



Heat-loss worked examples 2026

Three fictional but realistic facilities, three leak levels: method, parameters, results, payback and uncertainty. From a thermal survey to a HUF-quantified action list, step by step.

Issued: 10 October 2026 Energy-price basis: 9 October 2026 Calculation engine v1.0.0

Example – illustration, not a real client. The facilities are fictional; the figures are model-based estimates, not guarantees. Not an accredited test, not an energy performance certificate, not an energy audit, not an electrical-safety inspection.

In brief

- Depending on the example facility, the three defect levels amount to **1.5–1.8 %** (small, localised), **7.3–9.3 %** (medium) and **19.8–26.6 %** (large, widespread) of the heating bill.
- Fixing the quick-payback (A, up to 24 months) items pays back in **7–12 months** at medium level and **10–13 months** at large level (fix cost only, flat today's gas price).
- For small, localised defects the survey fee **does not pay back** from the saving within a reasonable time (40–104 months including the fixes); the numbers show this honestly.
- Uncertainty is large: typically $\pm 30\text{--}50\%$ per item; the 10th–90th percentile of the corner-case combinations lies between $-37 \dots -30\%$ and $+62 \dots +75\%$ relative to the central value.

Facility	Level	Items	W/K	Cost (HUF/season)	Share of bill	Fix (HUF)	Payback (mo.)
Warehouse / logistics hall	Small (localised)	3	47	120,000 (93,000–160,000)	1.5 %	520,000 (260,000–1,000,000)	54
	Medium	8	250	620,000 (490,000–880,000)	7.6 %	2,700,000 (1,400,000–5,200,000)	52
	Large, widespread	13	1,100	2,700,000 (2,200,000–3,900,000)	26.6 %	8,900,000 (4,700,000–17,000,000)	39
Supermarket / retail unit	Small (localised)	2	36	120,000 (94,000–170,000)	1.6 %	270,000 (140,000–500,000)	27
	Medium	6	230	760,000 (600,000–1,100,000)	9.3 %	1,900,000 (1,000,000–3,500,000)	29
	Large, widespread	7	720	2,400,000 (1,900,000–3,300,000)	24.2 %	6,300,000 (3,400,000–12,000,000)	32
Workshop / small production hall	Small (localised)	2	39	99,000 (79,000–140,000)	1.8 %	140,000 (75,000–260,000)	17
	Medium	5	160	420,000 (330,000–590,000)	7.3 %	1,300,000 (720,000–2,500,000)	39
	Large, widespread	6	520	1,300,000 (1,000,000–1,900,000)	19.8 %	4,000,000 (2,200,000–7,500,000)	36

Ranges follow the low–high gas price; rounded to 2 significant digits. “Fix” and “payback” use the indicative, quote-based fix cost and exclude the survey fee (see Section 8).

1. What we claim and what we do not

A thermal camera measures **surface temperature**. It shows *where* a fault is (wet or missing insulation, thermal bridge, gap, leaking door, bad connection) but does not read the watts lost. A loss in forints is therefore a **model-based estimate**: computed from the thermogram and on-site dimensions (m², m, gap width in mm) with standard physics and sourced parameters.

What a thermogram gives us well: location, extent (m², m), relative severity, approximate gap width. **What it cannot give precisely:** the real air flow (wind and stack pressure change hour by hour), the real conductivity of wet insulation, the ψ -value of a thermal bridge, the true price of a repair (quotes needed), actual building use.

Our figures are therefore **estimates, not guarantees**. Savings occur only if the fix is carried out and works; the survey itself saves no energy. This document is not an accredited test, not an energy performance certificate, not an energy audit and not an electrical-safety inspection.

2. Calculation chain

Every finding is turned into a **conductance H [W/K]**, then into seasonal energy, gas and money.

Finding	Formula	Inputs
Damaged, wet or missing insulation	$H = (U_{\text{defect}} - U_{\text{intact}}) \cdot A$	A [m ²] from the thermogram; $U_{\text{defect}} = 2.5 \text{ W/m}^2\text{K}$ (1.5–3.5); $U_{\text{intact}} = 0.35$ (older panel)
Linear thermal bridge	$H = (\psi_{\text{found}} - \psi_{\text{designed}}) \cdot L$	L [m]; $\psi = 0.35 \text{ W/mK}$ (0.10–0.80); the designed 0.10 is already in the baseline
Air gap (door, dock, panel joint, ridge, skylight)	$H = 0.335 \cdot V$	V [m ³ /h] from the leakage network; length [m] × gap width [mm]
Open-door exchange (entrance, air curtain)	$H = 0.335 \cdot Q_{\text{open}} \cdot \text{open fraction} \cdot \Delta(\text{residual transfer})$	A, height, open fraction

0.335 Wh/(m³K) is $\rho \cdot c_p$ of air ($1.2 \text{ kg/m}^3 \times 1.005 \text{ kJ/kgK} / 3.6$).

2.1 Air gaps: pressure, orifice equation, series connection

- Pressure.** Stack effect: $\Delta p_s = g \cdot h \cdot \rho_0 T_0 \cdot (1/T_{\text{out}} - 1/T_{\text{in}})$, $h = 80\%$ of the hall height, $T_{\text{out}} = 4.4^\circ\text{C}$ (heating-season mean on days below 12°C). Wind: $\Delta p_w = \frac{1}{2} \rho v^2 \Delta C_p$, modest: $v = 2.5 \text{ m/s}$, $\Delta C_p = 0.4$. Combined $\Delta p = \sqrt{(\Delta p_s^2 + \Delta p_w^2)}$: about 3.9 Pa in the warehouse. We deliberately take the lower plausible pressure.
- Orifice equation.** $V = C_d \cdot A \cdot \sqrt{(2\Delta p/\rho)} \cdot 3600$, $C_d = 0.6$. Illustration: 1 m of gap, 1 mm wide, at 4 Pa = 5.58 m³/h = 1.87 W/K.
- Series connection.** Air that enters must also leave, so the flows of independent leaks are not added (the same air would be counted twice). The hall is a **two-level leakage network**: low level (doors, docks, lower joints) and high level (ridge, skylights, roof joints); wall joints split 50/50. The series area is $A_{\text{ser}} = 1/\sqrt{(1/A_{\text{low}}^2 + 1/A_{\text{high}}^2)}$. **A defect is charged only with the increase of the flow it causes** (diminishing returns included); the split between defects uses leave-one-out differences scaled so they add up exactly to the joint increase.
- Activity.** A dock gap only leaks while a trailer is docked with the door open (25 % of heated hours, assumption); a sectional-door gap only while the door is closed (97 %). The normal leakage of a door (EN 12426 class 1) is subtracted from the gap found.

2.2 Seasonal energy, gas, money

$$Q [\text{kWh}] = H [\text{W/K}] \cdot \text{HDD} [\text{K} \cdot \text{day}] \cdot 24 \cdot f / 1000$$

- HDD matches the facility base (indoor / balance) temperature (Nyíregyháza, ERA5, 11 seasons): warehouse 16/12 °C, supermarket 20/12 °C (free heat from refrigeration, lighting and people), workshop 18/12 °C (interpolated). f is the heated time fraction (night / weekend set-back, assumption).
- Fuel:** invoice-kWh = $Q / \eta_{\text{NCV}} \cdot 1.1076$. Hungarian gas is billed in MJ on a net-calorific basis: invoice-kWh is 10.8 % more energy than physical NCV-kWh. **Gas:** m³ = invoice-kWh / 10.52.
- Cost:** invoice-kWh × **marginal, net, all-in** gas price (the fixed capacity fee cannot be saved and is excluded): low / central / high 32.1 / 40.4 / 56.9 HUF per invoice-kWh, 9 October 2026 (TTF + MVM Basic fees; the contract premium is an assumption).
- 5 years:** (a) flat at today's central price; (b) forward curve (40.4 / 35.8 / 27.1 / 27.1 / 27.1 HUF/kWh; futures are not forecasts, holding after year 3 is an assumption). The two are the upper and lower bounds.

- **Fix cost:** per item low/central/high, indicative and quote-based (table in Section 3).
- **Simple payback** (months) = fix [+ survey] / seasonal saving · 12. **5-year net** = 5-year savings – fix cost. **Priority:** A ≤ 24 months, B ≤ 60 months, C otherwise.
- **CO₂:** physical NCV energy × 0.202 kg/kWh (IPCC 2006 default).

2.3 Baseline (fault-free) heating demand and “% of the bill”

To express a leak as a share of the bill we compute the fault-free baseline of every facility: envelope (U·A), thermal-bridge supplement (8 %), baseline infiltration, ventilation (with heat recovery), door traffic; same HDD, efficiency and price. “% of the bill” = defect cost / (baseline + defect cost), central case. Sanity check: small 1–3 %, medium 5–12 %, large 15–30 %. The inputs were not tuned towards the target; if they fell outside, the inputs would have to be revisited rather than forcing the result. The fault-free baseline is 56–101 kWh/m²·a of heat.

3. Parameters and sources

The full list with sources and status flags: calc/params.mjs and calc/out/results.json. The main ones:

Parameter	Value	Status	Note
Gas price (marginal, net)	32.1 / 40.4 / 56.9 HUF/invoice-kWh, 9 October 2026	DERIVED	TTF + MVM Basic fees; premium is an assumption; the invoice price rules
Forward curve, 5 seasons	40.4 / 35.8 / 27.1 / 27.1 / 27.1 HUF/invoice-kWh	DERIVED	futures are not forecasts; held flat after year 3
Gas: invoice-kWh per m³	10.52 invoice-kWh/m ³ (34.2 MJ/m ³ ; 33–35)	DERIVED	34.2 MJ/m ³ unverified; the invoice value rules
NCV → invoice-kWh	× 1.1076	DERIVED	3.6 / 3.2504
HDD (warehouse / supermarket / workshop)	2,161 / 2,904 / 2,533 Kd (1,788–2,546, ...)	DERIVED	ERA5, Nyíregyháza, 11 seasons; balance temperature is an assumption
Efficiency (radiant tube / warm air / condensing)	0.80 (0.72–0.88) / 0.85 / 0.95	ASSUMPTION	on net calorific value; assumption
Heated time fraction (warehouse / supermarket / workshop)	0.85 / 1.00 / 0.80	ASSUMPTION	night / weekend set-back
U of defective insulation	2.5 W/m ² K (1.5–3.5); U 0.35	SOURCED	Ljubljana district-heating study / assumption
Thermal-bridge ψ	ψ 0.35 W/mK (0.10–0.80); panel joint 0.15; as designed 0.10	ASSUMPTION	analogy (Phius, IEA-EBC); EN ISO 14683 Annex C not accessible
Air-gap parameters	C _d 0.6; wind 2.5 m/s (1.5–4) × ΔC _p 0.4; stack distance 0.8·H	ASSUMPTION	ASHRAE Fundamentals not accessible; modest assumptions
Baseline leakage q50 (warehouse / retail / workshop)	6 / 3 / 5 m ³ /(h·m ²)	ASSUMPTION	blower-door style value; older clad steel shed 6
Dock active fraction / door closed fraction	0.25 / 0.97; EN 12426 class 1: 24 m ³ /(h·m ²) @ 50 Pa	CALC-LOCAL	manufacturer / EN 12426 table not accessible
Wetted pipe loss	200 W/m (100–380)	SOURCED	Ljubljana district-heating study: 200–380 W/m; low value is an assumption
District-heat fee	9,965 HUF/GJ (5,500–12,959)	UNVERIFIED	Budapest non-residential tariff as a proxy; local tariff not found
Make-up water	1,500 HUF/m ³ (800–2,500)	ASSUMPTION	
CO₂ (natural gas, NCV)	0.202 kg/kWh	STANDARD	IPCC 2006 default; not fetched in the research

Status: SOURCED = taken from a source; DERIVED = derived from a source; STANDARD = standard / physical constant; ASSUMPTION = assumption; UNVERIFIED = not verified; CALC-LOCAL = value set locally for the calculation.

Fix costs (indicative, quote-based)

Item	low (HUF)	central	high
Dock seal pad / curtain repair, per dock	150,000	300,000	600,000

Item	low (HUF)	central	high
New complete dock seal / shelter	600,000	1,000,000	1,800,000
Dock leveler pit seal	80,000	150,000	300,000
Sectional door seal set (bottom, sides, top)	40,000	90,000	180,000
Door adjustment / service	25,000	45,000	80,000
Brush seal replacement per door	15,000	30,000	60,000
Panel joint resealing per m (incl. lift access)	2,500	4,500	8,000
Insulation patch / PU foam per m2 (open, dry, fill, close)	12,000	22,000	40,000
Roof skylight seal, each	60,000	120,000	250,000
Pipe insulation repair above ground per m	3,000	6,000	12,000
Buried pipe: locate, excavate, repair, reinstate (spot)	1,500,000	3,000,000	6,000,000
Electrician hourly rate (industrial)	9,000	13,000	18,000
Cabinet terminal re-torque + checks	25,000	45,000	90,000
Replace terminal / contactor	60,000	120,000	250,000
Thermal-bridge remediation (insulation strip + cladding) per m	8,000	15,000	30,000
Air curtain replacement / overhaul	250,000	450,000	800,000
Roof penetration sealing, each	25,000	50,000	100,000

No Hungarian price list was retrievable; the estimates are built from the national minimum overhead labour rate and typical materials (ASSUMPTION). A quote is always required.

4. The three example facilities

The facilities are fictional but realistic. The fault-free baseline is computed with the same method as the defects; its cost is the denominator of “% of the bill”.

Facility	m ²	Indoor / balance temp.; HDD	H W/K	Baseline heat (kWh/season)	Baseline cost (HUF/season)	Our survey price (net)
Warehouse / logistics hall 60 x 40 m, 9 m high, sandwich-panel walls and roof (older, U ~ 0.35), 16 C, gas radiant-tube heating, 4 dock doors + 2 sectional doors, Nyiregyhaza area.	2,400	16 / 12 °C 2,161 Kd	3,057	130,000 56 kWh/m ²	7,500,000 (6,000,000– 11,000,000)	3D package 489,000 HUF pioneer: 275,000 HUF
Supermarket / retail unit 50 x 36 m (1,500 m2 sales + 300 m2 back room), 5 m high, 20 C, condensing gas boiler + AHU with heat recovery, vestibule entrance with air curtain, 1 rear dock door. Refrigeration waste heat enters only through the lower 12 C balance temperature.	1,800	20 / 12 °C 2,904 Kd	2,252	160,000 87 kWh/m ²	7,400,000 (5,900,000– 10,000,000)	3D package 423,000 HUF pioneer: 275,000 HUF
Workshop / small production hall 40 x 25 m, 7 m high, 18 C, gas warm-air heaters, 1 roller door (4.0 x 4.5 m) + 1 sectional door (3.5 x 3.5 m), process extraction.	1,000	18 / 12 °C 2,533 Kd	2,086	100,000 101 kWh/m ²	5,300,000 (4,200,000– 7,500,000)	Quick diagnostic 190,000 HUF pioneer: 135,000 HUF

5. Results per facility

Each facility appears at three levels: small (localised), medium and large (widespread). Mean power refers to the average outdoor temperature of the heating season. Five-year values: flat today's price / forward curve.

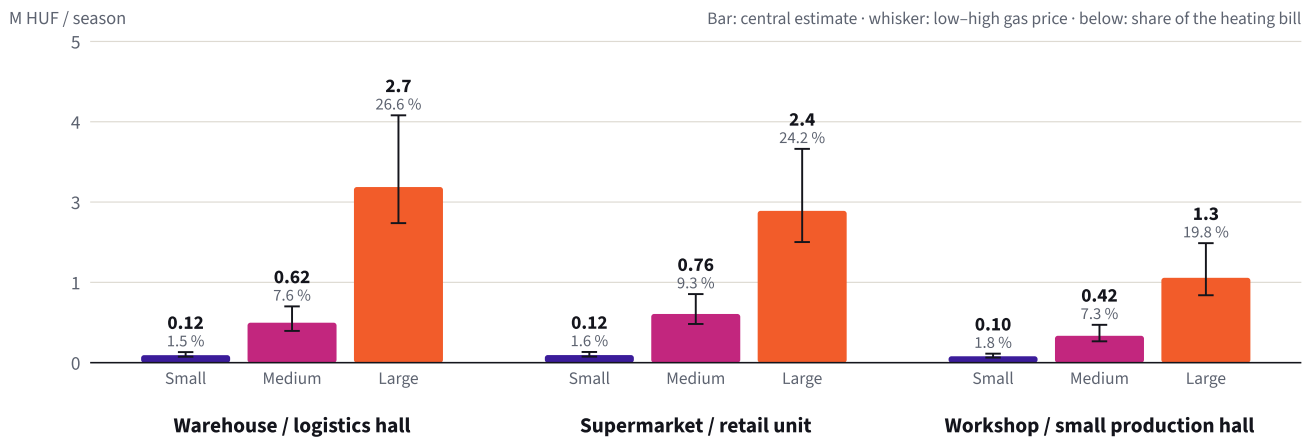


Figure 1. Seasonal cost of the defects, central estimate, at 9 October 2026 gas prices; whisker = low–high gas price; below the bar: share of the heating bill.

5.1. Warehouse / logistics hall

EXAMPLE / illustrative: a fictional but realistic facility. Not customer data, not a promise. 60 x 40 m, 9 m high, sandwich-panel walls and roof (older, $U \sim 0.35$), 16 C, gas radiant-tube heating, 4 dock doors + 2 sectional doors, Nyiregyhaza area.

Fault-free baseline: $H = 3,057 \text{ W/K}$; 130,000 kWh heat per season (56 kWh/m^2); 18,000 m^3 gas; 7,500,000 (6,000,000–11,000,000) HUF/season. Gas radiant tubes, $\eta = 0.80$.

Level	Items	W/K	Mean W	Heat (kWh)	Gas (m^3)	Cost (HUF/season) central (range)	Share of bill
Small (localised)	3	47	550	2,100	270	120,000 (93,000–160,000)	1.5 %
Medium	8	250	2,900	11,000	1,500	620,000 (490,000–880,000)	7.6 %
Large, widespread	13	1,100	13,000	49,000	6,400	2,700,000 (2,200,000–3,900,000)	26.6 %

Level	Fix (HUF)	Payback, fix only (mo.), range	5-year savings: flat / forward	5-year net, fix only: flat / forward	CO ₂ kg/season
Small (localised)	520,000 (260,000–1,000,000)	54 (19–187)	580,000 / 450,000	61,000 / –67,000	530
Medium	2,700,000 (1,400,000–5,200,000)	52 (19–178)	3,100,000 / 2,400,000	430,000 / –260,000	2,800
Large, widespread	8,900,000 (4,700,000–17,000,000)	39 (15–131)	14,000,000 / 11,000,000	4,800,000 / 1,800,000	12,300

Warehouse / logistics hall – Small (localised)

One dock-seal side pad torn, one sectional-door bottom seal missing, 6 m² wet roof insulation.

Finding	W/K	HUF/season	Fix (HUF)	Payback (mo.)	Prio.
Dock 3: side pad torn (2.8 m x 40 mm)	14	35,000	300,000	103	C
Sectional door 1: bottom seal missing (4.0 m x 15 mm)	20	50,000	90,000	22	A
Wet roof insulation near a drain (6 m ²)	13	32,000	130,000	50	B

Warehouse / logistics hall – Medium

3 dock seals faulty, 2 sectional doors with worn seals, 35 m of failed wall-panel joint, 35 m² wet roof insulation, 45 m eaves / slab-edge thermal-bridge run.

Finding	W/K	HUF/season	Fix (HUF)	Payback (mo.)	Prio.
Dock 1: both side pads compressed (5.6 m x 30 mm)	7	16,000	300,000	223	C
Dock 2: both side pads compressed (5.6 m x 30 mm)	7	16,000	300,000	223	C
Dock 3: head curtain missing (2.6 m x 80 mm)	9	21,000	300,000	171	C
Sectional door 1: worn perimeter seals (17 m x 8 mm)	18	43,000	90,000	25	B
Sectional door 2: worn perimeter seals (17 m x 8 mm)	18	43,000	90,000	25	B
Wall-panel joints open (35 m x 2 mm)	110	270,000	160,000	7	A
Wet roof insulation (35 m ²)	75	190,000	770,000	50	B
Eaves / base thermal-bridge run (45 m)	11	28,000	680,000	292	C

Warehouse / logistics hall – Large, widespread

All 4 dock seals failed + leveler pits, all door seals poor, ridge and skylight gaps, 90 m of wall-panel joints, 140 m² wet roof insulation (~6 % of the roof), 120 m of thermal bridges (column bases, eaves).

Finding	W/K	HUF/season	Fix (HUF)	Payback (mo.)	Prio.
Dock 1: seal failed (7.6 m x 26 mm)	7	18,000	300,000	196	C
Dock 2: seal failed (7.6 m x 26 mm)	7	18,000	300,000	196	C
Dock 3: seal failed (7.6 m x 26 mm)	7	18,000	300,000	196	C
Dock 4: seal failed (7.6 m x 26 mm)	7	18,000	300,000	196	C
4 leveler-pit side gaps (4 x 3.0 m x 15 mm)	27	66,000	600,000	109	C
Sectional door 1: perimeter seals (17 m x 8 mm)	17	42,000	90,000	26	B
Sectional door 2: perimeter seals (17 m x 8 mm)	17	42,000	90,000	26	B
4 dock-door perimeter gaps when closed (4 x 8.2 m x 5 mm)	15	38,000	360,000	113	C
Roof-ridge gap (60 m x 3 mm)	280	690,000	270,000	5	A
8 skylight perimeter gaps (80 m x 2 mm)	250	610,000	960,000	19	A
Wall-panel joints open (90 m x 2 mm)	150	360,000	410,000	14	A
Wet / missing roof insulation (140 m ²)	300	740,000	3,100,000	50	B
Column-base and eaves thermal bridges (120 m)	30	74,000	1,800,000	292	C

5.2. Supermarket / retail unit

EXAMPLE / illustrative: a fictional but realistic facility. Not customer data, not a promise. 50 x 36 m (1,500 m² sales + 300 m² back room), 5 m high, 20 °C, condensing gas boiler + AHU with heat recovery, vestibule entrance with air curtain, 1 rear dock door. Refrigeration waste heat enters only through the lower 12 °C balance temperature.

Fault-free baseline: H = 2,252 W/K; 160,000 kWh heat per season (87 kWh/m²); 17,000 m³ gas; 7,400,000 (5,900,000–10,000,000) HUF/season. Condensing gas boiler + AHU, $\eta = 0.95$.

Level	Items	W/K	Mean W	Heat (kWh)	Gas (m ³)	Cost (HUF/season) central (range)	Share of bill
Small (localised)	2	36	560	2,500	280	120,000 (94,000–170,000)	1.6 %
Medium	6	230	3,600	16,000	1,800	760,000 (600,000–1,100,000)	9.3 %
Large, widespread	7	720	11,000	50,000	5,600	2,400,000 (1,900,000–3,300,000)	24.2 %

Level	Fix (HUF)	Payback, fix only (mo.), range	5-year savings: flat / forward	5-year net, fix only: flat / forward	CO ₂ kg/season
Small (localised)	270,000 (140,000–500,000)	27 (10–86)	590,000 / 460,000	320,000 / 190,000	530
Medium	1,900,000 (1,000,000–3,500,000)	29 (11–95)	3,800,000 / 3,000,000	1,900,000 / 1,100,000	3,400
Large, widespread	6,300,000 (3,400,000–12,000,000)	32 (12–103)	12,000,000 / 9,200,000	5,500,000 / 2,900,000	10,700

Supermarket / retail unit – Small (localised)

Rear dock-door bottom seal missing, 8 m2 wet flat-roof insulation.

Finding	W/K	HUF/season	Fix (HUF)	Payback (mo.)	Prio.
Rear dock door: bottom seal missing (2.6 m x 20 mm)	18	60,000	90,000	18	A
Wet flat-roof insulation (8 m2)	18	58,000	180,000	37	B

Supermarket / retail unit – Medium

Dock-door and staff-door seals faulty, entrance air curtain under-performing, 24 m of shopfront-to-wall junction open, 45 m2 wet flat roof, 40 m parapet thermal bridge.

Finding	W/K	HUF/season	Fix (HUF)	Payback (mo.)	Prio.
Rear dock door: perimeter seals (10.7 m x 6 mm)	20	65,000	90,000	17	A
Staff door threshold / side gap (5 m x 4 mm)	6	19,000	30,000	19	A
Entrance air curtain under-performing (residual 0.28 -> 0.60)	51	170,000	45,000	3	A
Shopfront-to-wall junction open (24 m x 3 mm)	45	150,000	110,000	9	A
Wet flat-roof insulation (45 m2)	99	330,000	990,000	37	B
Parapet thermal bridge (40 m)	10	33,000	600,000	219	C

Supermarket / retail unit – Large, widespread

Air curtain not working and vestibule inner door left open, all door seals poor, 80 m of open shopfront junction, roof-penetration gaps, 160 m2 wet flat roof (~9 %), 110 m parapet thermal bridge.

Finding	W/K	HUF/season	Fix (HUF)	Payback (mo.)	Prio.
Rear dock door: perimeter seals (10.7 m x 6 mm)	33	110,000	90,000	10	A
Staff door threshold / side gap (5 m x 4 mm)	11	36,000	30,000	10	A
Air curtain off and vestibule door held open (residual 0.28 -> 1.0)	110	380,000	500,000	16	A
Shopfront-to-wall junction open (80 m x 3 mm)	130	430,000	360,000	10	A
4 roof-penetration gaps (8 m x 10 mm)	52	170,000	200,000	14	A
Wet flat-roof insulation (160 m2)	350	1,200,000	3,500,000	37	B
Parapet thermal bridge (110 m)	27	90,000	1,700,000	219	C

5.3. Workshop / small production hall

EXAMPLE / illustrative: a fictional but realistic facility. Not customer data, not a promise. 40 x 25 m, 7 m high, 18 C, gas warm-air heaters, 1 roller door (4.0 x 4.5 m) + 1 sectional door (3.5 x 3.5 m), process extraction.

Fault-free baseline: H = 2,086 W/K; 100,000 kWh heat per season (101 kWh/m²); 13,000 m³ gas; 5,300,000 (4,200,000–7,500,000) HUF/season. Gas warm-air heaters, η = 0.85.

Level	Items	W/K	Mean W	Heat (kWh)	Gas (m ³)	Cost (HUF/season) central (range)	Share of bill
Small (localised)	2	39	530	1,900	230	99,000 (79,000–140,000)	1.8 %
Medium	5	160	2,200	7,900	980	420,000 (330,000–590,000)	7.3 %
Large, widespread	6	520	7,000	25,000	3,100	1,300,000 (1,000,000–1,900,000)	19.8 %

Level	Fix (HUF)	Payback, fix only (mo.), range	5-year savings: flat / forward	5-year net, fix only: flat / forward	CO ₂ kg/season
Small (localised)	140,000 (75,000–260,000)	17 (6–49)	500,000 / 390,000	360,000 / 250,000	450
Medium	1,300,000 (720,000–2,500,000)	39 (15–127)	2,100,000 / 1,600,000	750,000 / 290,000	1,900
Large, widespread	4,000,000 (2,200,000–7,500,000)	36 (14–118)	6,600,000 / 5,100,000	2,600,000 / 1,100,000	6,000

Workshop / small production hall – Small (localised)

Roller-door brush seal worn, 5 m2 wet roof insulation.

Finding	W/K	HUF/season	Fix (HUF)	Payback (mo.)	Prio.
Roller door: brush seal worn (13 m x 6 mm)	28	72,000	30,000	5	A
Wet roof insulation (5 m2)	11	28,000	110,000	48	B

Workshop / small production hall – Medium

Both door seals poor, 25 m of wall-panel joint, 30 m2 wet roof, 30 m eaves thermal bridge.

Finding	W/K	HUF/season	Fix (HUF)	Payback (mo.)	Prio.
Roller door: perimeter seals (13 m x 10 mm)	26	65,000	30,000	6	A
Sectional door: perimeter seals (13 m x 8 mm)	19	50,000	90,000	22	A
Wall-panel joints (25 m x 2 mm)	46	120,000	110,000	11	A
Wet roof insulation (30 m2)	65	170,000	660,000	48	B
Eaves thermal bridge (30 m)	7	19,000	450,000	281	C

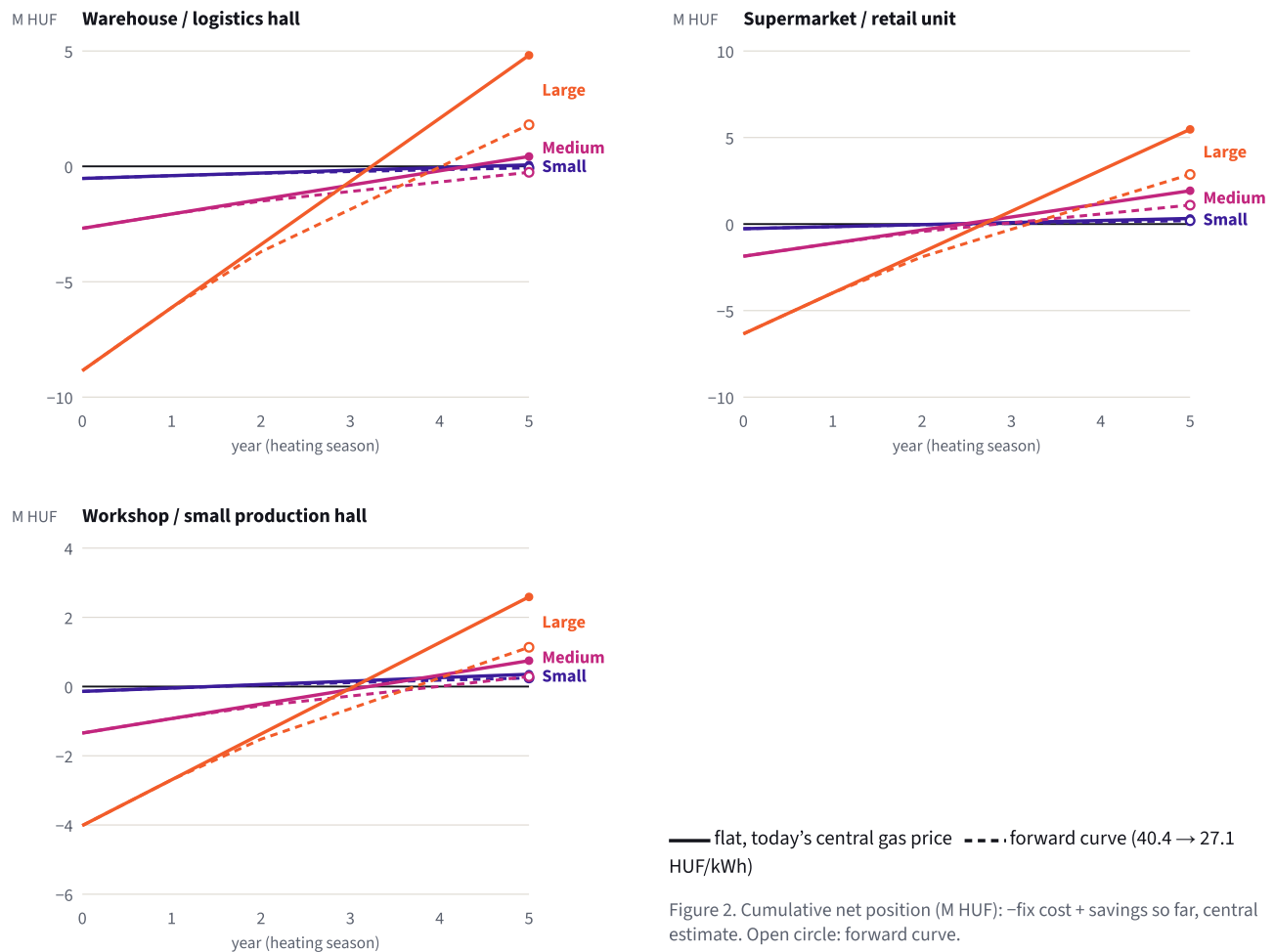
Workshop / small production hall – Large, widespread

All door seals poor, ridge gap, 70 m of panel joints, 100 m2 wet roof (10 %), 80 m of thermal bridges.

Finding	W/K	HUF/season	Fix (HUF)	Payback (mo.)	Prio.
Roller door: perimeter seals (13 m x 10 mm)	52	130,000	30,000	3	A
Sectional door: perimeter seals (13 m x 8 mm)	41	110,000	90,000	10	A
Roof-ridge gap (40 m x 3 mm)	110	280,000	180,000	8	A
Wall-panel joints (70 m x 2 mm)	78	200,000	320,000	19	A
Wet roof insulation (100 m2)	220	550,000	2,200,000	48	B
Column-base and eaves thermal bridges (80 m)	20	51,000	1,200,000	281	C

6. Five years: cumulative financial position

The fix cost arrives up front, the savings season by season. The charts show fixing **all** surveyed items (excluding the survey fee); where a line crosses zero is the payback. The solid line follows the flat today's gas price, the dashed line the forward curve: reality will most likely lie between the two.



7. Only the quick-payback (A) items

It does not pay to fix everything. Fixing the A-priority items (payback up to 24 months) typically removes most of the loss for a fraction of the fix cost. The table shows payback with the fix cost only and together with the survey fee (list price).

Facility	Level	A items	Saving (HUF/season)	Fix (HUF)	Payback, fix only (mo.)	Payback, survey + fix (mo.)	5-year net, fix only: flat / forward
Warehouse / logistics hall	Small (localised)	1/3	50,000	90,000 (40,000–180,000)	22	140	160,000 / 100,000
	Medium	1/8	270,000	160,000 (88,000–280,000)	7	29	1,200,000 / 890,000
	Large, widespread	3/13	1,700,000	1,600,000 (860,000–3,200,000)	12	15	6,600,000 / 4,800,000
Supermarket / retail unit	Small (localised)	1/2	60,000	90,000 (40,000–180,000)	18	102	210,000 / 150,000
	Medium	4/6	400,000	270,000 (140,000–510,000)	8	21	1,700,000 / 1,300,000
	Large, widespread	5/7	1,100,000	1,200,000 (630,000–2,200,000)	13	17	4,400,000 / 3,200,000
Workshop / small production hall	Small (localised)	1/2	72,000	30,000 (15,000–60,000)	5	37	330,000 / 250,000

Facility	Level	A items	Saving (HUF/season)	Fix (HUF)	Payback, fix only (mo.)	Payback, survey + fix (mo.)	5-year net, fix only: flat / forward
	Medium	3/5	230,000	230,000 (120,000–440,000)	12	22	940,000 / 680,000
	Large, widespread	4/6	720,000	620,000 (330,000–1,100,000)	10	13	3,000,000 / 2,200,000

The survey fee is discussed in Section 8. Five-year net values exclude the survey fee.

8. Payback of the survey fee

The survey itself saves no energy: its fee has to be earned back by the savings from the repairs. We therefore give two numbers: with the fix cost, and with the survey fee on top. List price and pioneer-programme price are shown separately.

Facility (list / pioneer price)	Level	Payback, all items: list / pioneer price (mo.)	5-year net incl. survey, all items: flat / forward	Payback, A items only: list / pioneer price (mo.)	5-year net incl. survey, A only: flat / forward
Warehouse / logistics hall 489,000 HUF / 275,000 HUF	Small (localised)	104 / 82	–430,000 / –560,000	140 / 88	–330,000 / –380,000
	Medium	61 / 57	–62,000 / –750,000	29 / 19	700,000 / 400,000
	Large, widespread	41 / 40	4,300,000 / 1,300,000	15 / 14	6,200,000 / 4,300,000
Supermarket / retail unit 423,000 HUF / 275,000 HUF	Small (localised)	70 / 55	–98,000 / –230,000	102 / 73	–210,000 / –280,000
	Medium	36 / 34	1,500,000 / 670,000	21 / 16	1,300,000 / 860,000
	Large, widespread	34 / 34	5,000,000 / 2,400,000	17 / 16	4,000,000 / 2,800,000
Workshop / small production hall 190,000 HUF / 135,000 HUF	Small (localised)	40 / 33	170,000 / 58,000	37 / 28	140,000 / 61,000
	Medium	44 / 42	560,000 / 98,000	22 / 19	750,000 / 490,000
	Large, widespread	38 / 38	2,400,000 / 940,000	13 / 13	2,800,000 / 2,000,000

The pioneer-price payback is the list-price calculation with the survey fee replaced (flat today's gas price, central value). At the small level the survey fee does not pay back from the saving within a reasonable time; the case for the survey is then finding the defect and reducing risk, not financial payback.

9. Sensitivity: why ±30–50 %

The loss of one defect is roughly the product of independent factors: gas price (–20 % / +41 %), weather (–17 % / +18 %), efficiency (+11 % / –9 %), U_{defect} (about ±50 % on ΔU), gap size, C_d and pressure (±30–50 %). Root-sum-square ≈ 0.48 , i.e. **±30–50 %** per item. The $3 \times 3 \times 3 \times 3 = 81$ corner combinations (price $\times$ efficiency $\times$ weather $\times$ defect severity) have a 10th–90th percentile of about –35 % / +70 % around the central value; min/max at $0.5 \times / 2.4 \times$. The central value is roughly the median. Common system-level factors (gas price, weather, efficiency) do not average out across several items. Mandatory wording: “*model-based estimate, range: see table*”.

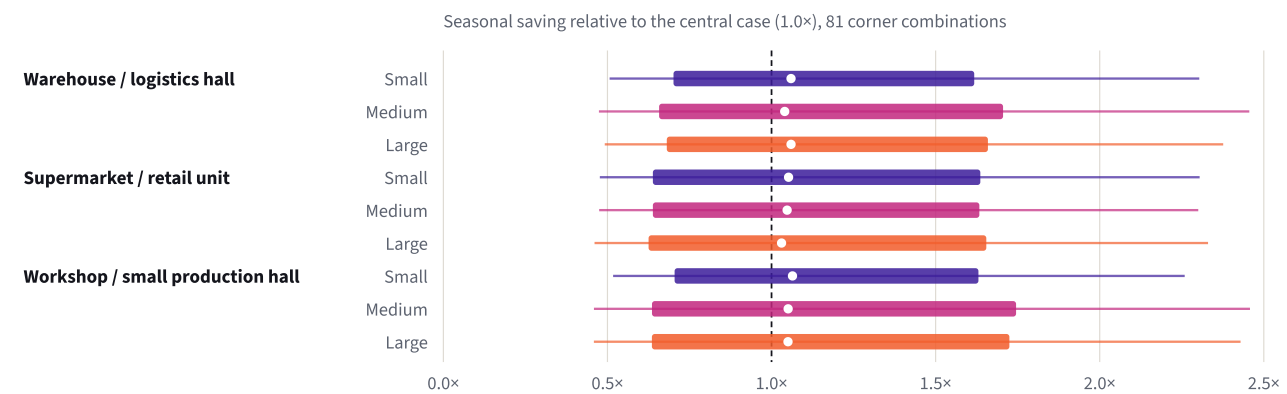


Figure 3. Distribution of the seasonal saving relative to the central case (1.0×): thin line = minimum–maximum, thick bar = 10th–90th percentile, white dot = median.

Facility	Level	min	p10	median	central	p90	max
Warehouse / logistics hall	Small (localised)	59,000	82,000	120,000	120,000	190,000	270,000
	Medium	290,000	410,000	650,000	620,000	1,100,000	1,500,000
	Large, widespread	1,300,000	1,900,000	2,900,000	2,700,000	4,500,000	6,500,000
Supermarket / retail unit	Small (localised)	56,000	75,000	120,000	120,000	190,000	270,000
	Medium	360,000	480,000	790,000	760,000	1,200,000	1,700,000
	Large, widespread	1,100,000	1,500,000	2,400,000	2,400,000	3,900,000	5,500,000
Workshop / small production hall	Small (localised)	51,000	70,000	110,000	99,000	160,000	220,000
	Medium	190,000	270,000	440,000	420,000	730,000	1,000,000
	Large, widespread	610,000	840,000	1,400,000	1,300,000	2,300,000	3,200,000

HUF/season, rounded to 2 significant digits; 81 combinations (gas price × efficiency × weather × defect severity).

10. Pipe and electrical examples

10.1 Leak in a buried pre-insulated hot-water line

25 m of wetted pre-insulated (PUR) hot line between two buildings (80 °C supply); the leak is **downstream** of the district-heat meter, so the loss is billed 1:1. Conduction loss: 200 W/m (100–380) × 25 m ≈ 5.0 kW; make-up water = leak [l/h] × hours; heating the make-up = 1.163 kWh/(m³K) · ΔT. Cost: district-heat heat fee plus make-up water, priced separately from gas with a proxy tariff (Section 3). Repair: locate, excavate, repair, reinstate 3,000,000 HUF (1,500,000–6,000,000); our survey (pipe-run option) 90,000 HUF.

Leak (l/h)	Hours / year	Conduction loss (kWh)	Make-up water (m³)	Heating make-up (kWh)	Cost (HUF/year) central (range)	Payback fix / survey + fix (mo.)	5-year net, fix (HUF)
5	5,342 h heating season	27,000	27	2,200	1,100,000 (590,000–1,400,000)	33 / 34	2,400,000
5	8,760 h all year	44,000	44	3,600	1,800,000 (970,000–2,300,000)	20 / 21	5,800,000
50	5,342 h heating season	27,000	267	22,000	2,100,000 (1,200,000–2,900,000)	17 / 17	7,700,000
50	8,760 h all year	44,000	438	36,000	3,500,000 (1,900,000–4,800,000)	10 / 11	15,000,000
500	5,342 h heating season	27,000	2,671	220,000	13,000,000 (7,000,000–18,000,000)	3 / 3	61,000,000
500	8,760 h all year	44,000	4,380	360,000	21,000,000 (11,000,000–30,000,000)	2 / 2	100,000,000

In a large district-heating network a closed-circuit water balance is only reliable above $\sim 4 \text{ m}^3/\text{h}$, so smaller leaks hide there; on a small private system the make-up water meter is the first check and the thermal camera is for locating the leak. A thermal image of a buried run is indicative only.

10.2 Loose three-phase terminal (electrical hot spot)

Phase terminal carrying 160 A with $+0.5 \text{ m}\Omega$ extra contact resistance: $P = I^2 R = 12.8 \text{ W}$ per phase. The energy is negligible (a few thousand HUF a year). The real stake is failure and fire, which we **do not put a monetary figure on** because we have no reliable source for downtime cost. The only sourced fact: of 736 fires investigated in Hungary in 2022, 73 (9.9 %) had electrical energy as the cause (OKF sample, all building types). The local temperature rise ($P \cdot R_{\text{th}}$, $R_{\text{th}} = 1\text{--}4 \text{ K/W}$) is illustrative only: why a few watts can show on a thermogram. Fix: re-torque terminals + checks 45,000 HUF (25,000–90,000); replace terminal 120,000 HUF (60,000–250,000). Cabinet screening costs 12,000 HUF per cabinet with a package, 18,000 HUF per cabinet stand-alone (minimum 60,000 HUF).

Case	Power (W)	Hours / year	Energy (kWh/year)	Cost (HUF/year) central (range)	Local rise (K, illustrative)
one phase	12.8	3,000	38	5,100 (4,000–5,900)	13–51
all three phases	38.4	3,000	115	15,000 (12,000–18,000)	38–154

Thermal screening of cabinets is not an electrical-safety inspection and not a fire-safety inspection; the cabinet is opened by your authorised electrician.

11. Limitations and known gaps

- A thermal camera measures surface temperature; the watts lost are estimated by a model. Not every hidden defect is visible to a thermal camera.
- Without the valid survey conditions (indoor–outdoor $\Delta T \geq 10 \text{ K}$, wind $< 5 \text{ m/s}$, no sun, stable heating) the result is only condition-limited.
- Conservative choices: lower pressure, series leakage network, activity factors, subtraction of normal door leakage, marginal gas price, condensing boiler at 0.95, heated time fraction < 1 , forward curve as lower bound, electrical risk not monetised. The method **may underestimate** several open doors at busy docks, the weight of cold hours (Jensen inequality) and deterioration of doors and seals.
- Known gaps before publishing numbers:** a real gas invoice and offer (premium, capacity-fee class); the local non-residential district-heat tariff; 2–3 Hungarian quotes each for dock seals, door and panel-joint repair, PU-foam patching, excavation; EN ISO 14683 Annex C and the EN 12426 table; the design outdoor temperature ($-15 \text{ }^\circ\text{C}$, unverified); a source for downtime cost; local wind statistics. After the first 1–2 real measurements (blower door, door test) q_{50} , C_d and wind can be calibrated.
- Fix costs are indicative; savings occur only if the fixes are carried out, and only if they work.

12. Sources

Sources used for the parameters (pages and documents as downloaded; availability may change). Detailed notes: [calc/out/results.json](#), [research/energy-and-physics.md](#).

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Engineering thermal-imaging survey – not an accredited or certified inspection. It does not replace an energy performance certificate, a statutory energy audit, mandatory electrical-safety or fire-safety inspections; those are carried out by professionals authorised under Hungarian law.

Example – illustration of fictional facilities, not a real client. Loss and payback figures are model-based estimates, not guarantees.