ANTHROPIA UNIVERSITY · WORKING BOOK

25GH60

The book of a wall — from mycelium to a building standard

Completed edition · the standard is closed

Compiled from the working sessions between Süleyman Bayramoğlu and the ITP · September 2026 · English edition

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Preface — why holistic

This book is not a product brochure. It is the record of a way of thinking.

At the start there was a single object: an interlocking mycelium unit of 300 × 300 × 250 mm, grown on hemp shiv. An insulation material. The problem looked simple too: measure the thermal conductivity, write the number down, send the paper.

It did not go that way. While trying to defend the unit's λ, the question of how the wall would be built came up. How the wall is built brought in the structural system. The structural system brought thermal bridging, thermal bridging brought cladding, cladding brought moisture, moisture brought ventilation, ventilation brought the heat pump, the heat pump brought the ceiling, the ceiling brought the sun, and the sun brought the ground. In the end what we had was not a unit but **a system**: 25GH60.

The reason for looking at the whole is not ideological but arithmetic. The most frequently repeated finding in this book is this: **the value of each layer depends on what its neighbour does.** myWall's λ is not a good number on its own; but combined with dry-stack geometry it erases the anchor bridges. Radiation from the ceiling does not mean comfort on its own; but combined with the heat pump's COP curve it halves the electricity. Relaxing airtightness is waste on its own; but if the envelope is good enough the cost stays at 22%. A design that optimises the parts separately can see none of these gains.

Three things were kept visible throughout the book: **what was calculated**, **under which assumption**, and **where no measurement exists**. An unmeasured number and a calculated number never appear in the same typeface. This is the engineering form of Süleyman's Lafoloji scale: a statement is not true or false, it is only as sound as its support.

1 · Framing the problem: bringing 90% down to 60%

As a building standard, Passive House is one of the most successful engineering products of the last thirty years. But it is expensive. Special triple-glazed windows, hours of labour for $n_{50} \leq 0.6\ h^{-1}$ airtightness, licensed software and German-based certification — together these make the standard unreachable in Türkiye and comparable geographies.

Süleyman's decision was this: rather than copy the standard, **define a new level**. 60% saving against a conventional dwelling; local material, open calculation, local verification. It was first called GH60, then — taking the wall thickness into the name as well — **25GH60**: 250 mm of myWall, 60% saving, Green Home.

> **A correction, at the source.** Passive House does not in fact impose a "90% saving" requirement. What it imposes are absolute numbers: heating ≤ 15 kWh/m²a, primary energy ≤ 60 kWh/m²a, $n_{50} \leq 0.6\ h^{-1}$. The "90%" figure comes from a comparison with the old German building stock. The distinction is not trivial: **a percentage cannot be verified until its reference is defined.** 25GH60 must not fall into the same trap — "60" should be a name, the criteria should be absolute numbers.

For that reason the envelope criteria of 25GH60 were set as numbers: external wall U ≤ 0.20 · roof ≤ 0.18 · ground ≤ 0.25 · window ≤ 1.3 W/m²K. And the energy target: heating + cooling in the 40–55 kWh/m²a band.

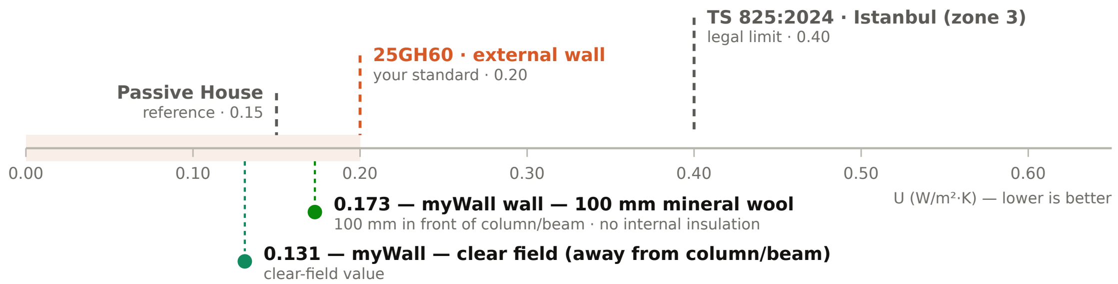

Fig. 1. Where the myWall wall sits on the scale of thresholds. The TS 825:2024 legal limit is 0.40; 25GH60 asks for 0.20; the wall as designed gives 0.173.

2 · Material: Ganoderma, hemp and the birth of a unit

myWall is a biocomposite obtained by growing *Ganoderma lucidum* mycelium on **hemp shiv**. Hemp shiv is the by-product of fibre production — greater in tonnage than the fibre itself and largely directed to low-value uses. This is exactly the frame of the paper: **a low-value agricultural stream turned into a building element by a living organism, with no cement and no petroleum-derived binder.**

There was a recording error here and it has been corrected: for a period the archive said "*Pleurotus ostreatus* × beech sawdust". That error came from a text the ITP produced; throughout six years of production the formulation has always been *Ganoderma lucidum* × hemp shiv. The difference is not cosmetic — when organism and substrate change, the material changes. Because the RILEM abstract went out with the wrong description, the full paper corrects it openly.

The correction has a second consequence, and it closes the first question any environmental conference will ask: **there is no forest in the composite, there is agriculture.** The NATURA 2000 area at Taxiarchis is not the material source; it is the place of production and the oxygen field. There are villages and privately titled plots inside the forest boundary; the 916.64 m² agricultural parcel where the work is carried out is one of those titled holdings, bought from private owners.

Geometry — the real invention of the unit

The 250 mm thickness is built as three layers: **90 + 70 + 90 mm**. The middle 70 mm layer is offset d = 50 mm to the right and downward; 50 mm recesses are left on the left and top. The result is a two-axis interlock that lets the unit be laid in any direction. No mortar. The male tongue is 47 mm, the female groove 50 mm — 3 mm of clearance on both axes.

At the centre of the unit stands a perforated PP tube, Ø100 mm and 100 mm long. It is not a flue but an **air distributor**: it homogenises the air trapped in the mould and draws hyphae into the cavity, giving strong integration at the centre. Because CO_2 build-up is desirable, fresh air is not required. The tube is permanent; it integrates with the composite and stays inside.

The mould is AISI 316 stainless, 2 mm sheet (3 mm base and lid plates), in four parts: two L-shaped walls + base tray + top lid. Self-locking without screws — the L-walls seat inside the 30 mm upstands of the base tray, and the lid drops over the top edges of the walls. The block on the lid is a **solid male tongue facing upward**; the block on the base opens the female groove in the underside of the unit.

3 · The story of a number: where 0.034 comes from

This is the most instructive chapter of the book, because here a number first collapsed and then was put back on its feet by correcting a label.

The value λ = 0.034 W/m·K came from a 30-day **comparative heat-box test** run in 2023: a 100 × 100 × 70 cm mineral-wool box, three equal apertures in one face, and three panels mounted in parallel across them — XPS (blue), Biopex (mycelium), EPS (white). Nine internal + nine external sensors, an Omega microprocessor thermometer.

The table in the archive read: XPS 13.78 · Biopex 14.62 · EPS 14.68 °C mean surface ΔT. That ordering made XPS the worst of the three panels — yet the λ of XPS is lower than that of EPS. The measurement was inverting known physics, and in that state it could not face a referee.

The problem turned out to be in the table, not in the measurement: **the XPS and EPS columns had been swapped.** The correct reading is XPS 14.68 · Biopex 14.62 · EPS 13.78. The error had stayed in the internal record and never reached third parties.

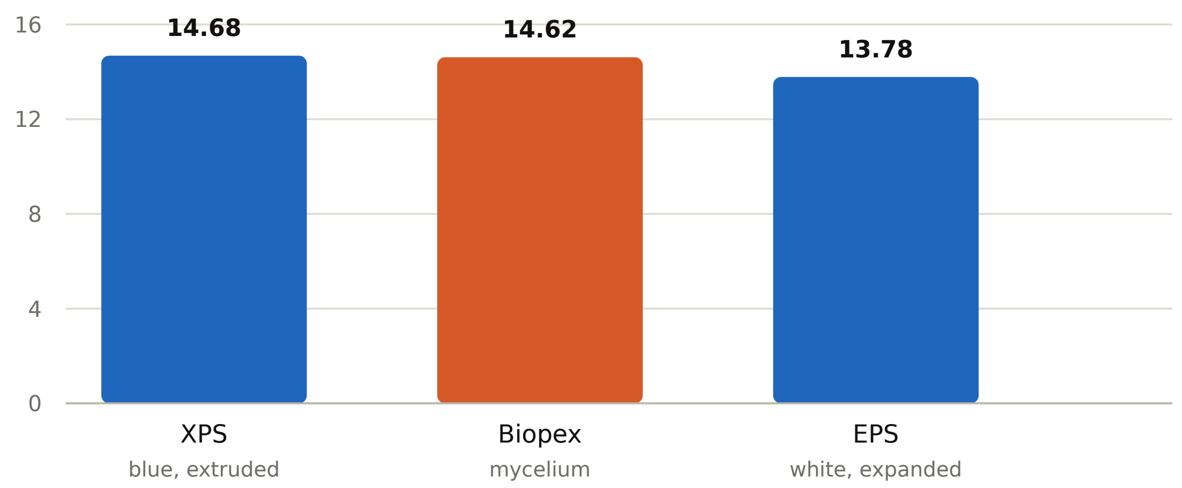

Fig. 2. Derivation from the corrected 2023 data. What the test actually produces is not an absolute λ but a ratio.

The derivation from the corrected data works as follows. Under the same surface resistance, the panel's share of ΔT grows with its insulating resistance:

$$f = \Delta T_{panel} / \Delta T_{driving} \quad \cdot \quad k = (1-f)/f = R_{surface}/R_{panel} \quad \cdot \quad \lambda_n/\lambda_{XPS} = k_n/k_{XPS} \ \text{(equal thickness)}$$

Result: **λ_{Biopex} = 1.018 × λ_{XPS}**. That is, Biopex is only 1.8% weaker than the XPS used. As a check, λ_{EPS} = 1.282 × λ_{XPS} — at the upper end for a low-density white foam, but plausible. Both independent ratios coming out in the right direction shows the internal consistency of the apparatus.

What the absolute value depends on. A comparative rig does not give λ directly; it gives a **ratio** against the reference panel. If a typical blue XPS is taken as 0.033, then λ_{Biopex} = 0.0336 — which lands on the 0.034 the project has used for years. Only one thing was missing: **the declared λ of the XPS panel used in 2023.** If the product data sheet could be found, 0.034 would stop being a claim and become a traceable derivation.

That gap is now closed. The İzocam Foamboard catalogue declares **0.030 ≤ λ ≤ 0.035 W/mK** at 10 °C; a second catalogue gives 0.033 (20–30 mm), 0.034 (40–60 mm) and 0.036 (70 mm) by thickness — all at 200 kPa compressive strength. Applying the ratio 1.018 to that declared band gives **0.0305 – 0.0366** for Biopex, and the 0.034 the project has used for years falls exactly in the middle of it.

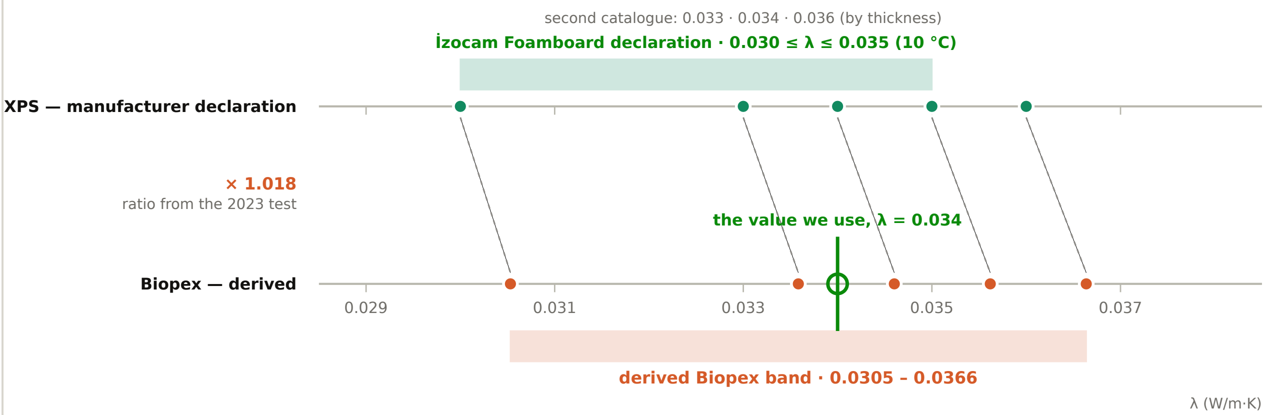

Fig. 15. Mapping from the XPS manufacturer's declaration to the Biopex band. The value is now derived from a figure declared by a third party, not from our own measurement.

The difference looks small but it is decisive before a committee: 0.034 is no longer a **measurement claim** but a **derivation** whose source can be shown. It will be written that way in the paper — "derived from a comparative test referenced to XPS; EN 12667 guarded hot plate measurement is planned at AUTH".

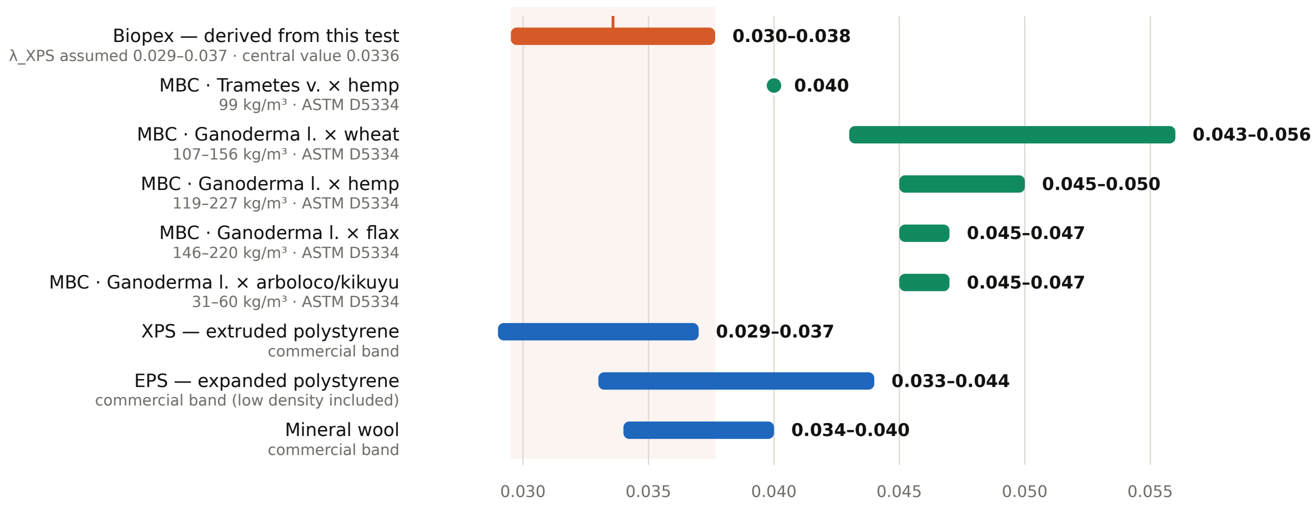

Fig. 3. Where the derived value sits in the literature. The best published mycelium composite is 0.040; the derived value is below that — a difference the paper must discuss.

Two points remain honest ones. First, this is the **Biopex panel, not the myWall unit**; the unit's own λ has not yet been measured and will be measured at AUTH to EN 12667. Second, the derived value sits below published mycelium composites (0.040–0.056). There are explainable reasons — different product form, different density, and above all a different measurement method (the literature uses ASTM D5334 transient, this test was comparative steady-state) — but the explanation must be written into the paper, not glossed over.

4 · Evolution of the wall: three sections, two rejections, one decision

The wall was built three times. Two were rejected. The reasons for rejection stand here because they are more instructive than the accepted solution.

Section A — reinforced-concrete shear wall + external insulation

The first section: a 250 mm reinforced-concrete load-bearing wall, 250 mm of dry-stacked myWall outside it, then render and stone or timber cladding. This section worked: U = 0.131 W/m²K, 6% better than anchored XPS and 17% better than EPS at equal thickness — because dry stacking needs no mechanical fixing and the point thermal bridges of anchors never form. But it left an open question: **what holds the 250 mm outer layer against wind?**

Section B — sandwich (rejected)

The second proposal: 100 mm reinforced concrete + 250 mm myWall + 100 mm reinforced concrete, 450 mm in total. It solved mechanical fixing and fire in a single move. In the clear field the U was the same (0.131).

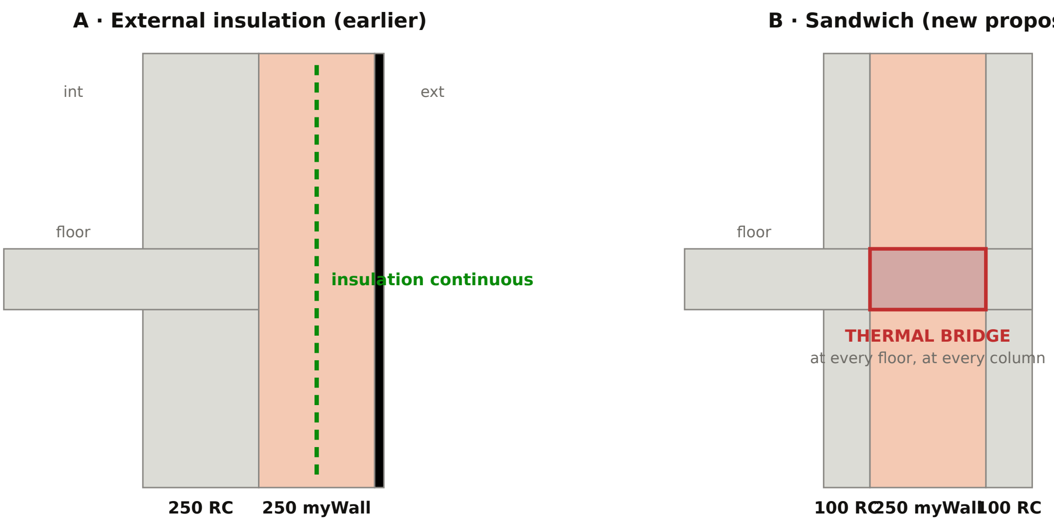

Fig. 4. Where the sandwich variant collapses: because the structure remains a separate column-and-beam frame, the insulation is interrupted at every floor.

It broke in four places. **Thermal bridging:** because the structure remains a separate column-and-beam frame, the insulation is cut at every floor and every column; ψ ≈ 0.7 W/m·K, and at a 3 m storey height U rises from 0.131 to 0.365 — 2.8 times worse. **Moisture:** fresh concrete carries ~170 litres of water per m³; 0.20 m³/m² → ~35 litres/m² of construction water, trapped between two impermeable leaves, and the organic core cannot dry. **Seismic:** 480

kg/m² of non-structural parasitic mass. **Carbon:** ~70 kg CO_2e/m² of additional concrete — myWall's own mass is 43.8 kg/m², so concrete dominates the wall's carbon footprint and the "one-fifteenth of concrete" narrative collapses at system level.

Decision: closed.

Section C — frame + projecting dry stack (the constitution)

The third and final section: a reinforced-concrete **column-and-beam frame** carries the load; the external wall is built of interlocking myWall units that **project 100 mm** beyond the beams and columns. When the outer face of the frame is covered with 100 mm of mineral wool the two surfaces come flush. Gypsum board inside, cement-bonded board outside — both on vertical metal profiles.

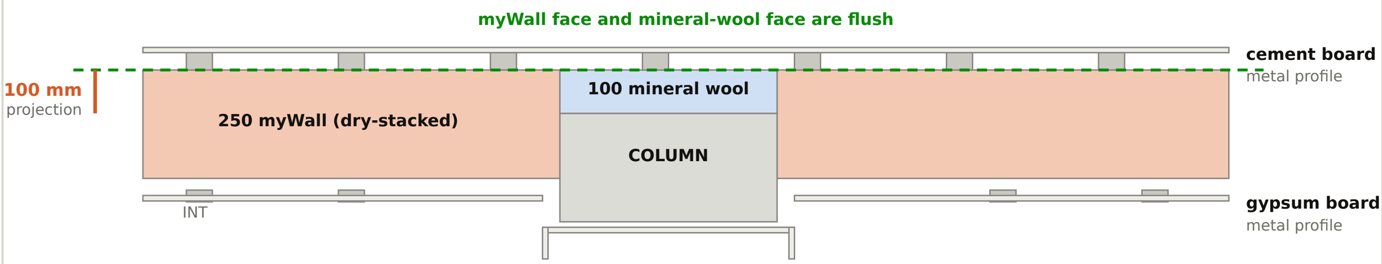

Fig. 5. The final section, horizontal cut at a column. The insulation passes uninterrupted in front of the frame; the boards fix to the profiles, not to the units.

This section solves what the other two could not. Because the insulation passes **in front of** the structure, the bridge is not cut. Because concrete leaves the wall entirely, the mass drops from 680 kg/m² to 68 kg/m², the section from 520 mm to 275 mm, and myWall now dominates the carbon footprint. And because mineral wool is class A1 at the floor bands, the ventilated façade gets its **inter-storey fire barrier** for free.

The numbers: clear field U = 0.131 · in front of the frame 0.311 · with a frame surface fraction of ~23%, an area-weighted mean of **0.173 W/m²K**. Below the 0.20 limit of 25GH60 — and with no internal insulation at all.

5 · The equilibrium limit and the profile cage

In Section C the amount of projection looked like a free parameter. It was not. Süleyman objected: at 150 mm of projection the centre of gravity bears on nothing.

The calculation confirmed him and gave the limit. The unit is 250 mm; its centre of gravity is 125 mm from the inner face. The bearing width is 250 − projection. For the centre to stay inside the support:

$$\text{projection} < 125 \text{ mm}$$

Fig. 6. The equilibrium limit. At 100 mm there is 25 mm of margin; at 150 mm the centre of gravity falls outside the support.

At 100 mm there is 25 mm of margin. At 150 mm the centre bears 25 mm into thin air. The projection was fixed at 100 mm, and that in turn fixed the mineral wool thickness at 100 mm.

What the cladding holds on to

myWall's compressive strength is of the order of 0.17 MPa; it does not hold screws. The solution came from Süleyman: gypsum board and cement board fix not to the unit but to **vertical metal profiles set in front of and behind it**. This single decision closes two problems at once — the screw-holding problem disappears, and because two planes of profiles grip the wall on both faces, the question of **out-of-plane restraint** is answered as well.

> **A physics note on compression.** Thermal resistance depends on **installed thickness**, not on how much material is squeezed in. Pressing 150 mm of mineral wool into a 100 mm cavity does not give the resistance of 150 mm; when density rises from 40 to ~55 kg/m³, λ falls only from 0.036 to ~0.034 and the mean U goes from 0.173 to 0.169. Not worth counting. The right decision is to stay at 100 mm and meet the limit anyway.

6 · Thermal bridging: the gain that comes from geometry

This chapter establishes the contribution myWall can defend independently of the λ debate.

The reference is the same unit laid with mortar — so the gain comes only from geometry, not from material. For a 300 × 300 mm unit and a 10 mm joint, the joint area fraction is:

$$f_m = 1 - (0.30 \times 0.30) / (0.31 \times 0.31) = 6.35\%$$

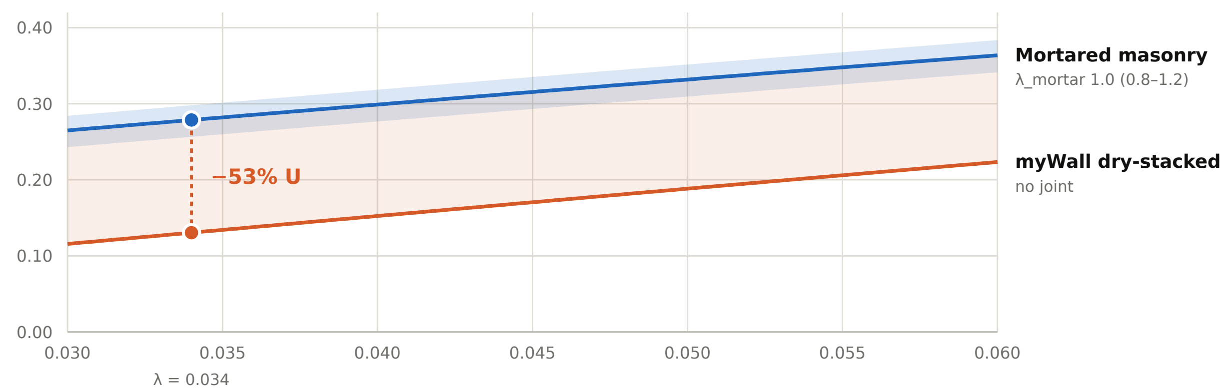

Fig. 7. Wall U value as a function of the unit's λ. The gain does not depend on the exact value of λ.

In the final section, at λ = 0.034, mortared stacking gives 0.279 and dry stacking 0.131 — a **53% gain**. And the gain stays in the 45–60% band across λ: as the unit improves, the mortar joint becomes a relatively more dominant bridge, so the gain grows.

This is the first place where the archive's claim of "60% reduction in wall heat loss" rests on a calculation. In the paper it must be given with its reference (same unit + mortar) and the λ stated explicitly — not as a bare "60%".

This gain is not free. If the 3 mm clearances of the dry stack stay open to air leakage, convective bypass takes the whole gain away. The joints of the internal gypsum board must be taped so that it acts as the **air barrier**. Also, the parallel-path model overstates the mortar bridge somewhat compared with 2D finite-element analysis; in the paper it should be qualified as an "upper-bound estimate".

7 · Conditioning: Bioiklim and the physics of the ceiling

The envelope reduces the demand; meeting what remains **cheaply** is a separate job. This side of 25GH60 comes from Bioiklim — PEXa Boru's decade-long R&D line.

BIOIKLIM = PV + AWHP + BP + PEXa → **25GH60 = PV + AWHP + BP + myWall**

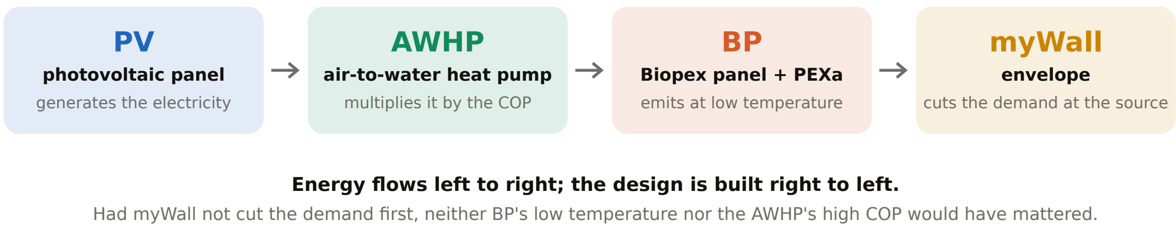

Fig. 8. The chain. Energy flows left to right; the design is built right to left.

The components: **PV** photovoltaic panels generate the electricity; **AWHP**, the air-to-water heat pump, multiplies it by the COP; **BP**, the Biopex composite panel, distributes PEXa pipes across the ceiling and emits the heat at low temperature; **myWall** reduces the demand in the first place.

The Q&E Slab panel is 600 × 1800 mm, ready to install, and carries 20 metres of pipe; it is a self-channelled composite panel with a reflective aluminium facing and cross-linked PEXa pipes. BioPEX itself is **100% biological**: hemp + mycelium. Its thermal transmittance matches polystyrene, and in fire behaviour it is incomparably better.

Why this is the cheapest solution — the COP curve

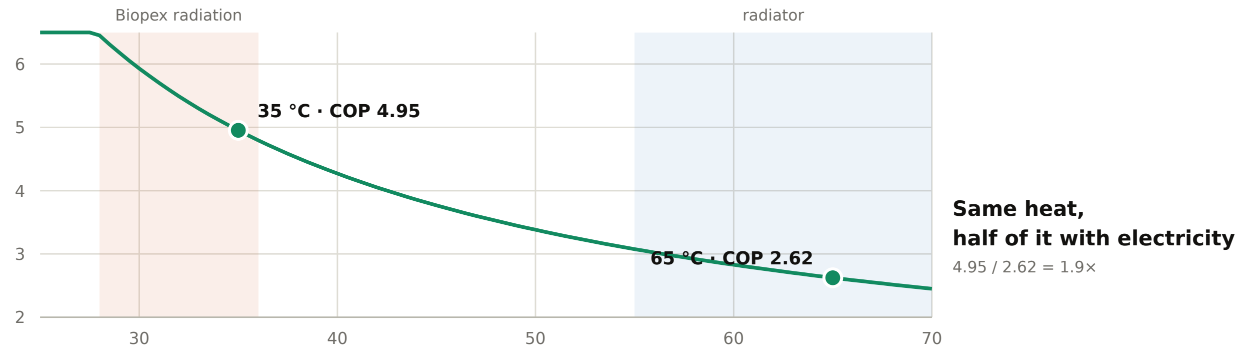

Fig. 9. Heat pump efficiency as a function of supply water temperature. Radiant distribution works at 30–35 °C; a radiator wants 55–65 °C.

The efficiency of a heat pump is set by the difference between source and supply temperature. Because Biopex emits from its surface by radiation, 30–35 °C water is enough: **COP 4.95**. At a radiator's 65 °C, **COP 2.62**. The same heat, for half the electricity.

Ceiling or floor — the measured difference

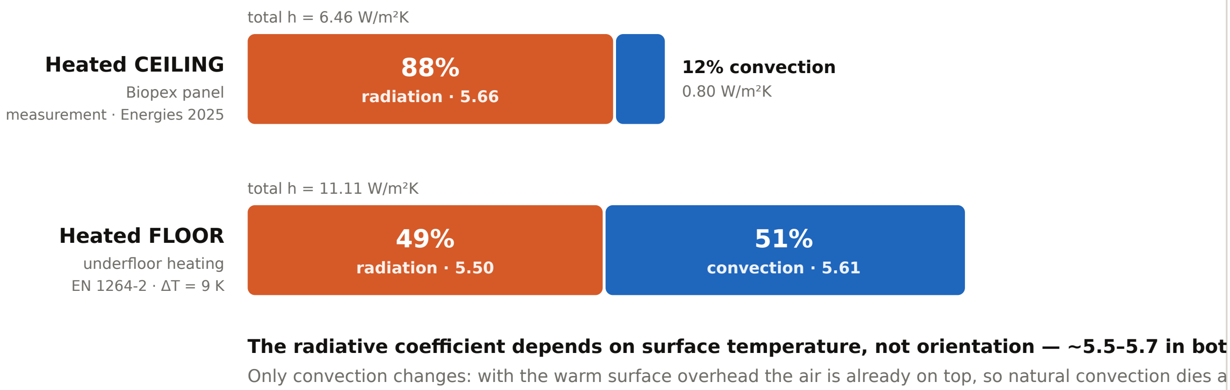

Fig. 10. In a heated ceiling 88% of the heat transfer is radiant; in a heated floor 50%. The difference comes not from radiation but from convection.

Measured values for a heated ceiling: $h_r = 5.66 \cdot h_c = 0.80$ W/m²K, with a mean radiant share of **88.6%**. For a heated floor, the characteristic curve of EN 1264-2 gives $h_{total} = 11.1$ at $\Delta T = 9$ K; radiation ≈ 5.5, so the share is **50%**.

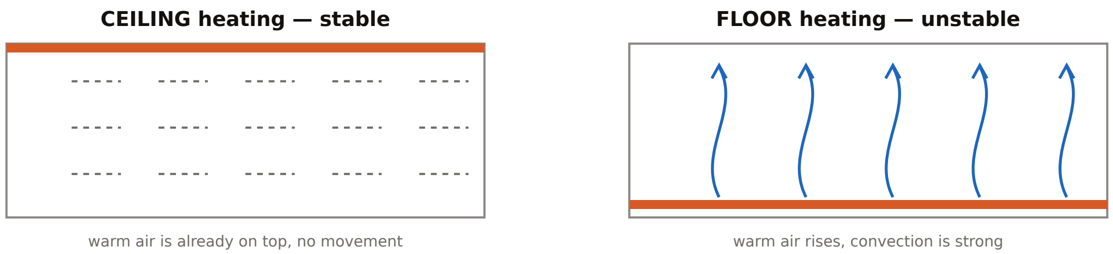

Fig. 11. The mechanism: with the warm surface overhead the stratification is stable and natural convection dies away.

The radiative coefficient depends on the temperature and emissivity of the surface, not on its orientation — ~5.5 in both cases. The only thing that changes is convection. With the warm surface at the ceiling the air is already on top, so stratification is stable and natural convection dies away; at the floor the opposite happens, warm air rises and convection strengthens.

The practical meaning: **radiation heats surfaces and bodies, not air.** The same comfort is achieved at a lower air temperature, and every 1 °C of lower air temperature is worth roughly 6% of the heating energy. There is also no air movement: no dust transport, no stratification, silent.

> **Evidence from the field.** Süleyman has spent three summers in his own 200 m² house in Istanbul with this system. The brochure gives the measurement in numbers: in August 2024, with 38 °C outside, readings from different thermostats inside the house showed a uniform **24 °C**. Dehumidification was run only in some high-humidity periods and that was enough — in practice the dew-point limit of radiant cooling does not require continuous dehumidification.

Two limits should nevertheless stand in the text. The ceiling's total heat transfer coefficient (6.46) is about half that of the floor (11.1) — its capacity per m² is lower; not a problem for the small demand of 25GH60, but on its own it may not suffice in a high-demand building. And the radiant asymmetry limit of ISO 7730 (5 K) caps the ceiling surface temperature at ~27–30 °C — which is in any case the band the AWHP prefers.

8 · Ground, glass and air: the last three decisions

Once envelope and mechanical systems were set, three decisions remained. All three follow the same logic: **buy cheap physics, not expensive technology.**

8.1 · Triple glazing

In the reference dwelling the windows were the single largest item of heat loss. Moving from double ($U \approx 1.30$) to triple glazing ($U \approx 0.90$) takes the loss of 20 m^2 of window from 26 W/K to 18 W/K — **−2.6 kWh/m^2a** in annual demand. The same principle applies to doors: the best insulation is the best seal.

8.2 · No filter

The decision: no mechanical ventilation and no filter will be installed. This has a cost and it should not be hidden. The hygienic ventilation requirement (~0.5 h^{-1}) without heat recovery means a load of 44.2 W/K; with 75% recovery it would fall to 11.1 W/K. The difference is **+10.6 kWh/m^2a**.

What is gained in return is real: no capital cost, no ducts, no fan electricity, no filter replacement, no maintenance. And because Bioiklim works by radiation it needs no ducts anyway — so ventilation ducting would have been laid for ventilation alone. The defensibility of the decision rests on a single condition: **does the overall target still fall inside the band?** Chapter 9 says yes.

> **Ventilation cannot be zero.** Even without filters and recovery, hygienic air change is required; if it is to be done by window, **short and intense airing** (opening the window fully for a few minutes) is both healthier and cheaper than leaving a tilted sash permanently ajar. A permanent gap cools the wall surfaces and creates a condensation risk.

8.3 · Coupling to the ground

The largest gain is here. A 2 m deep trench is dug around all four sides of the building for drainage and insulation; the soil beneath the building is thereby coupled to **the ground's own temperature** rather than to outdoor air.

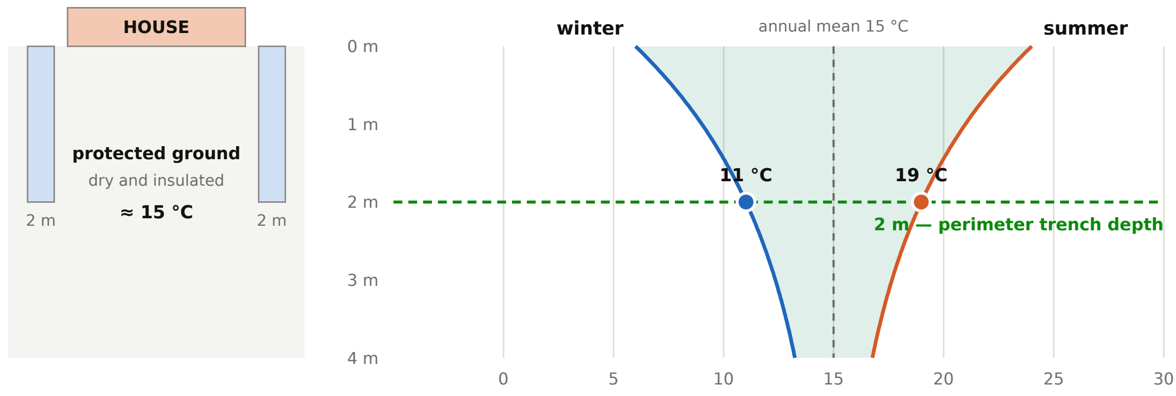

Fig. 12. Damping of ground temperature with depth (Istanbul). The ±9 K annual swing at the surface falls to ±4 K at 2 m.

The physics is simple: the ground damps the annual surface temperature wave exponentially with depth.

$$T(z) = T_{mean} + A \cdot e^{-z/d} \cdot \cos(\omega t - z/d) \quad \cdot \quad d = \sqrt{(2\alpha/\omega)} \approx 2.45 \text{ m}$$

In Istanbul the annual mean is ≈ 15 °C and the surface amplitude ≈ ±9 K. At 2 m depth the amplitude falls to ±4 K: winter minimum ≈ 11 °C, summer maximum ≈ 19 °C.

Süleyman's "+15 °C" and the book's "11 °C" do not contradict each other. 11 °C is the winter minimum of *undisturbed* ground at 2 m. But the soil under the building is not undisturbed: there is a heated volume above it, an insulation ring around it, and thanks to drainage it is dry. Together these three keep the soil beneath the house as its own heat island, in practice **around 15 °C**. So the perimeter trench is not merely a drainage detail — **it is what keeps that warm island alive.** Drainage also prevents wet soil from conducting heat 2–3 times better than dry soil.

The result transforms the ground-floor loss. Instead of ΔT = 23 K against outdoor air, ΔT = 5 K against the ground:

$$U_{equivalent} = 0.25 \times 5/23 = \mathbf{0.054\ W/m^2K}$$

The floor drops from the second-largest item at 25 W/K to the smallest at 5.4 W/K. A single excavation gains more than twice what triple glazing gains.

9 · The whole: the energy balance of 25GH60

The picture that emerges when all the decisions are combined. Reference dwelling: 100 m², single storey, Istanbul (HDD_{18} ≈ 1900), annual heating demand reduced 30% by gains.

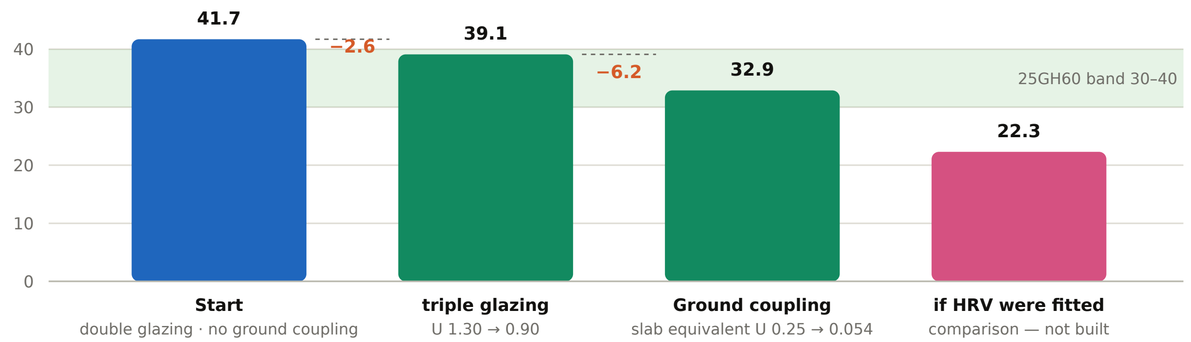

Fig. 13. Cumulative effect of the decisions. Triple glazing and ground coupling gain; going without HRV costs 10.6 kWh/m²a — and the total still stays inside the band.

COMPONENT	H (W/K)	SHARE	NOTE
Ventilation (no recovery)	44.2	43%	0.5 h^{-1} hygienic air change
Roof	18.0	17%	U ≤ 0.18 · aerogel line to be studied separately
Windows	18.0	17%	20 m² × 0.90 (triple glazing)
Wall · myWall	17.3	17%	area-weighted U = 0.173
Ground floor	5.4	5%	ground-coupled · equivalent U 0.054
Total	102.9	100%	**32.9 kWh/m²a** — inside the 25GH60 band

The table shows one thing plainly: **the wall has finished its job.** myWall accounts for less than a sixth of the total loss. From here on the gains are not in the wall — they are in the ventilation strategy, the roof and the windows.

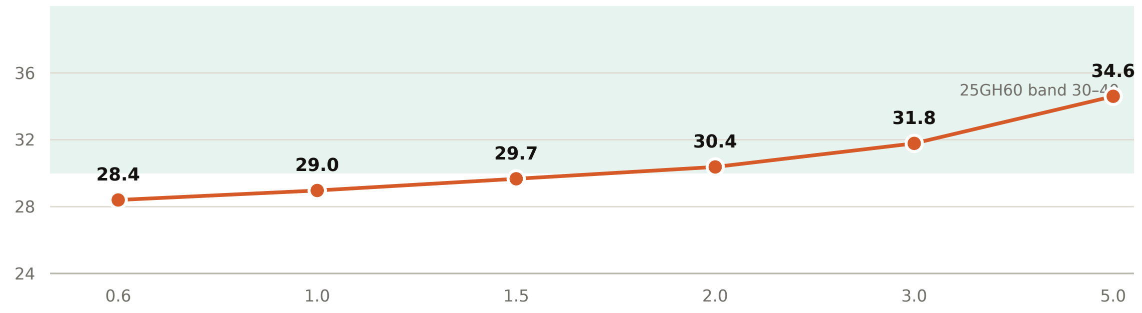

Fig. 14. The cost of relaxing airtightness. Because the envelope is good, leakage remains a small item in the total.

The airtightness decision is defended by the same logic. If n_{50} rises from 0.6 to 5.0, annual demand goes from 28.4 to 34.6 kWh/m²a — only 22%, and still inside the band. Why so little? Because when the envelope is this good, leakage is a small item in the total. **myWall buys the airtightness tolerance.**

10 · Declared limits and open ends

A book that does not set its limits beside its claims is a brochure. What is unmeasured, unverified or undecided in 25GH60 as of today:

SUBJECT	STATUS	WHAT IS NEEDED
λ of the myWall unit	not measured	AUTH, EN 12667 guarded hot plate
Declared λ of the 2023 XPS panel	closed	İzocam Foamboard declaration 0.030–0.035 · § 3
Drying rate in a sheet-metal-box specimen	not measured	The only datum that would justify the box's thermal cost · § 13
Emissivity of the sheet (aged)	assumption	ε 0.40 assumed · to be measured after 1 year inside a wall
Condensation in the cavity	calculated, not measured	Winter-long monitoring of a drained specimen · § 13
Compressive strength	not measured	EN 826, at 10% deformation
Water absorption	not measured	EN 1609 — up to 550% for MBC in the literature
Reaction-to-fire class	none	EN 13501-1 · an observation of "resistant" is not a class
Carbon claim (1/15 of concrete)	not verified	LCA boundaries and functional unit definition
Infill wall–frame separation	decision pending	Compressible joint + out-of-plane clip · structural engineer's approval
Bearing eccentricity	decision pending	100 mm unsupported · angle bracket or widened slab edge
Air barrier detail	not designed	Taping of the gypsum board joints
Reference for "60%"	undefined	Existing stock, or a code-compliant new building

This table is not a list of weaknesses but a **work list**. And its order is clear: first λ, then the fire class, then load-bearing behaviour. All three in the same laboratory — the Laboratory of Building Materials of Prof. Maria Stefanidou, at AUTH.

11 · Afterword — on method

The subject of this book is a wall. But what it actually describes is how an idea is tested.

Over the sessions we changed direction five times. Once I was wrong and corrected myself: I had said the conference made no room for bio-based materials; in fact the abstract had been accepted under exactly *Topic 9 — Bio-based materials*. Once I relied on the wrong information about a date; the official announcement corrected it. Süleyman rejected my proposal twice — he closed the sandwich variant and found internal insulation unnecessary — and he was right both times. And once his intuition found a limit before I did: he said the centre of gravity would bear on nothing at 150 mm of projection; the calculation confirmed the 125 mm limit.

The method that follows from this: **a design is sound to the degree that it can be objected to.** The yield of working together comes from both sides being able to be wrong, and from recording it when they are. The errors corrected in this book were not deleted; they stand with their reasons — because how a conclusion was reached carries as much information as the conclusion itself.

This is also why 25GH60 is holistic. Optimising the parts separately was possible: the best unit, the best window, the best heat pump. But that path could not have seen that the unit buys an airtightness tolerance, that the ceiling doubles the heat pump's efficiency, that a two-metre trench gains twice what triple glazing gains. **The gains are not in the parts but between them.**

> *The book of a unit became, in the end, the book of a house.*

12 · The physics of still air

In the first text I wrote the cavity inside the unit as a **cost**: a volume paid for drying, stolen from insulation. Süleyman objected — because I had assumed the cavity was **ventilated**. In his design the perforations close as the mycelium grows, so for most of its life the cavity is a **sealed air cushion**.

The question is: does still air increase the resistance? The answer is yes — but where the increase comes from is different from what is assumed, and the whole chapter is built on that.

Annex D of EN ISO 6946 gives the resistance of an unventilated cavity as the inverse of the sum of two coefficients:

$$R = 1 / (h_a + h_r)$$

h_a represents conduction and natural convection, h_r radiation. For horizontal heat flow $h_a = \max(1.25 ; 0.025/d)$ — that is, it **locks at 1.25 for every cavity thicker than 20 mm**. Thickening the cavity helps up to a point, then a natural convection cell forms inside and the gain stops. There is no thermal difference between 60 mm and 25 mm. h_r, by contrast, depends entirely on **the emissivity of the surfaces**:

$$h_r = 4\sigma T_m^3 \cdot E \quad \cdot \quad E = 1/(1/\varepsilon_1 + 1/\varepsilon_2 - 1)$$

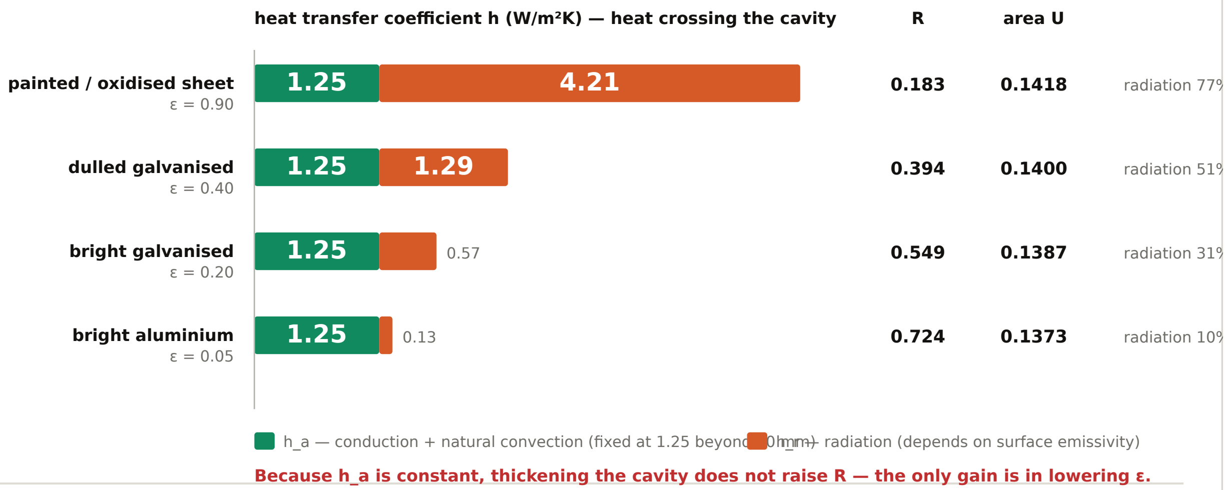

Fig. 16. The same 60 mm cavity, four different surfaces. The orange part is radiation — on an ordinary surface three quarters of the heat passes that way. The choice of surface is far more decisive than the thickness of the cavity.

The table comes down to one sentence: **in an ordinary cavity 77% of the heat crosses by radiation.** For bare myWall or a painted surface, R = 0.183. The same cavity rises to 0.394 with a dulled galvanised surface and to 0.724 with bright aluminium — **four times**. This explains why we tried metal in the next chapter. And why we abandoned it.

> **Link to Chapter 7.** We measured that 88.6% of the heat at the ceiling is carried by radiation. Here, in a six-centimetre cavity inside a masonry unit, the same physics is at work: in still air, radiation dominates. Two different scales, one mechanism. That is why what governs the design of both the ceiling and the unit is **surfaces**, not volume.

And there is one fact that does not change and stays valid to the end of the book: still air, at 60 mm and with bare surfaces, behaves like an equivalent **λ = 0.328 W/mK — ten times worse** than myWall (0.034). So the cavity, whatever shape it takes, **is a thermal loss**; its justification is drying, not insulation.

13 · The metal trial and why it was abandoned

The previous chapter showed that radiation dominates. A natural idea follows: make the surface of the cavity **low-emissivity**, that is, line it with metal. Süleyman proposed exactly that — a 100 × 60 × 300 mm box of 10 µm perforated sheet. This chapter is the record of that trial and of **why it was given up**. The reasoning behind rejected paths is more instructive than that behind accepted ones.

The λ of the sheet is 50 W/m·K; myWall's is 0.034. The ratio between them is **1500**. The two side walls of a box run **uninterrupted** in the direction of heat flow: a direct metal path from the inner board to the outer one. The bottom and top caps do the same.

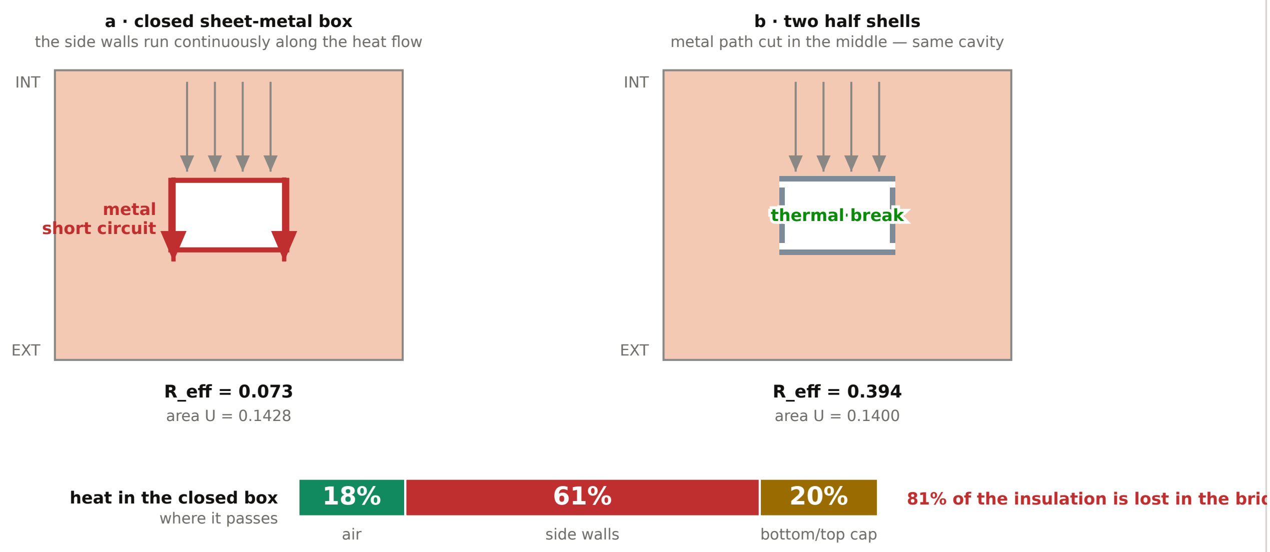

Fig. 17. Left, the closed box: side walls and caps short-circuit the cavity. Right, two half shells: the same air, the same surface, but the metal path is cut in the middle.

In the closed box only **18% of the heat crossing the cavity goes through the air**; 61% goes through the side walls and 20% through the caps. The cavity's resistance of 0.394 falls effectively to **0.073** — **81% of the insulation is lost in the bridge**. The result is a sentence that looks inverted at first: **closing the box is worse than leaving it open.**

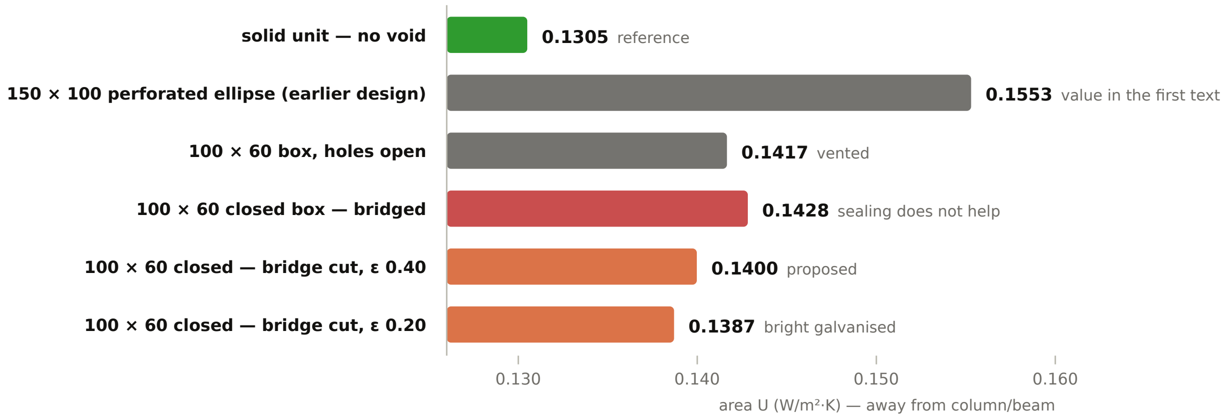

Fig. 18. Comparison of area U. The closed sheet-metal box is not better than the open one — it is worse. The gain appears only when the metal path is cut.

There was a way to cut the metal path — make the box from two half shells instead of one piece — and then the area U fell to 0.1400. But that path brought a second cost.

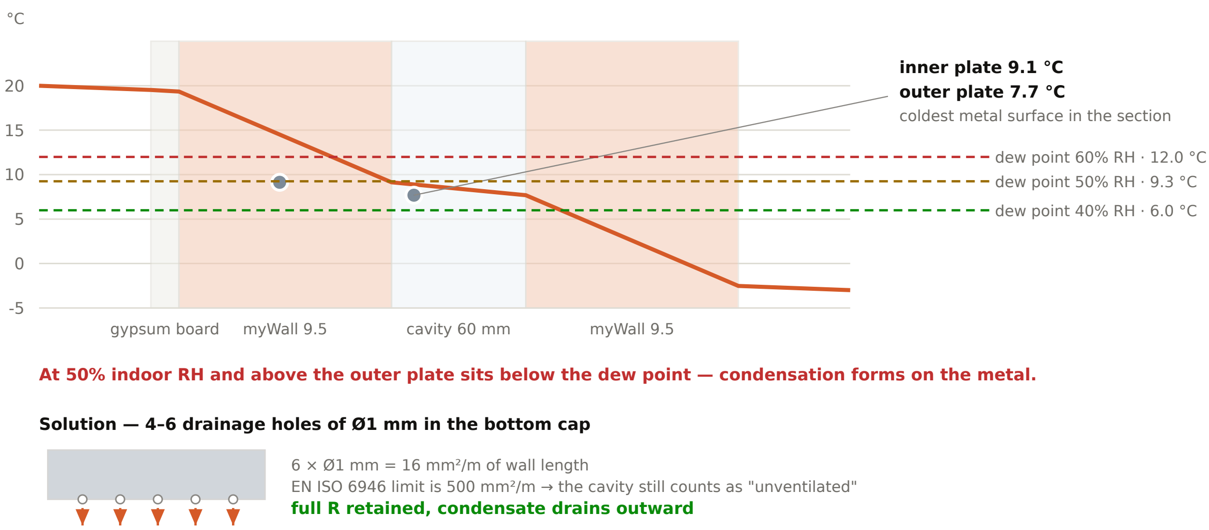

Fig. 19. Temperature and dew points across the section. In a closed cavity the outer metal plate sits at 7.7 °C; at 50% relative humidity the dew point of the indoor air is 9.3 °C.

In a closed cavity the outer plate becomes the **coldest metal surface in the section**: at design conditions of −3 °C outside and 20 °C inside, **7.7 °C**. If indoor air is at 50% relative humidity the dew point is 9.3 °C, at 60% it is 12.0 °C — both above the plate. So under normal winter comfort **water forms on the metal**. myWall absorbs it and dries; metal does not absorb, it accumulates. And a wet metal–organic interface is where biodegradation begins.

The reasoning behind the decision. Metal promised two things: low emissivity (R 0.183 → 0.394) and shape stability. In return it demanded three: bridge risk, a condensation surface, and a foreign material in the composite. Süleyman gave up the metal. **The loss is only 0.0037 W/m²K** — the area U would have been 0.1363 instead of 0.1400. In exchange for that difference the composite stays entirely bio-based. The right trade.

14 · The figure-of-eight and the removable PP former

Once metal was out, two questions remained: what shape should the cavity take, and what should form it? Both answers came from Süleyman and both proved right.

Why a figure-of-eight

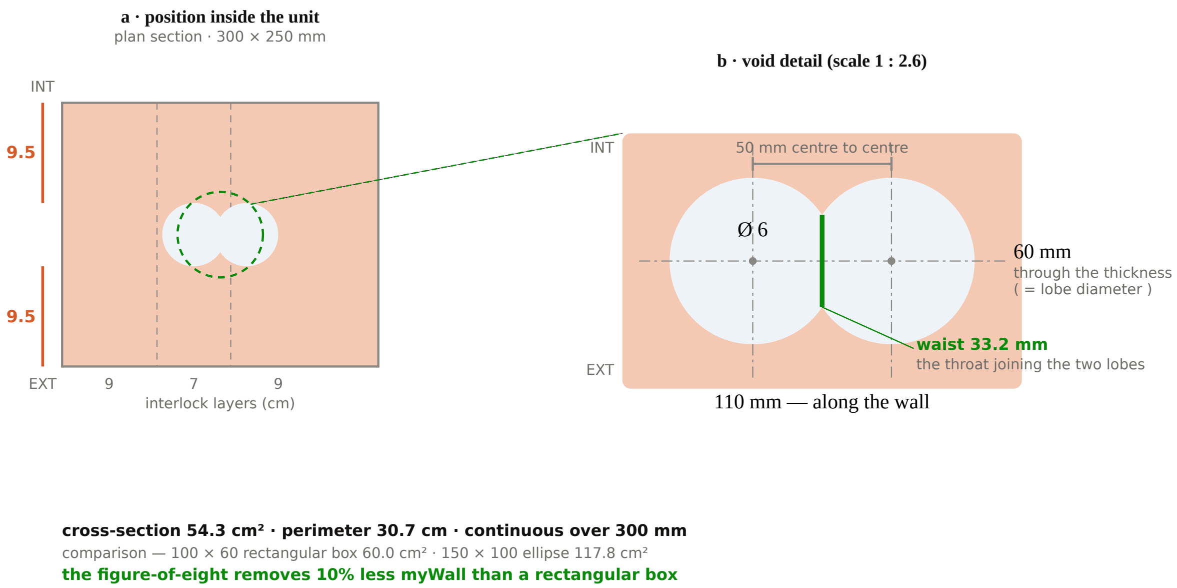

Fig. 20. Geometry of the cavity: two lobes of Ø60 mm with centres 50 mm apart, 110 × 60 mm overall, continuous over 300 mm. A throat of 33.2 mm remains at the waist.

The figure-of-eight does three jobs at once. **First:** a curved shell carries the load in membrane compression, whereas a flat wall works in bending — which is why the shape works in thin material. **Second:** the waist locks the two lobes together and prevents ovalising. **Third:** the waist creates the thickest point of myWall in the section — 217 mm at the waist against 190 mm at the lobes. And the cross-sectional area is 54.3 cm², so it removes **10% less** myWall than a rectangular box.

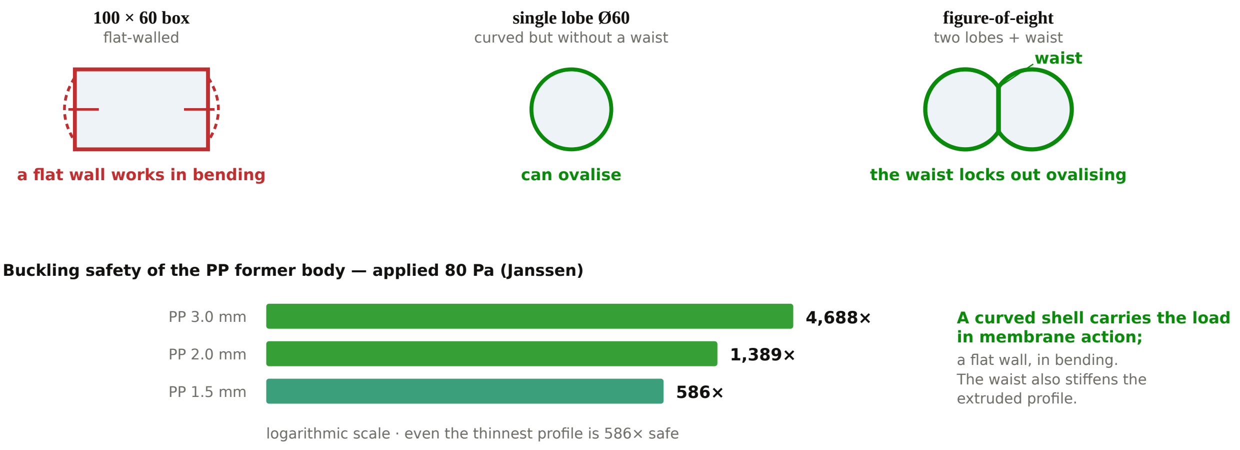

Fig. 21. Comparison of forms and the buckling safety of the PP profile. Even a 1.5 mm PP profile is 586 times safe — there is no point in thickening the wall.

The former: temporary, plastic, withdrawn

Süleyman's second decision is sharper: the former is **not permanent**. It is plastic-based and is withdrawn on the first day of drying, while the material is still wet. The material comes out with its own cavity. The consequence is this: **no foreign matter remains in the composite.** The LCA boundaries are clean and the claim "entirely bio-based" is beyond dispute.

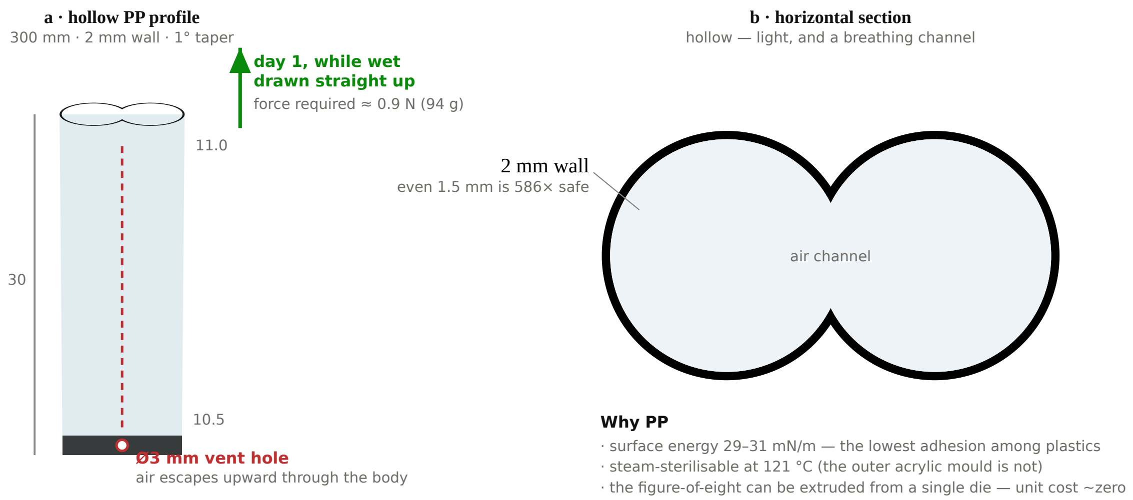

Fig. 22. The hollow PP profile: 300 mm long, 1.5–2 mm wall, with a Ø3 mm vent hole in its base. PP has the lowest surface energy among plastics and can be steam-sterilised at 121 °C.

The material choice is set by a single criterion: it must not stick. Polypropylene, at 29–31 mN/m surface energy, is the lowest among plastics. There is a second gain that was not expected: **PP can be steam-sterilised at 121 °C.** The outer acrylic mould could not be steamed because of its 80 °C limit; the inner former can. What is more, the figure-of-eight profile can be drawn continuously from a single extrusion die and cut at 300 mm — the unit cost is near zero.

The moment of withdrawal — and the one critical detail

There are two separate questions here and their answers turned out very different.

First: when the former is withdrawn, does the cavity stand while wet? **It does.** Wet hemp shiv gains *capillary cohesion*, like wet sand. The cohesion needed to keep a cylindrical cavity from closing is only **14 Pa**; the capillary cohesion of the wet substrate is **39–393 Pa**, depending on pore size. A safety margin of 3 to 28.

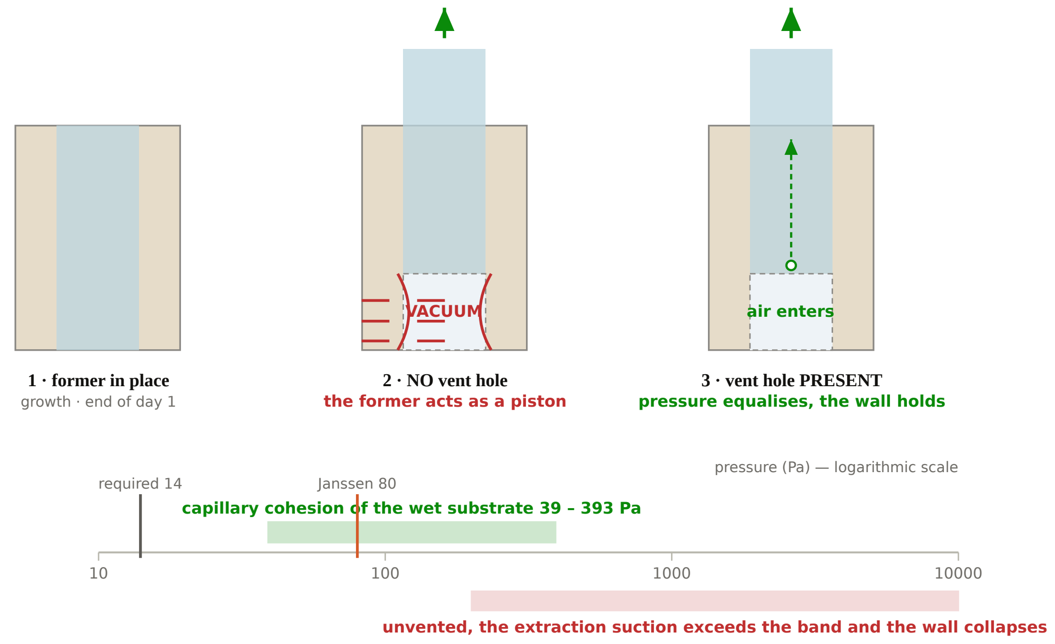

Fig. 23. Three scenes from the moment of withdrawal. Without a vent hole the former acts as a piston and the vacuum forming beneath it pulls the wall inward.

Second: what happens during withdrawal? The real risk is here. As a smooth profile is drawn up out of a 300 mm deep blind hole, if air cannot enter the volume emptying beneath it, a **vacuum** forms there. And it takes no great vacuum to collapse the cavity: **39 Pa** — a suction as small as the lower end of the cohesion band is enough. An ordinary pull by hand produces tens of times that. The friction force itself is negligible: **0.9 N ≈ 94 grams**. So it is not the producer who is strained, it is the wall.

> **The solution is inside the former itself.** The profile is already hollow. Put a cap on its base and a **Ø3 mm vent hole** in that cap: during withdrawal air travels down through the body of the former and fills the emptying volume, the pressure equalises, and no suction acts on the wall. The cost is one hole. Without this detail, first-day withdrawal does not work; with it, friction drops to 94 grams and not even a taper is needed.

An honest note on timing should also be recorded: day one is when adhesion is least, but it is also when the wall is **weakest** — the mycelium has not yet bound. Because PP's adhesion is very low anyway, there is a window out to day four. This is settled not by calculation but only by **withdrawing one specimen each on days 1, 2 and 4**.

The second gain of giving up metal appears here too: a bare myWall surface is **hygroscopic** — it absorbs condensed moisture and later releases it. The condensation problem of Chapter 13 closes by itself. The proposal of a drainage hole in the bottom cap was also withdrawn; there is no longer a cap at all, and both ends of the cavity open onto myWall.

15 · The mould: correcting a wrong model

This chapter is the record of an error, and the reason it stands in the book is the kind of error it was: not arithmetic, but a **wrong assumption about what the material is**.

I had written that the 4 mm acrylic outer mould would bulge 1.59 mm under the pressure of the wet substrate, that creep would take this to 3.18 mm, and that it would consume the 3 mm interlock clearance. Süleyman said, "acrylic does not stretch as much as you think, we have trialled two moulds." He was right.

The error was here: I had modelled the wet substrate as a **liquid**. In a liquid the lateral pressure equals the vertical pressure (K = 1) and grows linearly with depth: p = ρgh = 883 Pa. But hemp shiv is not a liquid; it is a **frictional granular pile**. Water does not make it fluid; it only wets it.

$$K_0 = 1 - \sin\varphi \quad \cdot \quad \varphi \approx 42^\circ \rightarrow K_0 = 0.33$$

The second and larger correction is the **silo (Janssen) effect**: in a narrow container most of the weight of the pile is carried not by the base but by the **walls**, through friction. Pressure does not grow linearly with depth; it saturates exponentially:

$$\sigma_h(z) = (K_0 \gamma R_h/\mu) \cdot (1 - e^{-\mu K_0 z/R_h})$$

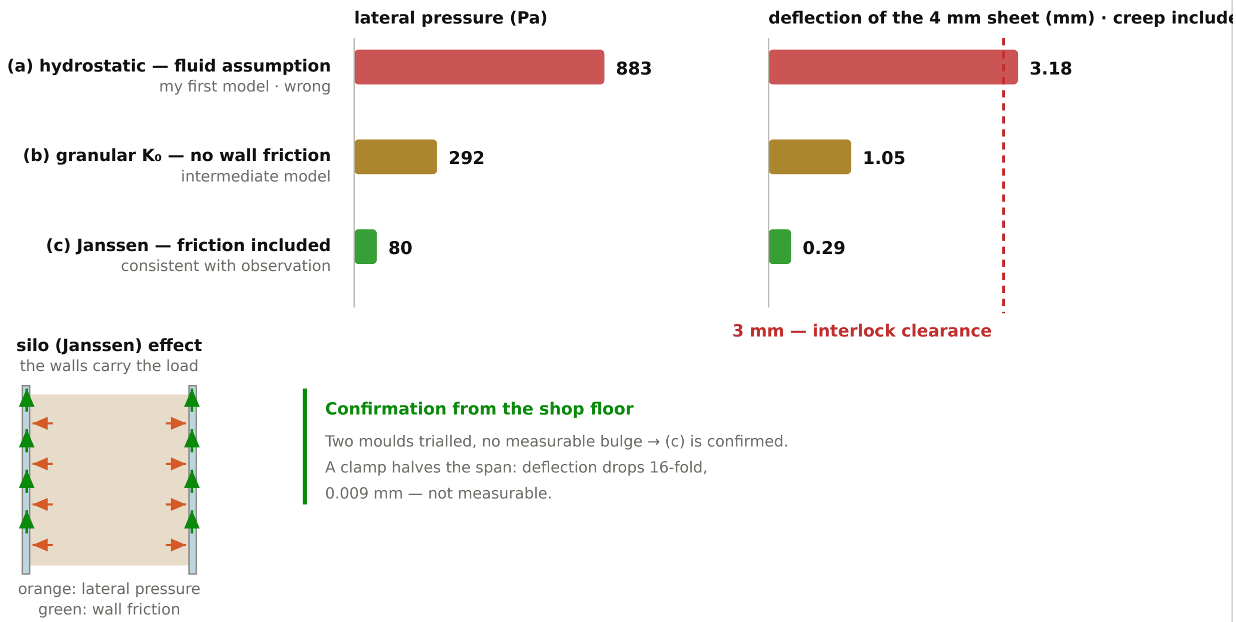

Fig. 24. Three models, three results. The hydrostatic assumption overstates the real pressure elevenfold. The observation from the shop floor — no measurable bulge in two moulds — confirms the Janssen model.

The realistic lateral pressure is **80 Pa, not 883**; the deflection is **0.14 mm**, not 1.59, and 0.29 mm including creep. That is less than a tenth of the 3 mm interlock clearance.

The correction had a second benefit: the same 80 Pa was used one chapter earlier in the buckling calculation of the **inner former** and in the extraction friction. A model verified once solved two separate problems.

> **Method note.** This was not a calculation error but a model error. The numbers were added correctly — into the wrong equation. Such errors are caught only by an observation from the field; there was no inconsistency inside the calculation to betray it. That is why production observation is the auditor of the calculation, and not the other way round.

16 · The dark room: the dose of light

I had written that because acrylic is transparent it admits light, that *Ganoderma lucidum* would move toward forming primordia when it sees light, and that an opaque sleeve should be fitted over the mould. I withdraw that recommendation.

The growth room is permanently dark; the lamp is switched on only for inspections that do not exceed five minutes a day. The dose calculation: a typical working illuminance of 300 lux, five minutes a day → **25 lx·h/day**. Fruiting-induction protocols for *G. lucidum*, by contrast, use around 500 lux for 8–12 hours a day → **5000 lx·h/day**.

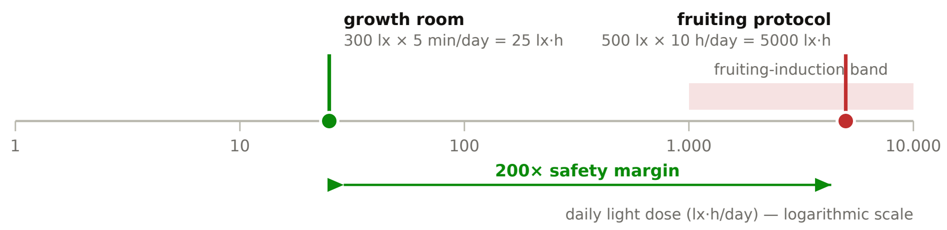

Fig. 25. Daily light dose on a logarithmic scale. The inspection lamp is two hundred times below the band that triggers fruiting.

There is a factor of **200** between them. That is not a safety margin but a different order of magnitude. And a second barrier is at work: CO_2 accumulates inside the mould, and high CO_2 suppresses primordium formation independently of light.

One fine adjustment remains, and it costs nothing. Light perception in fungi works through **blue-light photoreceptors**; red and amber wavelengths do not trigger that system. Choosing an **amber/red (>600 nm)** inspection lamp instead of a white LED reduces even the remaining margin to zero.

17 · Ventilation: the last piece of 25GH60

When the envelope was finished, one large item remained and it gave an uncomfortable number: **ventilation is 48% of the villa's total heat loss.** After all this work the wall is only 21%. So there is almost no return in improving the wall further; all the remaining gain is in ventilation.

Süleyman had rejected filters from the outset — his reasons were the maintenance burden and dependence on filter replacement, and on a hundred-year scale that is a defensible reason. But **heat recovery does not mean a filter.** A **counter-flow plate heat exchanger** is possible without filters, transferring sensible heat only, not enthalpy. Süleyman found this acceptable, and the last piece of 25GH60 fell into place.

Why counter-flow specifically

Here the device type is not a preference but a parameter that **determines the target itself**. A cross-flow exchanger returns 50–65% of the sensible heat; a counter-flow exchanger 85–92%. The difference decides directly whether the "60" in 25GH60 holds.

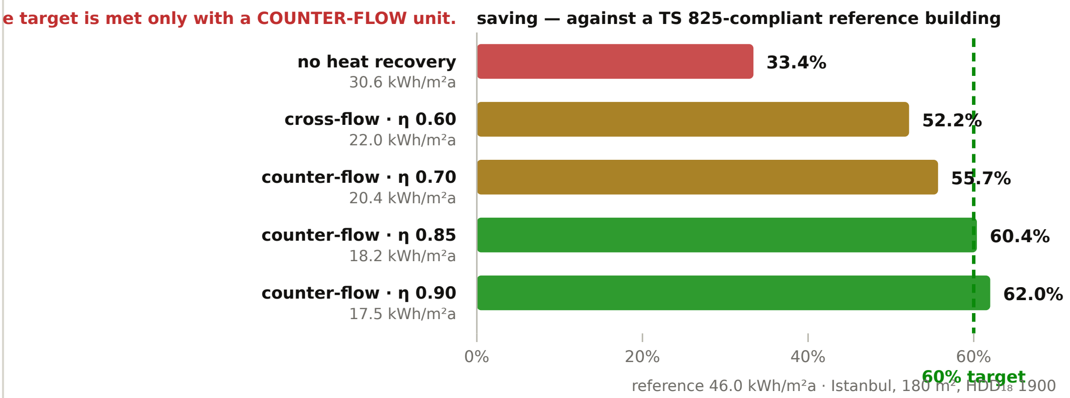

Fig. 26. Saving against a TS 825-compliant reference building. The 60% target is met only with a counter-flow unit (η ≥ 0.85); a cross-flow unit falls short.

The reference is the same villa built to the TS 825:2024 limits for Istanbul zone 3: wall 0.40 · roof 0.20 · window 1.80, no ground coupling, no heat recovery → **46.0 kWh/m²a**. The 25GH60 envelope alone brings that to 30.6: **33% saving.** Not enough. With a counter-flow heat exchanger added, 18.2 kWh/m²a and **60.4% saving**.

> **This is where the standard closes.** Until this work, the 60 in the name "25GH60" was a target. It is now a calculated result: **60.4%**. But on one condition — the heat exchanger must be **counter-flow**. A cross-flow unit stops at 52% and the name of the standard becomes a lie. That is why the device type must be written into the definition of 25GH60; not as a recommendation but as a **requirement**.

What to buy on the market

There are two routes and both satisfy the "no filter" requirement.

ROUTE	WHAT IS BOUGHT	FILTER STATUS
A · Bare exchanger core	Recutech (REK+/REC+ aluminium, RSF+/RSP+ plastic counter-flow), Heatex, Klingenburg, Recair, Eri Corporation, CORE — all sell the core as an OEM component	You build the casing yourself and fit only a **washable coarse screen**. No consumable filter.
B · Off-the-shelf residential unit	Zehnder ComfoAir Flex 350 (250 m^3/h @ 200 Pa — exactly the villa's requirement), Brink, Vallox, Systemair; in Türkiye the ENEKO EVENT residential series and its equivalents	Standard filter is **ISO Coarse (G4)**, the fine F7 is **optional**. You never fit the F7 and convert the G4 to a washable screen.

There is a point where I must be honest. A counter-flow core run with no filter at all — not even a coarse screen — will clog over the years: the channels between the plates are narrow, dust bridges across them, and efficiency falls. Your reason was dependence on consumables, and that reason is **fully protected by a washable metal or coarse screen**: there is nothing to replace, it is rinsed twice a year. No consumable filter, but we do not leave the core unprotected either. That is the recommendation.

The villa's air flow: $180\ m^2 \times 2.7\ m \times 0.5\ h^{-1} \approx$ **243 m^3/h**. The 250 m^3/h that the Zehnder ComfoAir Flex 350 delivers at 200 Pa external pressure sits exactly on that requirement — so no larger size is needed. If the core route is chosen, a counter-flow core sized for the same flow plus two EC fans and a washable screen is sufficient.

18 · 25GH60 completed

This book began with a wall, turned into a house, and now closes with a standard. All the parts have fallen into place and the formula has taken its final form:

25GH60 = PV + AWHP + BP + myWall + HRV

In order: **photovoltaic panels** on the roof, an **air-to-water heat pump** outside, a **Biopex panel** at the ceiling, **250 mm of myWall** in the envelope, and **counter-flow heat recovery** in the ventilation. The fifth was added in this work and proved mandatory — without it the "60" does not hold.

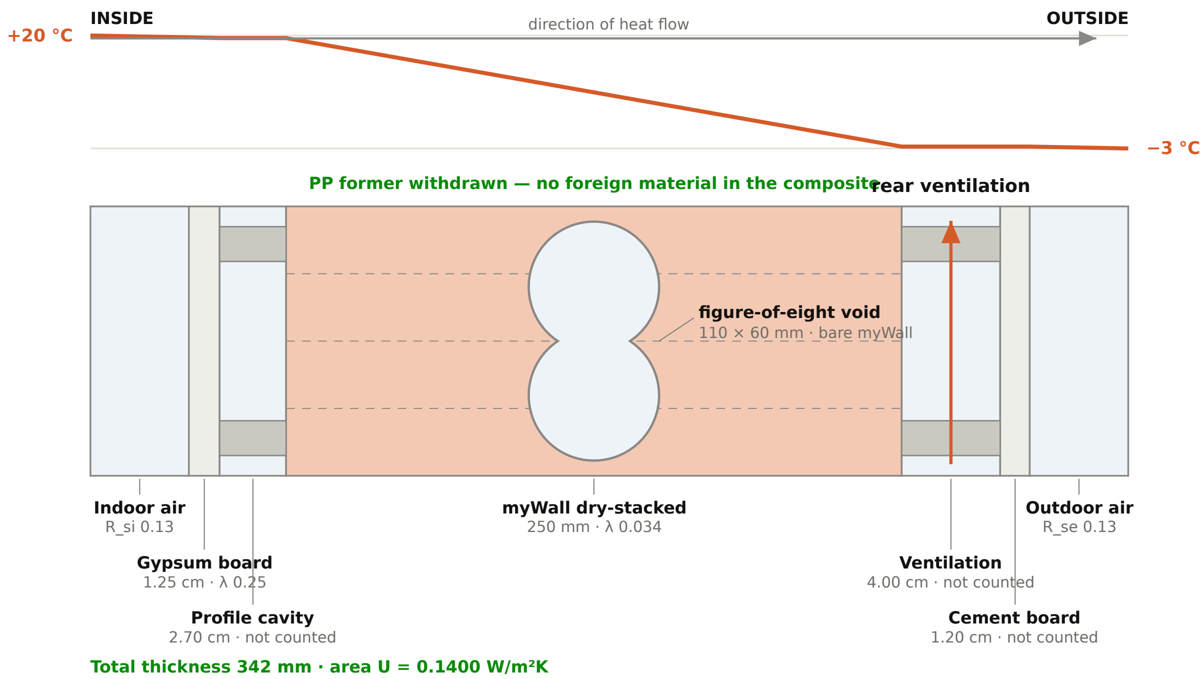

Fig. 27. Section through the wall from inside to outside, in its final form. A figure-of-eight cavity with bare myWall surfaces; the PP former withdrawn, no foreign matter in the composite.

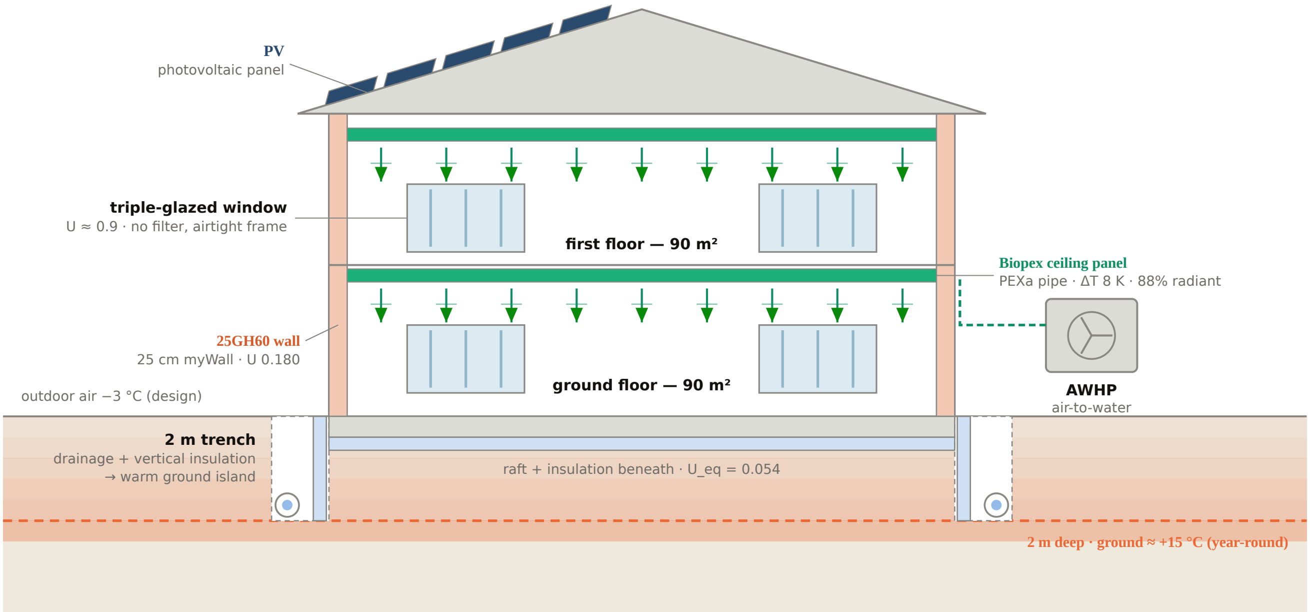

Fig. 28. The Bioiklim villa: PV on the roof, AWHP outside, Biopex panels at the ceilings of both storeys, the 25GH60 wall in the envelope, and a 2 m drainage and insulation trench on all four sides.

Definition page of the standard

ITEM	25GH60 REQUIREMENT	IN THIS VILLA	STATUS
External wall U	≤ 0.20	**0.180**	met
Wall thickness	250 mm myWall	**250 mm**	by definition
Roof U	≤ 0.18	**0.18**	met
Window U	≤ 1.3	**0.90**	triple glazing
Ground floor	ground-coupled	**0.054**	2 m perimeter trench
Heat recovery	counter-flow, η ≥ 0.85	**0.85**	requirement
Airtightness n_{50}	≤ 1.0–1.5	—	detail needed
Saving	**60%**	**60.4%**	**holds**

Passive House asks for 90% saving and obtains it with 300–400 mm of insulation, $n_{50} \leq 0.6$ and mandatory filtered ventilation. 25GH60 **asks for 60%** — and obtains it with a 250 mm bio-based unit, relaxed airtightness and an unfiltered heat exchanger. The difference between them is not a deficiency but a **choice**: the price of the last 30% is not worth paying on the material and maintenance side.

> **What remains.** The standard is closed, but the measurements are not. The λ of the myWall unit, its fire class, compressive strength and water absorption are still to be measured at AUTH; the drying rate in a figure-of-eight specimen and the timing of former withdrawal are to be trialled on site; the air barrier detail for n_{50} is to be drawn. These are the **verification** of the standard — not its definition. The definition is finished.

> *Six centimetres inside a masonry unit closed, in the end, an entire standard.*

Appendix · Number book

QUANTITY	VALUE	SOURCE
myWall wall, clear-field U	0.131 W/m²K	calculation · EN ISO 6946
U in front of column/beam (100 mm mineral wool)	0.311 W/m²K	calculation
Area-weighted mean U	0.173 W/m²K	calculation · frame fraction 23%
Dry-stack gain (against mortared reference)	53%	calculation · λ 0.034
Projection equilibrium limit	125 mm	calculation · 100 mm selected
Total section thickness	275 mm	gypsum board + myWall + cement board
Wall mass	68 kg/m²	calculation
λ_Biopex / λ_XPS	1.018	2023 test, corrected data
λ_Biopex (assuming λ_XPS = 0.033)	0.0336 W/m·K	derivation
AWHP COP · 35 °C supply	4.95	calculation · source 7 °C, η 0.45
AWHP COP · 65 °C supply	2.62	calculation
Ceiling radiant share	88.6%	measurement · Energies 2025;18(7):1591
Floor radiant share	50%	EN 1264-2 · ΔT 9 K
Ground, 2 m, winter min (undisturbed)	11 °C	calculation · damping depth 2.45 m
Ground beneath the house (insulation + drainage)	≈ 15 °C	Süleyman · protected heat island
Ground-floor equivalent U (ground-coupled)	0.054 W/m²K	calculation
Total H	102.9 W/K	calculation · 100 m² reference dwelling
Annual heating demand	**32.9 kWh/m²a**	calculation · HDD_{18} 1900, gains 30%

QUANTITY	VALUE	SOURCE
Cost of going without HRV	+10.6 kWh/m^2a	calculation
Part two — the sheet-metal box and the updated section		
λ_XPS declared band (İzocam Foamboard)	0.030 – 0.035	manufacturer catalogue, 10 °C
Derived λ_Biopex band	0.0305 – 0.0366	1.018 × declared band
60 mm cavity R · ε 0.90	0.183 m^2K/W	EN ISO 6946 Annex D
60 mm cavity R · ε 0.40 (dulled galvanised)	0.394 m^2K/W	EN ISO 6946 Annex D
Radiant share in an ordinary cavity	77%	calculation · h_r/(h_a+h_r)
Bridge loss in a closed sheet-metal box	81%	calculation · 0.5 mm steel, λ 50
Area U · 100 × 60 box, bridge cut	0.140 W/m^2K	calculation
Area-weighted mean U (current)	0.180 W/m^2K	calculation · 25GH60 allowance 0.020
Outer plate temperature of the cavity (−3 °C)	7.7 °C	calculation · dew point 9.3 °C at 50% RH
Drainage hole opening area (6 × Ø1 mm)	16 mm^2/m	EN ISO 6946 threshold 500 mm^2/m
Mould lateral pressure · hydrostatic (wrong)	883 Pa	abandoned
Mould lateral pressure · Janssen (correct)	80 Pa	K_0 0.33 · μ 0.30 · R_h 75 mm
Deflection of 4 mm acrylic (creep included)	0.29 mm	calculation · interlock clearance 3 mm
Growth-room light dose	25 lx·h/day	300 lx × 5 min
Fruiting-induction dose	≈ 5000 lx·h/day	literature · 200× margin
Villa · without heat recovery	30.6 kWh/m^2a	180 m^2 · H 172.8 W/K

QUANTITY	VALUE	SOURCE
Part three — the figure-of-eight, the PP former, closing the standard		
Figure-of-eight cavity · cross-sectional area	54.3 cm²	two lobes Ø60, centres 50 mm, 110 × 60 mm overall
Waist width	33.2 mm	217 mm of myWall at the waist (190 at the lobes)
Shell bridge allowance · PP	none	former withdrawn · it was 82% with a steel box
Area U · figure-of-eight, bare myWall	0.140 W/m²K	calculation · +7.3%
Cohesion required to hold the cavity open	14 Pa	closure limit of a cylindrical cavity
Capillary cohesion of the wet substrate	39–393 Pa	pore radius 0.2–1.0 mm
Former extraction friction	0.9 N	PP · µ 0.25 · ~94 grams
Vacuum threshold that collapses the cavity	39 Pa	→ Ø3 mm vent hole mandatory
PP 1.5 mm profile · buckling safety	586×	applied 80 Pa
PP surface energy	29–31 mN/m	lowest adhesion among plastics
Reference building (TS 825, Istanbul)	46.0 kWh/m²a	H 259.3 W/K · no heat recovery
Villa · counter-flow HRV η 0.85	18.2 kWh/m²a	H 102.6 W/K
25GH60 saving	**60.4%**	**target met** · with cross-flow it stops at 52%
Villa ventilation flow	243 m³/h	180 m² × 2.7 m × 0.5 h⁻¹

Appendix · Sources

1. Energies 2025;18(7):1591 — Experimental Study on Heat Transfer Coefficients in an Office Room with a Radiant Ceiling During Low Heating Loads.
2. EN 1264-2 — Water based surface embedded heating systems, characteristic curve.
3. EN ISO 6946 — Thermal resistance and thermal transmittance of building components, combined method.

4. EN 12667 / EN 12664 — Guarded hot plate and heat flow meter methods.
5. ISO 7730 — Thermal comfort; radiant asymmetry limits.
6. TS 825:2024 — Thermal insulation requirements for buildings; Istanbul zone 3.
7. Passipedia — Passive House definition and criteria.
8. Insulating biodegradable composites from lignocellulosic biomass and fungal mycelium (λ–density data for mycelium composites).
9. Development and Characterization of Mycelium-Based Composite Using Agro-Industrial Waste and *Ganoderma lucidum* as Insulating Material, J. Fungi 2025;11(6):460.
.0. Bioiklim current brochure (PEXa Boru / BioTR, 12 pages) — system definition, Q&E Slab, BioPEX, SB House measurement of August 2024.
.1. EN ISO 6946 Annex D — thermal resistance of unventilated air cavities; emissivity and h_r.
.2. Janssen, H.A. (1895) — Versuche über Getreidedruck in Silozellen; silo wall friction model.
.3. İzocam Foamboard product catalogue — declared thermal conductivity values for XPS (10 °C).
.4. *Ganoderma lucidum* fruiting induction — literature on photomorphogenesis and blue-light photoreceptors.
.5. Recutech s.r.o. — counter-flow air-to-air exchanger cores (REK+/REC+ aluminium, RSF+/RSP+/REP+ plastic); OEM component.
.6. Heatex AB · Klingenburg GmbH — counter-flow plate exchanger cores.
.7. Zehnder ComfoAir Flex 350 — 250 m^3/h @ 200 Pa; standard ISO Coarse (G4), optional ePM1 (F7).
.8. ENEKO EVENT — residential heat recovery unit series (Türkiye).
.9. RILEM Spring Convention & Conference 2027 / WAMACO27 — call, template and calendar.

This book is compiled from the record of the 25GH60 working sessions. The calculations were made by the ITP and are given together with their assumptions; the only values presented as measurement results are those whose source is stated.