The environmental impact of concrete

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Introduction

The environmental impact of cement and concrete- low per unit volume of material→ amount used impact of the sector highly significant

Cement ~4 gigatonnes (Gt) per year

Concrete ~ 900 Gt added since the beginning of the industrial revolution

Selected source	Embodied energy: MJ/kg		
	Steel	Timber	Concrete
Alcorn *et al.*[27,28]	35·9	0·3–24·2	0·81–2
Eaton and Amato[29]	31	13–36	0·84–1·36
Franklin Associates[30]	44·6	14·9	–
West *et al.*[31]	32	5·7–10	–
Berge[32]	25	3–16	1
All database sources	6–81·8	0·3–61·3	0·07–23·9

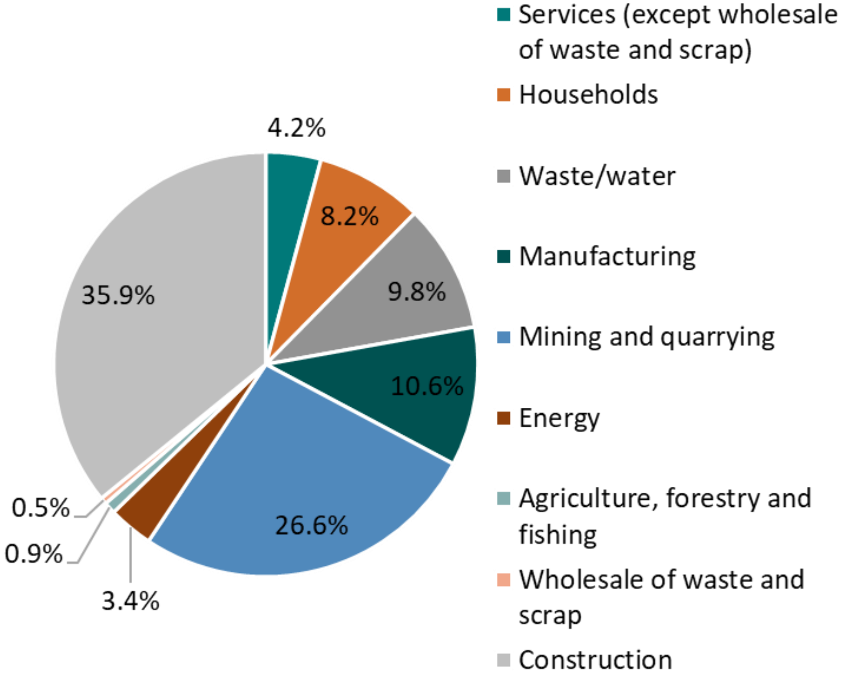
Source: Hammond & Jones, 2008

Sustainable development in the construction industry

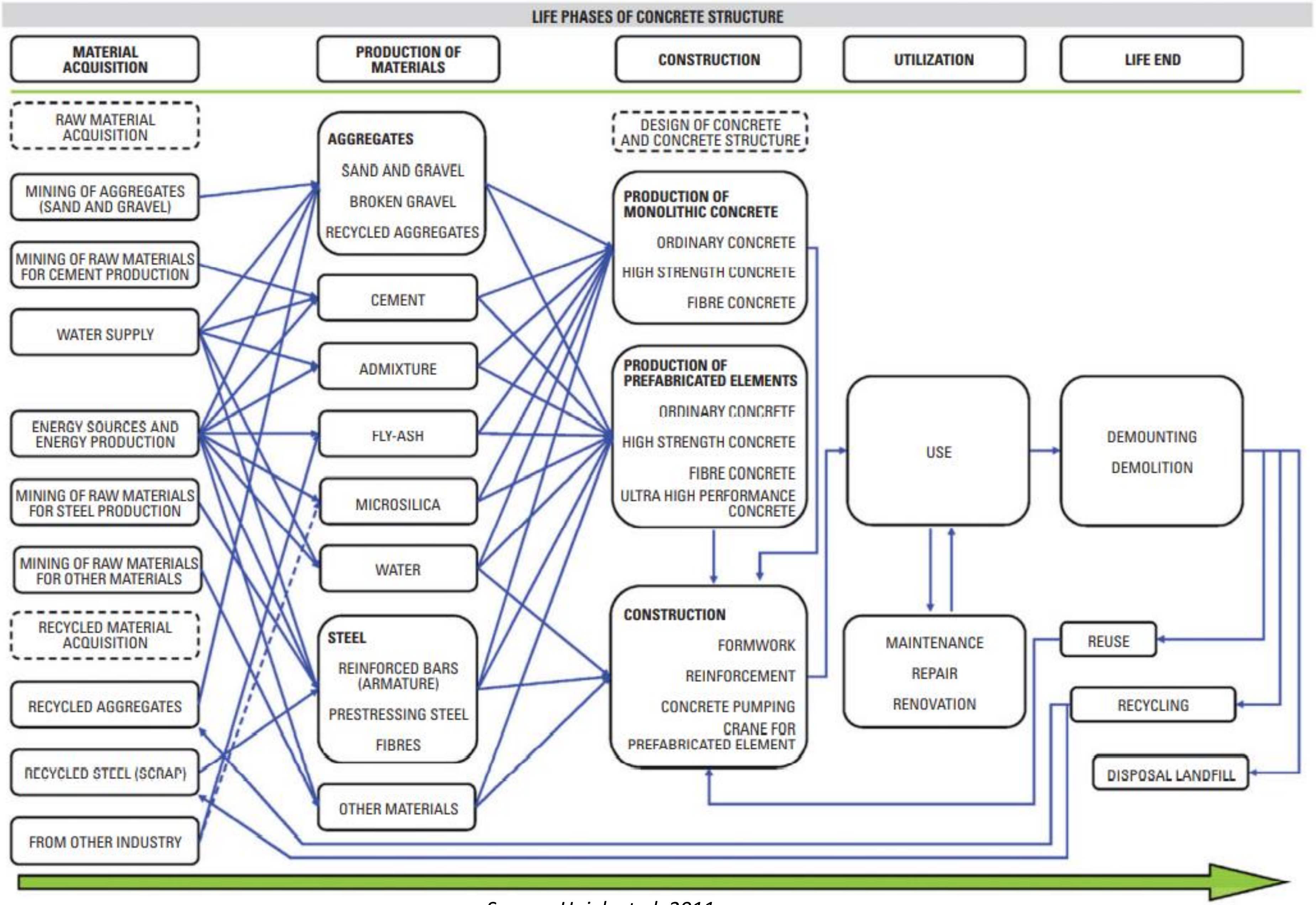
raw materials *energy* *CDW**

**construction and demolition waste*

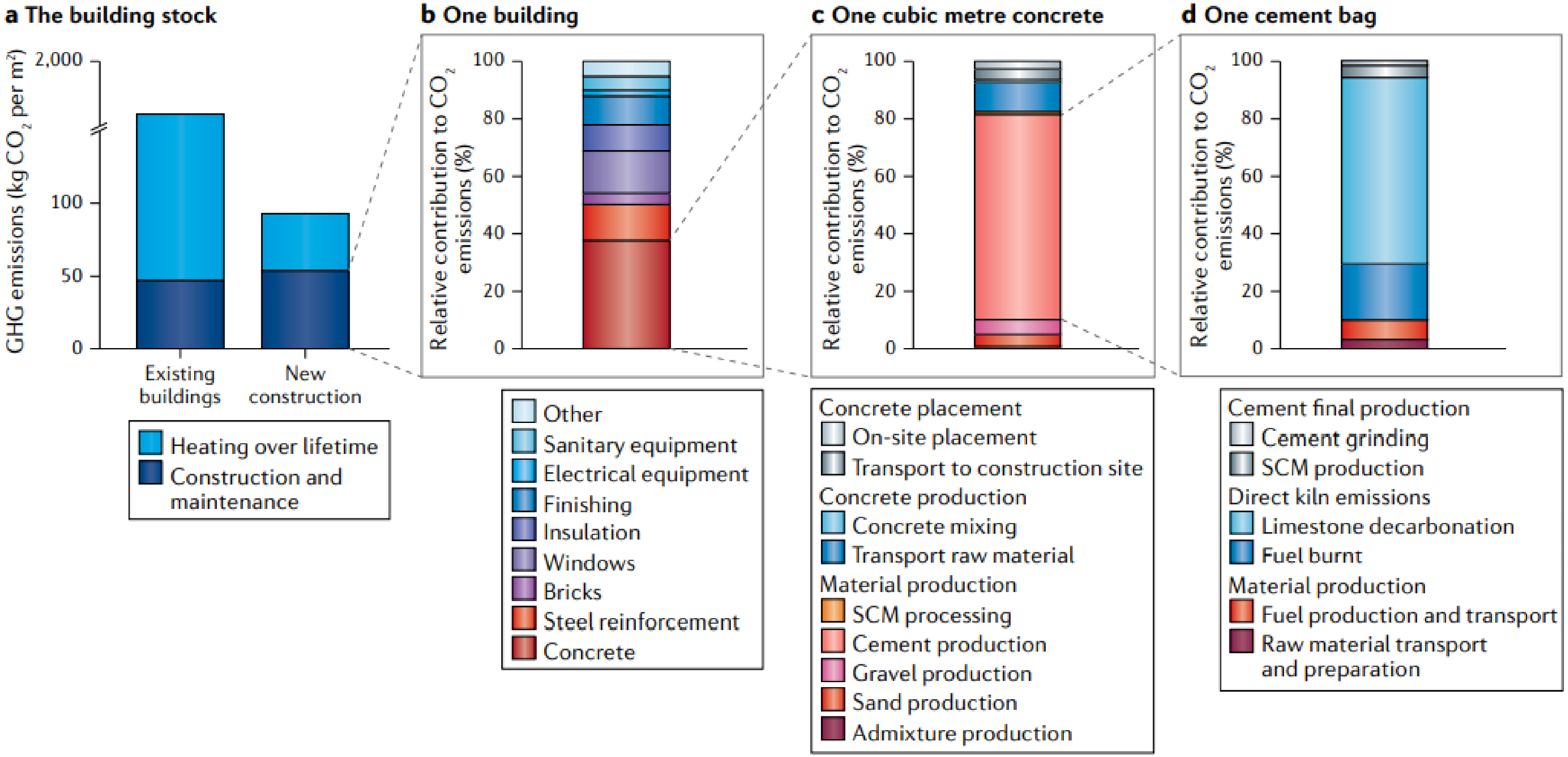
- 50 % of natural raw materials
- 40 % of the energy produced
- 50 % of global waste generated



Source: Eurostat, 2018



Source: Hajek et al. 2011



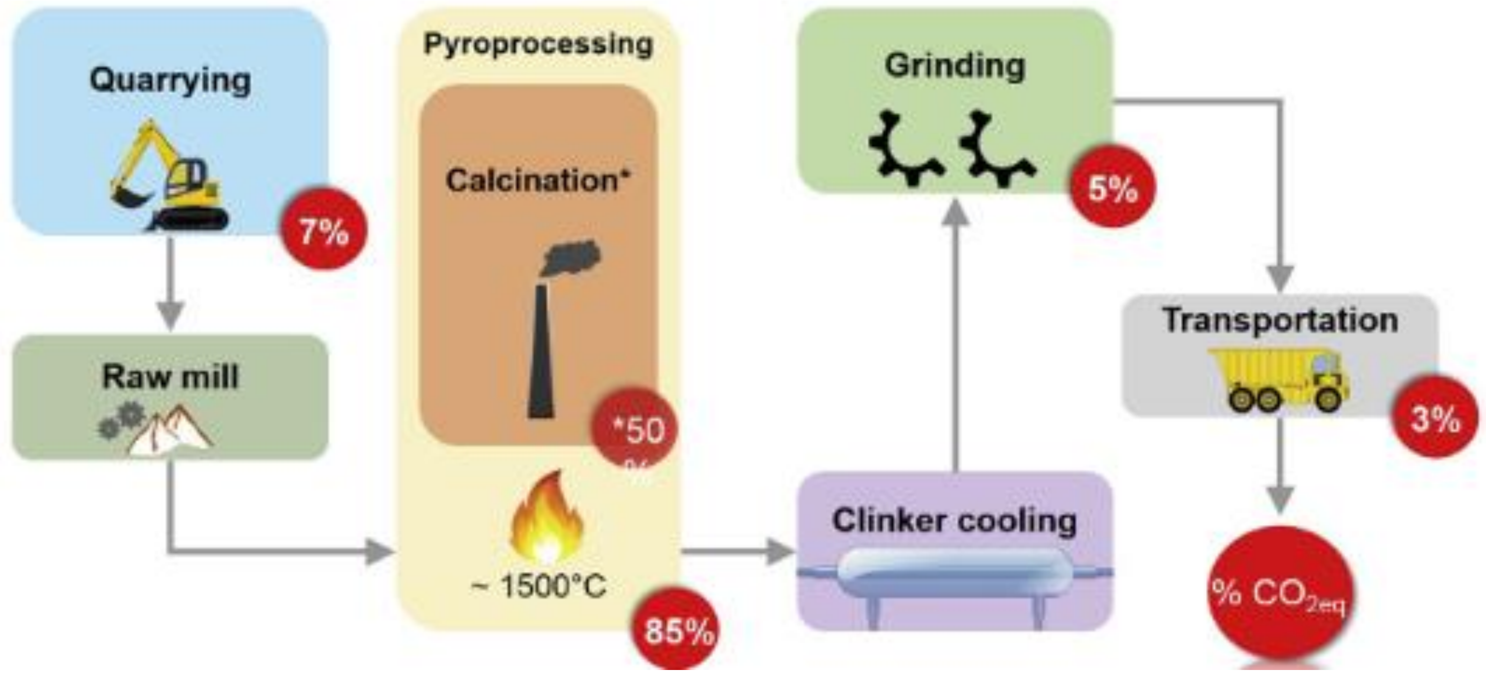
Source: Habert et al. 2020

a- average values from 230 buildings in Europe (75%) and Asia (25%)

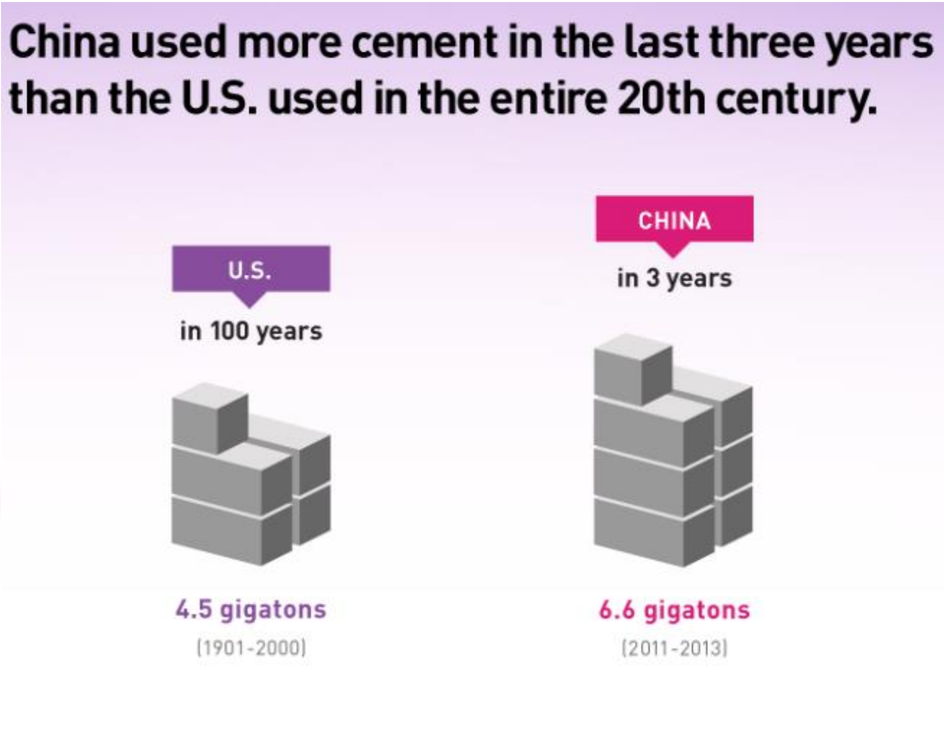
b- average of 35 buildings from France and Switzerland built between 2010 and 2015

c- average of the main concrete type made with 25% supplementary cementitious materials (SCMs) in Australia and Switzerland

d- averages of French values



Source: Maddalena et al. 2018

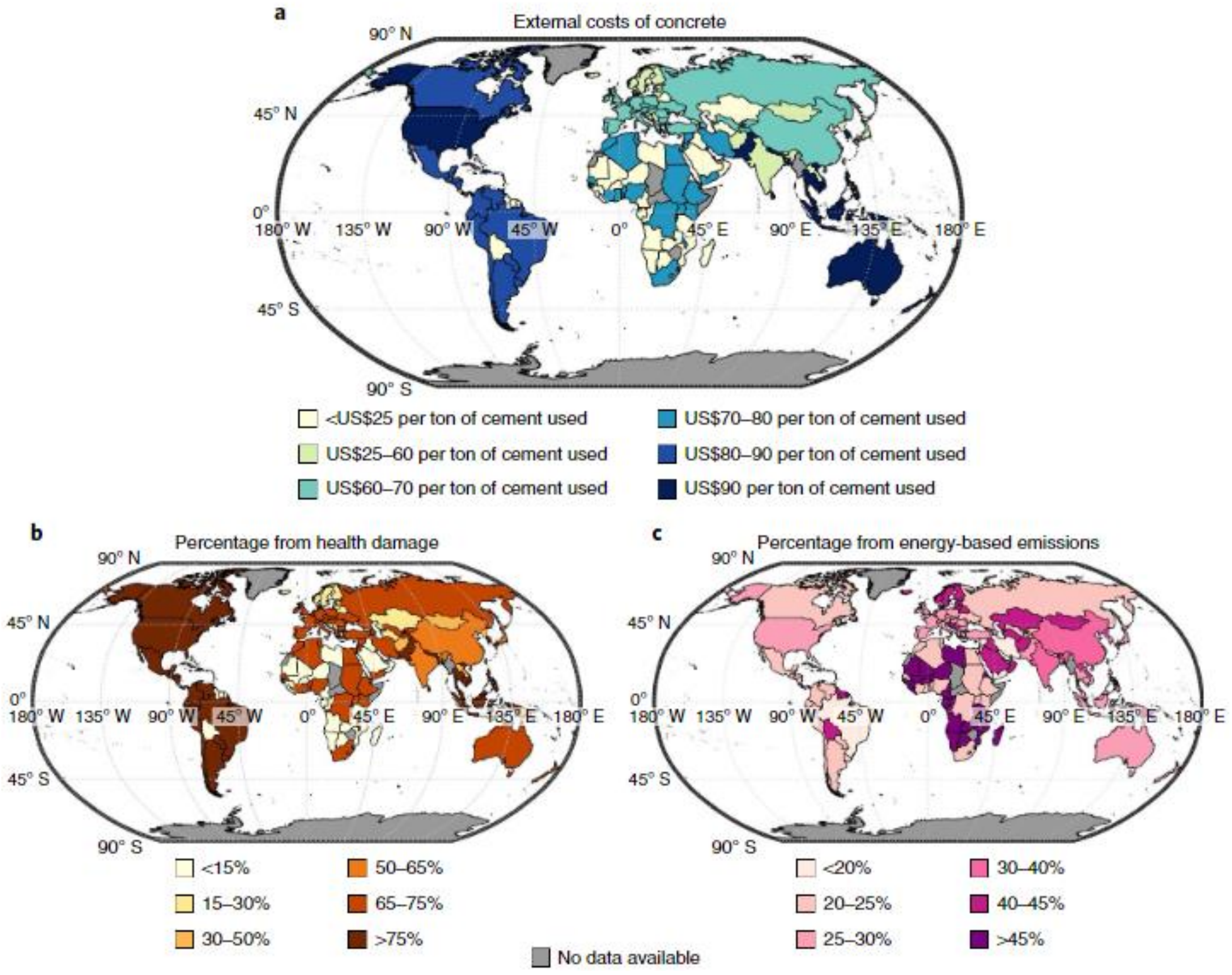


Source: https://www.gatesnotes.com/books/making-the-modern-world

Health damage

Concrete production →approximately US$335 billion annually of external climate and health damages (nearly 75% of the industry's value reported in 2015 = US$450 billion)

- a- cumulative costs- all considered economic damages for the production of concrete and mortar, as a ratio to a metric ton of cement produced for each country in 2012
- b- percentage contribution to cumulative economic damages from health damages, reflecting air pollutant emissions calculated from PM2.5, PM10, SOX and NOX emissions
- c- percentage contribution to cumulative economic damages from energy-based emissions



Production of concrete and mortar by country- Source: Miller & Moore, 2020

Stages of concrete production

- cement production → approximately 50% of the total climate and health damages of concrete: ~32% in climate and ~18% in health damages
- chemical reactions to produce clinker for cement= 45–60% of the total GHG emissions from concrete production (depending on region)
- next-greatest contributor -aggregates → 4% in climate damages and 34% in health damages of concrete.
- next-largest contributor to the cumulative health damages -concrete batching, the mixing of concrete constituents (high associated PM emissions)
- batching- negligible amount to climate but ~11% in health damages
- mineral and chemical admixtures- small relative to these other components of concrete production despite their typically longer transportation distances to the batching sites

Mid term solutions

- The efficiency of clinker production
- The efficiency of cement production
- Optimizing the efficiency of concrete
- Improving construction efficiency
- Design efficiency
- Reduction of GHG emissions

Long term solutions

- Use of alternative cements
- Carbonation of cement and concrete
- Increasing CO_2 uptake at end of life
- Carbon capture and storage

Conclusions

- Sustainable solution on all the stages of value chain:
  - clinker production
  - cement production
  - cement use
  - concrete use
  - design of structures
  - use of structures
  - end-of-life.
- Investment in innovation
- Inclusion of environmental performance in standards

References

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3. Visintin et al. *Journal of Cleaner Production.* **2020,** *248, 119243.*
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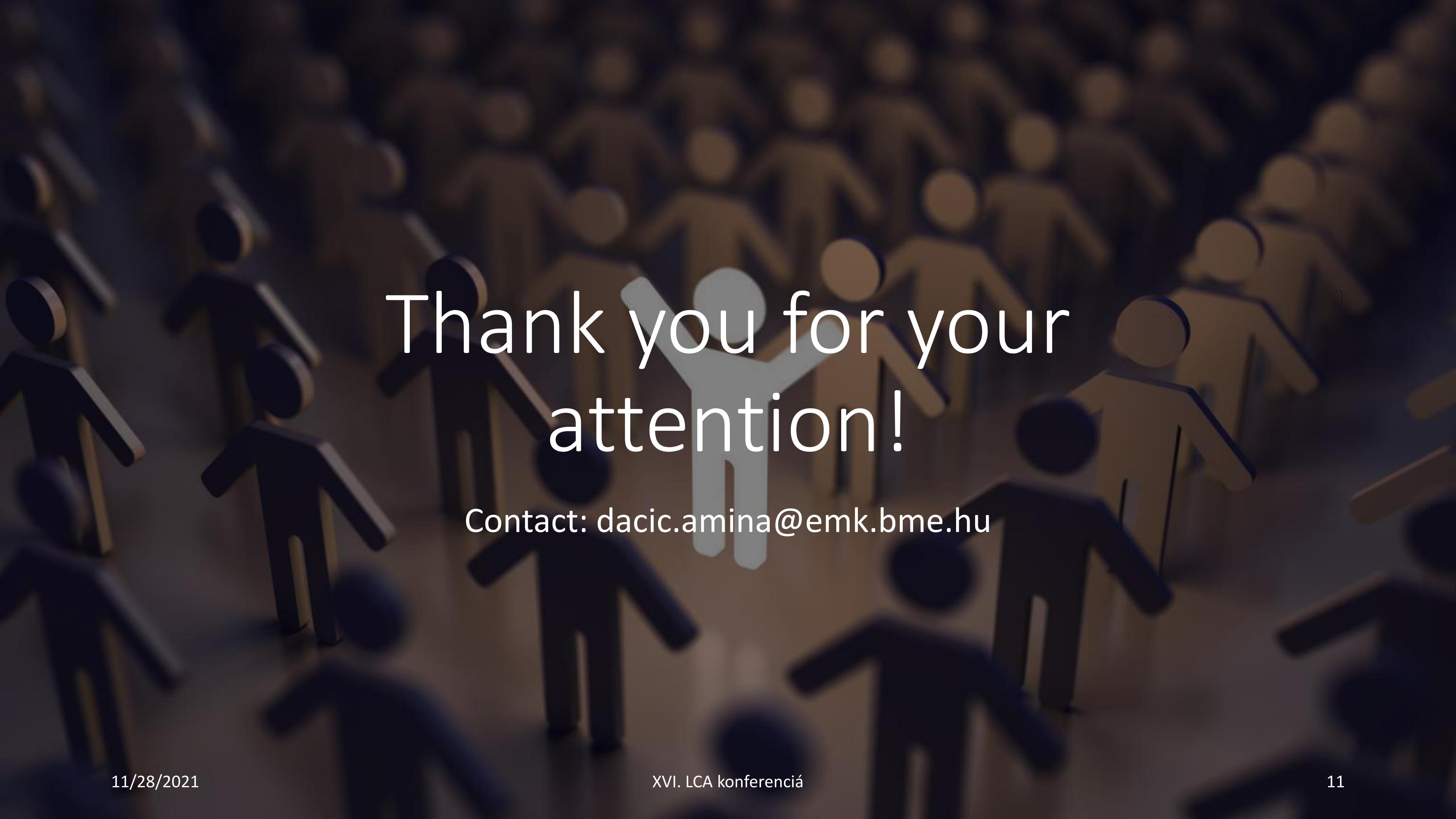

Thank you for your attention!

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