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The ecological footprint of building and living in your home

How much CO_2 does building a house generate? And living in it for 50 years? We analyse the ecological footprint of conventional construction and the sustainable alternatives.

The carbon footprint of building and living in a home: real data

Every building that goes up leaves a carbon footprint long before anyone switches on the first light inside it. The manufacture of the materials, the transport to the site and the construction process generate CO_2 emissions that, taken together, account for a significant part of a home's total environmental impact. At PAPIK Group, for years we have measured this footprint across our projects with life-cycle assessments (LCA), and the data lets us speak in concrete figures, not generic estimates.

Phase 1: the carbon footprint of construction

Building a house generates emissions. The question is how many, and here the structural material changes everything.

Producing one cubic metre of conventional concrete releases around 215 kg of CO_2 into the atmosphere, mainly through the calcination process of Portland cement (data from the European EPD database). Structural steel emits approximately 1,500 kg of CO_2 per tonne produced. These are materials with a high carbon footprint that dominate conventional construction.

By contrast, one cubic metre of structural fir or pine timber (the species we use at PAPIK Group) not only emits nothing during its growth, but stores approximately 500 kg of CO_2, captured from the atmosphere through photosynthesis. This figure, documented in the timber sector's environmental product declarations (EPD), varies according to species and density: for fir timber (Picea abies, density ~450 kg/m^3), the value lies between 470 and 520 kg of CO_2 per m^3.

> At the K-Alzina project, our LCA calculation showed that the FSC timber structure stores 41.82 tonnes of CO_2, and that the project saves 23.90 tonnes compared with the concrete equivalent. It is not theory: these are the real figures of a 180 m^2 house in the Montseny.

If we translate this to a typical home of 180 m^2 (the size of K-Alzina), the comparison is as follows. A conventional house with a concrete structure and masonry generates between 40 and 55 tonnes of CO_2 during the construction phase, depending on the type and finishes. An equivalent home with a lightweight certified timber frame structure stores between 25 and 30 tonnes of CO_2 in its structure (depending on the total volume of timber). The net balance between one option and the other exceeds 65-80 tonnes of CO_2.

Phase 2: the carbon footprint of use

The footprint of construction, however, is only part of the equation. Once the home is occupied, a second phase of emissions begins that extends across the entire useful life of the building: the energy consumption to heat, cool, light and run the home.

According to data from the IDAE (Institute for Energy Diversification and Saving), a conventional home in Catalonia consumes on average between 100 and 120 kWh/m^2/year in heating, cooling and domestic hot water. For a 180 m^2 house, this represents around 18,000-21,600 kWh per year.

With the Passivhaus standard, the demand for heating and cooling is limited to a maximum of 15 kWh/m^2/year each. In our projects, the real demands typically lie between 12 and 14 kWh/m^2/year for heating and between 8 and 12 kWh/m^2/year for cooling, depending on orientation and location. The overall saving compared with a conventional home lies between 75% and 90%.

We project these figures over a 50-year horizon, which is the minimum estimated useful life of a residential building. The cumulative difference between a conventional home and a Passivhaus exceeds 600,000 kWh for a 180 m^2 house. If we apply the emission factor of the Spanish electricity grid (approximately 0.14 kg CO_2/kWh, data from Red Eléctrica), we are talking about around 84 tonnes of CO_2 saved over half a century. If the conventional home uses natural gas for heating and DHW (emission factor of 0.20 kg CO_2/kWh), the saving figure rises even higher.

The complete balance: construction + use

We add up the two phases. For a 180 m^2 home with the characteristics of our projects:

Saving in the construction phase (timber vs. concrete): 65-80 tonnes of CO_2. Saving in the use phase over 50 years (Passivhaus vs. conventional): 84-120 tonnes of CO_2. Total favourable balance: between 150 and 200 tonnes of CO_2 avoided across the complete life cycle.

To put it in perspective: 150 tonnes of CO_2 are equivalent to the emissions of a combustion car over more than 50 years (assuming 12,000 km/year and 120 g CO_2/km).

What PAPIK Group does to minimise the footprint

The figures above do not come about by chance. They are the result of conscious and systematic decisions that we apply to every project:

European-origin FSC timber. All the structural timber we use carries FSC chain-of-custody certification. This guarantees that the source forests are managed sustainably and that the timber felled is replanted. Traceability is complete, from the forest to the stud.

Local sourcing. The expanded cork we specify as exterior insulation comes from Catalan cork oak woodlands (Alt Empordà, Selva), less than 200 km from our sites. The blown-in cellulose is manufactured on the peninsula. We reduce the transport footprint whenever the material's quality allows it.

Eliminating gas. None of our Passivhaus homes uses natural gas. Heating and cooling are resolved with an aerothermal heat pump (efficient even at low outdoor temperatures), and electrical storage is provided by lead batteries, a robust and recyclable technology. Without gas, we eliminate direct combustion emissions across the entire useful life of the building.

Rigorous airtightness. A Blower Door of 0.3-0.5 ACH (the usual results in our projects, well below the Passivhaus limit of 0.6 ACH) means that the energy invested in conditioning the indoor air does not escape through infiltration. Every improvement in airtightness directly reduces energy consumption and, therefore, the operational carbon footprint.

> We do not build "carbon-neutral" houses because the concept strikes us as appealing. We do it because the LCA data from our projects shows it is technically viable and economically reasonable, with an extra cost of 10-15% that is recovered through energy savings.

Sources and methodology

The data in this article comes from public, verifiable sources: the European EPD database for material emissions (Environdec, IBU), the IDAE data for residential energy consumption in Spain, the emission factors of Red Eléctrica de España, and the guidelines of the Passivhaus Institut in Darmstadt for energy demand limits. The specific figures for PAPIK Group projects (K-Alzina, K-Codines) come from our internal LCA calculations, carried out following the EN 15978 standard for assessing the sustainability of construction works.

The carbon footprint of a home is not an abstract concept. It is a figure that can be calculated, compared and, above all, reduced. Every project decision, from the structural material to the heating and cooling system, tips the balance in one direction or the other. Our commitment at PAPIK Group is that every house we build tips the balance towards the right side.