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The CO_2 pyramid: which construction materials pollute the most

The Royal Danish Academy's Centre for Industrial Architecture has applied the logic of the food pyramid to construction materials. The result is a clear map of each element's environmental impact, measured in CO_2 emissions.

The Centre for Industrial Architecture (CINARK) at the Royal Danish Academy has developed a tool that ranks construction materials by their environmental impact. It borrows the familiar shape of the food pyramid and applies it to the building sector, so that any client, architect or builder can see at a glance which materials to prioritise and which to use sparingly.

The aim is to give a clear picture of the environmental impact associated with each material, particularly in terms of CO_2 emissions. It is a way of steering material selection towards more sustainable options on a quantified, comparable basis rather than on general intuition.

How the pyramid is ordered

The classification places materials at different levels according to their environmental impact, measured in kilograms of CO_2 equivalent per cubic metre (kg CO_2eq/m^3). Materials at the base of the pyramid have a lower impact, while those at the top carry a significantly higher one. This ordering lets professionals quickly recognise which materials are more environmentally sound.

At the base sit the elements with the lowest impact, some of which act as carbon sinks: they absorb more CO_2 than they emit across their initial life cycle, understood as the manufacturing phase of the finished material. That is the case with natural materials such as linoleum and cross-laminated timber (CLT). CLT can reach a value of -664.0 kg CO_2eq/m^3, because timber captures carbon dioxide from the atmosphere as it grows. These materials are also renewable, and incorporating them into projects is a direct strategy for reducing the overall emissions of building.

How far the measure reaches

The scope of the tool is worth stating precisely. The pyramid focuses on the initial phases of a material's life cycle, up to the point it reaches the consumer (phases A1-A3). It does not, therefore, include emissions from the use phase or from end of life. Even with that boundary, it provides a solid and consistent basis for comparing the environmental impact of materials during production, which is precisely where much of the design decision is concentrated.

Some reference values

The contrasts between families of materials are considerable:

- **Sustainable materials:** cross-laminated timber (CLT), common in structures, registers -664.0 kg CO_2eq/m³. It is this behaviour that allows us to state that an Eskimohaus home, built from timber, is a net benefit to the environment and not merely a low-impact option.
- **Mineral materials:** plasterboard sits at 93.6 kg CO_2eq/m³, while ceramic tiles reach 1,103.0 kg CO_2eq/m³, a reflection of how wide the gap can be within a single family.
- **Metals:** copper and aluminium show very high values, of 12,433.6 and 28,890.0 kg CO_2eq/m³ respectively, placing them at the top of the pyramid. The reason is the large amount of energy their processing requires.

A tool for better decisions

In a context of climate emergency, and bearing in mind the weight of the construction sector in the origin of CO_2 emissions, the use of sustainable materials should weigh decisively on the industry's decisions. The pyramid also works as an educational guide for professionals and students, encouraging greater environmental awareness in both the design and the execution of projects.

The most hopeful part is what this ordering implies. A sector that today ranks among the most polluting can, with the right choices, shift to retaining CO_2 and become an ally in the fight against the climate crisis. That opportunity exists, but it does not come about on its own: it requires every actor to take part. There would be little point in building highly energy-efficient homes if the surrounding environment continues to degrade, because no one wants to live sealed off from a world that has ceased to be habitable.

Finally, it is worth remembering that these values are not fixed. Advances in technology, the arrival of new materials and cleaner manufacturing processes may reduce the emissions associated with materials that pollute today. That is why tools like this one must be updated regularly. The CINARK materials pyramid is openly available for anyone who wishes to consult it.

> Timber reverses the underlying question: a material that captured carbon as it grew turns every structure into a store rather than an emission.