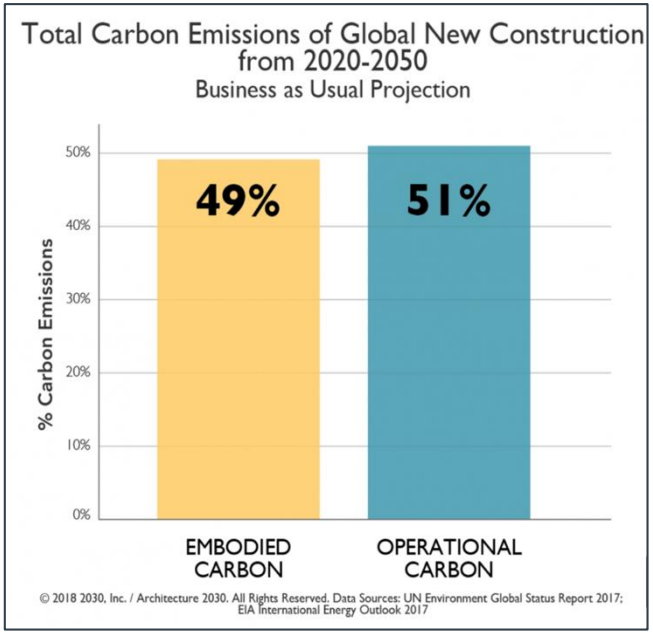
The 20 countries that emitted the most carbon dioxide in 2016

Rank	Country	CO_2 emissions (total)
1	China	9056.8MT
2	United States	4833.1MT
3	India	2076.8MT
4	Russian Federation	1438.6MT
5	Japan	1147.1MT
6	Germany	731.6MT
7	South Korea	589.2MT
8	Islamic Republic of Iran	563.4MT
9	Canada	540.8MT
10	Saudi Arabia	527.2MT
11	Indonesia	454.9MT
12	Mexico	445.5MT
13	Brazil	416.7MT
14	South Africa	414.4MT
15	Australia	392.4MT

4. LC3 in the current policy framework

c. New smart, green, sustainable cities

- Emphasis on embodied carbon
  - CO2-savings today more valuable than in the future
  - Operational carbon can be adjusted, embodied carbon cannot
- The LC3-Project is working on awareness raising among city planners and architects

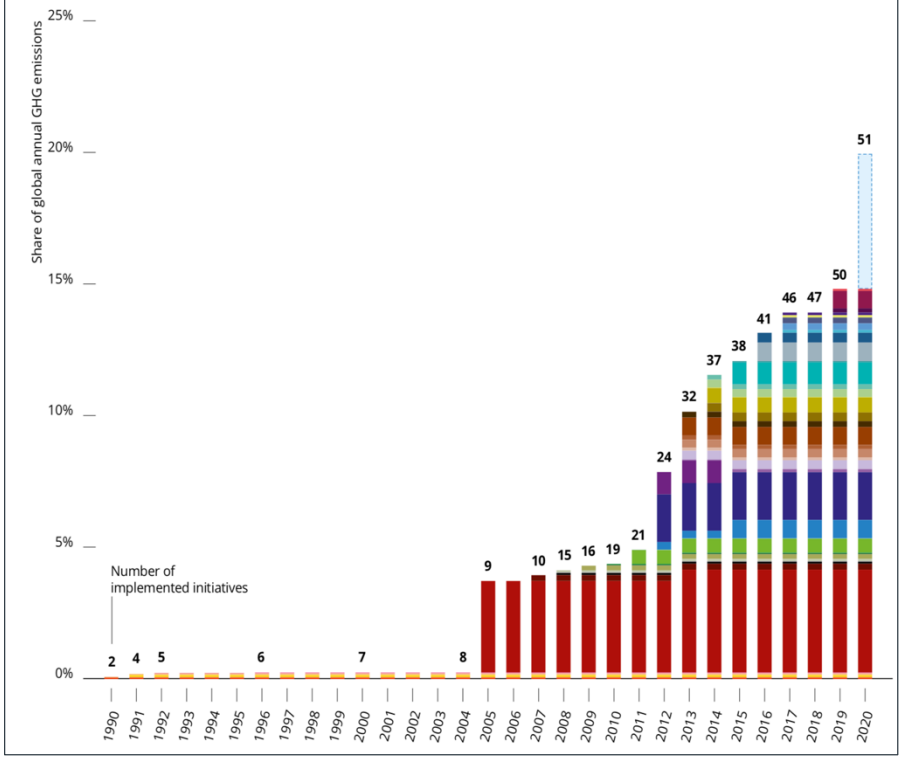


5. LC3 in the future policy framework

a. Global trend, Outlook

- Throughout the past decade, increasing number of green policies
- Remarkable increase from 2004, when just 1 percent of emissions were covered under carbon pricing
- General trend shows ambition to lower emissions

Figure 5 / Regional, national and subnational carbon pricing initiatives: share of global emissions covered
Source: Woldbank, State and Trends of Carbon Pricing 2018 Washington DC, May 2018

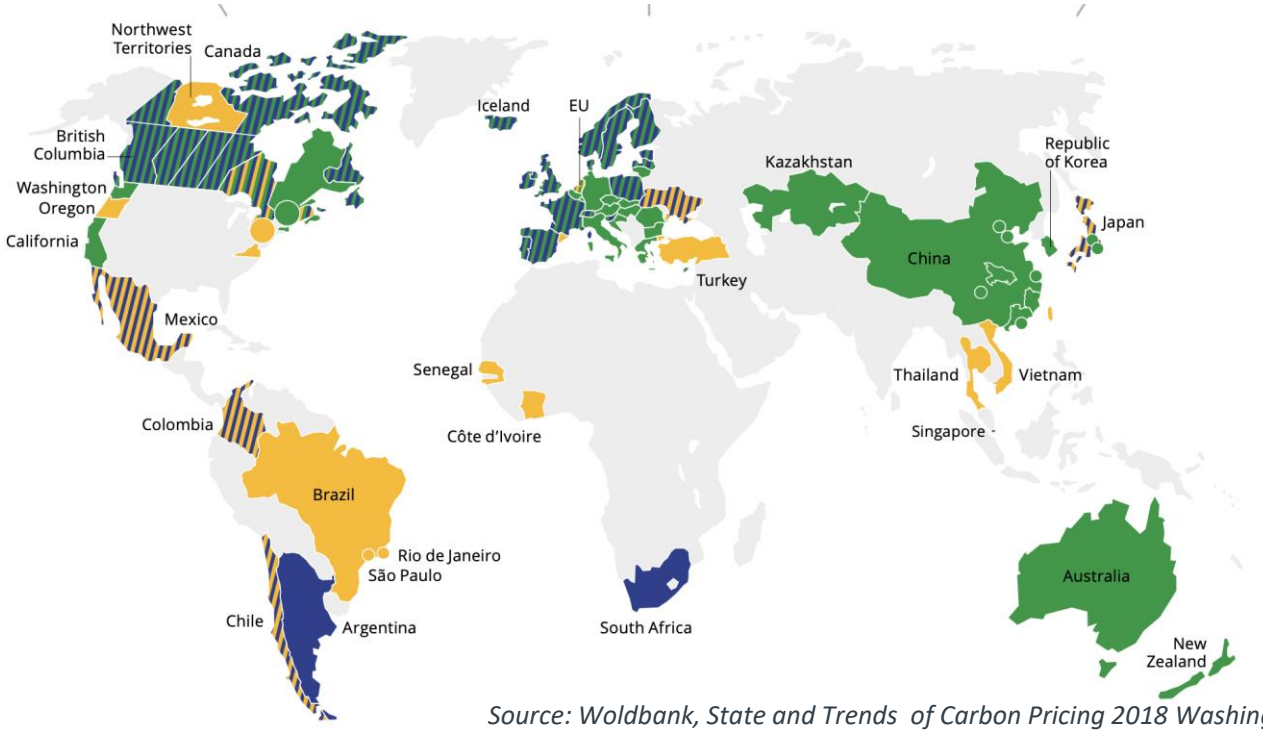


- **88 Parties have submitted their NDC, stated that they are planning or considering the use of carbon pricing as a tool to meet their commitments**

5. LC3 in the future policy framework

a. Global Outlook

» Summary map of regional, national and subnational carbon pricing initiatives implemented, scheduled for implementation and under consideration (ETS and carbon tax)



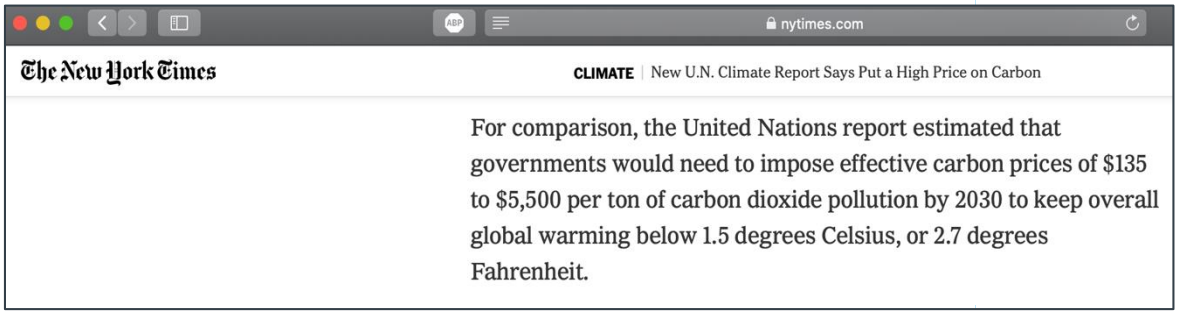
Source: Woldbank, State and Trends of Carbon Pricing 2018 Washington DC, May 2018

» **Debate about climate change and climate actions exponentially growing and regionally spreading**

5. LC3 in the future policy framework

b. CO2-prices: case study South Africa

- First phase from 01 June 2019 to 31 December 2022:
  - 8 USD/t of CO2
  - Low rate and several exceptions
  - Increase over time
  - Review before phase 2 from 2023 to 2030
- Rise in CO2-prices expected for the future
  - World Bank recommends between 40 and 80 US/t of CO2



nytimes.com

The New York Times

CLIMATE | New U.N. Climate Report Says Put a High Price on Carbon

For comparison, the United Nations report estimated that governments would need to impose effective carbon prices of $135 to $5,500 per ton of carbon dioxide pollution by 2030 to keep overall global warming below 1.5 degrees Celsius, or 2.7 degrees Fahrenheit.

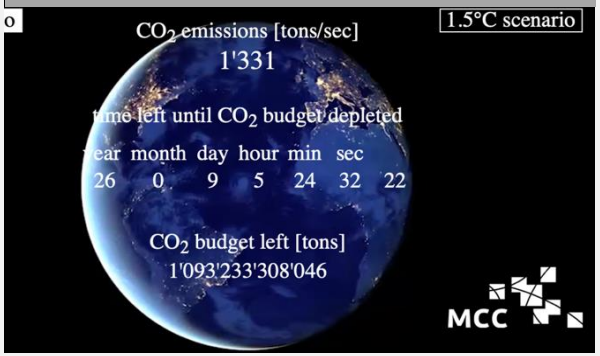
Source: https://www.nytimes.com/2018/10/08/climate/carbon-tax-united-nations-report-nordhaus.html

5. LC3 in the future policy framework

c. Outlook

Current instruments not effective enough

Limited time



Public pressure

COP25

Policy makers promoting faster actions

- **More radical political actions on climate change expected in the near future**
- **Significant changes for business environment possible / likely**

5. LC3 in the future policy framework

d. Conclusion of outlook

- No alternative to cement, LC3 can lower 1-2% of global emissions
- Policy makers will aim at changing the framework to build low carbon economies making low carbon technologies the rational choice
- Such a framework will further increase the attractiveness of LC3
- The trend needs to be taken into consideration and quantified for strategic corporate choices
  - Foreseeing the trend will make companies more resilient against upcoming changes
  - Create competitive advantages

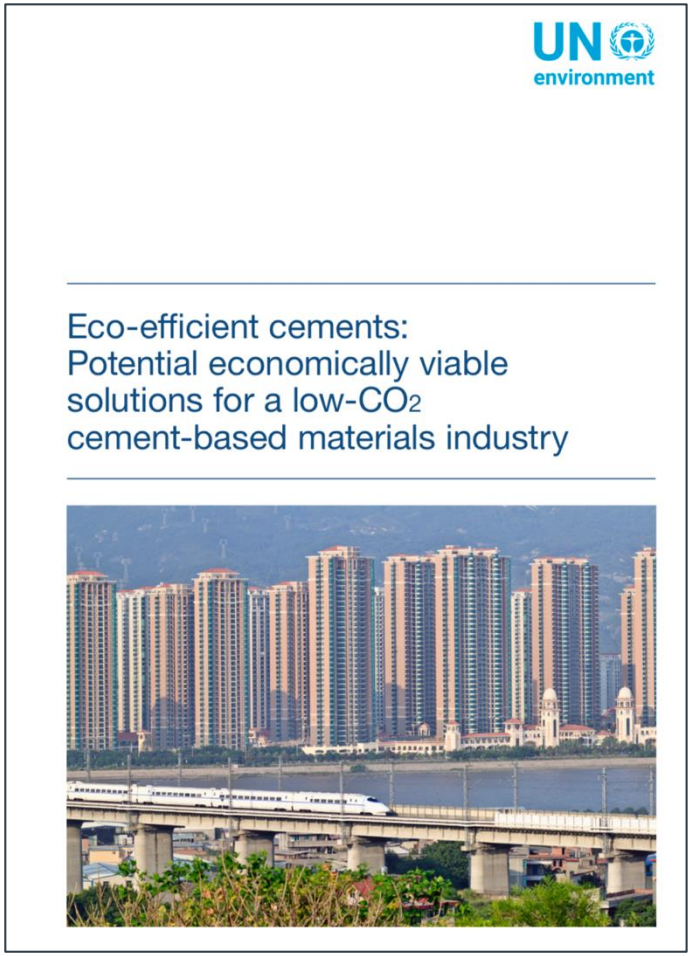
5. Summary of presentations

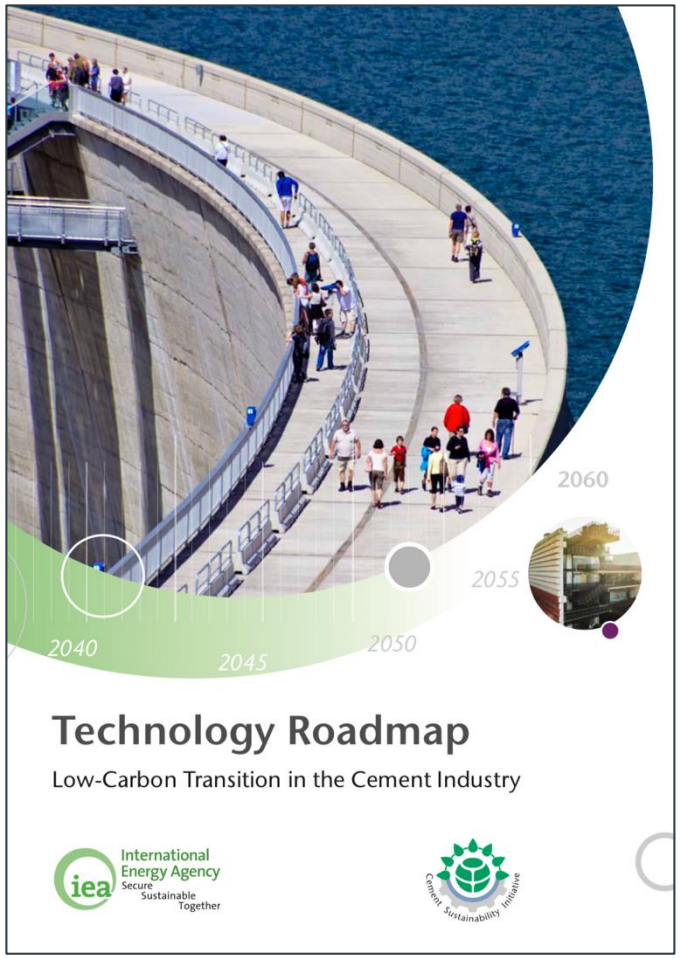
Checklist applied on LC3

a. **Low-carbon**	a. **LC3 saves 30 - 40% of CO_2 compared to OPC, globally 1 - 2 % CO2-reduction**
b. Resource-saving	b. Save scarce resources and uses waste material
c. High performance	c. Performance similar or better than OPC
d. Globally scalable	d. LC3 can serve global demand of 4'200 mt p.a and is still scalable
e. Cost-effective	e. Saves up to 25% of cost in production
f. Ready to be implemented	f. LC3 can be used just as OPC and is partly even better in performance, no special training required

» **LC3 is a feasible solution for both climate protection and development efforts**

6. Further reading





All publications available on www.lc3.ch

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More information on: www.LC3.ch

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Support from SDC is gratefully acknowledged