Solar Installation Report

Project	Small off-grid home, Jumla (example)
Client	-
Location	Jumla
Prepared by	-
Report date	2026-10-30
Software	ElectricalCalc AI v0.6.0
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Reviewer	Not reviewed

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Summary in plain words

- You need 1 solar panel of 550 W (0.55 kW in total), needing about 3 m² of roof.
- They should make about 1,016 units (kWh) a year - about 85 a month on average; you use about 26 units a month.
- Inverter (turns solar power into normal 230 V power): about 0.3 kW.
- Battery: 89 Ah at 24 V (about 2.1 kWh), lasting about 12 years.
- Estimated cost: about Rs 118,904 (indicative Nepal prices - get installer quotes).
- This is a first estimate. A qualified electrical engineer must check it, the site and the equipment before anything is bought or installed.

Scope and notes

Roof: Flat roof - panels go on a metal frame. Panels modelled at 29° tilt, azimuth 0° (0 = south). PVGIS v5.3 (PVGIS-ERA5, 2005-2023) at 29.2747, 82.1838; tilt 29°, azimuth 0° (0 = south); 14.0% system loss.

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A. What to buy (shopping list)

Buy equipment that meets NEPQA-2025 (AEPC) and ask the seller for each datasheet. Ratings are the minimum - equal or higher is fine unless stated. The second column says whether the item is compulsory in Nepal or optional; section B explains every item.

Item	Compulsory or optional?	Specification	Qty	Why / rule	Why it is needed
Solar PV module	Compulsory (safety)	550 Wp mono/TOPCon, Voc 49.5 V, Vmp 41.6 V, Isc 14 A, efficiency ≥ 21 %, power warranty ≥ 80 % at 25 yr, IEC 61215/61730	1	Array 1 in series × 1 string(s) = 0.55 kWp; NEPQA-2025 module floors	IEC 61215/61730; NEPQA-2025 efficiency and warranty floors
Mounting structure	Compulsory (safety)	Hot-dip galvanised / aluminium tilt frame with anchor bolts, tilt as designed	1 row(s) of up to 1	Boxwell, Solar Electricity Handbook §123; roof must carry the weight - check structure	Must resist wind uplift and earthquakes
Mounting rails	Compulsory (safety)	Aluminium PV rail (2 per row of panels)	3 m	2 rails under each panel	Must resist wind uplift and earthquakes
End clamps / mid clamps	Compulsory (safety)	Matching panel frame thickness	4 end / 0 mid	4 end clamps per row, 2 mid clamps between neighbouring panels	Part of the mounting structure
Roof feet / anchors	Compulsory (safety)	Stainless fixings, sealed against leaks	4	One fixing about every 1.2 m of rail	Part of the mounting structure
PV cable (red and black)	Compulsory (safety)	10 mm² solar cable EN 50618 (H1Z2Z2-K), UV resistant, 1500 V DC	13 m red + same black	Cable schedule; book §87, §110	Solar-rated (EN 50618) or correctly sized copper
MC4 connector pairs	Compulsory (law / NEA)	Same brand as panel connectors (never mix brands)	4	Field-made string ends + spares	NEPQA-2025: connector of the panel maker's type, IEC 62852, IP67
DC isolator (PV)	Compulsory (safety)	150 V DC, ≥ 25 A, 2-pole, lockable	1	Rated above cold string Voc 54 V and 1.25 × Isc; book §79, §80, §109	Safe disconnection of panel power (IEC 60364-7-712)
DC surge protection device (Type 2, PV)	Strongly recommended	Ucpv ≥ 150 V DC, In ≥ 20 kA	1	Lightning-induced surges are common in Nepal; above cold string Voc	Nepal lightning risk (237 deaths 2021-2025); AEPC specs include SPDs
MPPT charge controller	Compulsory (safety)	30 A, 24 V battery, PV max 150 V, efficiency ≥ 95 %, battery-type setting for LiFePO4 (lithium)	1	Array current × 1.25; NEPQA MPPT floor; book §90	Charges the battery; NEPQA: PWM only below 20 A, MPPT >= 95 %

Item	Compulsory or optional?	Specification	Qty	Why / rule	Why it is needed
Off-grid inverter	Compulsory (safety)	0.5 kW continuous, surge ≥ 0.2 kW, 24 V DC input, pure sine 230 V 50 Hz	1	≥ 4/3 × loads running together (book §91); motors need surge	Battery inverter: NEPQA-2025 efficiency, overload and warranty floors
Battery	Compulsory (safety)	LiFePO4 24 V 100 Ah with BMS, ≥ 3000 cycles @ 80 % DoD, round-trip ≥ 85 %, warranty ≥ 5 yr, communication with inverter (CAN/RS485)	1	1 in series × 1 in parallel = 2.4 kWh; needs 89 Ah at 24 V (book §89)	Stores the backup energy; NEPQA-2025 cycle, capacity and warranty floors
Battery cable (red and black)	Compulsory (safety)	10 mm² flexible copper, crimped lugs	4 m each colour	Cable schedule; keep as short as possible (§125)	Must carry the fuse rating and inverter current
Battery fuse (DC, high breaking capacity)	Compulsory (safety)	32 A NH/ANL/class-T DC fuse	1	≥ 1.25 × max battery current 23 A; on the + terminal so all current passes (§109)	A lithium bank can push thousands of amps into a short
Battery isolator / DC breaker	Compulsory (safety)	32 A, 24 V DC rated	1	Lets you disconnect the battery safely (book §79)	Protects the cable it feeds
AC MCB (inverter output)	Compulsory (safety)	6 A, C-curve, 1-pole + N	1	≥ 1.25 × inverter AC current 2.2 A; cable sized to carry it	Protects the AC cable (IEC 60364)
RCD / RCBO	Compulsory (safety)	30 mA, Type A (Type B if the inverter manual requires)	1	Shock protection on AC circuits (§109)	Prevents electric shock (IEC 60364)
AC surge protection device (Type 2)	Strongly recommended	275 V AC, In ≥ 20 kA	1	Protects inverter and loads	Nepal lightning risk (237 deaths 2021-2025); AEPC specs include SPDs
AC cable	Compulsory (safety)	2.5 mm² copper (phase + neutral) + 2.5 mm² earth	7 m	Cable schedule	Solar-rated (EN 50618) or correctly sized copper
Earth electrode	Compulsory (safety)	Copper-bonded rod ≥ 1.5 m (or copper plate earth pit per local practice), inspection pit	1	Earth the array frame, inverter and battery negative (§109, §121, §124)	AEPC spec: 2 electrodes, 10 ohm or less
Earth cable (green/yellow)	Compulsory (safety)	6 mm² frame bonding, 16 mm² to electrode, 2.5 mm² PE	17 m total	Cable schedule	AEPC spec: 2 electrodes, 10 ohm or less
Conduit / cable tray, glands, ties	Compulsory (safety)	UV-resistant conduit outdoors; glands sized to cables	as required	Protect cable runs (§110)	Solar-rated (EN 50618) or correctly sized copper

Item	Compulsory or optional?	Specification	Qty	Why / rule	Why it is needed
Warning labels	Compulsory (safety)	'Solar DC - live in daylight', isolator labels, dual-supply label at DB and meter	1	IEC 60364-7-712 practice	IEC 62548: warn that DC is live in daylight

B. Compulsory or optional in Nepal (your system type)

Compulsory (law / NEA) = NEPQA-2025 or NEA require it. Compulsory (safety) = IEC safety standards and AEPC specifications require it. Strongly recommended = a real Nepal risk. Optional = convenience.

Part	Off-grid
MC4 connectors of the panel maker's type	Compulsory (law / NEA)
Battery with BMS (lithium)	Compulsory (law / NEA)
MPPT charge controller (PWM only below 20 A)	Compulsory (law / NEA)
Solar panels (IEC 61215 + 61730)	Compulsory (safety)
Mounting structure, anchored	Compulsory (safety)
Solar DC cable (EN 50618)	Compulsory (safety)
DC isolator	Compulsory (safety)
Inverter with NEPQA/IEC certificates	Compulsory (safety)
AC breaker (MCB)	Compulsory (safety)
RCD 30 mA	Compulsory (safety)
Earthing (2 electrodes, <= 10 ohm)	Compulsory (safety)
Warning labels	Compulsory (safety)
Multimeter for testing	Compulsory (safety)
Battery fuse (10-20 kA) + isolator	Compulsory (safety)
DC surge protector	Strongly recommended
AC surge protector	Strongly recommended
Lightning air terminal	Optional
Monitoring app	Optional

C. Every part explained - what it is, which type is best, how to choose and connect it

One card per part, written for your system. Read the card before you buy that part.

Solar panels (PV modules)

Panels turn sunlight into DC electricity. Their power rating (Wp) is measured in a laboratory at 25 °C and full sun, so on a real roof they give less - that loss is already included in your design.

Types

Type	How it works	Good	Bad	Best for
Monocrystalline TOPCon / PERC [modern]	Single-crystal silicon cells, black look	Highest efficiency (21-23 %), small roof area, long life	Slightly dearer per watt	Almost every Nepali roof today
Bifacial	Glass on both sides collects reflected light too	A few % extra on a bright raised frame	Little gain flat on a tin roof; heavier	Ground or high open frames over light-coloured surfaces
Polycrystalline	Many-crystal cells, blue look (book §76)	Cheap	Lower efficiency (13-18 %), mostly discontinued; fails NEPQA ≥ 21 % above 350 Wp	Small old-stock DC lighting kits only
Thin-film / amorphous	Very thin layer on glass (book §76)	Copes better with partial shade and heat	Needs about 2.5× more roof area	Rarely sold in Nepal now

Best for your system

Monocrystalline (TOPCon/PERC) panels of about 550 W - you need 1 of them (about 3 m² of roof). Buy all panels of the SAME model and batch.

How to select (your numbers)

- Power about 550 Wp each, quantity 1 (your design).
- Datasheet values close to: Voc 49.5 V, Vmp 41.6 V, Isc 14.0 A, Imp 13.2 A - if your panel differs, re-enter its values in Engineer settings and recalculate.
- Voc temperature coefficient around -0.25 %/°C (smaller number = less voltage rise in cold).
- Maximum system voltage 1000 V or 1500 V (higher than your string's cold voltage).
- Efficiency at least 21 % for panels above 350 Wp (NEPQA-2025).

When buying, check

- Label on the back: model, Wp, Voc, Isc, Vmp, Imp, max system voltage, max series fuse, certificates IEC 61215 and IEC 61730.
- Power tolerance 0/+3 % or 0/+5 W (never a minus tolerance) - NEPQA-2025.
- Warranty: product ≥ 10 years; power ≥ 80 % after 25 years (NEPQA floor).
- Buy from any brand listed/certified under NEPQA-2025 (AEPC); always ask the seller for the datasheet.
- Signs of a poor/fake panel: weight much lighter than the datasheet, no serial number, bubbles or brown spots in the cells, bent frame, a junction box that opens easily, 'Wp' far too high for its size.
- Ask the shop to measure Voc in the sun in front of you - it should be close to the label value.
- Certificates from an IECEE/IECRE-listed lab: IEC 61215:2021 and IEC 61730; above 350 W also PID (IEC 62804-1), salt-mist (IEC 61701) and ammonia (IEC 62716) - NEPQA-2025 (AEPC, Aug 2025) and Amendment-1 (Apr 2026).
- Serial number laminated INSIDE the glass (a sticker only is a warning sign); fill factor ≥ 75 % - NEPQA-2025 (AEPC, Aug 2025) and Amendment-1 (Apr 2026).
- Power warranty ≥ 97 % in year 1, ≥ 90 % at 10 years, ≥ 80 % at 25 years (≤ 0.8 %/yr) - NEPQA-2025.

Series or parallel?

Your 1 panels are wired as 1 in series × 1 string(s). In series the VOLTAGES add and the current stays the same: 1 × 41.6 V = about 42 V while working, 50 V open-circuit on a 25 °C test, and up to 54 V on the coldest morning (-15.0 °C). The current is that of one panel, about 13.2 A working / 14.0 A short-circuit.

How to connect

- 1. Keep panels face-down or covered with an opaque sheet until all wiring is finished - a panel in daylight is always live (book §117-§120).
- 2. Fix each panel to the rails with 4 clamps on the frame's clamping zone shown in the manual.
- 3. Join the panels in a chain: + of panel 1 to − of panel 2, and so on, for 1 panels. The free − of the first panel and the free + of the last panel are the string ends.
- 4. Measure the string's open-circuit voltage with a multimeter before connecting it anywhere (see Skills).
- 5. Bond every panel frame / rail to earth with 6 mm² green-yellow cable.
- 6. Leave about 10 mm between neighbouring panels and at least 10 cm between the panel frame and the roof for cooling (manufacturer manual, e.g. LONGi 2026).
- 7. Bond each frame to earth through the marked earthing hole with the proper star washer/lug - never drill new holes in the frame (manufacturer manual).

Common mistakes

- Mixing different panel models or wattages in one string (the weakest one limits all).
- Wiring in the shade of a water tank, railing or neighbour's building - even small shade cuts output a lot (book §57: 5 % shaded can lose 50-80 %).
- Walking or standing on panels; drilling the frame.
- Leaving the panel's own short leads hanging in water - tie them to the rail.

Reference: Book §56-§61, §76, §106, §117-§120; NEPQA-2025 §1.1

Mounting structure (frame, rails, clamps)

The frame holds the panels at the right angle and must survive Nepal's monsoon storms for 25 years. It also lifts the panels so air can cool them.

Types

Type	How it works	Good	Bad	Best for
Raised tilted frame on a flat RCC roof	Galvanised/aluminium legs bolted to the slab	Correct tilt and direction, cooler panels	Must be anchored for wind	Flat roofs
Rails on a tin / sloping roof	Rails fixed through the sheet into the purlins	Cheap, quick	Follows roof angle; leaks if badly sealed	Tin or tiled roofs
Ground frame / pole	Concrete footings in the yard (book §66)	Easy cleaning, any angle	Uses land; needs fencing from animals/children	Houses with yard space

Best for your system

A hot-dip galvanised or aluminium tilted frame bolted to your RCC slab with anchor bolts and sealed.

How to select (your numbers)

- Size: holds 1 panels (shopping list: Hot-dip galvanised / aluminium tilt frame with anchor bolts, tilt as designed).
- Rails: 3 m; clamps: 4 end / 0 mid; roof feet/anchors: 4.
- Leave at least 10 cm of air under the panels (book §59: hot panels make less power).
- Face the panels south; tilt as in your design (flat roofs: about equal to your latitude).

When buying, check

- Steel must be hot-dip GALVANISED (dull grey, thick zinc) - not painted mild steel which rusts in 2-3 monsoons.
- Stainless steel (A2) bolts and clamps; matching the panel frame thickness (e.g. 30-35 mm).
- Ask for the wind rating of the frame and follow its anchor spacing.

How to connect

- 1. Mark the frame positions on the slab; keep 30-50 cm from roof edges and away from the water tank's shadow.
- 2. Drill the slab, set anchor bolts with chemical/epoxy anchor or expansion bolts, and seal around each one.
- 3. Bolt the legs, check the tilt with a phone angle app, then fix the rails level.
- 4. Tighten all bolts to the torque in the manual; re-check after the first storm (book §135).

Common mistakes

- Fixing into the tin sheet only - it tears in wind.

- No sealing → roof leaks inside the house.
- Rusting black steel frames.
- Panels too close to the roof surface (overheating).

Reference: Book §59, §66, §123; local building rules for roof loads

PV cable and MC4 connectors

Special solar cable carries the DC power from the panels to the inverter/controller. MC4 connectors are the waterproof plugs used to join panels and cables.

Types

Type	How it works	Good	Bad	Best for
Solar cable EN 50618 (H1Z2Z2-K)	Double-insulated, UV- and heat-proof, rated 1500 V DC	Lasts 25 years outdoors	Dearer than house wire	All panel wiring
Ordinary PVC house wire	Single insulation, not UV proof	Cheap	Cracks in sun within a few years → fire/shock risk	Never for PV

Best for your system

10 mm² solar cable EN 50618 (H1Z2Z2-K), UV resistant, 1500 V DC, 10 mm², red for + and black for −, 13 m red + same black; 4 MC4 pairs of the same make as the panel plugs.

How to select (your numbers)

- Size 10 mm² (larger of: current rule 2.5 mm², voltage-drop rule 10 mm²); voltage drop about 1.39 % over 10.0 m.
- Voltage rating ≥ 54 V DC (your coldest-morning string voltage) - EN 50618 cable is 1500 V.
- Current: each string carries up to 17.5 A (1.25 × Isc).

When buying, check

- Print on the cable sheath: 'EN 50618' or 'H1Z2Z2-K', size in mm², 1500 V DC.
- Tinned copper strands; correct size (strip a sample - undersized copper is a common fake).
- MC4 connectors: IP67/IP68, rated ≥ 30 A and ≥ 1000 V, same make as your panels' connectors.
- Buy from any brand listed/certified under NEPQA-2025 (AEPC); always ask the seller for the datasheet.

Series or parallel?

Solar cable is not 'in series' or 'in parallel' itself - it simply carries the string. Keep + and − of the same string together (same route) so they do not form a large loop that picks up lightning surges.

How to connect

- 1. Route the + and − cables side by side in UV-proof conduit or tied to the rails; never lie them in water.
- 2. Crimp MC4 ends with an MC4 crimp tool (see Skills) - never squeeze with pliers.
- 3. Check polarity with a multimeter before plugging into the isolator.
- 4. Label both ends: 'PV string 1 +' / '−'.

Common mistakes

- Mixing MC4 brands (they look the same but can overheat and melt).
- Using house wire on the roof.
- Sharp bends over metal edges cutting the insulation.
- Cables dangling and rubbing in the wind.

Reference: Book §87, §110; EN 50618; IEC 62548

DC isolator / DC breaker (panel side)

A switch that safely disconnects the panels from the inverter or controller, so you can work on the system. DC is harder to switch off than AC - it makes a lasting spark - so the switch must be DC-rated.

Types

Type	How it works	Good	Bad	Best for
DC isolator (rotary switch)	Manual switch rated for DC voltage	Simple, lockable, cheap	No automatic overcurrent trip	Disconnect at the inverter

Type	How it works	Good	Bad	Best for
DC MCB (breaker)	Switch + automatic trip on overcurrent	Protects as well as isolates	Must be polarity-correct; dearer	Small PV/battery circuits
AC MCB used on DC	Wrong device	-	Can fail to break DC → fire	Never

Best for your system

150 V DC, ≥ 25 A, 2-pole, lockable - qty 1 (one near the inverter; a second at the array if the cable run is long or crosses the roof).

How to select (your numbers)

- Voltage rating ≥ 54 V DC (string voltage on the coldest morning).
- Current rating ≥ 17.5 A × number of strings (1).
- 2-pole (breaks + and −), lockable in the OFF position.

When buying, check

- 'DC' and the voltage (e.g. 600 V DC / 1000 V DC) printed on the device - not just '230/400 V'.
- Utilisation category DC-PV2 / DC-21B on the datasheet; IEC 60947-3.
- Buy from any brand listed/certified under NEPQA-2025 (AEPC); always ask the seller for the datasheet.

How to connect

- 1. Mount within reach of the inverter, before its PV input.
- 2. Panels + to the isolator's '+ IN', isolator '+ OUT' to the inverter PV +; same for −. Follow the terminal markings - many DC devices are polarity-sensitive.
- 3. Keep it OFF until commissioning tests are done.

Common mistakes

- Using an AC breaker on the PV side.
- Swapping + and − on a polarity-marked DC breaker.
- Opening a DC connector (MC4) under load instead of using the isolator (dangerous arc).

Reference: Book §79, §80, §109; IEC 60947-3

DC surge protector (SPD)

Nepal has frequent lightning in the pre-monsoon. A surge protector diverts lightning-induced voltage spikes on the panel cables to earth before they destroy the inverter.

Types

Type	How it works	Good	Bad	Best for
Type 2 PV SPD	Varistors that conduct to earth during a surge	Protects against induced surges	Wears out after big surges (indicator turns red)	All rooftop systems [modern practice]
Type 1+2 SPD	Handles part of a direct strike current	Needed with a lightning rod on the building	Dearer	Buildings with lightning protection

Best for your system

Ucpv ≥ 150 V DC, In ≥ 20 kA.

How to select (your numbers)

- Ucpv (max continuous PV voltage) ≥ 54 V DC.
- In ≥ 20 kA (8/20 µs), with a status window.
- Your panel-to-inverter cable is 10 m: because it is 10 m or more, fit a SECOND DC SPD in a box near the panels as well as the one at the inverter (IEC 61643-32 practice).
- Nepal recorded 237 lightning deaths in 2021-2025 (Koshi and Lumbini worst) - do not skip surge protection.

When buying, check

- Marked 'PV' or 'DC' with Ucpv; IEC 61643-31.
- Replaceable cartridges with a visual indicator.

How to connect

- 1. Connect it after the DC isolator (between isolator and inverter), + and − to the SPD, its earth terminal to the earth bar with short (< 0.5 m), straight 6 mm² cable.
- 2. Check the window colour every month.

Common mistakes

- Long, looped earth lead (makes the SPD useless).
- Using an AC SPD on DC.

Reference: IEC 61643-31; IEC 60364-7-712 [modern]

Charge controller (MPPT)

In an off-grid system the controller sits between the panels and the battery. It charges the battery safely and stops overcharging. An MPPT type also converts the high panel voltage down to battery voltage without wasting it.

Types

Type	How it works	Good	Bad	Best for
MPPT	Finds the panel's best working point and converts voltage down	About 20-30 % more energy than PWM (book §90); allows high-voltage strings and thinner cable	Dearer	All systems above about 120 W (book §90)
PWM	Simply connects/disconnects panels to the battery	Very cheap	Panel voltage must match battery; wastes ~25 % (book §58)	Tiny 12 V lighting kits

Best for your system

MPPT controller: 30 A, 24 V battery, PV max 150 V, efficiency ≥ 95 %, battery-type setting for LiFePO4 (lithium).

How to select (your numbers)

- Charge current rating ≥ 29 A (array W ÷ battery V × 1.25).
- Battery voltage 24 V; max PV input voltage ≥ 54 V (your cold string Voc) - your input limits: max 150 V, MPPT 34-146 V.
- Has a LiFePO4/lithium battery setting (or user-programmable voltages).
- Efficiency ≥ 95 % (NEPQA-2025).
- NEPQA-2025 allows PWM controllers only below 20 A; above that use MPPT (efficiency ≥ 95 %, PWM ≥ 90 %) - NEPQA-2025 (AEPC, Aug 2025) and Amendment-1 (Apr 2026).
- Keep the coldest-morning string Voc at or below about 95 % of the controller's maximum PV voltage.

When buying, check

- Datasheet: max PV Voc, max PV current, rated charge current, battery voltages, efficiency.
- Real MPPT: has a large heatsink and a stated tracking efficiency; fake 'MPPT' units are often PWM inside (very light, no input-voltage range above battery voltage).
- Buy from any brand listed/certified under NEPQA-2025 (AEPC); always ask the seller for the datasheet.

How to connect

- 1. ALWAYS connect the BATTERY to the controller first (so it detects the system voltage), then the panels. Disconnect in the reverse order: panels first, then battery (book §107).
- 2. Battery cable from controller to battery busbar through a fuse/breaker (see cable schedule).
- 3. Set the battery type/voltages before turning on the panel isolator (see Skills: configure the charger).

Common mistakes

- Connecting panels before the battery (can damage the controller).
- PV voltage above the controller's max on a cold morning (destroys it).
- Wrong battery type setting.

Reference: Book §58, §90, §107; NEPQA-2025 §1.3

Inverter

The inverter turns DC (from panels or battery) into normal 230 V, 50 Hz AC for your appliances. It is the most important electronic box in the system.

Types

Type	How it works	Good	Bad	Best for
On-grid / grid-tied	Panels → inverter → house and NEA grid; no battery	Cheapest per kW, most efficient	Switches OFF in power cuts (anti-islanding safety)	Lowering the bill where cuts are rare
Hybrid	Panels + battery + grid in one box; backup output for chosen loads	Saves bill AND gives backup in load-shedding [modern]	Dearer; needs a separate backup DB	Most Nepali homes with power cuts
Off-grid (stand-alone)	Battery → inverter → house; panels charge via controller	Works with no grid at all (book §91)	Battery must cover everything	Remote sites
Modified/square wave	Rough stepped AC (book §91)	Cheap	Fridges, fans and electronics overheat or hum	Avoid

Best for your system

A pure-sine off-grid inverter fed from the battery, with an MPPT controller for the panels: 0.5 kW continuous, surge ≥ 0.2 kW, 24 V DC input, pure sine 230 V 50 Hz.

How to select (your numbers)

- Continuous power ≥ 280 W (your design: everything that runs at once × 4/3 rule, and/or the array size).
- Surge (peak) rating at least 2-3× the running power of your largest motor (fridge, pump) - check the appliance labels (book §91).
- DC input 24 V (your battery voltage).
- Pure sine wave, 230 V 50 Hz; efficiency ≥ 95 % peak (≤ 5 kVA) / ≥ 97 % (> 5 kVA) per NEPQA-2025.

When buying, check

- Datasheet: continuous W, surge W (and for how many seconds), PV max V, MPPT range, MPPT current, battery V, efficiency, IP rating (IP65 if outdoors), warranty ≥ 5 years (NEPQA).
- For grid-tied/hybrid: anti-islanding certificate (IEC 62116 / IEC 62109) - NEA requires it.
- Service centre in Nepal and spare parts; app/Wi-Fi monitoring.
- Buy from any brand listed/certified under NEPQA-2025 (AEPC); always ask the seller for the datasheet.
- Grid-tied: test certificates IEC 61727, IEC 62116 (anti-islanding), IEC 62109-1/-2 (+ IEC 61683, IEC 61000 EMC per Amendment-1); efficiency ≥ 95 % (≤ 5 kVA) / ≥ 97 % above; IP65; built-in meter and data logger; warranty ≥ 5 years - NEPQA-2025 (AEPC, Aug 2025) and Amendment-1 (Apr 2026).
- Battery/hybrid inverters: efficiency ≥ 90 % (transformerless), must survive 150 % load for 2 s, hybrid must charge from solar first; warranty ≥ 3 years up to 5 kVA - NEPQA-2025 (AEPC, Aug 2025) and Amendment-1 (Apr 2026).

How to connect

- 1. Mount on a solid wall, indoors and ventilated if possible, out of direct sun, with 30 cm free space around (book §124).
- 2. Connect in this order with everything OFF: earth (PE) first → battery cables (through fuse/isolator) → AC output to the backup/main DB → PV through the DC isolator.
- 3. Tighten terminals to the manual's torque; double-check polarity on DC.
- 4. Configure settings (battery type, grid code 230 V/50 Hz) before first start (see Skills).

Common mistakes

- Undersizing the surge rating (fridge/pump won't start).
- Mounting in a hot, closed room or in sun.
- Buying a 'modified sine' inverter.
- Grid-tied inverter expected to work in power cuts - it won't.

Reference: Book §81-§83, §91, §124; NEPQA-2025 §1.4-§1.5; IEC 62109/62116

Battery bank

The battery stores energy for the night and for power cuts. It is the most expensive part to replace, so choosing and treating it well matters most.

Types

Type	How it works	Good	Bad	Best for
LiFePO4 (lithium iron phosphate) [modern]	Lithium cells + built-in BMS	Use 80-95 % of capacity, 3,000-6,000+ cycles, light, no topping up	Higher first cost; must not be charged below 0 °C	Almost all new systems
Tubular lead-acid (flooded)	Liquid acid, tall tubular plates (book §89)	Cheap, widely repaired	Use only ~50 %; distilled water top-ups; acid fumes; 4-8 years	Tight budgets with a ventilated space
AGM / gel (sealed lead-acid)	Sealed, no topping up (book §89)	No maintenance	Short life when deeply cycled; ~50 % usable	Small loads

Best for your system

LiFePO4 with a built-in BMS, LiFePO4 24 V 100 Ah with BMS, ≥ 3000 cycles @ 80 % DoD, round-trip ≥ 85 %, warranty ≥ 5 yr, communication with inverter (CAN/RS485) - quantity 1.

How to select (your numbers)

- System voltage 24 V; capacity at least 89 Ah at 24 V (usable energy needed 1,926 Wh).
- Depth of discharge used in the design: 90 %.
- Same voltage as the inverter/controller battery input; communication cable (CAN/RS485) compatible with the inverter for lithium.
- Your site can reach -15 °C: keep a lithium battery INDOORS in a room that stays above 5 °C, or choose a battery with self-heating; otherwise it must not charge on cold mornings.
- Lithium (LiFePO4) must only be CHARGED between about 0 °C and 50 °C (some makers say 5 °C) - charging below freezing permanently damages it (Pylontech US5000 operation manual (2024); Victron).
- Never connect 48 V lithium modules in SERIES - only in parallel, and at most the number the maker allows per group (Pylontech US5000 operation manual (2024)).
- Before joining modules in parallel, bring them to the same voltage (charge each fully) and let them rest at least 15 minutes.

When buying, check

- NEPQA-2025 (lithium): ≥ 3,000 cycles at 80 % DoD, round-trip efficiency ≥ 85 %, BMS, warranty ≥ 5 years.
- Datasheet: nominal V, Ah, kWh, max charge/discharge current, cycle life at stated DoD, operating temperature.
- Signs of poor batteries: weight much lower than datasheet, no cell grade/BMS data, re-labelled cells, no local warranty service.
- Buy from any brand listed/certified under NEPQA-2025 (AEPC); always ask the seller for the datasheet.
- NEPQA-2025: lithium ≥ 3000 cycles at 80 % DoD (≥ 2000 below 2 kWh), BMS with cell protection, round-trip efficiency ≥ 85 %, warranty ≥ 5 years; 12 V lead-acid ≥ 1200 cycles, warranty ≥ 3 years; test reports IEC 62619 / IEC 61427 / IEC 60896 - NEPQA-2025 (AEPC, Aug 2025) and Amendment-1 (Apr 2026).
- Measured capacity must be 0 to +20 % of the label, never less (NEPQA-2025) - ask the seller to show a discharge test or check it yourself in the first weeks via the inverter's energy counter.

Series or parallel?

Your bank is 1 module(s) in series × 1 in parallel of 24 V 100 Ah = 24 V, about 2.4 kWh. In SERIES the voltages add (Ah stays the same): e.g. two 12 V batteries in series = 24 V. In PARALLEL the Ah add (voltage stays the same). Use identical batteries of the same age and charge level - a weak one drags the others down and can overheat (book §89, §107).

How to connect

- 1. Place batteries on a stand off the floor, in a cool, dry, ventilated place, away from children (book §125).
- 2. Make the series/parallel links with the short cables supplied or equal-length cables of the bank's size.

- 3. Connect the bank's + through the battery fuse and isolator to the inverter; − directly (or via isolator).
- 4. Cover terminals with insulated caps; keep metal tools away from the top of the battery.
- 5. Turn the battery's own switch/BMS on only after all cables are tight.

Common mistakes

- Mixing old and new or different-brand batteries.
- Shorting terminals with a spanner (huge current, burns, explosion risk).
- Thin battery cables (they heat up).
- Charging lithium below 0 °C (cold Himalayan sites).

Reference: Book §85-§89, §107, §125; NEPQA-2025 §1.2

Battery cables, lugs, fuse and isolator

Battery cables carry the largest currents in the system, so they are thick and short. A fuse right next to the battery protects them from a short circuit; an isolator lets you switch the battery off.

Types

Type	How it works	Good	Bad	Best for
Flexible copper welding/battery cable	Many fine strands	Bends easily, large current	-	Battery links
NH / ANL / class-T DC fuse	High breaking capacity DC fuse	Safely breaks a battery short circuit	Must be replaced after blowing	Battery +
Automotive blade fuse	Low breaking capacity	Cheap	Can explode on a battery short	Never on the main battery cable

Best for your system

10 mm² flexible copper, 32 A NH/ANL/class-T DC fuse, 32 A, 24 V DC rated.

How to select (your numbers)

- Cable 10 mm² (current rule 6 mm², voltage-drop rule 10 mm²), length 1.5 m (keep it short), design current 22.9 A.
- Fuse 32 A DC, high breaking capacity, as close to the battery + as possible.
- Isolator/DC breaker rated ≥ 32 A at 24 V DC.
- A 48 V lithium module can push about 2,500 A into a short circuit: the battery fuse/breaker must be DC-rated with a breaking capacity of at least 10 kA (1-4 modules) or 20 kA (5-8 modules) - Pylontech US5000 operation manual (2024). Class T fuses (20 kA) meet this; small automotive-style fuses do not.

When buying, check

- Copper (not copper-clad aluminium) - scrape a strand to check colour.
- Lugs sized to the cable AND the terminal bolt; tinned copper.
- Fuse marked with DC voltage and breaking capacity (kA).

How to connect

- 1. Cut cables to length; crimp lugs with a hydraulic crimper (see Skills); cover with heat-shrink (red +, black −).
- 2. Order: battery + → fuse → isolator → inverter/controller +. Battery − → inverter/controller −.
- 3. Tighten to the torque in the battery manual; re-check after one week.

Common mistakes

- Fuse at the inverter end instead of the battery end.
- Loose lugs (they heat and melt).
- Crimping with a hammer.

Reference: Book §87, §109, §110, §125

AC breaker (MCB), RCD and AC surge protector

On the 230 V side the MCB protects the cable from overload, the RCD protects people from electric shock, and the AC surge protector protects appliances from grid and lightning spikes.

Types

Type	How it works	Good	Bad	Best for
MCB (C-curve)	Trips on overload/short	Standard	No shock protection	Every circuit
RCD 30 mA Type A	Trips if current leaks to earth (through a person)	Saves lives; works with inverter DC leakage	-	Solar systems [modern]
RCD Type AC	Older type	Cheap	Can be blinded by DC leakage from inverters	Not recommended with inverters
RCBO	MCB + RCD in one	Saves space	Dearer	Backup DB

Best for your system

6 A, C-curve, 1-pole + N; 30 mA, Type A (Type B if the inverter manual requires); 275 V AC, In ≥ 20 kA.

How to select (your numbers)

- MCB 6 A for the inverter output (inverter current 2.2 A × 1.25, next standard size).
- AC cable 2.5 mm² copper over 5.0 m.
- RCD 30 mA, Type A (Type B only if the inverter manual says so).

When buying, check

- IEC 60898 (MCB), IEC 61008/61009 (RCD/RCBO) printed on the device.
- Breaking capacity ≥ 6 kA.

How to connect

- 1. Mount in a small DB box next to the inverter or in the backup DB.
- 2. Inverter AC output L → MCB → RCD → loads; N through the RCD; PE to the earth bar - never through a breaker.
- 3. Press the RCD 'T' test button after switching on: it must trip.

Common mistakes

- Putting the RCD before the inverter instead of on its output loads.
- Using Type AC RCDs.
- Swapping L and N.

Reference: Book §109; IEC 60364-4-41

Earthing (grounding)

Earthing gives fault and lightning currents a safe path into the ground so metal parts never become dangerous to touch. Every solar system needs it (book §109).

Types

Type	How it works	Good	Bad	Best for
Copper-bonded steel rod	Rod driven 1.5-3 m into moist soil	Long life, easy to test	Needs depth	Most sites
Plate earth pit (copper/GI plate + charcoal/salt)	Traditional Nepali practice	Low resistance in dry soil	Salt corrodes; needs watering	Rocky/dry soil
GI pipe	Galvanised pipe in a pit	Cheap	Rusts in 5-10 years	Temporary

Best for your system

Copper-bonded rod ≥ 1.5 m (or copper plate earth pit per local practice), inspection pit; cables: 6 mm² frame bonding, 16 mm² to electrode, 2.5 mm² PE.

How to select (your numbers)

- PV frames/rails bonded with 6 mm² green-yellow copper; main earth to the electrode 16 mm²; inverter/DB PE as in the cable schedule.
- Bond the PV earth to the house's existing earth (one earthing system for the building).
- AEPC's own specification: at least TWO earth electrodes (pipe-in-pipe or copper-bonded rod) each ≥ 2.5 m long, 2.5 m

apart, each with ~30 kg earth-enhancing compound and a concrete inspection pit; bonding conductors 6 mm² (frames) / 16 mm² copper; electrodes linked with 50 mm² bare copper buried 0.5 m deep - AEPC 2 kWp institutional PV bidding specification (earthing clause).

- Target earth resistance 10 Ω or less (AEPC PV spec); lightning-protection earths are often required ≤ 5 Ω - AEPC 2 kWp institutional PV bidding specification (earthing clause).
- Hill sites in Nepal measured 39-226 Ω before improvement (AEPC Dhading tender): always measure, and add electrodes or compound until the target is met.

When buying, check

- Green-yellow copper cable, bronze/brass clamps, an inspection pit with a removable cover.

How to connect

- 1. Choose moist ground near the building, away from the septic tank.
- 2. Drive the rod, fit the clamp, build a small inspection chamber.
- 3. Run the 16 mm² cable to the main earth bar; connect PV frame bonding, inverter PE, SPD earths to the bar.
- 4. Test the earth resistance (see Skills) and write the value in the commissioning record.

Common mistakes

- No earth at all ('the inverter has one inside').
- Earth through a water pipe.
- Painted surfaces under earth clamps (no contact).

Reference: Book §109; IEC 60364-5-54; IEC 62305 (lightning)

Lightning protection

A lightning rod system is only needed when the building is tall or exposed (hilltop, the tallest roof around) or already has one. Surge protectors are needed in every case.

Types

Type	How it works	Good	Bad	Best for
Surge protectors only	DC + AC SPDs	Cheap, protects electronics	Does not protect against a direct strike	Most houses
Lightning rod (air terminal) + down conductor	Intercepts a direct strike	Protects the building	Must be designed (IEC 62305)	Exposed buildings

Best for your system

Surge protectors on DC and AC (already in your list). Add a lightning rod only if your building is exposed - keep panels at least 0.5-1 m from the rod's down conductor or bond them as its designer specifies.

How to select (your numbers)

- If your house has a lightning rod, use Type 1+2 SPDs instead of Type 2.

When buying, check

- IEC 62305 rated components.

How to connect

- 1. Never run PV cables alongside the lightning down conductor.

Common mistakes

- Assuming SPDs stop direct strikes.

Reference: IEC 62305; IEC 61643 [modern]

Monitoring (Wi-Fi dongle / app)

Most modern inverters send their data to a phone app. You see daily energy, battery charge and any fault codes, so you catch problems early.

Types

Type	How it works	Good	Bad	Best for
Wi-Fi/LAN data logger	Plugs into the inverter's COM port	Phone app, alerts	Needs Wi-Fi at the inverter	Every system [modern]
Inverter display only	LCD on the unit	Free	No history	Off-grid sites

Best for your system

Buy the inverter maker's own logger (Wi-Fi) and register the system in its app on day one.

How to select (your numbers)

- Make sure Wi-Fi reaches the inverter location.

When buying, check

- Logger model listed for your inverter model.

How to connect

- 1. Plug the logger in, connect it to home Wi-Fi from the app, check readings match the inverter display.

Common mistakes

- Never checking the app - most failures show there first.

Reference: [modern]

Tools and safety gear

Having the right tools makes the job safe and the connections reliable.

Types

Type	How it works	Good	Bad	Best for
Essential	-	-	-	-

Best for your system

Buy or borrow these before you start.

How to select (your numbers)

- Digital multimeter rated CAT III 1000 V DC (to measure your string voltage safely).
- MC4 crimp tool + MC4 spanners; cable cutter and stripper for 2.5-6 mm².
- Hydraulic lug crimper for 10 mm² cable (if you have a battery).
- Insulated screwdrivers and spanners (1000 V), torque wrench.
- Drill with masonry bits, spirit level, phone angle app, measuring tape, marker and cable labels.
- Safety: insulated gloves, safety glasses, non-slip shoes, harness/rope for roof work, opaque sheet to cover panels.

When buying, check

- Multimeter must show the CAT rating and 1000 V DC on the case.

How to connect

- 1. Check every tool before climbing the roof; never work alone on a roof.

Common mistakes

- Cheap multimeters without CAT rating on PV strings.

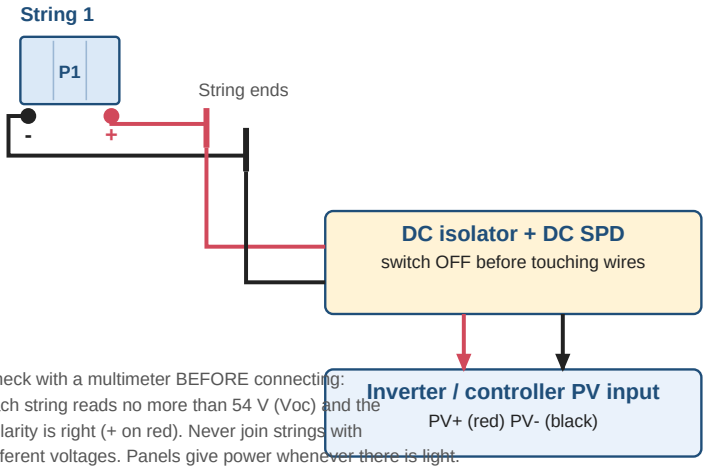
Reference: Book §117-§118

D. Series and parallel - your panels and batteries

Your panels: how to connect them

How to connect your panels

Each string: 1 panel(s) in SERIES (+ of one panel to - of the next): voltages add, 1 x 41.6 V = 42 V working (up to 54 V on a cold morning).
Current stays the same through a string: about 14.0 A maximum (Isc).
Panel: 550 W panel. Cable: 10 mm2 solar cable, red for +, black for -.

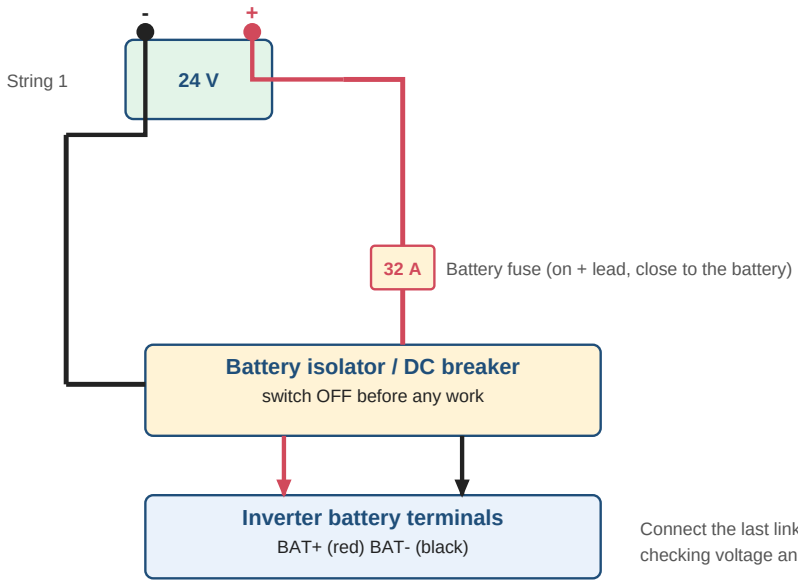


Check with a multimeter BEFORE connecting: each string reads no more than 54 V (Voc) and the polarity is right (+ on red). Never join strings with different voltages. Panels give power whenever there is light.

Your battery bank: how to connect it

How to connect your batteries

1 module(s) in SERIES per string (+ of one to - of the next): 1 x 24 V = 24 V.
Bank: 24 V, 2.4 kWh. Module: 24 V 100 Ah. Cable: 10 mm2, crimped lugs.
Use the same model and age for every module; make all links the same length; tighten to the datasheet torque.



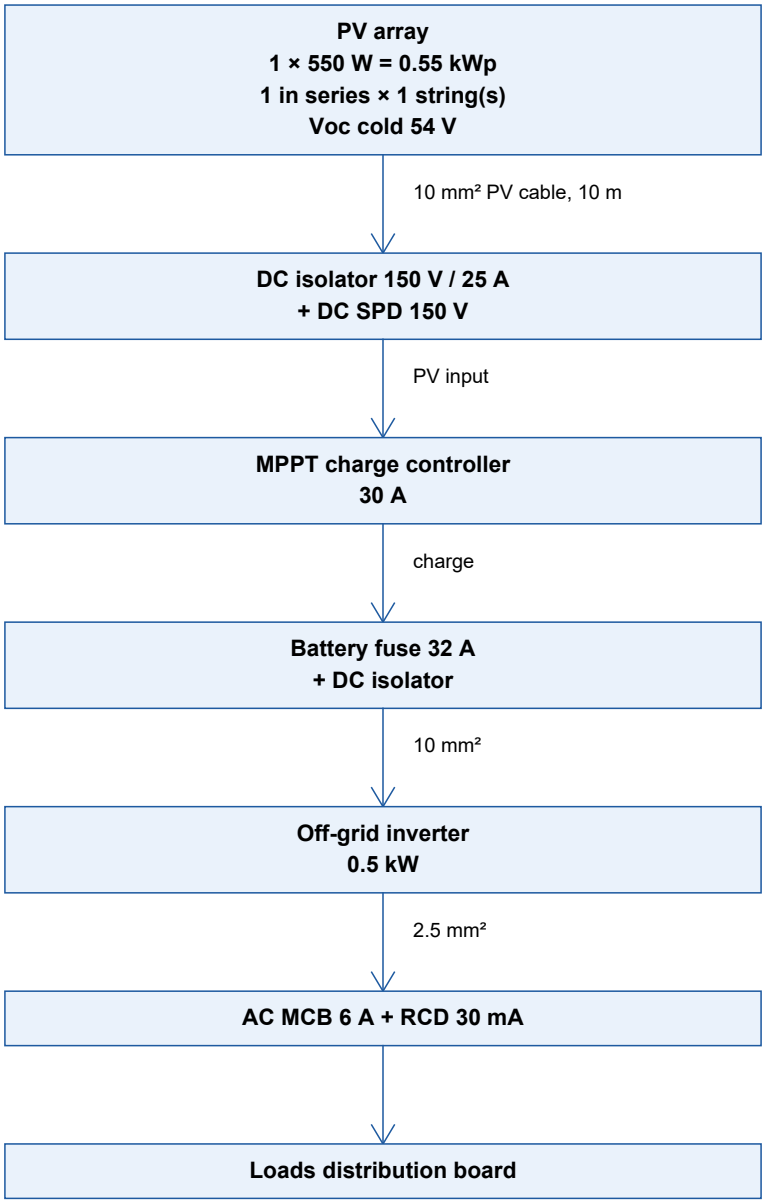
- SERIES (+ of one to − of the next): voltages add, current stays the same. PARALLEL (+ to +, − to −): currents add, voltage stays the same. Power = volts × amps either way.
- 1 panels in series per string × 1 string(s). String voltage: about 42 V working, 50 V open-circuit at 25 °C, up to 54 V on the coldest morning (-15.0 °C) and down to 37 V working on a hot afternoon. Your MPPT charge controller accepts: max 150 V, MPPT 34-146 V. Allowed string length for your equipment: 1 to 2 panels.
- Too many panels in series → cold-morning voltage above the inverter limit → the inverter is destroyed (not covered by warranty). Too few → voltage below the MPPT window on hot days → the inverter stops or harvests little.
- Every string joined in parallel must have the same number of the same panels facing the same way; otherwise the strings

fight each other and the system loses power.

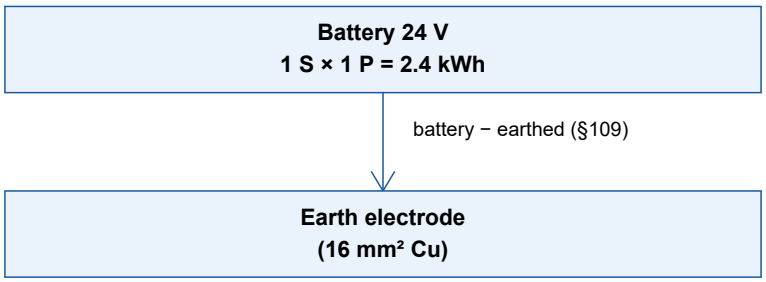
- 1 in series × 1 in parallel = 2.4 kWh. Series raises voltage to match the inverter; parallel adds Ah (hours of backup). Use identical batteries; for parallel strings take + from the first battery and − from the last (diagonal), with equal-length links (book §107).

E. Your whole system, drawn

Path 1



Path 2



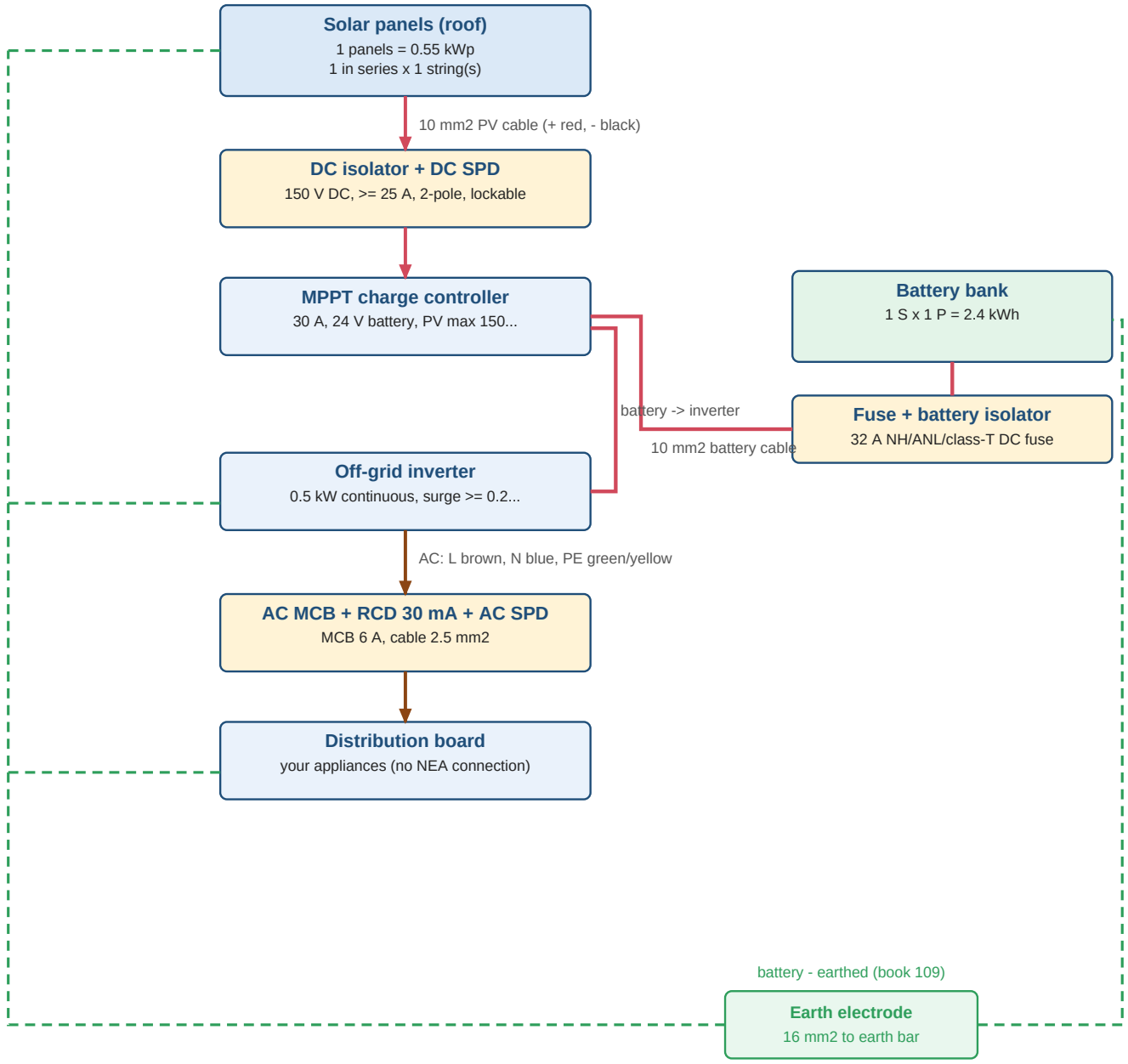
Every connection (wire from this table)

From	To	Cable / protection
PV array	DC isolator 150 V / 25 A	10 mm² PV cable, 10 m
PV array	Earth electrode	6 mm² frame bonding
Battery 24 V	Battery fuse 32 A	10 mm², 1.5 m
Battery 24 V	Earth electrode	battery − earthed (§109)

From	To	Cable / protection
DC isolator 150 V / 25 A	MPPT charge controller	PV input
MPPT charge controller	Battery fuse 32 A	charge
Battery fuse 32 A	Off-grid inverter	10 mm²
Off-grid inverter	AC MCB 6 A + RCD 30 mA	2.5 mm²
AC MCB 6 A + RCD 30 mA	Loads distribution board	
Off-grid inverter	Earth electrode	2.5 mm² PE

Complete system

Your whole system - Off-grid system

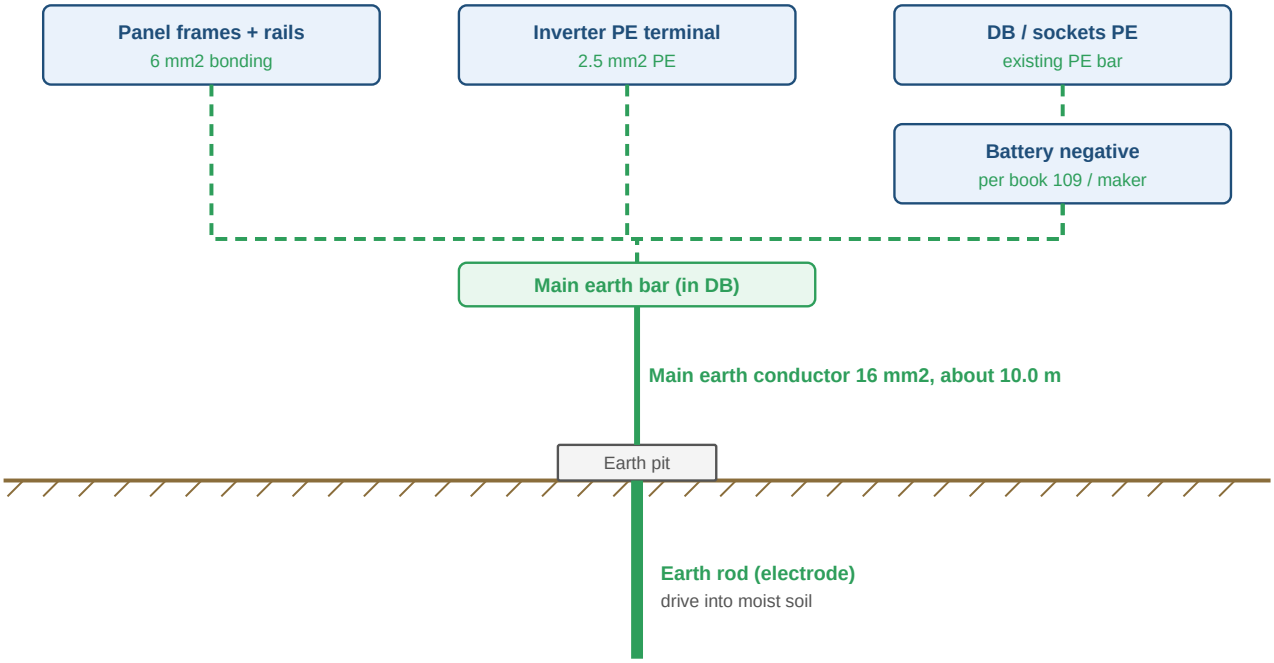


Dashed green = earth wires (green/yellow insulation).

Earthing

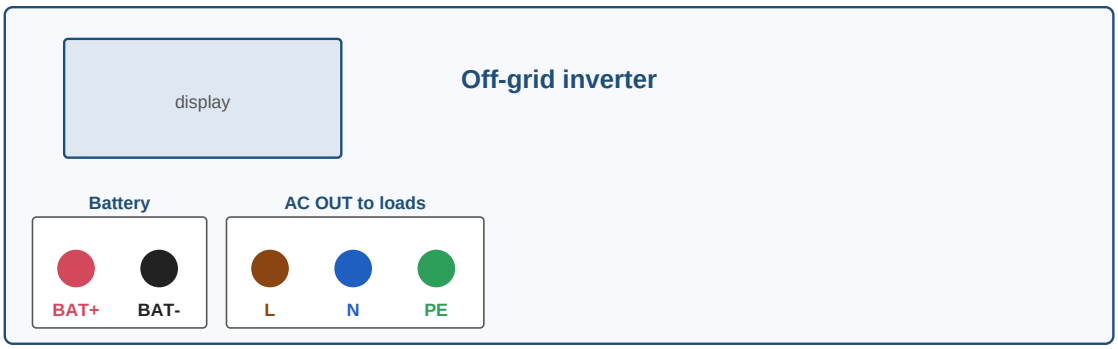
How to earth your system

All metal parts and the earth bar connect to ONE earth electrode. Use green/yellow cable only.
Measure the earth resistance after installation and write it in the test record.

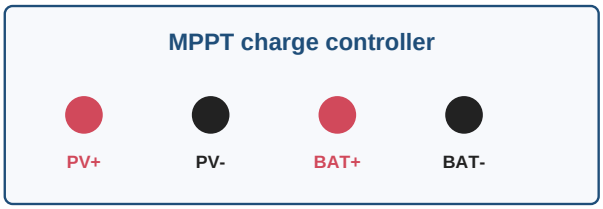


Inverter terminals - what goes where

Inverter terminals - what goes where



Colours: DC + red, DC - black. AC: L (line) brown, N (neutral) blue, PE (earth) green/yellow.
Check YOUR model's manual: terminal positions and labels vary between makes.
Connect in this order: earth (PE) first, then battery, then AC, then PV last; switch on battery -> inverter -> PV.



Connect the controller to the battery FIRST, then the panels (most controllers need battery voltage to start).

Wire colours: AC live brown, neutral blue, earth green-yellow; DC + red, - black.

F. Cables, fuses and breakers

Circuit	From → To	Length (m)	Design current (A)	Protective device (A)	Size for current (mm²)	Size for voltage drop (mm²)	Chosen (mm²)	Voltage drop (%)
PV string cable (each string, + and −)	Array → MPPT charge controller	10.0	17.5	17.5	2.5	10	10	1.39
Battery cable (+ and −)	Battery bank → fuse/isolator → inverter	1.5	22.9	32	6	10	10	0.63
Controller → battery	Charge controller → battery busbar	1.5	24.0	30	4	10	10	0.66
Inverter AC output	Inverter → distribution board	5.0	2.2	6	1.5	0.75	2.5	0.08
PV frame bonding (earth)	Each panel frame / rail → earth bar	-	-	-	-	-	6	-
Main earthing conductor	Main earth bar → earth electrode	10.0	-	-	-	-	16	-
Inverter / DB protective earth (PE)	Inverter → DB earth bar	5.0	-	-	-	-	2.5	-

Chosen size = the larger of the current-rating size and the voltage-drop size.

G. Safety first, and the legal stop-points

- Panels produce dangerous DC voltage whenever there is daylight - there is no off switch on a panel (§119, §132).
- Never unplug MC4 connectors or open a DC fuse holder while current flows - switch off the isolator first.
- A battery short circuit releases huge current: fire, burns, explosion. Fuse it, insulate tools, remove jewellery.
- Work at height only with a ladder footed by a helper, a harness on steep roofs, and never in rain or wind.
- Lead-acid batteries contain acid and release hydrogen - ventilate, no flames, wear goggles and gloves.
- Connecting to the NEA grid needs NEA approval and NEA's bidirectional meter; never back-feed the grid without approval (danger to line workers). House wiring at 230 V can kill: switch the main switch OFF, or use a CTEVT-certified electrician if you are not confident.
- Use NEPQA-2025 compliant equipment (AEPC) so warranties and any subsidy remain valid.
- House wiring (230 V AC): no Nepali law requiring a licensed electrician for house or solar wiring was found (only CTEVT/NSTB skill certificates exist). You may do it yourself if you follow this report exactly and test the RCD and earth afterwards - but 230 V AC can kill: if you are not confident, have a CTEVT-certified electrician do the AC connection while you watch, and check their work against this report.
- Everything on the DC side (panels, mounting, DC cables, isolator, SPD, battery) can be done by a careful owner following this report, but panels are live whenever light falls on them - cover them while wiring.
- If anything gets hot, smells of burning, or the display shows an earth/insulation fault: switch off in the shutdown order and do not restart until the cause is found.

H. Skills you will need (learn these before starting)

Using a multimeter safely

- 1. Why: You will check voltage and polarity before every connection - it is the installer's most important tool.
- 2. Set the dial to DC volts (V with a straight line), range above 1000 V if manual-ranging.
- 3. Black probe in COM, red probe in V/Ω. Never use the 10 A / mA socket for voltage.
- 4. Panel test: in sun, touch red to the panel + and black to −. Expect about 49.5 V (the panel's Voc). A minus sign means the probes are reversed.
- 5. String test: with the DC isolator OFF, measure the whole string's + and −. Expect roughly 50 V at 25 °C (higher on a cold morning, up to 54 V). Write it in the commissioning record.
- 6. Continuity test (beep mode) only on cables that are disconnected at both ends.
- 7. Never measure current by putting the probes across a battery or a string - that is a short circuit.
- 8. Safety: Use a CAT III 1000 V DC meter with good probes.
- 9. Safety: Keep fingers behind the probe guards.

Assembling and crimping MC4 connectors

- 1. Why: Badly made MC4 joints are the most common cause of solar fires (book §120 stresses good connections).
- 2. Strip about 7 mm of insulation without nicking the copper strands.
- 3. Insert into the metal pin; crimp with an MC4 crimping tool in the matching die (4 or 6 mm²).
- 4. Pull hard on the pin - it must not move.
- 5. Push the pin into the housing until it clicks; tighten the back nut with MC4 spanners.
- 6. Male pin goes in the female housing for one polarity - follow the panel's own plugs: + lead gets the connector that mates with the panel's − lead plug, and vice versa.
- 7. Check polarity with the multimeter before plugging in.
- 8. Safety: Never plug/unplug MC4 connectors while current flows - open the DC isolator first.
- 9. Safety: Never mix connector brands.

Fixing the frame to the roof and waterproofing

- 1. Why: The frame must survive monsoon storms and the roof must not leak (book §123).
- 2. RCC flat roof: mark positions, drill with a masonry bit, clean the dust, set anchor bolts (chemical or expansion), apply waterproof sealant around each one and over the base plate edges.
- 3. Tin / sloping roof: locate the purlins, use roof hooks or feet screwed into the purlins with EPDM washers and roofing sealant; never fix to the sheet alone.
- 4. Check the tilt with a phone angle app and that rails are straight before fixing panels.
- 5. Pour water around fixings after installation and check inside for leaks.
- 6. Safety: Use a harness on sloping roofs and keep away from roof edges.
- 7. Safety: Never work on a wet roof.

Cable routing, conduit and labelling

- 1. Why: Neat, protected cables last 25 years; labels keep the next person safe.
- 2. Run + and − of each circuit together in UV-proof conduit or tied to the rails.
- 3. Use cable glands where cables enter boxes; leave drip loops so water runs off.
- 4. Label: 'SOLAR DC - LIVE IN DAYLIGHT' at the isolator, inverter and DB; 'Two power sources' at the DB and meter; circuit names on every breaker.
- 5. Safety: Keep DC and AC cables apart where possible.
- 6. Safety: No joints inside walls.

Measuring earth resistance

- 1. Why: A good earth makes fault and lightning protection work.
- 2. Best: an earth resistance tester (3-pole method) - hire one or ask the electrician; record the value.
- 3. Target: as low as practical and within your local electrical rules (ask the electrician/NEA what value they require) - add a second rod if it is high.
- 4. Simple check without a tester: the RCD must trip when its test button is pressed, and the multimeter should show near 0

Ω continuity between each panel frame and the earth bar (system OFF).
- 5. Safety: Disconnect the earth conductor only with the whole system OFF.

Crimping battery lugs and tightening terminals

- 1. Why: Battery currents are large; a loose or badly crimped lug gets hot enough to melt (book §125).
- 2. Cut the 10 mm² cable square; strip exactly the lug barrel depth.
- 3. Insert fully, crimp with a hydraulic crimper using the die for that cable size (two crimps for big lugs).
- 4. Slide on heat-shrink (red +, black −) and shrink it with a hot-air gun.
- 5. Tighten terminal bolts with a torque wrench to the battery manual's value; re-check after one week.
- 6. Safety: Remove rings and watches; use insulated spanners.
- 7. Safety: Connect the − cable last, disconnect it first.
- 8. Safety: Never lay tools on top of batteries.

Setting up the inverter / charger for your battery

- 1. Why: Wrong charge settings shorten battery life or damage it.
- 2. Select the battery type in the menu: 'LiFePO4/Lithium' (use the battery's communication mode CAN/RS485 if both support it) or 'Flooded/AGM' for lead-acid.
- 3. If you must enter voltages manually, copy them from the BATTERY datasheet: charge (absorption) voltage, float voltage, low-voltage cut-off, max charge current.
- 4. Typical values for a 48 V (16-cell) LiFePO4 battery, ONLY if the datasheet gives none: charge about 54-56 V, cut-off about 46-48 V; never above 57.6 V = 3.6 V per cell (NEPQA-2025 high-voltage disconnect). For 24 V divide by 2.
- 5. Set the maximum charge current at or below the battery's recommended value.
- 6. Hybrid: set the backup reserve (e.g. keep 30-50 % for power cuts) and the grid charging on/off.
- 7. Safety: Typical values are a fallback only - the battery datasheet always wins.

First switch-on and safe shutdown

- 1. Why: The order protects the electronics (book §107, §126-§128).
- 2. Switch ON: battery isolator → inverter → (wait for battery detection) → PV DC isolator → AC output breaker → loads one by one.
- 3. Check the display: PV voltage close to your string voltage, battery voltage, no fault codes.
- 4. Shutdown: loads/AC breaker OFF → PV DC isolator OFF → inverter OFF → battery isolator OFF.
- 5. Safety: Never open the battery isolator while the inverter is running heavy loads.

Monthly self-check (10 minutes)

- 1. Why: Catches problems before they become expensive (book §131-§139).
- 2. Compare this month's energy in the app with the expected monthly figure in your report.
- 3. Look at panels for dirt, bird droppings, cracks; clean with water and a soft brush early morning.
- 4. Check SPD windows (green = OK), smell/heat at terminals, loose cables, rust on the frame.
- 5. Press the RCD test button.
- 6. Battery: no swelling, terminals clean and tight.
- 7. Safety: Do not hose panels in hot afternoon sun (thermal shock); never use detergent or pressure washers.

I. Step-by-step installation

1. Before you start - safety and tools (§118-§120)

- 1. Read every manual (inverter/controller, battery) first - the settings matter as much as the wiring.
- 2. Tools: digital multimeter (DC up to 1000 V), DC clamp meter, insulated screwdrivers, crimping tool for MC4 and battery lugs, torque wrench, drill, spirit level, compass (phone app), ladder or scaffold.
- 3. Protection: insulated gloves (Class 0 for arrays above 500 V, Class 00 below), safety glasses, safety shoes, harness for roof work. Keep a first-aid kit; for lead-acid add eye wash and acid spill kit.
- 4. Never work alone on a roof. Keep children and animals away and tell people nearby you are working with high voltage.
- 5. Remove rings, watches and bracelets before touching batteries - a short circuit can weld metal.

2. Site check (§63-§73, §121)

- 1. Confirm the roof spot is free of shade from about 9 am to 3 pm all year (trees, water tanks, neighbouring floors - Nepali rooftops grow!).
- 2. Check the roof can carry the panels and frame; on tin roofs fix into the purlins, never only the sheet.
- 3. Choose the inverter/battery place: dry, shaded, ventilated, close to the battery (within ~1-2 m, §125) and near the distribution board. Batteries off a cold concrete floor on a shelf (§124).
- 4. Mark the cable route and the earth-pit location.

3. Mount the structure and panels (§123)

- 1. Fix the tilt frame facing due south at the designed tilt; tighten all bolts.
- 2. Unpack each panel and look for cracked glass; measure each panel's open-circuit voltage in sun - expect about 49.5 V (cooler days higher).
- 3. Clamp the panels to the rails (end clamps at row ends, mid clamps between panels).
- 4. Keep panels covered with an opaque sheet, or leave the strings unconnected, while you wire - panels make electricity whenever light falls on them.

4. Wire the PV strings and check polarity (§106, §123)

- 1. Connect 1 panels in series per string (+ of one to − of the next) using the panel leads.
- 2. Make 1 string(s). Use only matching MC4 connectors, crimped with the proper tool.
- 3. Measure each string's open-circuit voltage before going further: expect about 50 V at 25 °C (up to 54 V on a cold morning). All strings should read within ~2 % of each other.
- 4. Check polarity with the meter (red + / black −). A reversed string can destroy the inverter.
- 5. Run the PV cables (10 mm² red and black) in UV-resistant conduit to the DC isolator; keep + and − close together to limit loops (lightning).
- 6. Leave the DC isolator OFF.

5. Earthing (§109, §121, §124)

- 1. Make the earth pit/rod and connect a 16 mm² green/yellow cable to the main earth bar.
- 2. Bond every panel frame and rail with 6 mm² green/yellow cable (or approved bonding clips).
- 3. Connect the inverter and distribution-board earth terminals to the earth bar.
- 4. For battery systems, earth the battery negative as the inverter manual allows (many LiFePO4 hybrid inverters require it to stay floating - follow the manual).
- 5. Measure and record the earth resistance; improve the pit (deeper rod, second rod) if it is high.

6. Install the battery (§124)

- 1. Place the battery upright on a sturdy shelf, ventilated, away from sparks, sun and children; label it with the installation date.
- 2. Connect 1 module(s) in series and 1 string(s) in parallel with the maker's interconnect cables; use equal cable lengths for parallel strings.
- 3. Tighten every terminal to the torque on the datasheet; protect terminals from short circuits.
- 4. Fit the 32 A battery fuse on the + cable close to the battery, then the battery isolator - leave it OFF.
- 5. Measure the bank voltage: LiFePO4 24 V-class banks rest at about 26-27 V; lead-acid about 25-26 V when charged.

7. Mount the inverter / controller (§125)

- 1. Mount vertically on a non-flammable wall with the clearances in its manual (it gets hot).
- 2. Connect the battery cables (10 mm²) to the inverter and controller: negative first, check polarity twice, then positive.
- 3. Connect the PV DC isolator output to the PV input terminals - still with the isolator OFF.
- 4. Set the battery type and voltages in the inverter/controller menu before switching on (§127).

8. AC connection - careful: 230 V can kill (§119, §126)

- 1. The inverter AC output goes through a 6 A MCB, a 30 mA RCD and an AC surge protector to the distribution board.
- 2. Switch OFF the house main switch first. No Nepali licence law for house wiring was found, so you may make this connection yourself following these steps exactly, then press the RCD test button; if you are not confident with 230 V, have a CTEVT-certified electrician do it while you check it against this report.

9. Switch on (§125, §127-§128)

- 1. Turn ON the battery isolator - the inverter/controller should wake up and show battery voltage.
- 2. Turn ON the PV DC isolator in daylight - check the PV voltage and charging/feeding power on the display.
- 3. Turn ON the AC MCB and test with a small load such as a lamp.
- 4. Shutdown order is the reverse: AC MCB off → PV isolator off → battery isolator off. Never open DC connectors under load.

10. Commissioning tests and first week (§127-§128, IEC 62446)

- 1. Fill in the commissioning record table in this report (expected values are given).
- 2. Insulation test of each string to earth at 250 V: minimum 0.5 MΩ.
- 3. Check the inverter reconnects after a grid interruption (anti-islanding test).
- 4. For battery systems, let the battery charge fully for a day before heavy use (§128).
- 5. Watch the daily kWh for a week; compare with the monthly estimate in this report.

J. Testing before switching on (write the measured values)

Test	Expected	Measured	OK?
String 1 open-circuit voltage (Voc)	≈ 50 V at 25 °C (max 54 V cold)		
String 1 short-circuit current (clamp meter, sunny)	≤ 14 A (≈ Isc × sunlight/1000 W/m²)		
Polarity of every string and the battery	Correct (+ to +)		
Insulation resistance, string + and − to earth	≥ 0.5 MΩ		
Earth electrode resistance	As low as practical - record value		
Battery bank voltage at rest	24-28 V		
Inverter AC output voltage / frequency	230 V ±10 %, 50 Hz (NEPQA)		
RCD trip test button	Trips		

K. Looking after the system

When	Task
Weekly	Glance at the inverter/controller display: daily kWh, battery state, any fault codes; keep a simple logbook (§139).
Monthly (dry season: Oct-May)	Clean panels early morning with soft brush and plain water - Nepal dust and brick-kiln soot cut output; no detergent abrasives.
Monthly	Check battery area: ventilation, no leaks, dust off battery tops; LiFePO4: check BMS alarms. Lead-acid: water level (§139).
Before monsoon	Check roof fixings, conduit seals and junction boxes for water ingress; clear drains around the earth pit.
Every 6 months	Re-torque battery and DC terminals (power off); look for hot or discoloured connectors; test the RCD button.
Yearly	Measure string voltages and compare with the commissioning record; test earth resistance; check SPD status windows; balance lead-acid batteries (§139).
After lightning / storm	Check SPD indicators and replace tripped cartridges; inspect panels for damage.

L. If something goes wrong

Symptom	Likely cause	What to check
Battery runs flat / power cuts off early	Using more energy than designed (§134)	Logbook or inverter daily use vs the design figure; reduce load or add panels/battery.
Lower solar output than expected	Dirt, new shade, wrong angle (§135)	Clean panels; look for new shade (tree, tank, new floor next door); compare string voltages.
Strange or intermittent faults, worse in heat/cold	Loose or damaged connection (§136)	With power off: tighten terminals, inspect MC4s for burn marks, measure voltage drop along cables.
Power fails when a big appliance starts	Inverter surge too small or weak battery (§137-§138)	Compare motor starting current with inverter surge rating; check battery voltage under load.
One battery hotter or lower voltage than others	Failing cell (§137)	Voltage difference > 0.7 V needs balancing; ≥ 2 V means a failed battery - replace it.
Inverter trips on hot afternoons	Overheating / poor ventilation (§138)	Clear space around the inverter, keep it out of direct sun, check its fan.
Inverter trips in rain	Earth leakage / insulation fault (§138)	Insulation-test strings; look for water in junction boxes and damaged cable.
Grid-tied inverter shows 'grid over-voltage' at midday	High NEA voltage plus cable rise	Measure grid voltage; a larger AC cable reduces voltage rise; ask NEA about transformer tap.

References: Boxwell, Solar Electricity Handbook §104-§112 (design, protection), §117-§130 (installation), §131-§139 (troubleshooting, maintenance); IEC 62548-1 (PV array design), IEC 62446-1 (testing), IEC 60364-5-52 (cable current ratings), IEC 60364-7-712 (PV installations); NEPQA-2025 and Amendment-1 (AEPC); Copper/PVC in conduit, IEC 60364-5-52 method B1, 2 loaded conductors (conservative)

1. Home solar - off-grid

Input parameters

System type	off grid
Charge controller / MPPT	MPPT
Panel rating	550.00 W
Inverter efficiency	94 %
Temperature loss	4.66 %
Shading loss	0 %
Battery type	LiFePO4 (lithium)
Depth of discharge	90 %

Calculation method and equations

- Daily Wh = Σ (W × qty × hours) (§48)
- Design Wh = DC Wh + AC Wh ÷ η_inverter ; then ÷ η_battery (§50)
- Array W = Design Wh ÷ sun hours (worst required month (Jul)) ÷ (η_controller × (1 − temperature loss) × (1 − shading)) (§56-§59)
- Panels = ceil(Array W ÷ panel Wp)
- Battery Wh = Design Wh × days of autonomy (§89)
- Battery Ah = Battery Wh ÷ system V ÷ depth of discharge (§89)
- Current = W ÷ system V (§86); Cable mm² = L × I × 0.04 ÷ (V ÷ 20) (§87)
- System V: lowest of 12/24/48 V keeping that cable ≤ 6 mm² (§85); 12 V only up to ~3 kW (§91)
- Controller A = array W ÷ system V × 1.25 [modern margin - the book gives none, §90]
- Inverter W ≥ 4/3 × appliances running at once (§91)

Results (calculated by deterministic code)

Appliance energy per day	860.00 Wh/day
Energy the solar must supply per day (after losses)	963.05 Wh/day
Everything switched on at once	210.00 W
Sun hours used (worst required month (Jul))	3.67 kWh/m²/day
Solar array needed	305.82 W
Panels of 550 W	1 panels
Installed solar array	550.00 W
Roof area for panels	2.58 m²
Battery / system voltage	24 V
Energy the battery must deliver	1,926.09 Wh
Battery capacity at 24 V	89.17 Ah
Battery nominal capacity	2.14 kWh
Charge controller rating (array current × 1.25)	28.65 A
Battery/array cable by the book's formula (5 % drop)	2.292 mm²
Estimated battery life (one cycle per day, capped)	12 years
Inverter continuous rating	280.00 W
Estimated solar generation per year	1,015.71 kWh/yr
Appliance use per year	313.90 kWh/yr

Appliance list (power analysis)

Appliance	W	Qty	Hours/day	Wh/day	Supply	Backup	Motor
LED bulb (typical - check label)	10.0	6.0	5.0	300.0	AC 230 V		

Appliance	W	Qty	Hours/day	Wh/day	Supply	Backup	Motor
LED TV (32-43 inch) (typical - check label)	60.0	1.0	4.0	240.0	AC 230 V		
Mobile phone charger (typical - check label)	10.0	2.0	3.0	60.0	AC 230 V		
Laptop (typical - check label)	60.0	1.0	3.0	180.0	AC 230 V		
Wi-Fi router (typical - check label)	10.0	1.0	8.0	80.0	AC 230 V		

Monthly generation vs use

Month	Sun hours	Solar (kWh)	Use (kWh)	Surplus (kWh)
Jan	6.49	94.9	26.7	68.3
Feb	6.94	91.7	24.1	67.6
Mar	7.33	107.2	26.7	80.6
Apr	6.9	97.7	25.8	71.9
May	6.06	88.7	26.7	62.0
Jun	5.07	71.8	25.8	46.0
Jul	3.67	53.7	26.7	27.0
Aug	3.82	55.9	26.7	29.2
Sep	4.98	70.5	25.8	44.7
Oct	6.39	93.5	26.7	66.8
Nov	6.66	94.3	25.8	68.5
Dec	6.55	95.8	26.7	69.2

Assumptions

- Method and step order from Boxwell, Solar Electricity Handbook (2012); sunshine is site data (PVGIS), not the book's UK/US tables.
- Controller factor 0.9 (MPPT) as in the book (§58).
- Temperature loss 4.7% from the site's PVGIS model (replaces the book's ×1.4 roof rule).
- Battery: LiFePO4 (lithium), depth of discharge 90%, efficiency 95%.
- Book cable formula assumes copper and a 5 % voltage drop; final cables must also meet current-rating rules.

Data sources and references

- Boxwell, Solar Electricity Handbook (2012)
- PVGIS v5.3 (EC JRC) monthly in-plane irradiation for the site

Review record

To be completed by the reviewing engineer. Signing below records review only; it does not by itself constitute certification under any jurisdiction's professional engineering rules.

Reviewed by	
Registration / licence no.	
Signature	
Date	
Comments	