

1. Benefits of Airtightness, Vapour Control and Windtightness

Airtightness, thermal insulation, thermal bridges, condensation, ventilation, cost-in-use and windows

ZEPHIR training session | Train-the-Trainers pilot programme (Day 3)

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Dr. Phys. Francesco Nesi | ZEPHIR Passivhaus Italia



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"Let's build ecologically together"

SECTION 1

Airtightness fundamentals

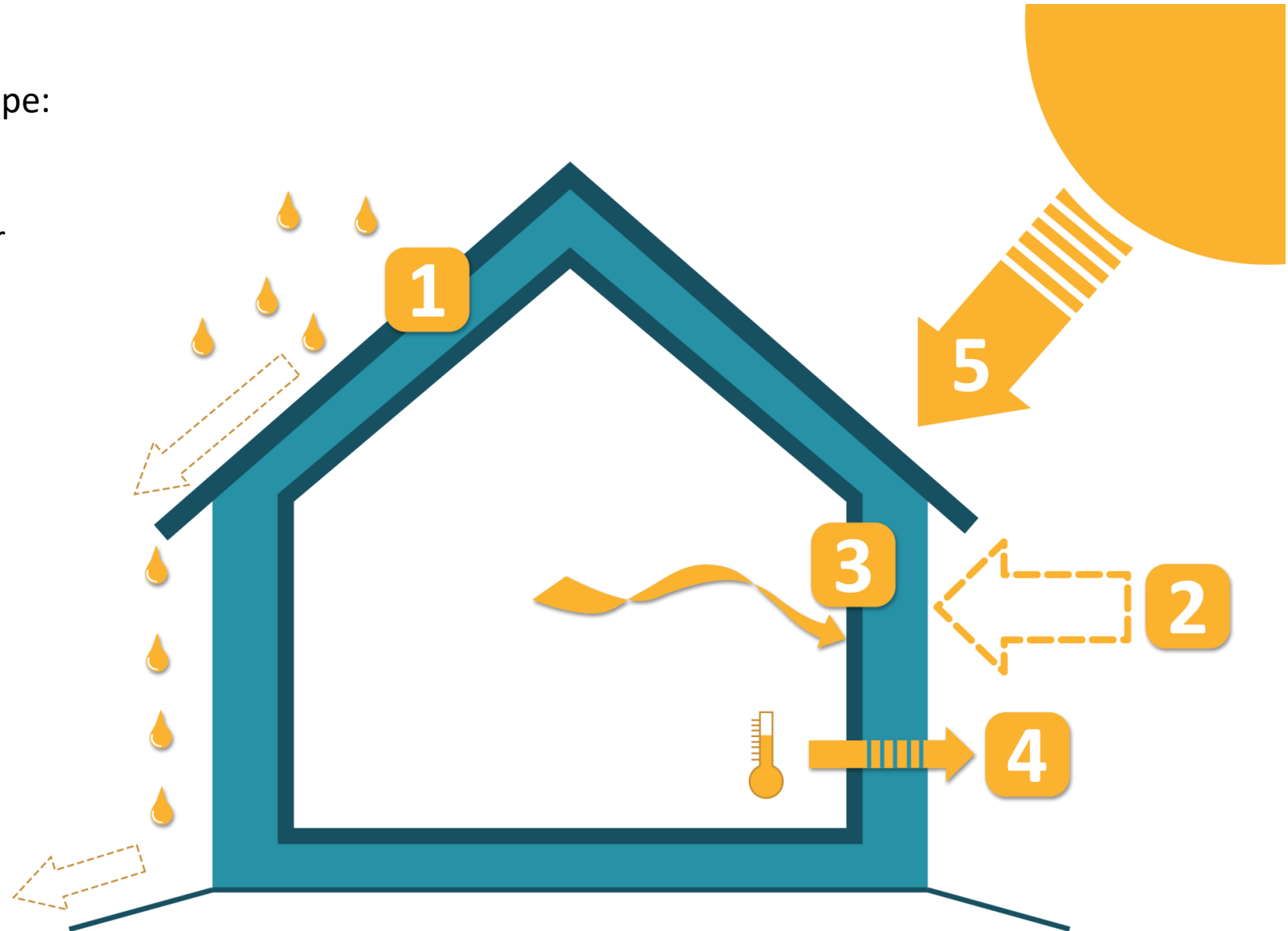
Why it matters, which materials to use, common mistakes

Goals of the Building Envelope



Functions of the thermal envelope:

- 1: Bulk-water run-off
- 2: Wind tight protection
- 3: Insulation & airtightness layer
- 4: Vapour control layer
- 5: Prevent overheating



Benefits of Airtightness



Image: Passive House Academy

- Eliminate drafts
- Improve comfort
- Reduce heat losses
- Reduce heating bills
- Improved sound proofing
- Increase efficiency of ventilation system

Benefits of Vapour Control

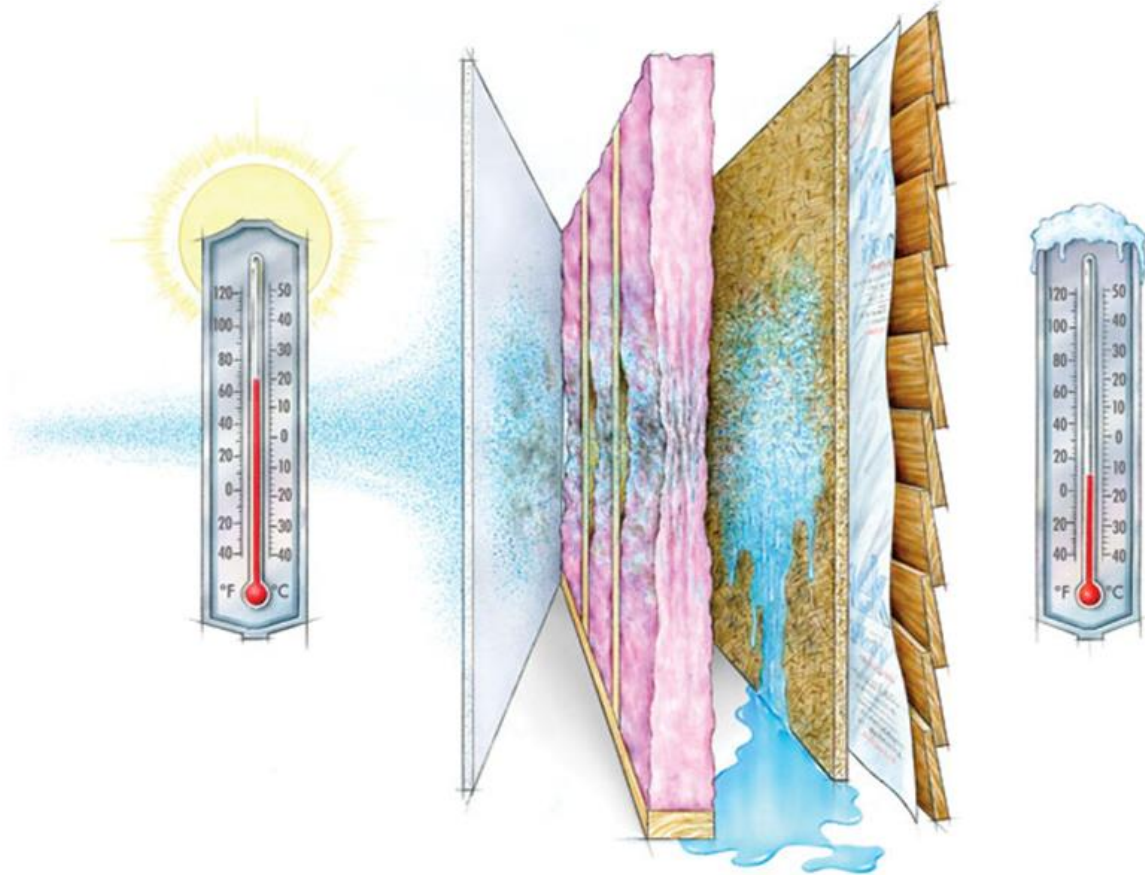


Image: Green Building Advisor

- Prevent vapour-laden air escaping into the exterior envelope
- Create vapour-open exterior face to allow envelope to 'breathe' to the outside
- Reduce risk of condensation and mould in the envelope
- Protect structural integrity
- Reduce risk of adverse health effects from mould

Benefits of Windtightness



Image: Foursevenfive.com

- Breathable but wind-tight layer located on the wall exterior
- Reduced impact of wind on the performance of the building
- Improved performance of the insulation layer (the heat is not blown away by the wind)
- Reduced heat losses and energy bills
- Improved comfort
- Especially important with 'loose' insulation such as cellulose or mineral wool

Summary Benefits



- Increased energy-efficiency
- Lower space heat demand and heat load + Savings in energy costs
- Lower primary energy usage and reduced CO₂ emissions
- No draughts and increased comfort for occupants
- Structural damage risk reduced – no condensation in construction
- Preventing air pollution of the internal air
- Improving sound insulation of building components
- Improving the operation and effectiveness of the ventilation system
- Improving the insulation effect of the external building components

n50 targets by standard



Standard / label	n50 limit (h-1 at 50 Pa)
Passive House	0.6
EnerPHit	1.0
CasaClima (Italy) Gold	0.6
CasaClima (Italy) class A	1.0
CasaClima (Italy) class B	2.0
German EnEV, with MVHR	1.5
German EnEV, without MVHR	3.0
Ireland residential for nZEB	5.0 [m ³ /hm ²] ← qE ₅₀
Italian general building regulation	no legal limit

n50 = complete air changes per hour at 50 Pa, roughly the wind pressure of a 15 to 35 km/h wind on a wall.

Airtightness, Vapour Control & Windtightness



International Residential
 Code
 $< X? \text{ ACH@50}$

EnerPHit
 $\leq 1.0 \text{ ACH@50}$

Proposed nZEB
 $= 5.0$
 $\text{m}^3/(\text{hr}/\text{m}^2)$

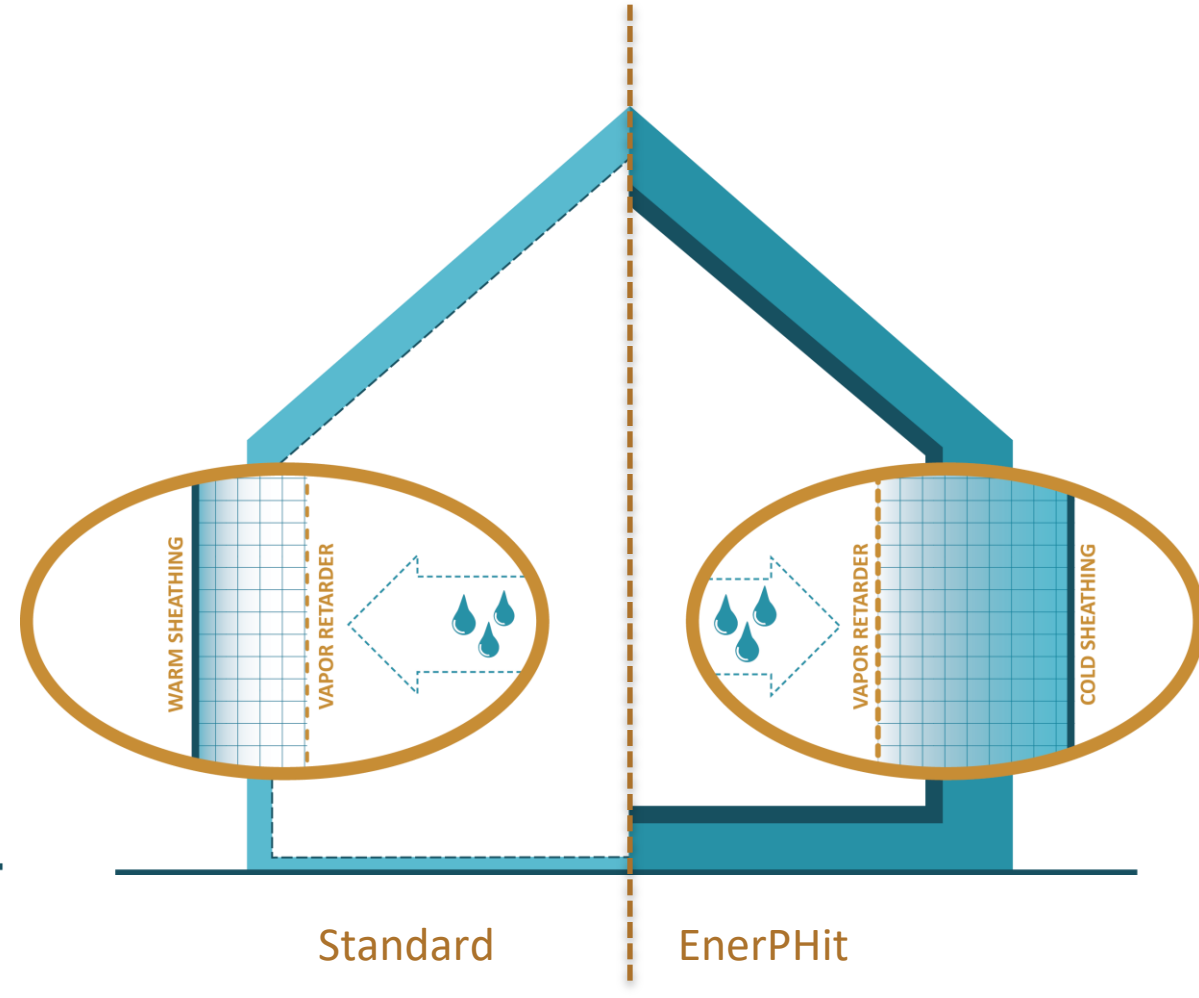
Most projects
 achieve 2 to 3
 $\text{m}^3/(\text{hr}/\text{m}^2)$

Continuous Air Barrier
 at all joints and seams

Standard

EnerPHit

Comparison of Conventional and EnerPHit



Importance of Vapour Control in Highly Insulated Envelopes

Non-Airtight Materials



Unplastered brick
or block



Some kinds of OSB Board



Insulation boards &
tongue & groove
cladding



Some kinds of
spray foam



Plasterboard



Duct tape

Airtight Materials



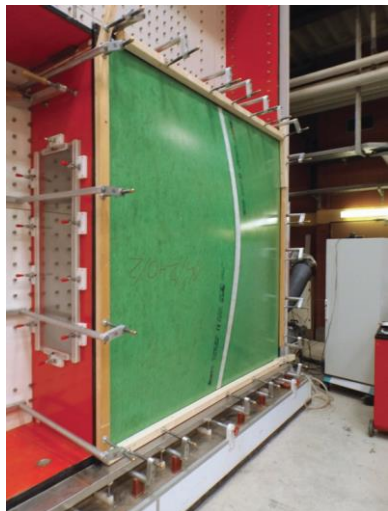
Plastered brick or blockwork



Special tapes and membranes



Special liquid applied membranes



Certified
airtightness
boards

Image: SmartPly



Concrete

Material Selection Will Depend on Site Conditions



Walls?

Ceilings?

Floor?

Windows?

Chimney?

Typical Weak Points in Airtightness Detailing



Bunched service penetrations fit tightly to corners which cannot be individually taped or sealed



Bunched service penetrations in a floor which cannot be sealed individually



Multiple services passing through wood without special airtight grommets

Typical Weak Points in Airtightness Detailing



Floor to wall junctions, where surfaces are rough and preparation is essential



Window to wall connections



Attic hatches

Making Airtight Window Connections



Step 1:
Plasterable tape used
to connect window
reveal to window
frame

Making Airtight Window Connections



Step 1:
Plasterable tape used
to connect window
reveal to window
frame

Step 2:
Reveals plastered,
hiding taped
connection

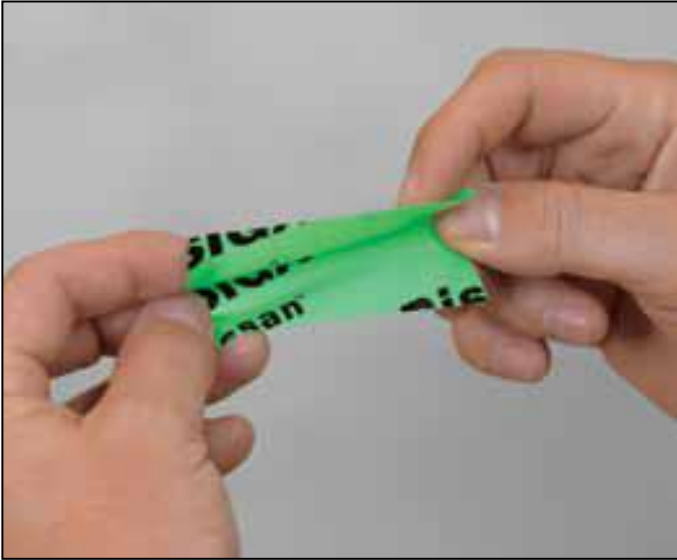
Step 3:
Applies decorative
finishes

Making Airtight Window Connections



Window placed external to the structural layer

Improvised Sealing of Penetrations without Grommet



1. Cut short **strips of flexible tape** (which can be formed around bends)
2. Tape the penetration all around piece by piece (no rounding of connection – 90 degrees)
3. Ensure good overlap between each piece, with no gaps

Verify performance during the airtightness test

Source: SIGA

Create a Service Zone Inside of Vapour Control Layer



Source: Empowerhouse,
Parsons/Stevens Solar Decathlon 2011

SECTION 2

Airtightness measurements

How to assess airtightness

Airtightness Testing Equipment



- Adjustable Aluminium Frame
- Elasticated Cloth Curtain
- Elasticated Cloth Fan Cover
- Depressurising/Pressurising Fan
- Flexible Hoses
- Manometer
- Power Cables & Fan Speed Controller



Airtightness Testing Equipment



Frame onto which the canvas is draped



Canvas draped over frame, with circular hole at bottom to accommodate the fan

Airtightness Testing Equipment



Fan used to create the pressure difference between inside and outside the building





Anemometer

Wind speed before and after ≤ 6 m/s at ground level on the side of the building where the fan is installed.

Recorded and included in the test report.



Barometer

Zero flow pressure before and after test ≤ 5 Pa over a 30 second interval. Recorded and included in the test report.



Thermometer

Temperature difference between inside and outside $\leq 10^{\circ}\text{C}$ before test begins and remains $\leq 10^{\circ}\text{C}$ after completion of test.

Recorded and included in the test report.

Timing of Testing – Don't Leave to the End



- On your first project(s), it is recommended to **do several intermediate tests** to determine how the building is performing
- If you leave the test to the very end, you will probably not have **access to the sources of any leaks**
- Build testing into the **construction programme – allow for this in the tender documents**

Typically on a house project the contractor should allow for 3 pressure tests:

1. Building sealed, including electrical first fix in place.
2. Mechanical ventilation system & all services penetrating external fabric of building have been fully installed.
3. Practical completion

Timing of Testing – Don't Leave to the End



A fan such as this Proclima Windcon or by Blowtest.de can be used by the contractor to find leaks during the construction process. While it is too early to give you an 'official' n_{50}/qE_{50} result, this devices will create a 50 Pascal pressure difference to help find leaks

At this point, it is **too late** for the airtightness test – needs to be tested while penetrations are all still exposed

Differential Pressure Measurement



The airtightness of a building is measured with a differential pressure measurement using a 'blower door'.

The procedure is used to detect leaks in the building envelope and to determine the air exchange rate / air permeability.

A fan is installed into the opening of a window or door with an airtight seal.

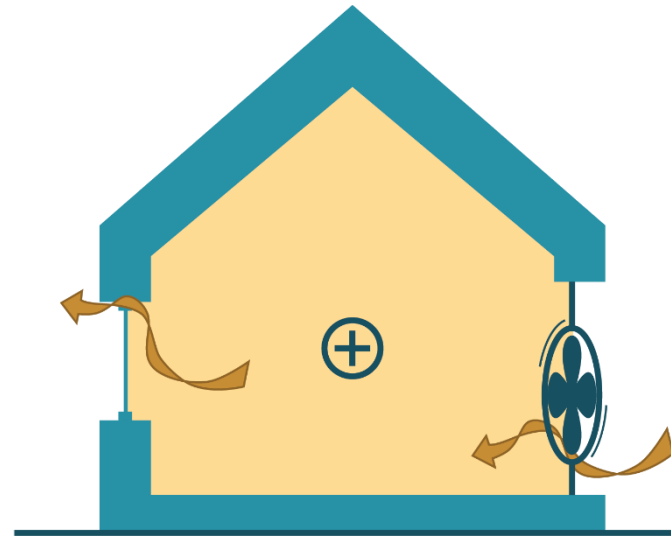
Measurements are made at varying pressure differences and results are normalized to 50 Pa.



Control Air Exfiltration



Negative Pressure Test



Positive Pressure Test

Test in Both Directions

- It is recommended to carry out **both a positive and negative** airtightness test on your project (many building regulations typically allow you to choose one of these)
- In testing in both directions, you can evaluate the **sealing provided by the window and door gaskets**
- Referring to the windows section shown, which is inward opening, a better airtightness result is expected for a positive pressure test where the sash gasket is 'pressed-against' the frame
- Official result is the **average of both tests**



European Norms:

EN 13829: 2001 “Thermal Performance of buildings. Determination of air permeability of buildings. Fan pressurization method”

International Standards:

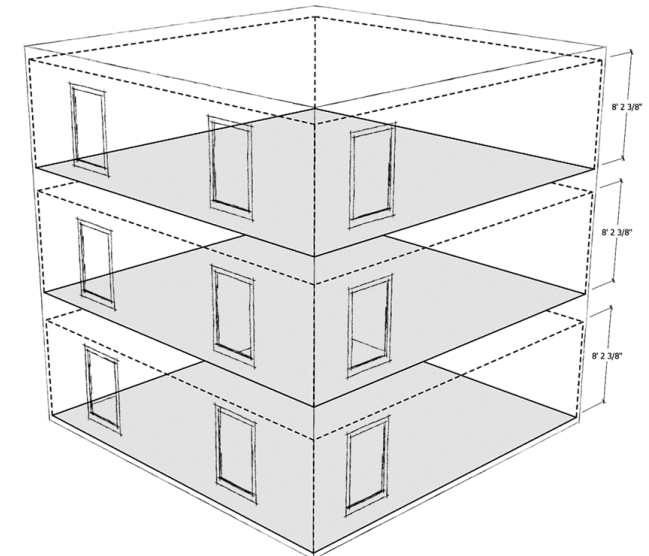
International Standards Organization **ISO 9972: 2015** “Thermal Performance of buildings – Determination of air permeability of buildings – Fan pressurization method”

The EN 13829: 2001 distinguishes between two methods:

METHOD A	METHOD B
Inspection of the building in operation. The building envelope should be in the same condition as it is when heating or ventilation are being used. This method is used to determine the n_{50} value for Passive House	Examination of the building envelope. Adjustable and intentional openings in the building envelope are closed / sealed.

Passive House Volume Calculation Methodology

Internal wall volumes as well as intermediate floors and dropped ceilings are all excluded



Leak Detection - Thermography



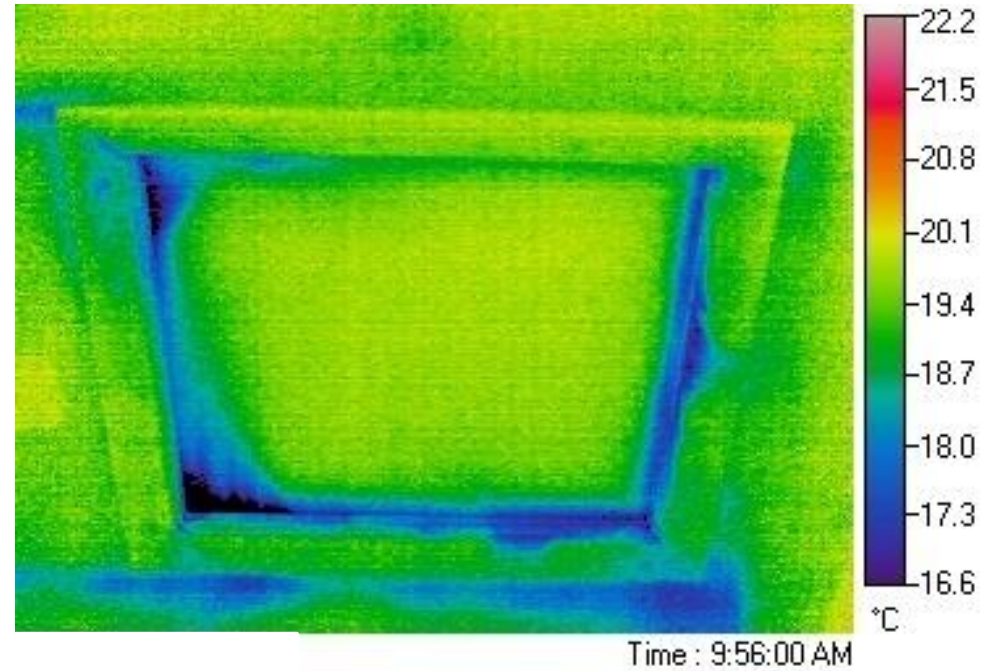
One can only see temperature effects on the surface - It isn't possible to see *inside* an object.

What can be analyzed?

- Leakages
- Insulation
- Thermal bridges
- Humidity
- Cable/pipe routes

Why Use Thermal Imaging?

- Structural survey – localization of deficiencies in the construction
- As a foundation for refurbishment measures
- Quality / process control



Calculate qE_{50} and n_{50}



In a deep retrofit project with a net air volume (V_{n50}) of 500 m³ and an external envelope area of 400m², an air flow rate of 420 m³/h was determined with a differential pressure measurement at 50 Pa.

What is the qE_{50} and n_{50} result?

$$qE_{50} = \frac{V_{50} = \text{flow rate through the fan}}{EA = \text{gross external surface area}}$$

$$qE_{50} = \frac{420 \text{ m}^3/\text{h}}{400 \text{ m}^2} \\ = 1.05 \text{ m}^3/\text{h} \cdot \text{m}^2$$

$$n_{50} = \frac{V_{50} = \text{flow rate through the fan}}{V_{n50} = \text{net air volume}}$$

$$n_{50} = \frac{420 \text{ m}^3/\text{h}}{500 \text{ m}^3} \\ = 0.84 \text{ h}^{-1} \text{ or } 1/\text{h} \text{ or "ACH"}$$

Thank you.

Every detail shown here is a detail you will teach a craftsman.

State the problem, give the principle, show the wrong and the right example,
let them practise by hand, test it, document it.

Dr. Phys. Francesco Nesi | ZEPHIR Passivhaus Italia | f.nesi@zephir.ph | passivhausitalia.com

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