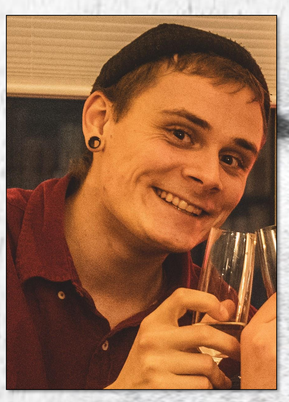

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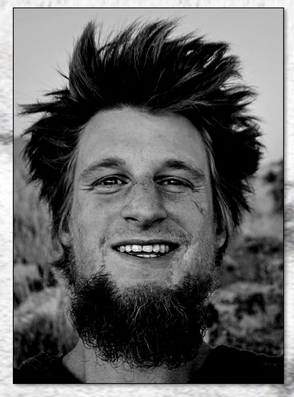

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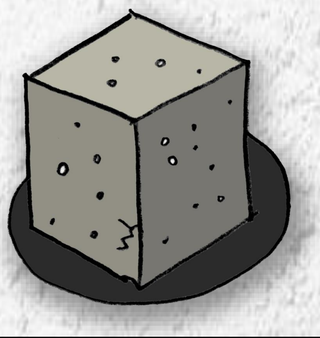
Sustainable Cement

- Future or Fiction? -

In the time it takes you to read this sentence, the global building industry will have poured out more than 7500 tons of concrete – an amount that would fill a whole Olympic swimming pool. This industry causes excessive environmental pollution as well as large-scale greenhouse gas emissions - up to 8% of all worldwide anthropogenic CO_2 emissions originate just from cement, environmentally speaking the most problematic part of concrete. [1, 2, 7]

But could one of the largest contributors to anthropogenic climate change actually be used in a more sustainable way?

THE MATERIAL



What is cement and what is concrete?

After water, **concrete** is the most widely used substance on the planet - a simple mixture of aggregates (sand, stone or gravel), water and the binding material cement.
Cement is made from calcium and silica-rich materials, such as limestone and clay. [1, 2, 7]

How is cement produced?

Cement is manufactured by heating finely ground **limestone**, clay and sand in a rotating furnace to temperatures reaching 1450°C. In the furnace, the limestone splits into **calcium oxide** and **CO_2** and eventually turns into **clinker**. After another grounding the clinker is mixed with gypsum and limestone. [2]

THE PROBLEM

What makes the cement industry environmentally problematic?.

Besides the emissions caused by **fossil fuels** that are used in the heating process, a chemical process known as **calcination** inevitably releases **CO_2** when limestone is burned into clinker. [2, 3, 7]
Associated problems like the high demand of concrete for water and sand as well as heavy air pollution around cement factories further increase the negative impact on the environment. [1]

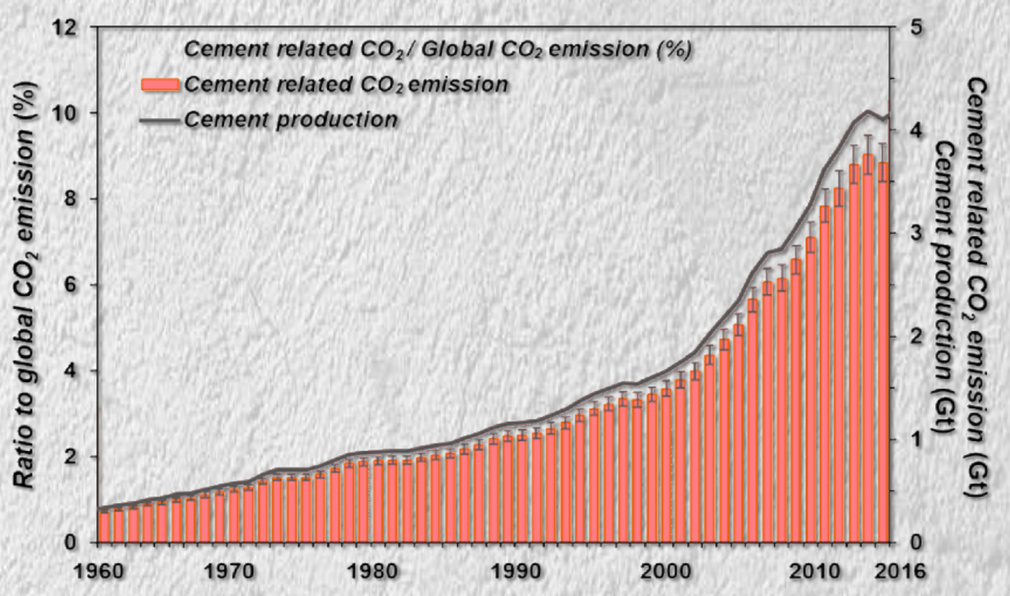


Fig. 1: Increase in CO_2 emissions related to the production of cement [3]

THE SOLUTION

How can we produce and use cement in a more sustainable way?

Change is needed along the whole chain from production to usage. While CO_2 emissions cannot be completely avoided, but there are several ways for reducing its environmental footprint. [2, 4]

- **Increase energy efficiency** by using the excess heat from the production and more efficient machinery [4, 6]
- **Substitute fossil fuels** (coal, coke, oil, gas) with renewable energy to use in the heating process [4, 6]
- **Reduce the 'clinker-factor'** by partly replacing limestone with materials like slag sand or fly ash [4, 6]
- **Use high-performance/carbon negative cements**, which reduce the carbon footprint of concrete [4]
- **Use direct CO_2-emissions** energetically or physically (for material recycling, carbon capture/CCUS) [4]
- **Recycle concrete** for reuse as aggregate [6]

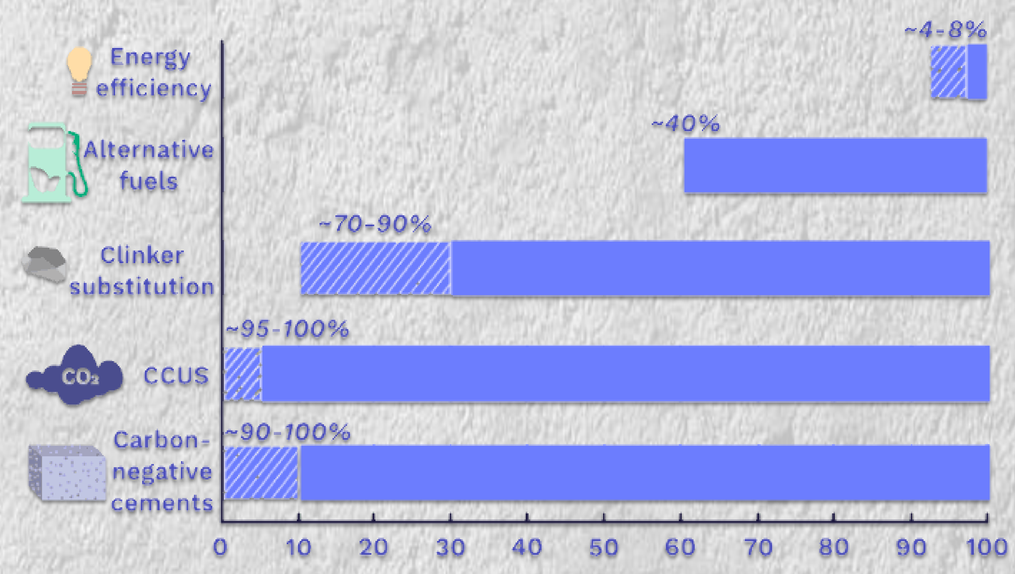


Fig. 2: Theoretical possible decarbonisation (in % of emissions) [7]

However, investment needs are high and investment cycles are long, considerably increasing the production costs which makes **sustainable cement** yet **unprofitable**. Without governments applying pressure on the industry or providing funding, this will not change in the near future. [2, 4]

References

1) Watts, Jonathan (2019), Concrete: the most destructive material on Earth, https://www.theguardian.com/cities/2019/feb/25/concrete-the-most-destructive-material-on-earth [last access 19.06.21]
2) Rodgers, Lucy (2018), BBC News. Climate Change: The massive CO2 emitter you may not know about. https://www.bbc.com/news/science-environment-46455844 [last access 20.06.21]
3) Chang, Ilhan; Lee, Minhyeong; Cho, Gye-Chun. (2019). Global CO2 Emission-Related Geotechnical Engineering Hazards and the Mission for Sustainable Geotechnical Engineering. Energies. 12. 2567. 10.3390/en12132567.
4) Umwelt Budesamt (2020), Dekarbonisierung der Zementindustrie, https://www.umweltbundesamt.de/sites/default/files/medien/376/dokumente/factsheet_zementindustrie.pdf [last access 12.06.21]
5) Justnes, Harald (2015), How to make Concrete More Sustainable, Journal of Advanced Concrete Technology, Vol13, pp. 147-154
6) Umwelt Bundesamt (2020), Prozesskettenorientierte Ermittlung der Material- und Energieeffizienzpotentiale in der Zementindustrie, https://www.vdz-online.de/fileadmin/wissensportal/publikationen/forschungsergebnisse/Forschungsvorhaben_Prozesskettenorientierte_Ermittlung_der_Material-_und_Energieeffizienzpotentiale_in_der_Zementindustrie.pdf [last access 15.06.21]
7) Lehne, Johanna; Preston, Felix (2018) Making Concrete Change. https://www.chathamhouse.org/sites/default/files/publications/research/2018-06-13-making-concrete-change-cement-lehne-preston.pdf [last access 20.06.21]