Calculation report

Preliminary calculation

Example: 9.9 kWp ground mount, Kyiv

Project	Example: 9.9 kWp ground mount, Kyiv
Version	1 · 02.11.2026
Location	Kyiv
Norms	DBN V.1.2-2:2006 (Ukraine, loads and actions) (UA-DBN-2006)
Engine version	0.15.0
Calculation id (calc_id)	29d47c7193f5e204bcfa4069f6adc56d72c64082cd2268cc498fa220ae50a792

Preliminary calculation. A qualified engineer must check it before installation.

PANELS	POWER	GENERATION
18	9,90 kWp	10 986 kWh/year PVGIS 5.3 (EU JRC)

CALCULATION PASSPORT

Snow and wind	Київ — from your address (the DBN table for the regional centre)
Altitude	default value
Soil	not entered — the pile holding and the ground are assumed; an engineer confirms them

5 checks rest on default or assumed inputs (Altitude, Supports and bolts) and need confirmation before installation.

Site

Panels	18
Power, kWp	9,90
Generation, kWh/year	11 063
Generation by PVGIS 5.3 (EU JRC), kWh/year (typical year 2014–2023)	10 986

System 1

Ballasted trusses (ground): 18 panels, 3 rows × 6, 35°

INPUTS

Panels	6 (portrait) × your panel 2 350×1 100
Angle	35.0° · trusses 6, spacing 1 240
Truss (c/c)	2 050 / 1 680 / 1 175
Supports	pile Ø76 × 2, layers 1
Rails	2 × 6 840 mm
Profile	closed 42×42, wall 2.0, stock length 6 000 × 30
Braces / post	Cross in end bays (4 pcs) · inclined C2
Bolts	M10×120 + M10×160 · 2 in node
Panel bottom / top	315 / 1 691 mm
Ballast / uplift	6 000 / 1 329 kg (DBN, margin ×1.0)
Supports and bolts	default value

CHECKS

RECOMMENDATION — RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

Dimensions 1680 / 1175 / 2050 as specified. Annual optimum for latitude 50.0° ≈ 35°. Wind: angle 35.0° is outside Table 7.6 EN 1991-1-4 (0–30°), c_f obtained by extrapolation; check against manufacturer or wind-tunnel test data (DBN 9.8). Up to 30° c_f — tabulated.

Parameter: Tilt angle
Actual: 35°
Source: heuristic, not a code check

RECOMMENDATION — RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

Rail 1: splice at 6 000 mm; Rail 2: splice at 840 mm. **Joint within the span** (520 mm to the truss) — that is where the rail bends most. Connector ≥ 300 mm with 4 bolts, or select “over trusses” (more connectors may be needed).

Source: heuristic, not a code check

RECOMMENDATION — RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

Closed: bolt M10×120 through 2 profiles. **Do not overtighten — the 2.0 mm wall will dent**, spacer sleeves are better. Diagram — see “Node”.

Source: heuristic, not a code check

INFO — INFORMATION

2 350×1 100×35 mm · 2.58 m². from the original brief. Rails 520 mm from the ends (≈ L/4.5). Row 9.90 kW, ≈ 11 063 kWh/year (estimate).

RECOMMENDATION — RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

Portrait: clamps on the long side — standard. Along the slope 2 350 mm.

Source: heuristic, not a code check

INFO — INFORMATION

Rails of the same profile as the trusses. For another rail (aluminium, C-channel) — select it from the list.

Basis documents: DBN V.1.2-2:2006

INFO — INFORMATION

Kyiv: snow S0 = 1 550 Pa, wind W0 = 370 Pa (DBN V.1.2-2:2006, Annex E). Frost depth ≈ 1.10 m (for reference). Wind at 1.7 m height: W_m = 527 Pa ($\gamma_{fm} \cdot W_0 \cdot c_e(z) \cdot C_{alt}$, c_e 1.42; the EN 1991-1-4 coefficients are defined on the peak pressure, DBN 9.8). S_0/W_0 — for the regional centre; check against the map in Fig. 8.1/9.1 or Annex E.

Parameter: Snow S_0
Actual: 1 550 Pa
Parameter: Wind W_0
Actual: 370 Pa
Basis documents: DBN V.1.2-2:2006

INFO

INFORMATION

Up to 500 m above sea level there are no corrections.

Parameter: Altitude
Actual: 150 m · **Required:** ≤ 500 m
Basis documents: DBN V.1.2-2:2006

INFO

INFORMATION

3 identical rows: materials, bolts, supports and estimate multiplied by 3. Shade-free row spacing ≥ 6 460 mm.

NEEDS CONFIRMATION

CODE CHECK

Rail at a span of 1 240 mm: strength 55%, deflection 9% (DBN V.1.2-2:2006 as amended by No. 1 (2007) and No. 2 (2020)).

Parameter: Strength
Actual: 55% · **Required:** ≤ 100% · **Result:** needs confirmation
Parameter: Deflection
Actual: 9% · **Required:** ≤ 100% · **Result:** needs confirmation
Basis documents: DBN V.1.2-2:2006

RECOMMENDATION

RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

Rails 520 mm from the panel ends — the typical clamping zone. Check against the panel datasheet.

Source: heuristic, not a code check

RECOMMENDATION

RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

At the bottom the panel overhangs by 100 mm. Top overhang 200 mm (up to 200 is OK).

Parameter: Panel top overhang
Actual: 200 mm · **Required:** ≤ 200 mm · **Result:** meets the requirement
Source: heuristic, not a code check

RECOMMENDATION

RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

Cross in spans 1 and 5: 4 braces of 1 580 mm each. Classic — rigid in both directions, diagonals on opposite sides of the posts, no bolt in the middle. Recommended.

Source: heuristic, not a code check

RECOMMENDATION

RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

From the rear bottom node to the middle of the top chord, 1 025 mm (= half the top chord at any angle). Top chord span 2050 → 2 × 1025, the load goes into the node above the support. Recommended.

Source: heuristic, not a code check

RECOMMENDATION

RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

2 bolts per node — the node does not rotate.

Source: heuristic, not a code check

INFO

INFORMATION

2 piles under the truss: under the nodes.

NEEDS CONFIRMATION

CODE CHECK

The piles of the whole row hold 6 000 kg (500 kg/pile — assumed, confirm by a trial pull-out test) ≥ 1 329 kg of uplift (DBN V.1.2-2:2006 as amended by No. 1 (2007) and No. 2 (2020): wind 527 Pa × c_f 2.00). **Screw pile Ø76 × 2000**. Not ballast but an anchor: held by the soil. Holding capacity assumed at 500 kg/pile — depends on the soil, verify with a trial screw-in. Height above ground is adjustable (300 assumed).

Parameter: Total ballast of the row (against uplift)
Actual: 6 000 kg · **Required:** ≥ 1 329 kg · **Result:** needs confirmation
Normative basis: DBN V.1.2-2 · **Clause:** Table 5.1
Method: EQU equilibrium: wind uplift against the weight of the ballast

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NEEDS CONFIRMATION

RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

Panel bottom edge 315 mm from the ground. Holding of the whole row ≈ 6 000 kg (assumed 500 kg/pile) — see “Ballast margin”.

Parameter: Ground clearance
Actual: 315 mm · **Required:** ≥ 300 mm · **Result:** needs confirmation
Source: heuristic, not a code check

NEEDS CONFIRMATION

CODE CHECK

The piles of the whole row hold 6 000 kg (500 kg/pile — assumed, confirm by a trial pull-out test) ≥ 1 329 kg of uplift (DBN V.1.2-2:2006 as amended by No. 1 (2007) and No. 2 (2020): wind 527 Pa × c_f 2.00).

Parameter: Total ballast of the row (against uplift)
Actual: 6 000 kg · **Required:** ≥ 1 329 kg · **Result:** needs confirmation
Normative basis: DBN V.1.2-2 · **Clause:** Table 5.1
Method: EQU equilibrium: wind uplift against the weight of the ballast

INFO

INFORMATION

Rail 6 840 is longer than the stock length — 6 profile connectors (3 per rail). Place splices over a truss, splices of different rails on different trusses. Saw kerf of 3 mm allowed for.

NEEDS CONFIRMATION

RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

On the ground: panel bottom edge ≥ 300 mm above the soil, supports on a compacted base.

Source: heuristic, not a code check

INFO

INFORMATION

Sun on 21 December at noon — 16.6° above the horizon. To keep the rear row unshaded, row spacing ≥ 6 460 mm.

INFO

INFORMATION

The simplification of CMU Resolution No. 77 of 28.01.2026 (cl. 32) applies only to PV systems on roofs and façades; for a ground-mounted PV system the general procedure applies.

RECOMMENDATION

RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

Inverter and battery: do not store combustible materials closer than 1 m to them or under the switchboard (NAPB A.01.001-2014, sect. IV ch. 1 cl. 1.18).

Source: heuristic, not a code check

INFO

INFORMATION

Switching off the inverter does not remove voltage from the module DC cables during the day: a DC isolator for each inverter is included in the electrical bill of materials (DSTU HD 60364-7-712, 712.537).

RECOMMENDATION

RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

Recommended (not mandatory in Ukraine): at the shutdown point — a sign “PV system, DC live during daytime” with a diagram and the shutdown location (SES of Ukraine guidelines, 2020).

Source: heuristic, not a code check

RECOMMENDATION

RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

Check insulation resistance and protection tripping at least every 2 years (NAPB A.01.001-2014, sect. IV ch. 1 cl. 1.20).

Source: heuristic, not a code check

RECOMMENDATION

RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

The need for lightning protection is determined by a risk assessment per DSTU EN 62305-2:2022 (DBN V.2.5-23:2025 cl. 4.5; DBN V.1.1-7:2016 cl. 6.45; NAPB IV 1.21); there is no rule “PV system ⇒ mandatory lightning protection”. For the estimate: N_G ≈ 2.0 1/km²·year (Kyiv, thunderstorm days per UkrHMC 2015–2023 / 10).

Source: heuristic, not a code check

RECOMMENDATION

RECOMMENDATION (RULE OF THUMB, NOT A CODE CHECK)

Bond the module frames and rails to each other and to the building's main earthing terminal (DSTU HD 60364-7-712, 712.54; PUE:2026 1.7.59).

Source: heuristic, not a code check

VALUES

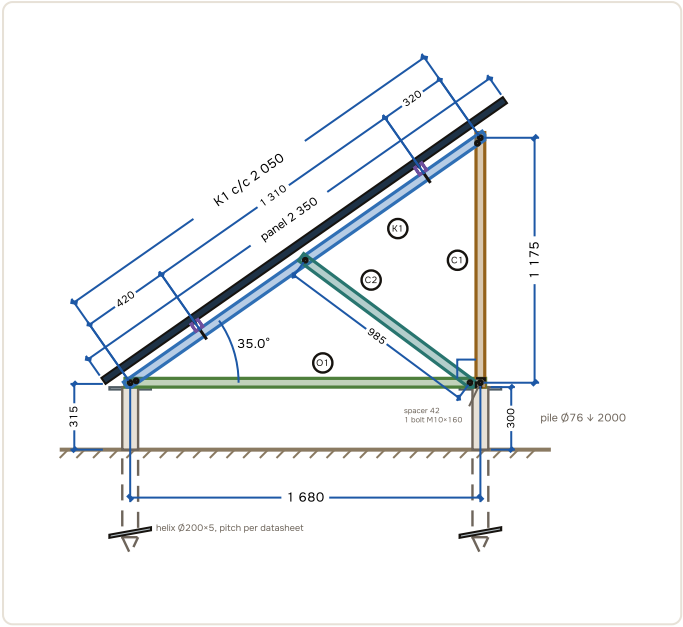
Low edge	315 mm
Ballast/wind	6 000/1 329
Stock lengths	30

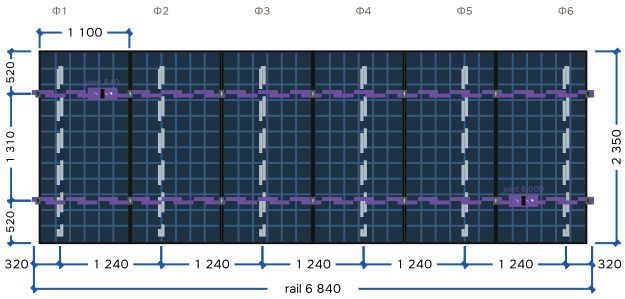
Angle	34.97°
Rail	6 840 mm
Truss spacing	1 240 mm
Panel bottom	315 mm
Panel top	1 691 mm
Hold-down	≈ 6 000 kg
Stock lengths	30 × 6 000
Power	9.90 kW
Row spacing	6 460 mm
Weight (metal+panels)	≈ 988 kg

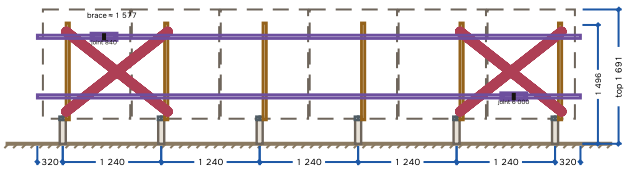
BILL OF MATERIALS

ITEM	QTY	
Truss profile 42×42 tube, wall 2.0 (trusses and rails), stock length 6 000 mm (price per metre)	30	bar
Profile connector 42×42 (sleeve L 300)	6	pcs
Bolt M10×120 cl. 8.8 (nodes, rails, braces) (+10%)	189	pcs
Bolt M10×160 cl. 8.8 (node M through the spacer insert)	36	pcs
Bolt M10×160 cl. 8.8 (node B: post and base through a spacer insert)	18	pcs
Bolt M10×70 cl. 8.8 (rail connector, 4 each) (+10%)	27	pcs
Nut M10 (+10%)	270	pcs
Washer M10 (2 per bolt) (+10%)	540	pcs
Spring washer M10 (+10%)	270	pcs
End clamp 35 mm	12	pcs
Mid clamp (30–40 mm)	30	pcs
Bolt M8×100 A2 right through the tube (+10%)	47	pcs
Self-locking nut M8 DIN 985 (+10%)	47	pcs
Washer M8 DIN 9021 (wide, underneath) (+10%)	47	pcs
Bolt M10×70 cl. 8.8 to pile head + washers, spring washer, nut (+10%)	80	pcs
Plate washer 40×40×4 (to avoid crushing the tube) (+10%)	80	pcs
Module earthing clip (under the clamp)	18	pcs
Wire PV-3 6 mm² green-yellow	31	m
Earth electrode: 2 rods Ø16×1.5 m + strip 40×4	3	set
Cable clip, stainless	54	pcs
End cap 42×42	48	pcs
Zinc paint / cold galvanising spray 400 ml	4	pcs
Screw pile Ø76 × 2000	36	pcs
Spacer inserts / packs — pieces of the same profile (from offcuts): 36 × 42 mm (at: O1–C1, K1–C2, O1–C1a)	36	pcs

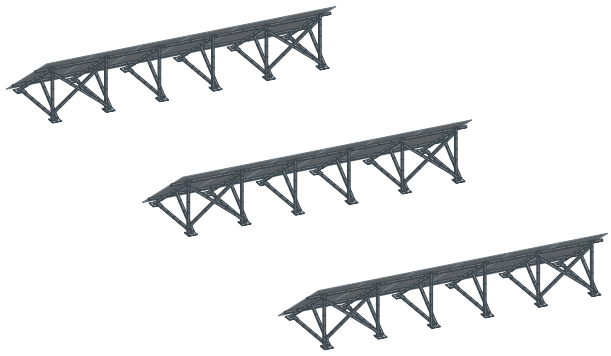
DRAWINGS







Rear isometric: frame as assembled



CALCULATION TABLES

1. Loads per DBN V.1.2-2:2006 as amended by No. 1 (2007) and No. 2 (2020)

Snow S_0 / wind W_0	Annex E, region (8.5, 9.6)	1 550 / 370 Pa
Return period T	parameter; γ_{fm} snow — Table 8.1, wind — Table 9.1	50 years → 1.00 / 1.00
C_{alt} snow / wind	(8.5), (9.4)	1.00 / 1.00
μ (snow)	Annex Zh, scheme 1: 1 up to 25°, 0 from 60°, linear in between	0.72
Snow S_m on horizontal projection	$\gamma_{fm}\cdot S_0\cdot C_{alt}\cdot\mu$, C_e = 1 (8.9)	1 109 Pa
$c_e(z)$	EN 1991-1-4 4.5, terrain type II as category EN, z = 1.7 m	1.42
Wind W_m	$\gamma_{fm}\cdot W_0\cdot c_e(z)\cdot C_{alt}$: the EN 1991-1-4 coefficients are defined on the peak pressure (9.8), W_0 taken as q_b (9.6, EN 1991-1-4 4.5); $C_{rel} = C_{dir} = 1$	527 Pa
c_f canopy uplift / pressure	EN 1991-1-4 Table 7.6 (φ = 0), per DBN 9.8; angle above 30° — extrapolated, check	**2.00 / 1.35**
γ_n	DBN V.1.2-14, consequence class — set in parameters	1.00

Combination — per 4.18 (Amendment No. 2): leading short-term load with ψ = 1.0, second — 0.9; both orders are checked (snow and wind). Annex I gives no aerodynamic uplift coefficients for a monopitch canopy, so c_f is taken from EN 1991-1-4, as permitted by 9.8.

2. Rail between trusses

tube 42×42×2, span 1 240 mm	continuous over trusses, M = q·L²/8	
q (worst rail)	1.05·G + W↓ + 0.9·S (DBN 4.18)	2.492 N/mm
M	q·L²/8	0.479 kN·m
Strength	DBN V.2.6-198 10.1.1 (10.3)	55%
Deflection / (L/200)	characteristic values; L/200 — adopted limit (check)	9%

3. Between rows

Sun elevation at noon on 21 December	90° - latitude - 23.44°	16.6°
Shade-free row spacing	length along slope · (cos α + sin α / tg h)	6 460 mm

4. Truss: member forces and checks

Section	tube 42×42×2: closed section along the wall centreline, outer corner radius 2t; f_y = 235 MPa	A 310 mm², W_y 3.86 cm³, i_{min} 16.2 mm
Load on truss	rails at 420, 1730 mm from node A; most heavily loaded truss No. 2, continuous rail ×1.10 applied to spacing 1240 mm; 1.05·G + S + 0.9·W↓ (DBN 4.18)	3.43 + 1.74 kN
Top chord K1	N = -2.24 kN (compression), M = 0.686 kN·m; strength: compression + bending — DBN V.2.6-198 10.1.1 (10.3); 1.05·G + W↓ + 0.9·S (DBN 4.18)	83%
Inner strut C2	N = -2.74 kN (compression), M = 0.000 kN·m, M_z = 0.058 kN·m (bolt through the back); strength: compression + bending — DBN V.2.6-198 10.1.1 (10.3); 1.05·G + W↓ + 0.9·S (DBN 4.18)	11%
Base O1	N = 2.20 kN (tension), M = 0.081 kN·m, M_z = 0.046 kN·m (bolt through the back); strength: tension + bending — DBN V.2.6-198 10.1.1 (10.3); 1.05·G + W↓ + 0.9·S (DBN 4.18)	18%
Rear post C1	N = -2.45 kN (compression), M = 0.000 kN·m, M_z = 0.051 kN·m (bolt through the back); strength: compression + bending — DBN V.2.6-198 10.1.1 (10.3); 1.05·G + W↓ + 0.9·S (DBN 4.18)	9%
Coefficients	DBN V.2.6-198 Table 7.1, 7.2: $R_y = R_{yn}/\gamma_m$, γ_m = 1.05; γ_c = 1.0	γ_n — included in loads

The rails do not sit at the truss nodes, so the top chord works in bending between nodes, not only in compression. The truss is analysed as a plane frame: top chord continuous, posts and base pinned, support A — pin, B — roller. Loads per DBN V.1.2-2:2006 as amended by No. 1 (2007) and No. 2 (2020): snow $S_m = \gamma_{fm} \cdot S_0 \cdot C_{alt} \cdot \mu$ = 1109 Pa (8.1), wind $W_m = \gamma_{fm} \cdot W_0 \cdot c_e(z) \cdot C_{alt}$ = 527 Pa (c_e = 1.42, EN 1991-1-4 4.5; W_0 taken as q_b, 9.6) × canopy c_f from EN 1991-1-4 Table 7.6 (the EN 1991-1-4 coefficients are defined on the peak pressure; DBN 9.8), resultant at d/4 from the windward edge; self-weight 120 Pa. Combination 4.18 (Amendment No. 2): ψ_{t1} = 1.0, ψ_{t2} = 0.9; γ_n = 1 (DBN V.1.2-14 not obtained — set it in the parameters). Tube — per DBN V.2.6-198:2014: strength (8.1, 10.3), stability (8.3–8.5, 10.6 of Table Zh.3). The posts and base are joined with a single bolt through the web, so the axial force acts eccentrically to the centroid.

5. Fire safety and lightning protection

Basis	Cabinet of Ministers of Ukraine Resolution No. 77 of 28.01.2026 (List, cl. 32); NAPB A.01.001-2014 (sect. IV ch. 1, cl. 1.18, 1.20, 1.21); DBN V.1.1-7:2016 (cl. 6.20, 6.45, 8.4–8.6, Annex A); DBN V.2.5-23:2025 (cl. 4.5, 7.53, 7.54, 7.62, 8.6); DSTU EN 62305-1:2012, -2:2022, -3:2021, -4:2012; DSTU HD 60364-7-712:2022	
Building type	the “Building type” parameter	detached, garden or country house; outbuilding

5. Fire safety and lightning protection

Lightning protection on the building	electrics parameter	none / unknown

Ukrainian codes do not set fire setbacks, rapid shutdown or marking for rooftop PV systems; the SES of Ukraine recommendations given are for reference only. The need for lightning protection is determined by a risk assessment per DSTU EN 62305-2; this calculation is preliminary.

- Right-angled triangle: 1 680² + 1 175² ≈ 2 050², angle 34.97°. Dimensions — along the profile centrelines.
- Truss dimensions (2 050 / 1 680 / 1 175) — between bolt centres. Blank 50 mm longer: hole 25 mm from each end (see “Parts”). If you have already cut exactly 2 050 / 1 680 / 1 175 — place the holes 25 mm from the end; the hole spacing is then 50 mm less and the angle slightly different.
- Panel along the slope 2 350 mm — longer than the top chord by 300 mm: bottom 100 mm, top 200 mm. Rails on the top chord: 420, 1 730 mm from the lower node.
- End clamps: 12, mid clamps: 30. Each — bolt M8×100 A2 right through the tube with self-locking nut DIN 985 (a closed tube has no slot for a hammer-head nut). Gap between panels 20 mm, torque 14–16 N·m.
- Rails are joined with a connector, 6 pcs. Joint — above a truss, stagger the joints of different rails.
- Inner strut inclined: rear bottom node → top chord midpoint, 1 025 mm between hole centres, 2 bolts at each end.
- Profile in profile (closed): clamping stack 84 mm → bolt M10×120; at node B the post and base are joined through a spacer insert, one bolt M10×160. See “Node”. Fasteners galvanised or stainless steel.
- Support: Screw pile Ø76 × 2000. Not ballast but an anchor: held by the soil. Holding capacity assumed at 500 kg/pile — depends on the soil, verify with a trial screw-in. Height above ground is adjustable (300 assumed).
- Loads: DBN V.1.2-2:2006 as amended by No. 1 (2007) and No. 2 (2020); Canopy c_f — EN 1991-1-4 Table 7.6 (DBN 9.8). This is a simplified check — not a substitute for an engineer's calculation.
- Row spacing 6 460 mm — only if there are several rows, calculated for 21 December at noon.

WHAT THIS CALCULATION DOES NOT COVER

- This is a preliminary calculation, not an independent review: the formulas and factors come from the codes named above.
- Snow and wind are those of the nearest regional centre, or your own values. A site in another snow or wind zone, or at another altitude, needs its own values.
- A qualified engineer verifies the design for the actual site, roof or soil and the local building rules before installation.

CHECKED BY ENGINEER

Full name _____

Licence no. _____

Date _____

Signature _____