

The window you can't see: the assumptions and calculations behind a home's invisible air leaks

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In most homes there is an opening no one ever drew on the plans and no one will ever close, because it is invisible to the naked eye. It is the sum of every air leak crossing the building envelope: poorly sealed window joints, service penetrations, junctions between different materials, blind boxes. Individually they are minor gaps. Together they add up to a hole left open in the façade all year round, letting cold in during winter and heat in during summer.

At PAPIK Group this invisible opening is not a loose metaphor. It is a quantity that is calculated and verified on every finished project. This article explains how it is measured and why a house built with the Eskimohaus system lets in far less air than a conventional dwelling.

How to measure what you cannot see

The discipline that quantifies these leaks has its own unit. The n50 parameter, the air change rate at 50 pascals, is the standard measure of a building's airtightness. It indicates how many times per hour the entire interior air volume is renewed when the dwelling is subjected to a pressure difference of 50 Pa. It is obtained through the Blower Door test, a procedure governed by the ISO 9972:2015 and EN 13829:2000 standards.

The relationship is direct: $n50 = Q50 / V$, where Q50 is the airflow measured at 50 Pa and V the interior volume of the dwelling. In a reference single-family home of 150 m² floor area and an average clear height of 2.5 m, the interior volume is 375 m³. The text also uses the conservative figure of 300 m³, equivalent to the usable height once ceilings, partitions and non-habitable spaces are deducted. The difference affects the intermediate results but does not change the conclusion.

A leaky conventional house hovers around an n50 of 6 air changes per hour. An Eskimohaus is designed for an n50 of 0.6 or lower, ten times more airtight, verified with a Blower Door test on the finished building.

From airflow to an equivalent hole

The n50 figure is rigorous but abstract. To make it tangible it helps to translate it into a physical image: what surface a single hole would have if all that air escaped through it under real conditions of use. The calculation starts from the leakage flow and applies a reduction factor, because the test is run at 50 Pa, a pressure far higher than what acts on the building under ordinary wind and temperature difference. The reference technical literature, including the Passivhaus Institute and the ASHRAE Handbook of Fundamentals, cites factors ranging from 1/30 in very exposed sites to 1/15 in very sheltered ones, with 1/20 as the central value for a Mediterranean climate with moderate exposure.

Once the flow under real conditions is known, the Bernoulli equation for flow through an orifice is applied, with a discharge coefficient of 0.61, a representative pressure difference of 4 Pa and the density of air at 20 °C. The result is a surface, and from that surface, the side of the equivalent square.

Two very different holes

To honestly reflect the uncertainty in the pressure and volume assumptions, the figures are published as ranges. The conventional house, with an n50 of 6, gives an equivalent hole of between 13 and 20 cm per side, somewhere between the size of a credit card and half an A4 sheet. The Eskimohaus, with an n50 of 0.6, stays between 4 and 6 cm per side, the order of magnitude of a walnut in its shell or a cork stopper.

The conclusion is robust regardless of the pressure hypothesis adopted: the equivalent hole of an Eskimohaus is roughly ten times smaller in surface than that of a leaky conventional house. That is, literally, the window you cannot see, and the reason the building system determines energy expenditure long before the boiler or the radiators.

Not every hole is a defect

It is worth distinguishing hidden leaks from intentional openings. A healthy house needs to renew its air, and regulation requires it. The Spanish Technical Building Code, in its Basic Document HS-3 on indoor air quality, imposes minimum ventilation surfaces that add up to their own equivalent area.

- Kitchen extractor hood with a 150 mm diameter duct, per the UNE-EN 61591 standard: 176.7 cm².
- Two bathroom extraction grilles, at 32 cm² per bathroom under CTE DB HS-3: 64 cm².
- General kitchen ventilation grille for a combined flow of 17 l/s: 68 cm².

Added to residual infiltration, these planned openings give an equivalent diameter of about 27 cm. An open fireplace with no damper, a flue that connects directly to the outside when not in use, can add some 500 cm² and raise the diameter to 37 cm. The difference between an airtight house and one that is not therefore lies not in planned ventilation, but in everything that escapes without anyone having decided it.

The regulatory framework

Airtightness remains uneven ground in regulation. The classic Passivhaus standard requires an n50 of 0.6 air changes per hour or lower, and the Plus and Premium variants keep that same threshold, since the leap is achieved through renewable generation rather than greater airtightness. The Spanish Technical Building Code sets no general n50 limit. The European recommendation for nearly zero-energy buildings sits around 3 air changes per hour, with no harmonised binding value. PAPIK Group's Eskimohaus houses adopt the Passivhaus threshold of 0.6 as a design target, including in energy retrofit projects where the starting airtightness is always worse than in new build.

All these assumptions, factors and sources are stated explicitly so that any professional or specialist reader can verify, question or extend them. The transparency of the calculation is part of the quality of the result.

The quality of a house is not measured by what you can see, but by what stops escaping without anyone noticing.