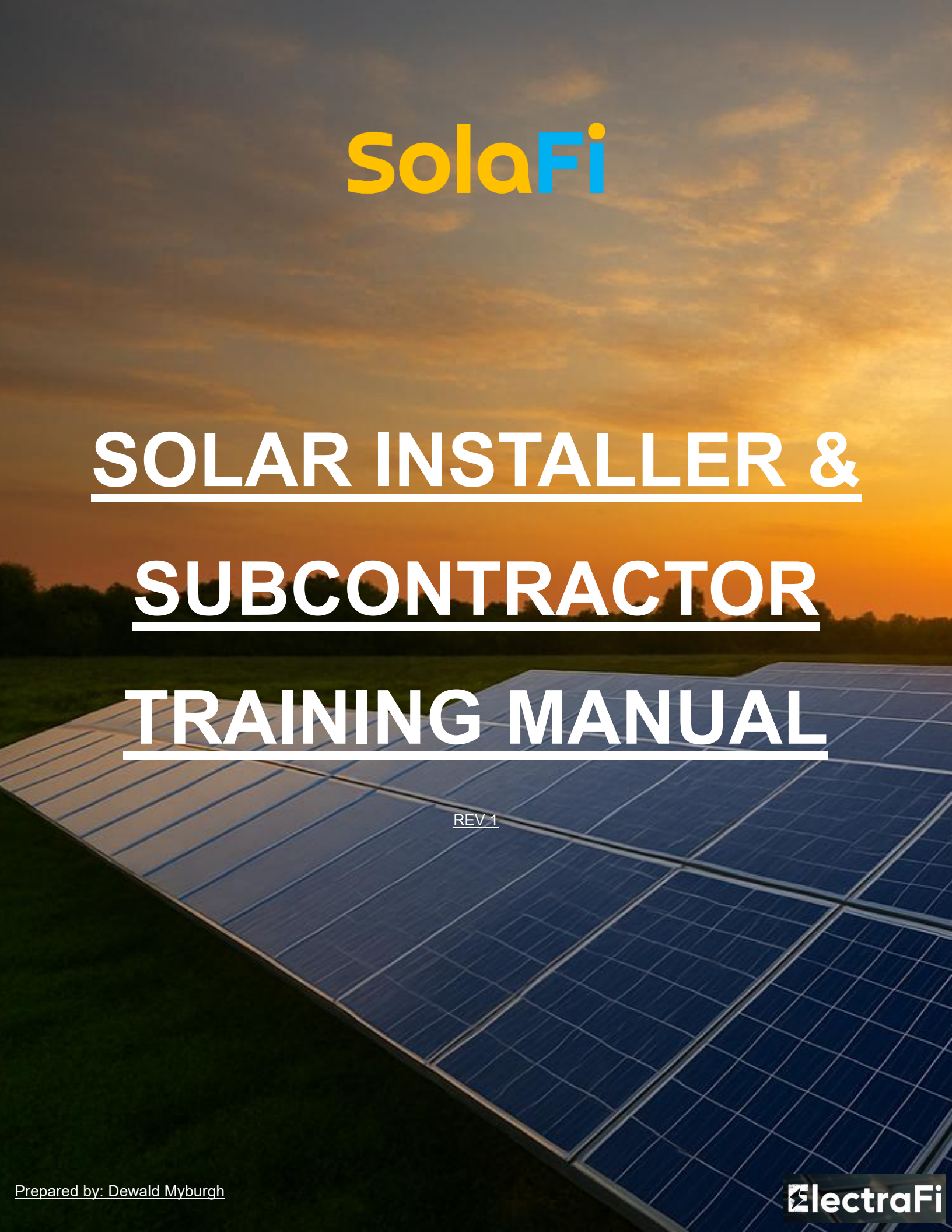

SolaFi

SOLAR INSTALLER & SUBCONTRACTOR TRAINING MANUAL

REV 1

Prepared by: Dewald Myburgh

ElectraFi

0. Basics of Electricity

◇ 0.1 Basics of Electricity

▸ Electricity Fundamentals

Electricity is the flow of electrons through a conductor. In solar systems, we primarily deal with two types of current:

- **DC (Direct Current)**: Used on the panel and battery side.
- **AC (Alternating Current)**: Used on the load/grid side.

💡 **Always remember**: Current (Amps), not Voltage, causes electrocution.

📌 **Key Electrical Terms:**

Term	Meaning
Voltage (V)	The electrical pressure or potential difference that drives current through a circuit.
Current (A)	The flow rate of electric charge (measured in amperes or amps).
Resistance (Ω)	The opposition to current flow within a conductor or circuit.
Power (W)	The rate of electrical energy consumption or generation (Watts = V × A).
Apparent Power (kVA)	Total power supplied, combining both real and reactive power (used for sizing transformers and generators).
Reactive Power (kVAR)	Power used to maintain the magnetic and electric fields in inductive/capacitive equipment (not usable for work).
Real Power (kW)	The actual usable power that performs work (kW = kVA × Power Factor).
Peak Power (kWp)	The maximum output a solar panel/system can deliver under ideal conditions (used in PV system rating).

⚙️ **Basic Electrical Formulas:**

Formula	Meaning
$V = I \times R$	Ohm's Law: Voltage = Current × Resistance
$P = V \times I$	Power = Voltage × Current
$R = V \div I$	Resistance = Voltage ÷ Current

📏 **Use a multimeter to measure:**

- **Voltage (V)** across terminals
- **Current (A)** in-line with conductor
- **Resistance (Ω)** across a component (**power OFF**)

🔌 **DC vs AC (Direct Current vs Alternating Current)**

Feature	DC (Direct Current)	AC (Alternating Current)
Flow Direction	Flows in one direction only	Alternates direction (typically 50Hz in SA)
Source Example	Solar panels, batteries	Grid electricity, generators

Feature	DC (Direct Current)	AC (Alternating Current)
Symbol on Diagrams	⎓ or +/−	~ or sine wave
Use in PV Systems	Panel output, battery charging	AC appliances, grid connection

✅ **Important**: Solar panels always produce DC. Inverters are used to convert DC into AC to power appliances or feed into the grid.

⚠️ **Note**: All DC wiring must use solar-rated cables per *EN 50618* (see section on wiring standards). Ensure polarity marking is visible and consistent.

🧠 **Quick Analogy:**

- **Voltage =** water pressure
- **Current =** flow rate
- **Resistance =** pipe width

✅ **Addendum** to DC vs AC:

- **AC (Alternating Current):**
  - Voltage and current **continuously change direction**
  - Common in **grid power**
  - Requires **inverter** for solar systems
- **DC (Direct Current):**
  - Voltage and current **flow in one direction**
  - Produced directly by **solar PV modules**
  - Used for **battery charging** and **internal wiring**

◇ 0.2 Series vs Parallel Connections

🔌 **What's the Difference?**

Connection Type	Voltage	Current	Use Case Example
Series	✅ Adds	❌ Same	PV panels in string
Parallel	❌ Same	✅ Adds	Batteries to increase Ah

🔗 **Understanding the Basics**

Series Connection:

- Increases voltage while current remains constant.
- Used to match inverter MPPT input voltage ranges.
- Good for reducing voltage drop over long cable runs.

Parallel Connection:

- Increases current while voltage remains constant.
- Used when designing higher current busbars or parallel battery banks.
- Ideal for boosting charging capacity or output power.

🔋 PV Example Calculations

Configuration	Result
3 × 40V, 10A panels in series	➔ 120V, 10A
3 × 40V, 10A panels in parallel	➔ 40V, 30A

🔋 Battery Example (Same Logic)

- **Batteries in Series**: Voltage increases, Ah stays the same.
- **Batteries in Parallel**: Voltage remains, Ah increases.

⚠️ Why It Matters:

- Series = Higher voltage → Better for long cable runs, reduced copper loss.
- Parallel = Higher current → More capacity for loads or charging.
- Incorrect combinations can overload MPPTs or damage batteries.
- Always ensure strings stay within **cold-weather max voltage** and **inverter limits**.

◇ 0.3 Voltage, Current, Resistance, Power & Cable Sizing

⚙️ Ohm's Law Recap

These formulas are essential for correct sizing of:

- Cables,
- Breakers, and
- Fuses.

Formula	Meaning
V = I × R	Voltage = Current × Resistance
I = V ÷ R	Current = Voltage ÷ Resistance
P = V × I	Power = Voltage × Current

📏 Cable Sizing Basics

Correct cable size is **critical** for:

- Preventing voltage drop,
- Ensuring safe current carrying,
- Meeting installation regulations.

✅ **Size cables based on:**

- **Current (Amps)** to be carried
- **Distance (metres)** the cable runs
- **Voltage drop (%)** limits (see below)
- **Installation method**: conduit, surface, buried, etc.

📐 **Voltage Drop Formula**

Use the formula below for quick cable sizing estimates:

Vdrop = (2 × L × I × R) / 1000
Where:
L = cable length (metres)
I = current (amps)
R = resistance of conductor (Ω/km)

📊 **Sizing Table Example (Single-phase Copper Cables)**

Cable Size	Max Current
4 mm²	≈ 25A
6 mm²	≈ 32A
10 mm²	≈ 45A

✅ **Target Voltage Drop Limits:**

- **DC circuits**: ≤ 3%
- **AC circuits**: ≤ 5% (ideal)

🔌 **Circuit Configuration Overview**

Series Circuits:

- Current flows through one path only.
- If any point breaks, the **entire circuit stops**.
- Example: Basic solar panel string.

Parallel Circuits:

- Multiple current paths.
- A break in one leg **does not stop** the whole circuit.
- Example: Household circuits, parallel battery banks.

◇ 0.4 Voltage Drop & Cable Sizing (with Example)

⚠️ Design Limits per Standard

As per **SANS 60364-7-712**, **voltage drop should not exceed 3%** in PV circuits under full load.

🔢 Voltage Drop Formulas

A. Basic Engineering Formula (using cable resistance):

Voltage Drop (V) = (2 × L × I × R) ÷ 1000

Where:

- **L** = one-way cable length (in metres)
- **I** = current (in Amps)
- **R** = resistance of conductor (in Ω/km)

B. Simplified Voltage Drop % Formula:

Voltage Drop (%) = (2 × L × I) ÷ (A × V) × 100

Where:

- **A** = cable cross-sectional area (in mm²)
- **V** = system voltage (in Volts)

C. Formula using resistivity constant:

Voltage Drop (V) = (2 × L × I × ρ) ÷ A

Where:

- **ρ** = resistivity of copper (≈ 0.0175 Ω·mm²/m)

🔍 Worked Example

System Setup:

- One-way cable length (**L**) = 10 m
- Load Current (**I**) = 20 A
- Voltage (**V**) = 48 V

- Cable size = 6 mm² copper
- Resistance of 6 mm² copper = **3.3 Ω/km**

Step 1 – Calculate VD (in Volts):
VD = (2 × 10 × 20 × 3.3) ÷ 1000 = **1.32V**

Step 2 – Calculate VD%:
VD% = (1.32 ÷ 48) × 100 = **2.75%**

✅ Result: Acceptable – under the 3% design limit.

🔁 Related Formulas for Reference

- **V = I × R** (Ohm's Law)
- **P = V × I** (Power Law)

Where:

- **V** = Voltage (volts)
- **I** = Current (amps)
- **R** = Resistance (ohms)
- **P** = Power (watts)

📋 Design Guidelines

Aspect	DC Side	AC Side
Max Voltage Drop	≤ 3%	≤ 5% (preferably)

- Use **thicker cables** for long runs to reduce losses.
- Always check **temperature and bundling derating factors** per **SANS 10142-1 Clause 6.3.6.3.4**.
- For **PV DC wiring**, use **EN 50618-rated** solar cables only.
- Refer to **Annexure** for string configuration impacts under cold conditions.

◇ 0.5 MPPT Matching (Voc, Vmp, Isc, Imp)

📌 What is MPPT?

MPPT stands for **Maximum Power Point Tracker** — it is a smart feature in solar inverters that continuously adjusts the input to extract the **maximum possible power** from PV panels.

🔍 MPPT Matching Steps

To correctly size PV panel strings to an inverter MPPT input:

1. **Check panel Voc** (Open Circuit Voltage from datasheet).
2. **Multiply**: Voc × number of panels in **series**.
3. Ensure the **total Voc is below the MPPT's maximum input voltage** — even on **coldest expected days**, when voltage rises.
4. Verify other parameters like **Vmp, Isc, and Imp** for safe and efficient sizing.

💉 Example Calculation

Setup	Voc per Panel	Panels in Series	Total Voc	Safe for 200V MPPT?
Example 1	48 V	4	192 V	✅ Yes
Example 2	48 V	5	240 V	❌ No – Exceeds limit

⚠️ Always calculate **cold-weather adjusted Voc**. Cold = higher voltage = inverter risk!

📊 MPPT Electrical Parameters

Parameter	Meaning	Use in Design
Voc (Open Circuit Voltage)	Max voltage when panel is open (no load)	Must stay **below MPPT max input**
Vmp (Max Power Voltage)	Voltage when panel gives maximum power	MPPT should operate **within this range**
Isc (Short Circuit Current)	Current when positive and negative are shorted	Used to size **fuses/combiner protection**
Imp (Max Power Current)	Current when panel outputs peak power	Used to size **cables, breakers, fuses**

✅ **Rule of Thumb for Design Safety** (based on SANS 60364-7-712):

Parameter	Safety Margin
Voc	Must be **< inverter MPPT max input**
Vmp	Should fall **within inverter MPPT range**
Isc	Use **× 1.25** multiplier for protection device sizing
Imp	Use **× 1.25** for cable sizing

📘 Best Practice

- **Check inverter specs and datasheets** for MPPT voltage and current ranges.
- **Apply cold temperature correction factor** to Voc values.
- Match **panel string voltage and current** to inverter MPPT ratings with proper **safety margins**.
- Refer to **Annexure** for cold weather design voltage tables.

◇ 0.6 Battery & Inverter Sizing Basics

⚙️ Core Principles

Inverter sizing and battery capacity planning must be based on **peak load**, **desired runtime**, and **battery chemistry**. Use real-world load data and include derating factors.

🔋 Inverter Sizing

- **Inverter Size (kVA)** = Total Peak Load (kW) ÷ Power Factor (typically ≈1 for residential)
- Choose an inverter **that can handle the maximum simultaneous load**, plus headroom for startup surges (e.g. fridges, pumps).

🔋 Battery Sizing – kWh Method

- **Battery Capacity (kWh)** = Load (kW) × Time (hours)

📌 Example:

- Load = 2kW
- Runtime = 5 hours
- Required = 2 × 5 = **10kWh**
- A 48V 100Ah battery = 4.8kWh → **Need ~3 batteries**

🔋 Battery Sizing – Ah Method

🔹 Formula:

Battery Capacity (Ah) = [Load (W) × Runtime (h)] ÷ [System Voltage (V) × Discharge Factor]

- Use **Discharge Factor** of:
  - 0.8 for Lead-Acid
  - 0.9–1.0 for $LiFePO_4$ (Lithium)

🔹 Example:

- Load = 1000W
- Runtime = 5 hours
- Voltage = 24V
- Battery type: Lithium (0.95 factor)

Battery Capacity (Ah) = [1000 × 5] ÷ [24 × 0.95]
= 5000 ÷ 22.8
≈ 219.30 Ah

✅ Need at least **220Ah at 24V**.

🔋 Convert Ah to kWh

✅ **1. Convert Ah to Wh:**
Battery Capacity (Wh) = Ah × V

✅ **2. Convert Wh to kWh:**
Battery Capacity (kWh) = (Ah × V) ÷ 1000

✅ **3. Estimate Runtime:**
Runtime (hrs) = Battery Capacity (Wh) ÷ Load Power (W)

🔧 **Practical Example:**

Two 48V 100Ah lithium batteries (DoD = 90%):

Total Usable Energy = 2 × 100Ah × 48V × 0.9 = 8.64kWh
If Load = 1.2kW:

Runtime = 8640Wh ÷ 1200W = 7.2 hours

⚠️ **Battery Sizing Notes**

- **C-Rating**: Indicates the maximum safe discharge rate.
  E.g. 100Ah at 1C → max 100A draw.
- **Charging Rate**: Match inverter's max charge rate to battery spec.
- **DoD (Depth of Discharge)** affects usable capacity.
- **Communication Compatibility**: Many lithium batteries require CAN/RS485 protocols for BMS-inverter sync.

◇ 0.7 Types of Solar Systems

- PV modules convert sunlight (radiant energy) directly into electrical energy.
- This is part of a broader energy ladder where sunlight is a **primary energy source**.

Component	Notes from PV Guidelines
Solar Panels	Generate DC electricity from sunlight
MPPT Controller	Optimises panel output to battery/inverter
Hybrid Inverter	Connects PV, batteries, and grid; can operate in island mode
Battery Storage	Stores excess PV energy for night use (usually lithium-ion)
Mounting Frames	Roof or ground-mounted structures
AC/DC Protection	DC isolators, SPDs, fuses, breakers
Wiring & Connectors	Ensure correct sizing, polarity, and labeling

---

1. Grid-Tied

- **Flow**: Panels → inverter → DB → grid
- **No battery backup**
- Powers loads only when the sun shines
- Will shut down during load shedding

2. Off-Grid

- **Flow**: Panels → charge controller → battery → inverter → DB
- **No grid/Eskom input**
- Must oversize battery & PV to meet all needs

3. Hybrid – All-in-One

- Single inverter handles PV, battery, grid
- MPPT + Inverter + Charger in one unit
- Examples: Sunsynk, Deye, Kodak

4. Hybrid – Modular

- Separate inverter, MPPT, battery components
- Customisable and scalable
- Example: Victron Quattro + SmartSolar MPPT

⚠️ **Note**: Grid-tied and hybrid systems must follow SSEG registration protocols.

Comparison Table

System Type	Features & Use Case
Grid-tied	No batteries; feeds excess power to grid (requires approval, NRS097 compliant)
Off-grid	Fully independent; must size for autonomy + peak load
Hybrid (Modular)	External inverter, MPPTs, batteries (Victron setups); more technical and scalable
Hybrid (All-in-One)	Combined inverter-MPPT (e.g. Sunsynk, Kodak); easier to install for residential clients

---

🔀 Victron-Type Split Setups

- Uses separate MPPTs, battery inverter, grid-tied inverter
- More flexible and robust
- Good for commercial or modular homes
- Requires syncing AC outputs

Type	Description	Features
Grid-Tied	Solar + grid only. Shuts down during outages	Needs anti-islanding & grid compliance
Off-Grid	Solar + full battery bank, no grid	Must cover entire load profile
Hybrid	Solar + grid + battery	Versatile, can operate without grid
Modular	Separate inverter + MPPT + batteries	Customisable, advanced setup
All-in-One	Combined unit (MPPT + inverter + charger)	Simpler install, residential-friendly

---

✅ **Summary Additions to 0.7 – System Types:**

- Off-grid: No grid connection. Requires full battery bank and oversized PV.
- Grid-tied: No batteries. Feeds into grid. Grid failures = no power.
- Hybrid: Combines both. Can export, back up, and optimise usage.
- ⚠ Ed. 3.2 update: Follow Annex on alternative supplies. All systems must be registered under SSEG where applicable.

◇ 0.8 Typical System Flow Diagrams

This section illustrates the most common configurations for solar PV systems using simplified flow diagrams. These diagrams help explain how energy flows from the sun through the PV system into usable power for various setups.

✅ **Use visual diagrams** in your manual for:

- **DC string to inverter layout**
- **Battery and inverter integration**
- **Grid + essential/non-essential load split**
- **Hybrid system with bypass & backup modes**

These visuals are useful for:

- Installers and designers
- System owners and end-users
- Inspectors and compliance officers

🔦 Grid-Tied (No Battery

[PV Panel] → [MPPT] → [Grid Inverter] → [DB Board] → [Grid]

- Powers daytime loads
- No storage – no power during outages
- Must comply with NRS097 and anti-islanding protocols

🔋 Off-Grid System

[PV Panel] → [MPPT] → [Battery] → [Off-grid Inverter] → [DB Board]

- Complete independence from the grid
- Needs full autonomy planning (battery size, PV over-sizing)
- Suitable for remote or rural areas

⚡ Hybrid – All-in-One

[PV Panel] → [Hybrid Inverter (MPPT + Battery)] → [DB Board] → [Grid]
↳ [Battery Bank]

- Inverter handles PV input, battery storage, and grid sync
- Works during load shedding (if batteries are present)
- Common in homes and small businesses

🔀 Hybrid – Modular (Victron-Type)

[PV] → [SmartSolar MPPT] → [Battery Bank]
↘
[MultiPlus Inverter] → [DB Board] → [Grid]

- Separate MPPT and inverter units
- High flexibility and scalability
- Used in complex setups (commercial, modular homes)

---

1. Introduction

◇ 1.1 This manual serves

As the **official reference and training guide** for all solar PV installations conducted under the **SolaFi/ElectraFi** brand. It outlines the expectations, regulations, and procedures necessary to maintain quality, safety, and legal compliance in all installations.
It is designed to:

- Ensure **installer safety**
- Standardize **workmanship and methods**
- Enforce **compliance with SANS regulations**
- Provide **legal and quality protection** for the company and its clients

Once signed, this manual becomes **legally binding** for:

- All internal installers and subcontractors
- Freelance technicians operating under SolaFi/ElectraFi contracts

⚠️ **No one may claim ignorance of these standards once issued.**

◇ 1.2 Version control

Ensures that all updates, procedural changes, and regulatory updates are tracked. Installers must use only the **latest approved version** of the manual during installations.
This document applies to all individuals and teams involved in the installation and commissioning of solar systems, including:

- Internal DC and AC teams
- Inverter & Battery Energy Storage System (BESS) specialists
- Subcontractors and freelance installers
- Site supervisors, auditors, and quality control inspectors

All persons listed above are expected to understand and apply the relevant sections applicable to their role.

The manual is arranged in sections with dropdown headers for quick navigation. Each section includes:

- **Regulatory references** (e.g., SANS, NRS standards)
- **Installation procedures**
- **Common errors and safety warnings**
- **Visual diagrams and annexures** for clarity

Sections are modular — you may be referred to a different section or annexure (e.g., “see annexure”) for detailed tables, cable sizing, safety protocols, or checklists.

📌 Tip: Refer to the voltage, current, battery, and MPPT matching basics early when planning system sizing and layout.

2. Code of Conduct & Workmanship Rules

◇ 2.1 Purpose:

This section outlines the professional behavior, safety standards, and workmanship quality required from all solar PV personnel — both internal teams and subcontractors — operating under the SolaFi/ElectraFi banner.

These are just general guidelines – Please find attached the full code of conduct document.

◇ 2.2 General Rules:

All workers must comply with the following at **all times**:

- Arrive on time and ready to work.
- Wear the correct PPE:
  - Helmet
  - Safety boots
  - Gloves
  - Flame-resistant clothing
- Keep the site **clean**, **tidy**, and **safe**.
- No swearing or rude behavior in front of clients.
- **Strictly no alcohol, drugs, or smoking** on-site.
- Never take shortcuts or say “I’ll fix it later.”
- Never tamper with other teams’ work without prior authorization.
- Immediately report any faults, breakages, or safety concerns.

◇ 2.3 Workmanship Expectations:

High standards of technical quality are mandatory:

- Cables must be:
  - Neatly routed
  - Clean
  - Properly labelled
- **No**:
  - Twisted wires
  - Open joints
  - Poorly terminated lugs
- Panels must be:
  - Flush
  - Secure
  - Square to the mounting rails
- DBs (Distribution Boards) and trunking must be:
  - Cleanly installed
  - Properly labelled
  - Neatly sealed
- **Never guess** — always **test and verify** using appropriate tools.

---

3. The 5 Cardinal Rules (Zero Tolerance)

◇ 3.1 The 5 Cardinal Rules

These are **non-negotiable safety and quality rules** that apply to all team members and subcontractors. Violation of any of these rules will result in immediate disciplinary action.

Rule No.	Cardinal Rule
1️⃣	**Never connect DC without isolating the panels and checking polarity.**
2️⃣	**Never work live on DC or AC unless officially authorised AND fully protected (PPE + team clearance).**
3️⃣	**Never bypass isolators, surge protectors (SPDs), fuses, or earthing.**
4️⃣	**Never leave exposed wires, open terminals, or unfinished live circuits.**
5️⃣	**Never fake test results or mark work as "complete" if it hasn't passed inspection.**

◇ 3.2 Consequences of Breaking These Rules

If any of the above rules are violated, the installer or team member may face:

- ❌ **Immediate removal from site**
- 🔴 **Blacklisting from future projects**
- 💸 **Financial liability for any damage, fire, or client loss**
- ⚖️ **Reporting to the Department of Labour or municipal authorities (if applicable)**

💡 **These rules are in place to protect your life, your team, your client, and the reputation of the company. There is zero tolerance for violations.** Every installer must sign acknowledgment of these rules before starting any project.

4. Safety Procedures

◇ 4.1.1 Protection Against Electric Shock

Regulation reference: Clause 712.413

- PV systems must be designed to prevent dangerous contact voltages in both normal and fault conditions.
- Protective measures include:
  - Basic insulation
  - Protective earthing (PE)
  - Automatic disconnection of supply (e.g. via RCDs)
- PV arrays must not allow indirect contact with live parts during normal operation.

Installer Note:

- Use Class II equipment or double insulation in DC circuits where possible to reduce shock hazard.

Additional Regulatory References:

- **Clause 6.7.5:** RCDs must comply with SANS 60947-2 or SANS 61008-1
- **Clause 6.7.6:** Earthing conductor for PV system must be at least 6 mm² Cu or equivalent
- **Clause 7.8.4:** Where double insulation is not used, automatic disconnection of supply through breakers/fuses/RCDs must occur within the prescribed disconnection time
- **Clause 8.6:** All bonding and earthing must be tested and recorded on the CoC with continuity measurements

◇ 4.1.2 (continued): Protection Against Electric Shock (AC & DC)

Applicable Clauses:

- SANS 10142-1: Clauses 6.7, 6.9.1, 7.12.4, and 8.6
- SANS 60364-4-41 reference for disconnection times

✅ **Requirements:**

- All live parts shall be inaccessible under normal conditions.
- Conductors and equipment shall be double insulated or installed within appropriate protective enclosures.
- Protection by automatic disconnection of supply must be ensured using:
  - Circuit breakers (CBs),
  - Fuses, or
  - RCDs (for AC side)
- PV cables must have Class II insulation and be routed with mechanical protection.
- RCDs used on the AC side must:
  - Be rated at ≤30 mA for personnel protection
  - Comply with SANS 61008-1 or SANS 60947-2
- Earthing conductors for exposed metalwork shall be minimum:
  - 6 mm² Cu or equivalent
  - Green/yellow colour-coded
- AC and DC distribution boards (DBs) must be bonded and tested for continuity before energisation.
- Use equipotential bonding at inverter, combiner, DBs, panel rails, and battery rack level.

⚠️ **Safety Notes:**

- “Solar PV systems involve high voltages and currents. Always install and test using approved procedures and personal protective equipment.”
- “Human body has electrical resistance; dangerous currents can cause fibrillation as low as 50 mA.”
- “All sources must be de-energised before work begins.”
- “DC systems pose greater arc risks because there’s no zero crossing like AC.”

◇ 4.2 Overcurrent Protection

Regulation reference: Clause 712.43

- All conductors must be protected against overcurrents that may occur from:
  - External sources (grid, inverter)
  - Internal faults (e.g. backfeed from multiple strings)

Installer Actions:

- Use fuses or DC-rated MCBs on each string if reverse current > 1.35 × Isc.
- Select protective devices rated for DC and the voltage class of the string (e.g. 600 V, 1000 V).

Relevant Clauses:

- **Clause 6.7.4:** OCPDs shall comply with SANS 60947-2 for AC and SANS 60947-3 or SANS 60269 for DC

- **Clause 7.12.3:** Breakers on DC must have arc-quenching features, rated for worst-case Voc and Isc conditions
- **Clause 7.12.5:** String fuses should be sized at 1.25 × Isc and be of the gPV type
- **Clause 6.7.2:** Do not install fuses in the neutral on TN-S or TN-C-S systems
- **SPD selection:** Must comply with SANS 61643-11
    - Install Type 2 SPDs on both DC and AC circuits within 10 m of inverter terminals
    - If PV panels are mounted more than 10 m from the inverter, remote SPDs at panel end may be required
    - All SPD earth paths must be short, straight, and have resistance below 0.5 ohm

---

Applicable Clauses:

- SANS 10142-1: Clauses 6.7.5, 7.8.4, 7.12.3, Annex P
- SANS 60364-7-712: Clauses 712.433, 712.434

✅ **Requirements:**

- All PV system conductors must be protected against:
    - Overload
    - Short-circuit
    - Reverse current faults (DC side)
- **String fuses (DC):**
    - Required when ≥2 strings in parallel
    - Must be gPV type, rated at 1.25 × Isc
- **OCPDs must conform to:**
    - SANS 60947-2 (circuit breakers)
    - SANS 60269-6 (fuses)
- **Overcurrent devices must:**
    - Disconnect both positive and negative simultaneously
    - Be installed as close as possible to the source (e.g., PV strings or batteries)
- **For AC distribution:**
    - Use CBs with the correct kA interrupting rating
    - Ensure type C or type D tripping curves are selected based on load type
- **Important:**
    - Ensure neutral conductors are **not** fused or switched independently (on TN-S / TN-C-S systems)

🔌 4.3 Isolation and Switching

Regulation reference: Clauses 712.536 & 712.537

✅ **Isolation Requirements:**

- Must isolate both positive and negative DC cables.
- Devices must:
    - Be lockable
    - Show clear ON/OFF position
    - Withstand DC arcing

✅ **Switching-Off Requirements:**

- Inverters must disconnect PV input when:

    - Grid is down
    - Maintenance is required
    - Fire or emergency
- All isolators shall be compliant with **SANS 60947-3** (switch-disconnectors).
- Isolators must be:
    - Lockable in **OFF** position
    - **Visible-break** type preferred
    - Placed where **accessible** and clearly **labeled**
- Isolators must withstand system **Voc max** and **Isc max**, with DC arc-breaking rated capacity.
- AC isolator must be placed **before re-entering customer DB** and clearly marked **"PV INVERTER FEED"**.

Applicable Clauses:

- **SANS 10142-1:** Clauses 6.9, 6.11, 7.12.1–7.12.6, Annex P
- **SANS 60364-7-712:** Clause 712.445

✅ **Requirements:**

- Provide isolation on both **AC and DC** sides of the inverter:
    - **DC Isolators:**
        - Located near the inverter
        - Must be double-pole
        - Comply with **SANS 60947-3**
        - Be **load-breaking**, not just disconnection
    - **AC Isolators:**
        - Must isolate inverter output from the DB
        - Located externally or clearly marked
- All isolators must be:
    - **Clearly labelled** with their function
    - **Lockable** in the OFF position
- Isolation must be possible under **full system load**
- In multi-inverter systems, **individual isolators** must be provided per unit
- Main AC switch must **disconnect all current-carrying conductors (L + N)**

⚡ 4.4 Arc Fault & Fire Prevention

Regulation reference: Clause 712.421.101

- Systems should be designed to minimize the risk of fire caused by DC arcs.
- If used, arc detection systems should be:
    - DC-specific
    - Installed near the PV source
    - Able to disconnect the faulty string

Practical Tip:

- Use MC4 connectors from the same manufacturer and crimp to spec. Loose or mismatched connectors are a top cause of DC arcing.

Additional Requirements:

- Systems >600 V DC: Arc-fault detection devices (AFDDs) are **recommended**
- Combiner boxes must be:
  - Fire-resistant
  - Made of **non-combustible enclosures** (e.g. steel or PC/ABS V-0 rated)
- Enclose all DC isolators in **non-combustible** or **metal** enclosures
- All system labelling must indicate:
  - **"DANGER: DC VOLTAGE – DO NOT DISCONNECT UNDER LOAD"**

Applicable Clauses:

- SANS 10142-1: Clauses 6.9.3, 7.13, Annex M, Annex O

✅ **Requirements:**

- All connections must be:
  - Properly **torqued**
  - Verified against **manufacturer specs**
- Avoid:
  - Loose terminations
  - Over-tightened lugs
  - Mixed conductor materials
- Use arc-fault detection devices (AFDDs) in:
  - Large residential, commercial, or rooftop systems **where feasible**
- **DC isolators, combiner boxes, and enclosures must be:**
  - IP65 or higher if installed outdoors
  - V-0 flame-retardant rated
  - Constructed from **metal** or **certified fire-retardant plastic**
- Maintain **minimum clearances** around all electrical enclosures and switchgear to prevent overheating
- Combiner boxes must include:
  - Internal barriers between DC and SPD/fuse compartments
- Avoid installing combiner boxes in **direct sunlight** – provide **shading** where necessary
- No exposed cable joints — **always use certified MC4 connectors**

🔥 **DC Arcs (Important Notes):**

- "DC current doesn't pass through zero; arcs are harder to extinguish."
- "Special attention must be paid to **connectors** and **isolators** to prevent arcing."

📌 4.5 Marking, Labels, and Warning

Regulation reference: Clause 712.514
Applicable Clauses:

- **SANS 10142-1:** Clauses 6.10, 6.11.4, 7.12.5, Annex H
- **SANS 1186-1** for warning signs

✅ General Requirements:

- All electrical equipment and circuits must be **clearly labelled**
- Labels must be:
  - **Weatherproof** and **UV-stable**
  - Legible after **10+ years** exposure
  - **Permanently fixed** (e.g., riveted or permanent adhesive)
- Label all of the following components:
  - DC junction boxes
  - Inverters
  - Disconnect switches
  - Combiner boxes
  - AC DBs fed by inverter
  - Fireman shutdown switches
- **Required label content includes:**
  - Nominal power (Wp)
  - Voc Max
  - Isc Max
  - Circuit ID
  - System voltage, current, and hazard class
  - Direction of energy flow (for bidirectional systems)
  - “Do Not Disconnect Under Load” (for DC isolators)
  - Arrows to indicate current flow at inverters and combiner boxes

---

⚠️ Label Format and Appearance:

- Use **yellow background with black text** for hazard warnings
- “DANGER – SOLAR DC CIRCUIT!” must be clearly shown on all DC isolators
- Labels must comply with **SANS 1186-1** (correct colour codes, pictograms, and layouts)
- Danger signage must be applied to:
  - Access panels
  - Isolators
  - Main inverter shutdown area
  - Any accessible PV DC components

🏷️ Example Label Format:

DC DISCONNECT
VOC MAX: 250V ISC MAX: 10A
PV ARRAY 1
DANGER – SOLAR DC CIRCUIT!

🗺️ Site Layout and Schematics:

- A system layout or **site schematic** must be displayed near:
  - The inverter

    - Main AC distribution board
- Schematics must clearly show:
    - Component locations
    - Circuit IDs
    - Main isolation points
    - Direction of current flow

🔧 4.6 Safe Working & Maintenance

Applicable Clauses:

- **SANS 60364-7-712** (general system safety)
- **SANS 10142-1:** Clauses 5, 8.2, Annex O

✅ **Recommended Procedures (Industry Best Practice):**

- Always **test for absence of voltage** before working on DC cables.
- Disconnect **all strings** at combiner or isolator before servicing the inverter.
- Use **insulated tools** and **arc-rated PPE** (especially for systems >120 V DC).
- **Never disconnect MC4s under load** – isolate upstream first.

✅ **Summary Checklist for Installers:**

Safety Item	Required?	Notes
Overcurrent protection	✅	Fuses/MCBs per string if reverse current > 1.35× Isc
DC isolation	✅	Disconnect both + and –; must be lockable
Arc fault prevention	⚠️	Strongly recommended for >600 V systems
Clear labeling	✅	Required on all DC/AC isolators, inverters, and junctions
RCDs / AC shock protection	✅	Follow general **60364 Part 4** rules
Maintenance procedures	✅	Ensure safe disconnection, PPE, test tools, signage

---

✅ **Maintenance Safety Requirements:**

- **Perform safe isolation procedures** before any maintenance:
    - Test-for-dead
    - Lock-out / tag-out (LOTO)
    - Use of **DC load-break disconnects**
- **Required PPE:**
    - Arc-rated gloves
    - Arc flash face shields
    - Insulated tools
- **Maintain safe conditions by:**
    - Ensuring safe **access** to all isolators, DBs, and terminations
    - **Preserving IP ratings** — do not drill or modify outdoor boxes post-install
- **Regular Maintenance Tasks:**

    - Torque-tightening of terminals (**record values**)
    - Visual inspection of connectors, insulation, and labels
    - Cleaning inverter filters (if applicable)
- **Recordkeeping:**
    - Maintain a **service logbook** or **digital record** for all maintenance activities

5. DC Side – Installation Workflow

✅ 5.1 Mounting the Structure (Panels)

Applicable Standards & Clauses:

- **SANS 60364-7-712:** Clauses 712.521, 712.552.1.101, 712.542, 712.413
- **SANS 10142-1:2020 Edition 3:** Clause 6.6.2, Clause 6.12, Annex O
- **SANS 10160-3** (Actions on roof structures)
- **SANS 10243** (Fastening techniques)

A. Structure Selection and Suitability

- PV module mounting systems must be:
    - Mechanically robust
    - Corrosion-resistant
    - Compatible with the roof or foundation type
- Common materials used:
    - **Anodised aluminium**: Lightweight and corrosion-resistant
    - **Galvanised steel**: Stronger, but ensure cut edges are treated to prevent corrosion
- Design considerations:
    - Must withstand wind, rain, and snow loads (per **SANS 10160**)
    - Follow manufacturer specs for assembly and torque settings

---

B. Tilt, Orientation & Spacing

- Tilt panels at the **optimum angle** for the site's geographic latitude
- Orient modules to face **true north** (Southern Hemisphere) for maximum yield
- Avoid shading from objects such as chimneys or trees, especially **9 AM–3 PM**
- Maintain a **minimum 100 mm gap** behind panels for proper airflow and cooling
- Ensure row spacing avoids mutual shading and allows for maintenance access

---

C. Fixings and Attachments

- Use:
    - UV-resistant stainless steel or galvanised mechanical fixings
    - Proper torque settings (typically **8–12 Nm**) on all bolts and clamps
- Do not:
    - Over-tighten to avoid stress fractures in module frames
    - Mix materials that could cause **galvanic corrosion** (e.g. aluminium directly on steel)
- Clamp specifications:
    - End clamps and mid-clamps must **match panel frame profiles**
    - Tighten using torque wrenches to spec

D. Roof Penetrations and Sealing

- For tile, IBR, or corrugated roofs:
  - Use **purpose-designed flashings** or penetration kits
  - Seal with **UV-stable silicone** or **butyl flashing tape**
  - Never compromise the roof's waterproofing integrity
- Mounting system must align with the roof type:
  - Corrugated iron, concrete tile, IBR sheeting, or flat concrete

---

E. Ground Mount Structures

- Ground-mounted systems must be:
  - Installed on **levelled terrain** with proper drainage
  - Secured using **anchor rods**, **piled foundations**, or **concrete footings**
  - Elevated to provide at least **500 mm ground clearance** for airflow and cleaning

---

F. Safety During Mounting

- Comply with **SANS 10085** (scaffolding) and **OHSA** fall arrest rules
- Use **fall protection systems** when working at height
- Do not leave heavy tools or panels **unsecured** on sloped or elevated surfaces

---

G. Bonding of Structure

- Structures must be electrically bonded as they are **exposed conductive parts**
- Bonding must follow **Clause 712.542.101**:
  - Use **6 mm² bare or green/yellow copper bonding wire**
  - Ensure continuity across rails using serrated washers or bonding jumpers
  - Connect bonding system to the **Main Earth Terminal (MET)**
  - Maintain equipotential bonding between modules, rails, and mounting system

---

H. Final Checks

- Before leaving site:
  - Inspect for **loose clamps**, **corrosion**, or **unsealed penetrations**
  - Check for any **stressed** or **cracked module glass**
  - Ensure **serial numbers** are recorded or visible
  - Confirm **no overhangs** extend past support points

✅ 5.2 Trunking, Wireways & Sleeving

Applicable Standards & Clauses:

- **SANS 60364-7-712:** Clauses 712.521, 712.522, 712.553, 712.514.101.1 & .2
- **SANS 10142-1:2020 Edition 3:** Clauses 6.7.6, 6.7.7, 6.9.3.5, 6.9.4, 6.12

A. General Requirements

- All **PV cables** must be protected against:
  - Mechanical damage
  - UV degradation
  - Excessive heat and moisture
- Only use **solar-rated, UV-resistant conduits or trunking** outdoors.
- Cables must be:
  - **Securely fastened**
  - **Neatly routed**
  - **Accessible** for inspection and maintenance

B. DC Cable Routing

- Keep DC and AC cables **in separate wireways** to avoid EMI and meet compliance.
- Avoid running cables through habitable areas unless inside trunking or conduit.
- DC cable layout must:
  - Minimise voltage drop (shortest path)
  - Avoid sharp bends (**min bend radius = 5 × cable diameter**)
  - Be fixed at intervals:
    - Max **300 mm** inside trunking
    - Max **400 mm** for exposed runs
- Route DC cables neatly **underneath PV panels**, secured to racking — **no cable sag** allowed.
- Ensure **+ and – conductors are run together** to minimise loop area (**Clause 712.443**).
- Cables must **not rest directly** on sharp metal edges of the structure.

C. Conduit, Trunking & Ducting

- Acceptable materials:
  - **PVC, HDPE**, or **metal** (galvanised or stainless)
- Outdoors:
  - Minimum **IP54**; preferred **IP65+**
  - Must be **UV-stabilised**
- Metal trunking:
  - Must be **earthed** per Clause 6.7.6.5
- All bends and connections must be:
  - Smooth-edged
  - Fitted with proper **glands, bushes, or adaptors**
- Never exceed **40% conduit fill** (per cross-sectional area)
- Provide **expansion joints** for long external runs exposed to heat variation

---

D. Cable Glanding & Entry

- Entry to boxes or DBs must use:
  - **Compression glands** matching cable diameter
  - **Multi-hole glands** for grouped entry
- Glands must:
  - Maintain enclosure **IP rating**

- Be **UV-resistant** and **properly torqued**
- Include **strain relief** where required

E. Sleeving & Identification

- Sleeving required on all cables exiting:
  - **MC4s**, open terminations, or enclosure entries (min **150 mm**)
- Colour coding (as per SANS):
  - **Positive (DC+):** red or brown
  - **Negative (DC–):** blue or black
  - **Earth:** green/yellow
- All string cables must be:
  - **Labelled at both ends**
  - Identified with:
    - **String number**
    - **Polarity**
    - **Destination**
  - Use **UV-stable printed cable markers**

F. Fire Safety & Access

- Avoid routing DC cables through:
  - **Combustible cavities**
  - **Ceiling voids** (unless properly enclosed)
- For fire isolation:
  - Install **metal conduit** in escape paths or fire-rated zones
  - Firestop all wall/floor entry points
- Ensure:
  - No **splices or joints** hidden in inaccessible trunking
  - All wireways are accessible for **inspection** if not permanently sealed

---

G. Trunking / Conduit Fixing

- Use **corrosion-resistant fixings** (e.g. stainless steel or UV-rated nylon)
- On rooftops:
  - Avoid penetrating waterproofing without **flashing**
  - Use stand-off brackets where needed
- Prevent mechanical stress by ensuring trunking is:
  - Straight, evenly supported
  - Fitted with **expansion spacing** where required

⚠ Common Mistakes to Avoid

- Mixing **AC and DC** in the same trunking
- Leaving **open cable loops**
- Creating **kinks or sharp bends** in wire
- Using **non-UV-rated** trunking outdoors
- Allowing cable **sag or resting on sharp edges**

✅ 5.3 Earthing & Bonding

Relevant Clauses & Standards:

- **SANS 60364-7-712:2018**: Clauses 712.542, 712.413, 712.421, 712.411.3.2.1.2, 712.411.6
- **SANS 10142-1 Ed. 3**:
  - Clause 6.12.5 (Earthing in PV systems)
  - Clause 6.7.6.5 (Earthing of wiring systems)
  - Clause 5.3.3 (Equipotential bonding)

A. Objectives of Earthing & Bonding

- Prevent dangerous **touch voltages** in fault conditions
- Ensure **equipotential bonding** between all exposed metal parts
- Provide a **fault current path** to trigger disconnection devices (e.g. RCDs, MCBs)
- Limit **electromagnetic interference**
- Support **lightning and surge protection** systems

B. Earthing of Metal Structures (Frames, Rails, Combiner Boxes)

- All PV mounting structures and exposed metal parts must be **bonded to earth**
- Use **minimum 6 mm² copper conductor**, green/yellow in colour (bare or insulated)
- Fixing methods:
  - Use **purpose-designed earthing lugs**, clamps, serrated washers
  - Ensure electrical contact by **penetrating anodised surfaces**
- Earthing conductors must:
  - Be **mechanically protected** (inside conduit or trunking if exposed)
  - Be **continuous** where possible; if joints are used, crimp lugs or terminals must be applied
  - Be fixed **securely**, and use **anti-corrosion paste** where required

---

C. Earthing of DC Components

- Earth all metallic:
  - Combiner boxes
  - Junction boxes
  - Cable glands or enclosure bodies
- Requirements:
  - Use **dedicated earth studs** or **earth bars** inside enclosures
  - Bond metallic gland plates if applicable
- Plastic components like **MC4s**:
  - Do not require bonding
  - Must still be **securely mounted and isolated** to prevent movement

---

D. Equipotential Bonding Grid

- The bonding system must interconnect:
  - PV array mounting structure

    - AC and DC DBs
    - Metallic conduit
    - Combiner chassis
    - Inverter casing
- Connect the bonding grid to the **Main Earth Terminal (MET)** of the installation
- Bonding is **mandatory** even for floating PV arrays or transformer-isolated systems

---

E. DC Surge Protection (SPD) Earthing

- If SPDs are installed:
    - SPD earth terminals must be bonded directly to the same earth system
    - Use **minimum 6 mm² copper wire**
- Routing rules:
    - SPD earthing cables must be **short and direct**
    - Avoid sharp bends; no more than **90° turns**
    - Place SPD bonding as **close as possible** to the grounding point

---

F. Earth Continuity Tests

- **Before commissioning**, perform:
    - **Continuity test** between each component and the main earth bar
    - Acceptable resistance: **< 6 Ω**
    - **Insulation resistance**: ≥ 1 MΩ between all live parts and earth
- Use:
    - **Continuity tester**
    - **Loop impedance tester**
    - As per **SANS 10142-1 Table 8**

G. Labelling & Visual Verification

- All earthing conductors must be:
    - **Green/yellow** in colour, or sleeved accordingly
    - Properly labelled at DBs, combiner boxes, and main earth terminal
- Use clear labels such as:
    - **“ ⚠️ PV SYSTEM – DC EARTH”** at each bonding point
- Visually verify:
    - Secure terminations
    - Corrosion-free bonding points
    - Continuity and appropriate conductor sizing

✅ 5.4 Build & Wire the DC Combiner Box

Applicable Standards & Clauses:

- **SANS 60364-7-712:2018:** Clauses 712.433, 712.434, 712.436, 712.443, 712.514, 712.522, 712.537.2.1.1
- **SANS 10142-1 Ed. 3:**
    - Clause 6.12.6 (DC side protection)
    - Clause 6.7.6.4 (Enclosures and DBs)
    - Clause 6.9.3.3 (Wiring inside enclosures)
    - Clause 6.7.6.5 (Earthing metal enclosures)

- Annex O (Fire protection)

A. Purpose of the DC Combiner Box

- Collects input from **multiple PV strings**
- Provides **overcurrent protection**, **surge protection**, and **isolation**
- Enables **safe, serviceable** connections
- Ensures **string-level fault protection** and simplifies maintenance

---

B. Combiner Enclosure Requirements

- **Minimum IP65** for outdoor use; **IP54** for sheltered indoor use
- Material:
  - **Polycarbonate** or **metal** (V-0 flame-retardant rated)
  - Metallic enclosures must be earthed (per Clause 6.7.6.5)
- Must allow:
  - **Adequate spacing** for heat dissipation
  - **Proper cable entry** via glands or trunking
  - **Clear internal labelling** (strings, SPD, fuses, output)

C. Overcurrent Protection (Fusing)

- Required for each string unless:
  - Only **2 strings in parallel**, and
  - Short-circuit current of one string is **≤ cable rating** of the other
- **Fuse selection:**
  - Type **gPV**, rated at:
    - Voltage ≥ **1.2 × Voc**
    - Current ≥ **1.25 × Isc**
- Use **DC-rated fuse holders** marked for polarity
- Optional:
  - Provide **spare fuse**
  - Include **fuse rating label** inside the lid

D. String Connection Terminals

- Acceptable options:
  - MC4-compatible plug-ins
  - DIN-rail terminal blocks with secure clamping
- Terminals must:
  - Be **DC-rated** (min. 1000 V DC)
  - Be **clearly labelled** with string number and polarity
- Cabling:
  - Routed via glands
  - Tied using cable ties or adhesive mounting clips
  - **No floating wires** permitted

E. Surge Protection Devices (SPD)

- **Type 2 DC SPD** required for:
  - Outdoor systems
  - Cable runs >10 m between array and inverter
- SPD installation:
  - Voltage-rated for **Voc of system**
  - Connected to **incoming DC terminals**
  - Earth conductor:
    - **Short, direct**, < 0.5 m preferred
    - Use **min. 6 mm² copper wire**
- Must have visible **status indicator** (green/red) on unit or visible via panel window

---

F. DC Isolation (Optional Internal Isolator)

- A **DC isolator** may be installed inside the combiner if:
  - **Rated to interrupt full PV load current**
  - Meets **DC-21B** classification or SANS 60947-3
- Location can also be external (near array or inverter)
- Must be labelled and accessible

G. Earthing & Bonding in Combiner

- Metal enclosures and SPD earth terminals must be:
  - Bonded using **min. 6 mm² Cu green/yellow wire**
  - Connected to earth bar or MET
- Bond **gland plates** if separate or isolated by design

H. Labelling & Safety Markings

- Required external/visible labels:
  - ⚠️ **"DANGER – SOLAR DC"**
  - **String diagram** or schematic (recommended)
  - **Fuse ratings, SPD voltage, and terminal IDs**
- Mark each:
  - **String ID** (e.g. String 1A, 2A)
  - **Polarity** (+ / –)
  - **Source/destination** (e.g. "To Inverter" or "From Panels")
- Use:
  - **UV-stable printed labels** or **engraved tags**

I. Final Assembly Notes

- Double-check:
  - **Polarity** on all inputs
  - No risk of **reverse feed** between strings
- Ensure:
  - Terminals are torqued per spec (**log values**)

    - All conductors are **tidy, routed, and sleeved**
- Final tests:
    - **Insulation resistance** (megger) ≥ **1 MΩ**
    - Visual inspection for:
        - Clearance
        - Secure fixings
        - Label presence

✅ **Summary of Required Devices:**

- **DC Isolator Switch** (rated to interrupt fault current)
- **Type 2 SPD** (upstream of fuses)
- **DC Fuses or Breakers** (rated for string Isc and voltage)
- **Label all inputs/outputs** clearly with:
    - String ID
    - Polarity
    - Direction

✅ **5.5 Stringing from Combiner to Panel Area + Testing**

Applicable Standards & Clauses:

- **SANS 60364-7-712:2018:** Clauses 712.521, 712.522, 712.443.101, 712.61, Annex B
- **SANS 10142-1 Ed. 3:**
    - Clause 6.12.5 (Earthing of PV wiring)
    - Clause 6.12.6 (DC cabling protection and layout)
    - Clause 6.9.2 & 6.9.3 (Cable routing and termination)
    - Clause 8.6 (Testing)

A. Cable Type & Rating

- Use **solar-rated** cables such as **PV1-F** or **TÜV-certified equivalents**:
    - UV- and ozone-resistant
    - Double-insulated
    - Flexible, tinned copper, stranded conductors
- Voltage rating:
    - ≥ system **Voc × 1.25** (commonly **1000 V DC**)
- Sizing:
    - Limit voltage drop to **≤ 3%**, ideally **≤ 2%**
    - Minimum: **4 mm²**, up to **10 mm²** depending on current and distance

---

B. Routing Requirements

- Route cables using:
    - UV-stable **trunking**, **wire mesh trays**, **conduit**, or **rail-mounted cable ties**
- Secure cables every:
    - **300 mm max** inside trunking
    - Avoid loose runs, especially across walkways or roofs
- Separation:

    - Keep **DC cables separate** from **AC cables** and **communication lines**
- Avoid:
    - Loops or coiling (reduces inductive risk)
    - Contact with hot surfaces (min. **25 mm air gap**)
    - Sharp bends (min. bend radius: **5× cable diameter**)
    - Dangling or unsupported connectors

C. Polarity, Labeling & Protection

- **Polarity marking**:
    - Use **coloured heatshrink**, wrap labels, or printed sleeves
    - Mark every **1.5 m** and at **all terminations**
- **Label string cables** at:
    - Combiner box
    - Panel origin
    - Optional mid-span points for large arrays
- Pass-throughs:
    - Use **DC-rated glands or bushings**
    - Earth all metallic conduits or enclosures used

D. Mechanical Protection

- Protect cables at:
    - Roof penetration points (use glands or grommets)
    - Outdoor runs (use UV-rated conduit or trunking)
- Ensure:
    - No resting on **sharp edges**
    - No pressure on cables from structure or movement

E. String Voltage & Insulation Resistance Testing

Before connection to the combiner box:

1. **Open-Circuit Voltage (Voc) Test**
    - Use **DC multimeter**
    - Verify **correct polarity**
    - Expected: panel Voc × number of panels
2. **Short-Circuit Current (Isc) Test**
    - Use **clamp meter in DC mode**
    - Expected: within **10% of panel datasheet Isc**
3. **Insulation Resistance Test**
    - Use **megger** at 500 V or 1000 V
    - Minimum: **>1 MΩ** between:
        - (+) to Earth
        - (–) to Earth
        - (+) to (–)
    - **Record all readings** on commissioning sheet

F. Connector Polarity & Compatibility

- Always **match MC4 brands** — do not mix types
- Verify polarity aligns with **combiner box layout**
- If incorrect:
    - Reverse at **panel side only**, **never** at the combiner

---

G. Lightning & Surge Protection

- For arrays > 10 m from the inverter:
    - Ensure **SPD** is installed in combiner or inverter
    - Bond **metal structure** to system earth
    - Route cables with **tight loops** and low-profile to reduce surge effect

---

H. Visual Inspection Before Energizing

- Confirm:
    - No **nicks, exposed copper**, or **insulation damage**
    - Glands and entries are **tight and sealed**
    - Polarity markings are **visible**
    - Routing is **neat** and **secure**
- Ensure:
    - No strain or pressure on **MC4 connectors**
    - No cable **resting on sharp edges** or **moving parts**

✅ 5.6 Install Panels

Applicable Standards & Clauses:

- **SANS 60364-7-712:2018:** Clauses 712.410.3.6, 712.526, 712.543
- **SANS 10142-1 Ed. 3:**
    - Clause 6.12.4 (Mechanical support for PV modules)
    - Clause 6.12.5 (Earthing of PV structures)
    - Clause 6.9.4 (Cable entry & sealing)

A. Mechanical Mounting

- Follow **panel datasheet** for mounting zones and torque specs
- Use approved **mid and end clamps**, tightened evenly and aligned
- Fasten mounting frames to:
    - Roof trusses or subframes
    - Using galvanised steel or aluminium rails
- All fasteners:
    - Stainless steel or zinc-coated
    - Torque per spec to avoid over-tightening or loosening

🛑 DO NOT:

- Mount directly to roof sheeting without structural support
- Reuse rusted or damaged mounting hardware

B. Fire & Weather Resistance

- Use proper **flashing or sealing washers** at penetration points
- Maintain roof's **fire rating** — confirm with local authorities
- Avoid exposed cabling over sharp edges or surfaces prone to heating

---

C. Panel Positioning & Spacing

- Align panels with uniform spacing (typically 20–30 mm)
- Maintain recommended **rear ventilation gap** for cooling
- Ensure:
    - Orientation and tilt are consistent across each string
    - No shading from nearby objects between 9 AM and 3 PM
    - Space is left for walkways or future maintenance access if required

---

D. Electrical Connections

- Only use **MC4-compatible connectors** — no twisting wires
- Confirm **polarity** before connecting any plugs
- Never connect or disconnect under load
- Secure string cables with:
    - Cable ties, clips, or adhesive mounts
    - Avoid sagging or loose loops under panels

E. Earthing of Panel Frames

- Bond frames if not double-insulated (Class II)
- Use **6 mm² green/yellow copper wire**
- Connect using:
    - Earthing lugs
    - Serrated washers to penetrate anodised coatings
- Ensure:
    - Continuous bonding
    - Corrosion-protected connections
    - Link to the **main earth terminal (MET)**

⚠️ Where a lightning protection system exists:

- Follow **SANS 62305**
- Connect PV frame bonding to the **LPS earth grid** if required

---

F. Visual Inspection & Labeling

- Confirm:
    - Clamps are tight and evenly spaced

    - No cracked glass or warped frames
    - Cable glands are sealed and secure
- Label:
    - Each string's origin (e.g. "String 1 – South Row")
    - Any damaged or suspect panels clearly as **"DO NOT CONNECT"**

✅ 5.7 Inline Fuses & Panel Earthing

Applicable Standards & Clauses:

- **SANS 60364-7-712:2018:** Clauses 712.433, 712.421.101, 712.432.101

A. When to Use Inline Fuses

- Required **per string** if:
    - More than **2 strings** are connected in parallel
    - Reverse current from adjacent strings could exceed **1.35 × Isc**
- Never rely on **blocking diodes** for overcurrent protection
- Fuses must protect against reverse current during faults or shading events

---

B. Fuse Selection & Placement

- Use **inline MC4 fuse holders** with:
    - **DC-rated fuses**
    - Voltage rating ≥ **system Voc**
    - Current rating ≥ **1.25 × Isc**
- Install fuses:
    - Close to the **panel source** or
    - Inside the **DC combiner box** (preferred)
- Fuses must be:
    - Accessible for inspection
    - Enclosed in **IP65+ rated** housing
    - Clearly **labelled**

C. Earthing of Panel Frames

- Bond all **module frames** to the main earthing system
- Use:
    - **6 mm² or larger** green/yellow copper conductor
    - **Approved lugs and terminals**
    - **Serrated washers** to break anodised coating for contact
- Bonding must be:
    - Continuous — no breaks
    - Corrosion-protected
    - Mechanically secure

D. Anti-Theft & Field Practice

- Use **anti-theft clips**, security fasteners, or **cable locks** where specified
- Confirm:
  - Earth continuity using a **low-resistance tester**
  - Clear labelling of fused strings:
    - "⚠️ DC FUSE – PV STRING PROTECTION"
    - Include **rated current** and **voltage**

✅ 5.8 Connect Panels & Test at DC Combiner

Applicable Standards & Clauses:

- **SANS 10142-1 Ed. 3:**
  - Clause 6.7 (Protection)
  - Clause 6.9.4 (Cable entry and glands)
  - Clause 6.12.6 (PV array cabling and combiner boxes)
  - Annex M (Testing of PV arrays, fusing, isolators)
- **SANS 60364-7-712:2018:**
  - Clause 712.413 (Protection against electric shock)
  - Clause 712.433 (Overcurrent protection)
  - Clause 712.536 (Switch-disconnectors)
  - Clause 712.61 (Verification)
  - Clause 712.421.101.1.3 (Fire risk prevention)

A. Safe Connection Procedure

1. **Isolate all DC isolators** and confirm no voltage is present at the combiner.
2. Use only **MC4-compatible connectors** of the **same make/model**:
   - Ensures proper fit and avoids arcing or thermal failure
   - Listen for **distinct click** to confirm locking
3. **Label each string** clearly at combiner entry (e.g., *String 1, String 2*)
4. **Verify polarity** before connecting:
   - Incorrect polarity can damage the inverter or create arc flash risk
5. If strings were **pre-tested (Voc)**:
   - Record results
   - Mark each string visibly with **Voc value** and test date

---

B. Testing After Connection (Before Energising)

1. **Open-Circuit Voltage (Voc) Test**
   - Measure across **+ and –** at each string input
   - Compare to panel specs × number of modules
   - All strings should be within **±5% tolerance** of each other
   - Large deviations may indicate:
     - **String break**
     - **Mixed orientation**
     - **Partial shading**
2. **Insulation Resistance Test**
   - Use 500 V or 1000 V **megger**
   - Test:
     - (+) to Earth
     - (–) to Earth
   - Required minimums:
     - **≥ 1 MΩ** for systems <120 V DC

        - **≥ 2 MΩ** for 120–1000 V DC
    - Perform **before inverter connection**
3. **Earth Continuity Test**
    - Confirm continuity from:
        - PV array → Combiner → Main Earth
    - Acceptable resistance: **< 1 Ω**

C. Labels and Safety Markings

- **Inside the combiner:**
    - String numbers and polarity
    - Indication of **fused vs. non-fused** inputs
    - Positive/negative **busbar labelling**
- **Outside the combiner:**
    - Red/white label: **" ⚠️ WARNING – DC VOLTAGE PRESENT"**
    - Voltage/current ratings (e.g., "Max 1000 V DC, 15 A per string")
    - Combiner ID (e.g., "Combiner A – Roof 1")

D. Torque Settings

- Tighten all terminals and fuses to **manufacturer specifications**:
    - Typically: **1.2–2.5 Nm**
- Use a **calibrated torque screwdriver**
- Loose connections are a **major fire risk** due to DC arcing

---

E. Combiner Box Final Checks

- Ensure:
    - **Glands sealed** and rated **IP65+**
    - **SPD status window** visible and **green** (operational)
    - No **mixed polarity connections**
- Take photos of:
    - **Open combiner box** with:
        - Labels
        - Cable routing
        - Proper fuse and SPD installation

F. Final Testing Summary

- After all strings are connected:
    - Measure total **Voc and Isc** at combiner output
    - Perform **final insulation resistance** test
    - Check for:
        - **Leakage current**
        - **Potential faults**
        - **Correct polarity**

✅ 5.9 Stringing from Combiner to Inverter

Applicable Standards & Clauses:

- **SANS 10142-1 Ed. 3:**
  - Clause 6.12.6 (Cabling from PV array to inverter)
  - Clause 6.9 (Cable routes, selection, and protection)
  - Clause 6.7 (Overcurrent protection)
  - Clause 6.12.6.3 (Voltage drop limits)
  - Clause 5.4 (Identification of conductors)
  - Annex M (String layout and testing)
- **SANS 60364-7-712:2018:**
  - Clause 712.434 (DC wiring to inverter)
  - Clause 712.52 (Cable sizing and voltage drop)
  - Clause 712.525, 712.536 (Switch-disconnectors)
  - Clause 712.543 (Protective earthing)

A. Conductor Selection and Sizing

1. **Cable Rating:**
   - Use DC-rated cable (600 V, 1000 V, or 1500 V) with PV-specific insulation (e.g., **EN 50618 compliant**)
   - Typical sizing:
     - **4 mm²** for ≤15 A and ≤30 m runs
     - **6 mm²+** for higher current or longer distances
2. **Voltage Drop:**
   - DC voltage drop should not exceed **1.5%** (preferably <1%)
   - Formula:

     $V_{drop} = \frac{2 \times L \times I \times \rho}{A}$

     Where:

     - L = cable length (m)
     - I = current (A)
     - ρ = 0.0175 Ω·mm²/m (copper)
     - A = cable cross-sectional area (mm²)
3. **Polarity Identification:**
   - Red = Positive (+)
   - Black = Negative (–)
   - Green/Yellow = Earth
   - Use **permanent markings** or sleeving at both ends

B. Routing Requirements

1. **Physical Protection:**
   - Route DC cable in **UV-rated trunking**, conduit, or cable tray
   - Prevent exposure to **sharp bends** or crushing
   - Outdoor conduits must be **IP65+**
2. **Segregation:**

    - Maintain **≥50 mm separation** from AC cables unless:
        - Using **double insulation**, or
        - Divided by a **metallic barrier**
3. **Routing Rules:**
    - Minimum bend radius: **4 × outer diameter**
    - Use **fire-rated clips or clamps** every **300–500 mm**
    - Neatly follow **structural pathways**

C. Protection and Switchgear

1. **DC Isolator (near inverter):**
    - Required for local shutdown of PV input
    - Must be:
        - **Double-pole**
        - Rated for:
            - Full system voltage (e.g., 1000 V DC)
            - Current ≥ **1.25 × total Isc**
2. **Surge Protection Devices (SPDs):**
    - Install **Type 2 SPD** if:
        - DC cable >10 m
        - Lightning risk present (per **SANS 62305** or installer policy)
    - Install in:
        - **Combiner box**, or
        - **Adjacent to inverter**
    - SPD earth cable must be:
        - **Short and direct**
        - ≤ **0.5 m** in length

D. Earthing & Equipotential Bonding

- Bond the following to the **main PV earth bar**:
    - DC cable glands (if metal)
    - Combiner enclosure
    - Inverter chassis
- Use **≥6 mm² Cu green/yellow** conductors
- Verify continuity:
    - Resistance **< 1 Ω** from frame to earth bar

E. Final Testing Before Inverter Connection

1. **Polarity Check:**
    - Use DC multimeter to confirm **correct polarity** at inverter terminals
    - **Never plug in** if polarity is uncertain
2. **String Voltage Confirmation:**
    - Measure **Voc per string** at inverter end
    - Compare to earlier combiner box values
3. **Earth Continuity Test:**
    - Confirm bonding from inverter to earth electrode via array and combiner
    - Acceptable resistance: **< 1 Ω**
4. **Documentation:**
    - Record:
        - Final **Voc values**

        - **Polarity checks**
        - **Earth continuity**
    - Update the **DC commissioning sheet**

6. Inverter/BESS side

◇ 6.1 Inverter Mounting

✅ Purpose

This section outlines the correct procedures and standards for mounting inverters in residential, commercial, or containerized PV installations. It applies to hybrid, grid-tied, and off-grid systems, whether wall-mounted, rack-mounted, or integrated into battery enclosures.

📘 Standards & Regulatory Clauses

- **SANS 10142-1 (Edition 3)**:
    - Clause 5.3 – Accessibility
    - Clause 6.3.6 – Equipment location
    - Clause 6.4.4.1 – Fire protection
    - Clause 7.12 – Inverter connection
- **SANS 60364-7-712:2018**:
    - Clause 712.312.2.1.1 – Equipment accessibility and ventilation
    - Clause 712.514.101 – Labelling and positioning
    - Clause 712.521.102 – Overheating risk and installation
    - Clause 712.512.2 – Inverter protection
- **Manufacturer Guidelines Referenced**:
    - CSI Solar
    - SolarEdge
    - Tesla
    - SMA
    - Huawei
    - NEC (for working clearance reference)

🧱 Mounting Surface & Structural Requirements

- Mount on a **non-combustible**, **vertical surface** such as:
    - Masonry (brick or concrete)
    - Fire-rated backboard (in containers or timber structures)
- Ensure surface can support **≥4× inverter weight**
- Use **anchor bolts**, wall plugs, or anti-vibration mounting kits where applicable
- In container or mobile setups, apply vibration-resistant mounting brackets

---

📏 Minimum Clearance Guidelines

Use the **highest value across all standards** and manufacturers:

Location	Recommended Clearance
Side	200 mm (min), up to 500 mm
Above	300–500 mm
Below	500–650 mm for airflow
Front (service)	≥900 mm (for monitoring/repairs)

🌀 Thermal & Environmental Requirements

- Install in a **shaded**, **cool**, and **ventilated** location:
  - Indoors (utility room) or
  - Outdoors with **IP54+** protection and shading cover
- Keep away from:
  - **Direct sunlight**
  - **Dusty or corrosive environments** (e.g., sea air)
  - **Heat sources** (e.g., geysers, stoves)
  - **Moisture ingress** areas
- Inverter operating temperature range (typical CSI models):
  −30 °C to +60 °C

🔧 Installation Position & Orientation

- Must be mounted **vertically** or **tilted back** by up to 10–15°
- Do **not**:
  - Mount inverted or lying flat
  - Stack units directly on top of each other
- Use **side-by-side** or **triangular offset** configurations for multiple units

---

⚙️ Mechanical Fixing Requirements

- Use:
  - **Unistrut rails**, metal struts, or **manufacturer-approved mounting kits**
- Secure all bolts/screws firmly with correct **torque** (per inverter manual)
- Mounting height:
  - **500 mm to 2 m** from floor (operator safety and visibility)

🔒 Accessibility, Noise, and Safety

- Inverters must be:
  - **Easily accessible** for inspection and maintenance
  - **Out of reach** of children and protected from vandalism/theft
  - **Not installed in**:
    - Bedrooms, lounges, or habitable rooms
    - Battery enclosures (unless designed for it)
    - Roof cavities without sufficient ventilation
- Consider audible noise (some inverters produce a hum):
  - Avoid installing near schools, offices, or noise-sensitive areas (e.g. ≥40 m as per Tesla guidance)

📝 Final Installer Checklist

Before proceeding to wiring or commissioning:

- Wall is level, non-combustible, and structurally secure
- All fixings torqued as per manufacturer specs
- Clearance around inverter complies with the summary table
- Ambient conditions meet inverter's operational range
- Enclosure rating verified if outdoors (minimum IP54)
- All labels and cable access points visible
- Photo taken of mounted inverter for compliance documentation

🔷 6.2 Battery Mounting & Configuration

✅ Purpose

This section outlines best practices, safety rules, and applicable standards for mounting, spacing, and configuring lithium and lead-acid batteries in solar PV systems. Applies to indoor, outdoor, wall-mounted, or rack-mounted setups.

📘 Standards & Regulatory Clauses

- **SANS 10142-1 (Ed. 3.00 & 3.2)** – Clause 6.12.6.4, Annex M
- **SANS 60364-7-712** – Clause 712.521.101
- **SANS 60364-5-52** – Cable installation
- **SANS 62040-1 / 62485** – Stationary battery safety
- **NRS 097-2-1** – Embedded generation (batteries)
- **OEM Guidelines** (e.g. BYD, Pylontech, Hubble, FreedomWon)

🧱 Mounting: Wall, Rack & Stacked Systems

Mount Type	Key Guidelines
Wall-Mounted	Use OEM brackets; only mount upright on non-combustible surfaces; ≤1.2 m height
Rack-Mounted	Use free-standing steel frames or enclosed cabinets with anti-tilt fixings
Stacked Units	Max 2–3 high unless OEM allows more; spacing ≥10 mm; use interlock brackets
Outdoor Mounting	Must be inside an IP54+ rated weatherproof enclosure, bolted to concrete base

---

🧯 Battery Location Requirements

Requirement	Minimum Guideline
Ventilation	Natural or fan-assisted airflow. No sealed cabinets for lead-acid or >1 kWh systems
Temperature	Operate between 0–50 °C; Ideal for $LiFePO_4$ = 15–25 °C
Sunlight/Heat	Keep out of direct sunlight and away from heat sources or inverter exhausts
Combustibles/Moisture	No batteries near fuels, solvents, or high-humidity corners
Access	≥600 mm in front of terminals for maintenance; avoid ground-level placement if avoidable

Requirement	Minimum Guideline
Raised Install	Use pedestal or OEM frame to allow airflow beneath batteries

---

🛠 Mechanical & Safety Guidelines

- Mount batteries **upright**, unless explicitly approved otherwise by the manufacturer
- Do **not exceed load rating** of shelf, rack, or wall
- Use **non-combustible mounting surfaces**
- Maintain spacing:
  - **≥100 mm between units**
  - **≥300 mm from inverters or other hot surfaces**
- Label each battery or string with:
  - **Polarity**
  - **String/Bank ID**
  - **Voltage (e.g. 51.2 VDC)**
  - **Capacity (e.g. 5.12 kWh)**
  - "**Isolate before working**" where required

⚙️ Electrical Configuration & Protection

Item	Requirement
Polarity Check	Confirm before connection. Red = (+), Black = (−). Never reverse terminals
Series vs. Parallel	Series = voltage ↑ ; Parallel = capacity ↑. Must match inverter specs
Cable Type	Use OEM-supplied busbars or 50–70 mm² DC battery cables
Fuse/Breaker	Install master fuse or DC-rated disconnector **≤300 mm** from battery terminal
Comms (if Li-ion)	Connect CAN/RS485 between inverter and battery (before energising)
Current/Voltage	Do not exceed battery charge/discharge ratings. Confirm with inverter setup

---

🔋 Configuration Tips (Stringing & Grouping)

- Use equal-length cables for parallel-connected batteries
- Never mix brands, chemistries, or capacities within a single bank
- Always observe **manufacturer's limits** on:
  - Max number of parallel/series connections
  - Operating voltage and current

🧪 Pre-Energising Checklist

- Batteries mounted upright, securely fastened
- All cables torqued to OEM specs
- Ventilation confirmed (especially for lead-acid)
- Polarity and voltage checked with multimeter
- CAN/RS485 communication active (LED flashing or comm OK)
- DC breaker or isolator OFF before inverter connection
- Labels applied on battery bank with warning if required

⚠️ Safety Notices & PPE

- **Hazards**: Acid burns, electrical shock, fire risk
- **Installers must wear**:
  - Safety gloves
  - Eye protection (goggles)
  - Enclosure must prevent accidental contact with live terminals
- Ensure signage near batteries includes:
  - “Install in ventilated area”
  - “Isolate before working”
  - “Do not mix battery types”

◇ 6.3 Wireways, Trunking & Glanding

☑ Purpose

This section ensures that all AC, DC, and communication cabling is routed, protected, labelled, and terminated in a manner that is **safe**, **code-compliant**, and **durable** in harsh environments, especially for rooftop and battery system installations.

▧ Applicable Standards & Clauses

Standard	Clause / Area Covered
SANS 10142-1 Ed. 3	Clauses 6.6.3, 6.9.2, 6.9.4, 6.12.6, 6.15, 6.17, Table 7.1 (trunking, cable routing, separation)
SANS 60364-7-712	Clauses 712.521, 712.522, 712.514 (PV-specific wiring protection and separation)
SANS 60529	IP rating standards for enclosures and glands
Manufacturer Manuals	Requirements for inverter, battery, and comms gland entries

---

🧱 Wireways: Trunking, Conduit & Ducting

Requirement	Guideline
Material	Use UV-resistant, flame-retardant plastic OR galvanized steel trunking
Sizing	Maintain at least **40% spare capacity** (refer to SANS 10142 Table 7.1)
Routing	Install horizontal/vertical only — no diagonal layouts
Support Spacing	Max **1–1.5 m intervals**, depending on weight
Bend Radius	Follow min. radius as per cable manufacturer specs (typically 4× cable diameter)
Mounting Surface	Screw to solid walls or structures — **glue alone is not acceptable**
AC vs. DC Routing	**AC and DC must use separate trunking** (Clause 6.6.3.1); metal barrier if same tray
Labeling	Use permanent labelling: "PV DC", "Battery Comm", "AC Output", etc.

⚠ **Never run AC and DC in the same duct or trunking**, even if using a divider.

🔩 Glanding (Cable Entry Points)

Cable Type	Requirement
DC Cables	Use metal or UV-resistant plastic glands, **min. IP65**, with strain relief
Battery Cables	Gland at both inverter and battery cabinet entry points
AC Cables	Use compression glands (flexible or armoured-compatible)
Outdoor Glands	IP66 minimum; orient downwards or shielded to avoid water ingress
Comms Cables	Enter through **separate gland ports**, avoid routing with power cables

🎯 Always drill gland holes to exact size. Use internal locknuts and washers to secure glands.

🌓 Mechanical Protection & Routing Rules

Scenario	Required Protection / Practice
Exposed Cable Paths	Use PVC duct with cover or steel conduit — impact resistant
Rooftop Installations	UV-stabilised conduit (HDPE or UV-PVC); run under panels or along metal support
Underground Runs	Enclose in rigid conduit, **300 mm min. depth**, with warning tape
Inverter Room Wiring	Run trunking neatly against walls. No mid-air/hanging paths
Switchboards/Combiners	Gland from **bottom or side only**; label all entries with source/destination

---

📏 Spacing & Clearance Requirements

Cable Group	Minimum Spacing
AC vs DC	≥100 mm if not in completely separate conduits
Battery vs Comms	≥50 mm separation
Ethernet/RS485	Must **cross at 90°**, never run in parallel with power cables

---

🏵️ Finishing & Safety Labelling

- Trunking ends must be:
  - **Deburred** (no sharp edges)
  - **Sealed** (no open slots unless approved by OEM)
- Glands and trunking must be:
  - **Tight-fitting**
  - **Rated IP65 or higher** in dusty/outdoor settings
- **Label every duct/wireway** with:
  - Origin and destination (e.g. “Battery → Inverter”)
  - **Voltage rating** if >50 V

- Communication paths (CAN, RS485, Ethernet) separately

☑ Use **engraved tags** or **permanent marker** — avoid stickers that can peel over time.

◇ 6.4 DC & AC Combiner Mounting

✅ Purpose

This section covers the installation, protection, labelling, and integration of **DC and AC combiner boxes**, which help consolidate wiring, apply surge protection, and ensure safe isolation. Combiner boxes may be optional if isolation is handled panel-side.

📘 Applicable Standards & Clauses

Standard	Clause / Area Covered
SANS 10142-1 Ed. 3 & 3.2	Clauses 6.7, 6.12.6, 6.16, 6.17, 7.12, 8.7, Annex Q
SANS 60364-7-712 Ed. 2	Clauses 712.434, 712.512, 712.536, 712.443
Manufacturer Guidelines	Installation heights, enclosure IP ratings, spacing, SPD compatibility

---

⚙️ General Combiner Mounting Principles

Requirement	Guideline
Mounting Surface	Only on fire-resistant surfaces: brick, steel frame, concrete wall
Mounting Height	1.2 m – 2.2 m from floor (switchboard access height per code)
Orientation	Vertical only — no tilted or upside-down installs
Environment Rating	Outdoor: IP65 minimum; UV & rainproof
Accessibility	Must be fully accessible without dismantling other equipment
Labelling	Front label: “DC Combiner” or “AC Combiner” + source, voltage
Lockable Covers	Boxes must be tool-access or lockable if accessible to the public

---

🔌 DC Combiner Requirements

Element	Requirement
DC Isolator (per MPPT)	One isolator per MPPT input group (Clause 712.536.2.1.1)
Fuses / Breakers	Required where 3+ strings are paralleled or per panel specs
Surge Protection (SPD)	Type 2 SPD needed if: V_{oc} > 120 V OR cable > 10 m (Clause 8.7.6)
Cable Marking	Label incoming/outgoing cables: "String 1", "String 2", etc.
Earthing Bar	Required if combiner includes earth bonding for PV frames
Busbars / Terminals	Rated ≥1.25× maximum current of parallel strings
Enclosure Sizing	Allow 30% spare room inside enclosure — no overcrowding

⚠️ **DC cable entry must be from the bottom or side. Top entry is not allowed outdoors.**

⚡ AC Combiner Requirements

Element	Requirement
Main AC Isolator	Must be load-rated; 4-pole if 3-phase + neutral
Main Breaker / MCCB	Must handle full inverter AC output with safety margin
Surge Protection (SPD)	Type 2 SPD if inverter lacks internal surge protection (Clauses 8.7.4, 8.7.6)
Neutral / Earth Bars	Segregated and clearly labelled
Output Labels	Label all outgoing lines: “To Load DB”, “To Backup”, etc.
Enclosure Rating	Indoor: IP42 minimum; Outdoor: IP65+
Breaker Labels	Each breaker must indicate function (e.g., “AC Out – Grid Tie”)
Bypass / Interlock	Safe switching logic must be documented to avoid backfeed

---

📏 Clearance & Cable Routing Practices

Area	Minimum Clearance
Sides of Combiner	≥150 mm clearance
Front Working Space	≥1 m clear floor space in front
Cable Routing	No crossing over internal terminals or conductors

---

🛑 Prohibited Practices

- ❌ Do **not** mount combiner on:
  - Timber or drywall
  - PVC panel boards
- ❌ Avoid mounting in **direct sunlight** unless box is UV-shielded
- ❌ Do **not** use generic DBs without proper solar labels or IP rating
- ❌ Do **not** combine AC & DC wiring in a single enclosure unless:
  - Double insulated
  - Segregated internally (Clause 7.12.5.1)

🧰 Final Installer Notes

- Ensure visual surge indicators (green/red) are **visible without disassembly**
- Earthing bars must be:
  - Bonded to the enclosure
  - Bonded to external earth if grounding is done at this point
- Document layout and current paths for future maintenance
- If combiner is skipped due to panel-side isolation:
  - Ensure full documentation shows isolation points and fusing

◇ 6.5 Earthing & Bonding (Inverter & Battery Section)

☑ Purpose

This section outlines the correct bonding and grounding practices for **inverters**, **battery banks**, **combiners**, and **DBs**, in accordance with national standards and manufacturer specifications. Correct earthing ensures safety, reduces electrical noise, and protects from surge or lightning events.

Applicable Standards & Clauses

Standard	Relevant Clauses / Areas
SANS 10142-1 (Ed. 3 & 3.2)	5.2, 6.12, 6.13, 6.14, 7.12, 8.6; 5.2.2, 6.12.6.2
SANS 60364-7-712 (Ed. 2)	712.411, 712.413, 712.54, 712.542, 712.61
SANS 60364-5-54	Earthing and protective conductors
SANS 10198	Earth resistance test procedures and earthing electrode design

General Earthing Requirements

Requirement	Description
System Type	Know whether the site is TN-S, TN-C-S, or TT — earthing layout will differ
Single Earth Point	Only one neutral–earth bond allowed, usually at the main grid AC DB
Inverter Bonding	Most inverters have internal N–E bonding; external bonding is often **not** needed
Bonding Conductors	Use **≥6 mm² copper** for all earth bonding paths unless specified otherwise
Continuity	All exposed metal parts must be electrically bonded (battery rack, inverter, DB)

Inverter Earthing

Element	Guideline
Frame Earth Lug	Connect to common earth bar or DB earth terminal
Internal N–E Bonds	If inverter has built-in bond, **do not add another** externally
Metal Mounting Surface	If inverter is wall-mounted to steel or aluminium, the surface must be earthed
SPD Earthing	Run SPD earth wires **direct to earth bar**, avoid passing through neutral

Battery System Earthing

Element	Requirement
Rack Bonding	Metal racks must be bonded using **≥6 mm² Cu** to earth
BMS Earthing	Follow OEM specs — some BMSs require a separate **functional earth (FE)**
Cable Shielding	If using armoured DC cable, **gland at one end only** to prevent earth loops
Earthing Resistance Target	<6 Ω preferred, <5 Ω in lightning zones (confirm via SANS 10198 or engineer approval)

⚠ Ground Loops & Interference Risk

Risk Area	Best Practice
Dual earths on shielded cables	**Earth only one end** of communication cables between batteries & BMS/inverter
Mixed trunking AC/DC	Never run DC earth through AC trunking or vice versa
Parallel paths	Avoid multiple parallel earth paths for AC and DC systems

---

☂ Surge Protection Earthing (SPD)

Component	Earthing Requirement
DC SPD	Connect directly to inverter or combiner box earth bar — shortest path, <0.5 m ideally
AC SPD	Connect to main AC DB earth terminal; do **not** share path with neutral
Bonding Path	Must be short, straight, and avoid sharp bends to reduce impedance during surges

---

🧪 Earthing Tests & Verification

Test	Method / Tool	Standard Referenced
Earth Resistance	Use earth resistance tester or earth loop tester	SANS 10198
Continuity (Bond Paths)	<1 Ω across all bonded parts — test using continuity meter	SANS 10142-1
Visual Inspection	Check lugs, ferrules, bonding integrity, and cable routing	Installer Commissioning Checklist

---

🔘 Do Not:

- ❌ Create earth loops between inverter, battery, and DBs
- ❌ Bond inverter neutral unless manufacturer specifically permits (especially in grid-tied systems)
- ❌ Mix AC and DC earthing terminals inside the same enclosure without full separation
- ❌ Use flexible copper without lugs or ferrules for earth terminations

---

☑ Installer Action List

Component	Required Bonding
Inverter frame	Bond to common earth bar using ≥6 mm² Cu
Battery negative	Bond only if required by BMS/inverter spec
PV Panel Frames	Bond to earth via combiner/inverter ground to final earth rod
AC DB Earth	Ensure connected to main system earth, and linked to SPD/neutral as per system type
Equipotential Bonding Bar	Use where **multiple earths** exist (grid, PV, generator, battery bank)

◇ 6.6 DC & AC Wiring to Inverters

✅ Purpose

This section outlines the correct wiring practices on both the **DC** and **AC** sides of the inverter. Proper segregation, cable sizing, torqueing, labeling, and compliance with voltage drop and safety standards are critical for performance and fire safety.

📘 Applicable Standards & Clauses

Standard	Clauses / Notes
SANS 10142-1 (Ed. 3 & 3.2)	Clauses 6.4, 6.7, 6.9, 6.12.6, 6.16, 8.6, Annex M
SANS 60364-7-712 (Ed. 2)	Clauses 712.434, 712.522, 712.525, 712.536
EN 50618	PV-specific DC cable requirements

🔧 DC Wiring (Combiner / Battery → Inverter)

Item	Specification
Cable Type	PV-rated, double-insulated, **tinned copper** (EN 50618)
Conductor Size	Sized to keep voltage drop ≤ 1.5%; typically 4 mm², 6 mm², or 10 mm²
Polarity ID	Positive = Red or “+”; Negative = Black or “–”
Routing	Dedicated trunking or conduit; avoid sunlight exposure or plenum spaces
Terminations	Tinned copper lugs; torque using calibrated wrench (1–2 Nm or per inverter spec)
DC Isolator	Within 1 m of inverter; double-pole, DC-rated above system Voc and Isc
Bend Radius	Maintain ≥ 4× cable outer diameter
Comms Delay	Do **not connect** battery communications until DC voltage is confirmed

---

⚡ AC Wiring (Inverter → AC Combiner or DB)

Item	Specification
Cable Type	Copper, PVC-XLPE, 600/1000 V-rated; XLPE preferred for durability
Voltage Drop	<3% allowed; design with cable calculator for correct gauge
Core Configuration	Single-phase = L, N, PE; Three-phase = 3L, N, PE
Colour Coding	L = Brown/Black, N = Blue, PE = Green/Yellow
Isolation Device	Double-pole (1ph) or four-pole (3ph) isolator near inverter output
Cable Protection	IP54 indoors, IP65 for outdoor runs; compression glands to seal entries
Termination	Torque terminals as per manufacturer (e.g., 2.5 Nm for Victron/GoodWe)

✅ General Wiring Rules

- Use **separate trunking** for AC and DC cables — minimum **150 mm physical separation**
- Use **clearly printed labels** on both ends of each cable (e.g., “PV DC+”, “INV AC L1”)
- Route **DC cables as short as possible**, avoiding loops and crossovers with AC
- Use **tinned copper lugs** and torque tools — never twist bare wire ends into terminals
- Install **SPD protection** on both AC and DC sides, where required
- Maintain **earthing continuity** using green/yellow PE cables — test for <1 Ω resistance

🧪 Testing Before Energising

Test	Method / Target
Insulation Resistance	Megger test ≥1 MΩ between conductors and earth (AC & DC separately)
Continuity (PE)	Test earth path from inverter to DB: must be <1 Ω
Voltage Drop Compliance	Confirm installed run meets design spec with <3% drop
Polarity Check (DC & AC)	Confirm correct polarity of all conductors **before power-up**
Phase Rotation (3ph only)	Use phase tester to confirm L1, L2, L3 are correct and in proper sequence

---

🛑 Common Errors to Avoid

- ❌ Twisting bare DC wires into terminals without proper lugs
- ❌ Running AC and DC cables in the same wireway or conduit
- ❌ Oversized voltage drop due to incorrect cable sizing
- ❌ Loose or incorrect gland fittings — breaks IP rating
- ❌ Forgetting to label both ends of cables clearly
- ❌ Terminating flexible wire without bushings or ferrules

✅ Installer Checklist Summary

Wiring Area	Key Action
DC Input (PV + Batt)	Use tinned lugs, torque to spec, short cable run, polarity check
AC Output	Correct isolator type, verify phase rotation, comply with voltage drop specs
Cable Routing	Keep DC and AC segregated; no shared ducts
Labeling	Label every wire clearly at both ends
Testing	Insulation, continuity, voltage drop, and phase checks before energising

◇ 6.7 Communications & Configuration

✅ Purpose

This section ensures proper data connectivity between all components (inverter, battery, CT clamps, and monitoring gateway) and confirms the system is configured correctly for safe operation, accurate monitoring, and compliance with site-specific settings.

📘 Relevant Standards & Protocols

Standard / Reference	Description
SANS 10142-1 (Ed. 3.2)	General installation and wiring documentation requirements
IEC 61850 / SunSpec / Modbus	Common data protocols for inverter and BMS communications
Manufacturer Manuals	System-specific settings for brands like Victron, Sunsynk, Deye, BYD, etc.

🔌 Communications Cable Setup

Device / Link	Communication Method
Inverter → Battery	CAN-bus or RS485 (verify battery compatibility and termination)
Inverter → Monitoring	Ethernet (Cat5e/Cat6), RS485, or Wi-Fi (based on system design)
Inverter → Inverter	RS485 daisy-chain (for parallel sync / master-slave mode)
CT Meter → Inverter	RS485 A/B line (ensure shielded twisted pair)
Router / Gateway	Wi-Fi or LAN; label cables and verify physical signal strength

🛠 **Installation Best Practices**:

- Use **separate trunking** for communications vs AC/DC cabling
- Maintain **≥50 mm spacing** or cross at 90° angles only
- Use **shielded CAT6** or twisted-pair RS485 cable; ground shield at **one end only**
- Terminate with **120 Ω resistor** at both ends of RS485 bus (if required)

🔧 **Configuration Requirements**

Setting / Step	Description
Device IDs	Assign unique Modbus or CAN address to each inverter, battery, CT, etc.
Firmware Updates	Update inverter, BMS, and gateway firmware via USB or Ethernet
Charge / Discharge Config	Set battery charge/discharge current, voltage window, and DoD
CT Clamp Settings	Confirm CT direction, scaling, and phase mapping
Grid Trip Limits	Configure export limits, frequency and voltage windows (NRS 097-2-1)
Time-of-Use Settings	Program load scheduling or time-based discharge where supported
Monitoring Portals	Verify that portal/cloud displays real-time voltage, SOC, temperature, etc.

📝 **Common Systems**:

- **Victron**: VE.Bus, VE.Can, VRM portal, GX devices
- **Sunsynk/Deye**: CAN/RS485, Wi-Fi dongle, or LAN to Sunsynk Portal
- **Voltronic**: USB port, WatchPower or ICC software
- **Sungrow/SolarEdge**: LAN or RS485 to gateway/cloud

🧪 **Verification & Testing**

Test	How to Perform / Check
Modbus Poll Test	Ping inverter and BMS addresses to confirm data traffic
Portal Monitoring Test	Log in and verify inverter shows grid, battery, PV, and load metrics
CT Clamp Test	Energize known load and confirm power readings correspond accurately
Error Logs	Clear logs before handover; ensure no red or warning flags on dashboard

---

🔐 **Security & Data Protection**

- Use **unique installer and client passwords**
- Change factory defaults; **disable Telnet/HTTP**, use **HTTPS/VPN** if remote access enabled
- Backup configurations in PDF or screenshot format

- If router is installed, **change SSID and admin credentials**

📝 Documentation Required for CoC

Item to Record	Purpose
Device Serial Numbers	Reference in CoC and fault logging
Firmware Versions	Proof of current version installed before handover
Modbus/Network IDs	Prevents conflict with other equipment
Configuration Screenshots	Include: charge settings, network settings, export limit, SOC parameters
CT Clamp Orientation	Log correct direction for import/export calibration

All documentation must be stored in the **handover folder** and referenced during CoC (Certificate of Compliance) preparation.

◇ 6.8 Pre-Commissioning Testing

✅ Purpose

To verify the integrity, safety, and compliance of the solar PV system before it is energized. All tests must be passed to ensure a safe, functional, and certifiable installation.

📘 Standards & Test References

Standard / Clause	Description
SANS 10142-1 (Ed. 3 & 3.2)	Clause 8.2 (initial verification), Clause 8.6 (PV system tests), Annex M
SANS 60364-7-712	Clause 712.61–712.63 (visual, continuity, insulation resistance)
SANS 60364-6	Full system verification & compliance tests
Annex I (SANS 10142)	Documentation required for CoC

🧰 Mandatory Test Sequence & Checks

Test Type	What to Check	Pass Criteria
Visual & Mechanical	No exposed conductors, sealed glands, trunking intact, correct routing	Safe, clean install
DC Polarity	Multimeter test at inverter input terminals with DC isolator **open**	Correct polarity, no reverse voltage
Battery Voltage Check	Measure each battery unit and total string voltage	Matches design specification
Insulation Resistance	Test using Megger: – DC: (+) to (–), each to earth – AC: L/N to earth	≥ 1 MΩ
Earth Continuity	From inverter frame, battery rack, combiner box, panel frames → earth bar	≤ 1 Ω

Test Type	What to Check	Pass Criteria
SPD Indicator Status	Visual check of both DC and AC SPD LEDs	GREEN or “OK” indicator
Function of Isolators	Test open/close cycles for both DC and AC isolators	Smooth mechanical action
Phase & Polarity (AC)	Confirm L–N wiring, phase rotation, and isolator breaks L only	Correct wiring, safe isolation
Comms & Monitoring	CT meter, battery SOC, inverter all visible in monitoring portal	All devices online
Static Operation Test	Resistive load applied, battery/inverter logic checked	Charging/discharging as designed
Emergency Shutdown Test	Simulate fault: open both isolators, confirm total shutdown	Safe, complete power-off
Firmware & Config	Check all firmware versions are current	Updated
Final Startup	After all tests passed, power system on	No errors or alarms

---

⚠ Important Notes

- **Do NOT energize** the inverter until **all pre-commissioning tests** have passed.
- **Reverse polarity** or insulation resistance failures may damage the inverter or void warranties.
- **Battery fuse and breaker protection** must be confirmed before connection.

📋 Documentation Required for CoC

Item	Purpose
Pre-commissioning Checklist	Complete and signed by the installing electrician
Test Results Log	Include test values (insulation resistance, voltage, continuity)
Photo Records	Labelled connections, isolators, SPDs, and inverter display
Screenshots	From inverter dashboard or monitoring portal (e.g., SOC, PV input)
Emergency Shutdown Verification	Log drill results and note any delays or failure points
Installer Sign-off	Include name, PR number, signature, date, and time

---

✅ Summary of Pass Criteria

Test	Minimum Requirement
Insulation Resistance	≥ 1 MΩ (DC and AC circuits)
Earth Continuity	≤ 1 Ω from any frame to main earth bar
Polarity Check	No reverse polarity at inverter DC input
Voltage Drop	DC < 1.5%; AC < 3%
SPD Status	Green indicator on both AC and DC sides
Monitoring Communication	All devices visible in portal
Isolator Function	Must operate smoothly and fully isolate lines
Emergency Shutdown	Must result in complete system power-off

7. AC Side – Load & Grid integration.

◇ 7.1 AC Wireways & Routing

✅ Purpose

To ensure safe, compliant, and interference-free routing of all AC-side wiring from the inverter output through to the client's distribution board (DB), including appropriate segregation from DC cabling, physical protection, labeling, and routing standards in line with SANS requirements.

📘 Source Standards & Clauses

Standard	Clauses Referenced
SANS 10142-1:2020 (Ed. 3)	6.4.4.2 (Circuit separation), 6.9.2–6.9.4 (Wiring installation & mechanical protection), 6.12.5.4 (AC DB wiring), Annex M (Embedded generation)
SANS 60364-5-52	Cable selection and installation requirements
SANS 60364-7-712	Clauses 712.514.101, 712.521.102, 712.522.101 (Routing and protection for PV systems)

🔌 Key Requirements: Routing & Installation

Category	Requirement / Instruction
Wireway Types	• Conduit (PVC, steel, HDPE – must be UV-resistant if exposed) • Trunking (metal or plastic) • Armoured cable with proper gland terminations • Cable trays or ladders with covers
Separation of AC/DC	• AC and DC must be routed in separate wireways • Where crossing, must do so at 90° angles only • Maintain minimum 150 mm horizontal separation in parallel runs
Mechanical Protection	• Wires must be protected from crushing, chafing, and heat • Use sleeves or bushings when passing through walls • Firestop penetrations in fire-rated walls • Minimum 50 mm depth for recessed wiring
Support & Fixing	• Secure cables every 300–500 mm (depending on weight and conduit type) • Use saddles, straps, or trays • No loose/hanging or unsupported wires
Routing Logic	• Use neat, vertical/horizontal routes • Avoid zigzag runs and sharp corners (min bend radius: 5× cable diameter) • Avoid high-heat areas (e.g., geysers)
Labeling & Marking	• All conductors must be clearly marked at both ends: – Phase: Brown or Black – Neutral: Blue – Earth: Green/Yellow • Use printed ferrules or heat-shrink labels
Indoor vs Outdoor	• Outdoor: Use UV-rated conduit, IP-rated DB entries, sealed junctions • Indoor: Fire-retardant conduit/trunking in enclosed spaces
Ventilation	• Allow sufficient ventilation space around trunking • Avoid overfilling conduits which can lead to overheating

---

⚠️ Circuit Separation & EMI Control

Guideline	Instruction
AC & DC Segregation	Separate trunking for AC and DC circuits – no shared enclosures
Data / Signal Cable Isolation	Do not route data cables (RS485, Ethernet) with AC power lines
Avoid Long Parallel Runs	Especially for AC/DC in close proximity – may induce voltage noise
90° Crossing Rule	Always cross AC and DC cables at 90° if intersecting is unavoidable

🔩 Gland & Entry Best Practices

Installation Zone	Best Practice
Distribution Boards (DBs)	• Use labelled, sealed glands • Maintain IP rating • Avoid excessive gland torque that could deform plastic boxes
AC Combiner Boxes	• Use UV-stable glands for outdoor exposure • Ensure proper Earth continuity of gland housings (if metallic)

🧱 Fire and Mechanical Safety

Condition	Requirement
Wall Entry	Use grommets or bushings to prevent insulation damage
High-Risk Zones	Use fire-rated trunking or conduit (near kitchens, battery rooms, etc.)
Penetration of Barriers	Use intumescent fire-stop compound where trunking passes through firewalls

---

📝 Documentation Requirements

Required Item	Detail
As-Built AC Wiring Diagram	Include clear wireway paths, DB positions, and conductor types
Cable Route Records	Label major segments with “AC Load”, “Grid Feed”, “Essential Supply”, etc.
Cable Size Verification	Ensure conductor sizes are logged and match design

---

✅ Summary Best Practices

Do	Do Not
Use separate, clearly marked trunking for AC and DC circuits	Do not mix AC, DC, and data cables in the same conduit or trunking
Use UV and fire-rated materials where required	Avoid routing cables across heat sources or moving mechanical parts
Label every conductor at both ends with permanent, legible markers	Do not leave any wire unlabelled or with temporary tape
Secure cables every 300–500 mm	Never allow unsupported cabling inside DBs or across ceilings
Cross AC and DC only at 90° if necessary	Do not allow long, parallel runs of AC and DC in close proximity

◇ 7.2 Cabling from Customer DB (Tie-in Point)

✅ Purpose

To ensure safe, compliant, and clearly identified connection between the solar inverter and the customer’s existing electrical distribution board (DB), including cable sizing, protection, isolation, labeling, and system integration per SANS and utility requirements.

📘 Source Standards & Clauses

Standard / Reference	Clause / Section
SANS 10142-1 (Ed. 3)	Clause 6.7.4 (circuit diagrams), 7.12.1.1 (final circuits), 7.12.2 (PV connection)
SANS 10142-1 Annex M	Embedded generation system requirements
SANS 60364 Part 7-712	Clauses 712.312 (tie-in), 712.514 (identification), 712.521 (overcurrent)
NRS 097-2-1	Utility connection compliance and anti-islanding requirements

---

⚡ Tie-in Principles & System Architecture

Element	Guideline
Connection Location	• Must be on the load side of the main breaker • Never connect upstream of point of supply
Breaker Type	• Use a backfeed-capable breaker or bidirectional isolator
Breaker Labeling	• Label clearly as: **“PV Supply – Isolate Before Working”**
AC Isolator Requirement	• A manually operable AC isolator must be installed between inverter and DB (visible disconnect)
Preferred DB Layouts	• If DB is congested, install a dedicated solar sub-DB or generation-ready extension panel
System > 5kVA	• Strongly recommended to use a separate sub-DB with own main breaker and isolator

---

🔧 Cable Selection & Routing

Factor	Cable Sizing & Routing Instruction
Current Carrying Capacity	• Use cable rated for at least 1.25× inverter’s max continuous output current
Minimum Sizes (Guide)	• Single-phase (≤20 A): 2.5 mm² • Long runs or >20 A: 4–6 mm² • Three-phase: ≥10 mm²
Insulation Type	• Use 600/1000 V PVC insulated, copper-core wire
Routing Method	• Use conduit, trunking, armoured cable • Avoid sharp bends • Secure cables every 300–500 mm
Voltage Drop Limits	• Must be <5% from inverter to DB
Environmental Derating	• Factor in heat, proximity to other cables, and wall-mounting in sizing

---

⚠️ Overcurrent Protection

Protection Type	Requirement
Breaker Rating	• Sized to inverter output (not larger than inverter spec)
Breaker Curve	• Type B or C curve preferred for residential or commercial installations
Breaker Positioning	• At tie-in point; easily accessible; in DB or sub-DB
Breaker Labeling	• Must read **“PV Backfeed”** or **“Inverter AC Input”**

⚠️ Isolation & Safety Signage

Requirement	Instruction
Main DB Label	• Must display **“Dual Supply – Isolate PV Before Maintenance”**

Requirement	Instruction
Sub-DB Schedule	• Must show PV feed circuit clearly and separate from other loads
AC Isolator	• Must be lockable and placed in accessible location
Emergency Shutdown Notice	• Must include isolator locations and instructions at point of supply (typically in the DB cover)

🧩 Embedded Generation Compliance (Annex M)

Compliance Item	Instruction
Anti-Islanding Protection	• Must be enabled and tested before commissioning
Utility Notification	• Do not energize without municipal approval (where applicable)
Parallel Supply Control	• Ensure system exports only within permitted limits or zero-export as required
Metering Compatibility	• Check if bidirectional metering is required by the local utility

---

📄 As-Built Documentation & Testing

Documentation	Details Required
DB Schedule Updates	• Mark PV supply breaker, isolators, and solar DB if used
Wiring Diagrams	• Include inverter output route, cable sizes, and circuit number in DB
Commissioning Test Results	• Continuity, polarity, and insulation resistance tests must be logged and signed
Photographic Evidence	• Labelled photos of isolators, breakers, and tie-in points

---

✅ Summary Best Practices

Do	Do Not
Use correct cable sizes and breaker ratings based on inverter specs	Do not oversize the AC breaker – must match or protect inverter output
Clearly label all PV connections in DB and isolators	Do not leave breaker or isolator unmarked
Install visible, lockable AC isolator	Never allow a PV connection without means of disconnection
Update DB schedule and keep record for CoC	Do not energize system without full as-built and signed-off documentation

◇ 7.3 AC Combiner Box Layout (if used)

✅ Purpose

To safely consolidate multiple inverter outputs or AC supply sources before feeding into the main distribution board (DB), while maintaining overcurrent protection, surge protection, and clear labelling for inspection and maintenance.

📘 Source Standards & Clauses

Standard / Reference	Clause / Section
SANS 10142-1 (Ed. 3 & 3.2)	Clause 6.7 (protection & control), Clause 6.9.4 (mechanical protection) Clause 7.12.2 (distribution), Clause 7.16 (parallel generation), Annex M
SANS 60364-7-712	Clauses 712.536.2.2.5; 712.537.2.1.1 (isolation and protection)

Standard / Reference	Clause / Section
SANS 60439 / 61439	Switchgear assemblies and layout spacing standards

---

🧰 AC Combiner Box – Basic Layout

Component	Description
Breaker 1	Inverter A Output (L/N/E)
Breaker 2	Inverter B Output (if applicable)
Breaker 3	Inverter C Output (if applicable)
Breaker 4	Grid Tie Output to DB
SPD	Type 2 (minimum); connect L-N-E
Earth Bar	Bonded to enclosure and system earth
Neutral Bus Bar	For all inverter neutrals (separated if required)
Labelling	All breakers and bus bars clearly marked (see examples below)

✅ Label Examples:

```
css
Copy code
INVERTER 1 AC OUT → 40A C/B
INVERTER 2 AC OUT → 32A C/B
GRID OUTPUT TO DB
SPD – AC SURGE PROTECTION
EARTH BAR – PV AC COMBINER
```

🔧 When to Use an AC Combiner Box

Use Case	Reason
Multiple inverter outputs	Combines circuits before entering DB
Essential/non-essential load separation	Enables zoning of load circuits
Generator + PV hybrid supply	Allows coordinated protection and changeover
Monitoring point needed for multiple systems	Allows current/voltage metering or CT installation

---

🛠 Construction & Enclosure Requirements

Component / Element	Requirements
Enclosure Type	• IP65+ for outdoor use • IP55+ minimum for indoor use
Material	• UV-resistant plastic or earthed steel enclosures
Cable Entry Glands	• Properly sized, sealed, and secured; no unused openings
Internal Layout	• Neat, labelled, with sufficient air clearance for breakers/SPDs
Label Outside Box	• “AC PV COMBINER” or “AC DISTRIBUTION (GEN)”

⚡ Required Protection Devices

Device	Specification / Instruction
MCBs	• 1 per inverter • Rated to inverter's AC output • Comply with IEC 60898
Main Isolator	• 4-pole isolator recommended for 3-phase • Must be labelled & visible
SPD (Surge Protection)	• Type 2 or Type 1+2 SPD on AC side • Installed downstream of MCBs
RCCB / RCBO (if needed)	• If required by DB or for standby circuits • 30 mA trip current if installed

---

⚠️ Safety & System Design Notes

Safety Element	Instruction
SPD Earthing	• SPD must be bonded to earth bar and enclosure
Visible Isolation	• Main AC isolator required, clearly accessible
Finger Safety	• Internal clearances per SANS 60439/61439 (no exposed live terminals)
No AC/DC Mixing	• AC and DC must be in separate enclosures and cable paths
Heat Dissipation	• Allow space around breakers; avoid crowding components

---

🔍 Labelling & Identification Requirements

Label Area	What to Label
Each Breaker	“INVERTER 1 AC OUTPUT”, “MAIN TO DB”, “SPD PROTECTED”
Box Cover / Lid	Include voltage, current rating, and warning: **“DANGER – MULTIPLE SOURCES”**
Inside Lid	Attach circuit layout diagram / single-line diagram
Earth Terminals	Must carry the standard grounding symbol

📋 Documentation Requirements

Required Documents / Info	Include in Handover
AC combiner wiring diagram	Fixed to lid or printed in system documentation
Component specification sheets (MCBs, SPD, Isolator)	As-built or commissioning folder
Final inspection photo	AC combiner cover open, showing labels and layout
CoC reference	Indicate combiner function in CoC diagram and part lists

◇ 7.4 Wiring from AC Combiner to Inverters

✅ Function and Scope

This section outlines the correct procedures and regulatory requirements for connecting the **AC output terminals of inverters** to the **AC combiner box** (or directly to the main DB if no combiner is used). Each inverter must have its own dedicated cable set, properly routed, protected, labelled, and terminated in compliance with SANS 10142-1 and SANS 60364.

📘 Key Regulations and Clauses

Standard	Relevant Clauses
SANS 10142-1 (Ed. 3.00)	Clause 6.3 (Conductors), 6.7 (Isolation), 6.9 (Wiring), 7.12.3, 7.16.2, Annex M
SANS 60364-7-712	Clauses 712.521, 712.525 (Separation and wiring requirements for inverter outputs)

✅ What to Do

- Connect from inverter AC OUT terminals to AC combiner box (one set per inverter).
- Maintain correct **phase rotation** (especially for 3-phase systems).
- Use **labelled wires**: e.g., INVA-L, INVB-N, INVC-E.
- Torque all terminals using the manufacturer's **torque specs**.
- Verify that all **neutral and earth** connections are clean, tight, and secure.

🔌 Cable Selection & Technical Guidelines

Factor	Requirement
Conductor Material	Copper (Cu) only
Insulation	PVC-insulated, 600/1000 V
Minimum Size	4 mm² Cu (larger for longer runs or 3-phase)
Derating Considerations	Adjust for ambient temperature, grouping, and surface mounting
Voltage Drop	Must be < 5% (preferably < 3%)
Routing Clearance	Minimum 300 mm from signal/data cables
Bending Radius	≥ 8× outer diameter of cable

🛡 Mechanical Protection

- Cables must be installed in:
  - Conduit (PVC/HDPE/Steel)
  - Trunking
  - Armoured cable (e.g. NYY, SWA)
- Cables exposed to sunlight must be **UV-resistant**.
- When passing through walls or floors:
  - Use **bushings, glands, or sleeves**.
  - Firestopping required for fire-rated barriers.
- **No sharp bends** or unprotected routes.

⚠️ Isolation & Overcurrent Protection

Device	Requirement
MCB at AC combiner	Sized to inverter output; IEC 60898 compliant
AC Isolator (per inverter)	May be required separately for grid compliance or remote isolation
Poles	Must isolate **both Live and Neutral** (especially in TT or TN-C-S systems)
SPD (AC-side)	Install if exposed outdoors or risk assessed as high (Type 2 minimum)
RCD/RCCB	Add where required by utility or installer design (30 mA if protecting user loads)

⚡ Earthing and Neutral Bonding

System Type	N–E Bonding Location
Grid-tied (no backup)	At main supply DB (e.g., Eskom or Municipality)
Hybrid (grid + backup)	Only at supply DB, NOT at inverter
Off-grid / Standalone	Single N–E bond required at inverter or inverter DB
Generator (no grid)	Generator DB or changeover switch

✅ Bonding Rules:

- Only **one** N–E bond allowed in the system (to prevent circulating current).
- Clause 6.12.4.2 and 7.12.3 require bonding **only at point of supply**.

🔍 Testing and Verification

Test	Expected Result
Earth continuity test	Resistance < 0.1 Ω preferred
Polarity test	Correct connection of L, N, and PE
Insulation resistance test	> 1 MΩ between conductors and earth
Earth loop impedance test	Only 1 N–E bond point must register continuity
Function test (under load)	Inverter AC output stable and synchronized

---

🧰 Installation Practices

- Torque all terminals using calibrated torque driver.
- Use ferrules or compression lugs at terminations.
- Avoid loose or floating neutrals – this is a common failure cause.
- Avoid daisy-chaining earths between inverters.
- Maintain clean, uncluttered DB or combiner layout.

⛔ Labelling Requirements

Component	Label Example / Instruction
AC cable (inverter end)	“INV1 → AC COMBINER – L1/N/PE”
AC cable (combiner end)	“AC COMBINER INPUT – INV1”
Isolators	“INVERTER 1 AC ISOLATOR” / “PV SUPPLY – DO NOT OPEN UNDER LOAD”
DB Schedule / Drawing	Update to reflect all AC inverter wiring

---

🔐 Installer Tip

If your inverter **has an internal N–E bond**, it must be **disabled in grid-tied mode** unless the utility specifically permits it. Always verify with the **installation manual** and **local utility requirements**.

◇ 7.5 Essential vs Non-Essential Load Segregation

🎯 Purpose

In PV or hybrid backup systems, load segregation ensures that only **essential loads** receive backup power during outages. This:

- Prevents overload on the inverter or battery system.
- Prioritizes critical functions like lighting, refrigeration, communication, and security.
- Allows high-consumption appliances (e.g., geysers, ovens) to remain disconnected during power failures.

✅ Segregation Methods

Method	Description
Essential Load Sub-DB	Separate distribution board for backup circuits.
Manual Changeover Switch	Manually selects between grid and inverter output.
Automatic Transfer Switch	Detects grid failure and switches essential loads to inverter supply.

🟩 Essential Load Circuits

Requirement	Detail
Physical Separation	Essential loads must be routed to a separate sub-DB or designated bank in the main DB.
Labeling	Use labels such as “Essential Load”, “Backup Only”, or “Inverter Supply”.
Protection Devices	MCBs and RCBOs required as per IEC 60898 or IEC 60947-2.
Neutral Return	Must return to the **inverter’s neutral bar** if operating in isolated (off-grid) mode.
Proper Earthing	Ensure continuity and separation of earth conductors.
Example Circuits	Lights, routers, security systems, garage motors, alarm systems, essential plug points.

🟥 Non-Essential Load Circuits

Requirement	Detail
Remain on Utility Supply	These loads stay connected to the grid supply only.
Isolation from Inverter	Not connected to inverter output or battery circuits.
Wiring Options	Separate MCB bank in same DB or in a dedicated non-essential DB.
Examples	Geysers, stoves, air conditioners, heavy plug circuits, pool pumps.

⚡ Wiring & Busbar Configuration

- Separate **neutral and earth busbars** must be used for essential load circuits when inverter supplies backup.
- **No shared neutrals** allowed between essential and non-essential circuits (especially in hybrid/off-grid).
- Only one **neutral–earth bond** is allowed in the system (refer to Section 7.4).
- Update DB wiring to reflect:
  - **Clear load groupings**
  - **Segregated trunking or conduit** (preferably colour-coded)

⚠️ Isolation & Switching

System Type	Switching Requirement
Grid-tied only	No switching required if inverter is grid-following only.
Hybrid (grid + backup)	Inverter disconnects from grid when grid fails; essential loads fed from inverter output.
Off-grid	All loads fed from inverter or generator; manual override options recommended.

🛡 Protections Required

- **MCBs** for all essential and non-essential circuits.
- **RCBOs/RCDs** required on socket outlet circuits or where fault protection is needed.
- **SPD (Type 2 minimum)** should be installed at the **DB entry point**.
- **Load balancing** must match inverter and battery capacity to avoid overload and auto-shutdowns.

👄 Labelling Requirements

Component	Label Example
Backup Circuits	“Backed Up by Inverter”, “Essential Load”, “Critical Load”
Manual Changeover Switch	“GRID ↔ BACKUP” or “MANUAL TRANSFER – ESSENTIAL LOADS”
Automatic Transfer Switch	“AUTO TRANSFER SWITCH – CRITICAL LOADS”
Trunking/Conduit	Use colour-coded tape or conduit (e.g., red for backup)
DB Schedule	Must reflect **segregated circuits** and inverter supply

---

📘 Source Clauses and Standards

Standard	Clause
SANS 10142-1 (Ed. 3)	Clause 6.6.1, 6.7 (Isolation and Protection); Clause 7.12.2; Clause 7.16; Annex M (M.6, M.9)
IEC 60364-7-712	Clause 712.411.3.2.1.2 – Backup supply for safety-critical installations

◇ 7.6 Generator Integration (if present)

✅ Purpose of Integration

Backup generators may supplement a PV system, especially in areas with frequent or extended outages. Integration must ensure:

- No **backfeed** into the inverter or grid.
- **Safe changeover** between power sources.
- Proper **earth-neutral bonding** and protection.

🪛 General Setup Requirements

Component	Requirement
Changeover Switch	Use ATS (Automatic) or MTS (Manual), clearly labelled
Four-Pole Switching	Switch Live, Neutral, and Earth simultaneously
Protection	Generator must have its own MCB, RCD/RCBO, and SPD if wired into a DB
Earthing	Earth must be bonded properly – only at one point in the system

Component	Requirement
Backfeed Prevention	No parallel feeding into inverter or grid
Inverter Settings	Set inverter to **generator mode** if supported (adjust frequency/start delay)

🔄 Switching & Transfer Mechanism

Configuration	Switch Placement
Grid ↔ Generator	ATS or MTS must fully isolate both sources
Inverter ↔ Generator	Use 4-pole switch to isolate neutral and prevent shared loop
Off-grid or Isolated Supply	Ensure generator can become the **primary N–E bonding source** if grid absent

⚠️ Always use **break-before-make** switches. Overlapping supply is prohibited.

⚡ Earth-Neutral Bonding

System Type	Earth-Neutral Bond Location
Grid-Tied	Bond at **utility main DB** only
Off-Grid (Generator)	Bond at **generator or inverter**, but not both
Hybrid	Bond at the **transfer switch** or **essential DB** depending on configuration

⚠️ Dual bonding = hazardous! Only **one** bond point per system is permitted.

🔦 Load Transfer & Segregation

Component	Requirement
Essential Loads Only	Generator must feed **only essential loads** (via sub-DB or segregated circuits)
Shared DB	Acceptable if MTS/ATS ensures isolation and circuits are clearly labelled
Inverter Integration	Inverter must not receive AC from generator unless approved by inverter OEM

🛡 Protection Devices

Device	Installation Requirement
MCB	Main breaker sized according to generator's output capacity
RCD/RCBO	Installed on **all load circuits**, especially socket outlets
SPD	Type 2 minimum, required if generator is hardwired into the DB
Neutral Monitoring	May be required for generators feeding isolated DBs

---

🪧 Labelling & Signage

Location	Required Label
Transfer Switch	"Grid ↔ Generator", "Switch Off Both Supplies Before Maintenance"
Generator Input Breaker	"Alternative Supply – Generator"

Location	Required Label
Near Changeover Equipment	“WARNING: Multiple Supply Sources – Do Not Backfeed”

📘 Source Clauses & Standards

Standard / Clause	Relevant Application
SANS 10142-1	Clause 6.6.1 – 6.7 (Protection & Isolation)
	Clause 7.12.2.3 (Alternative supply integration)
	Clause 7.12.3.1(b) (Earth–Neutral bonding for generators)
	Annex M.9 & M.10 (PV and generator embedded configurations)
SANS 8528 & SANS 10019	Generator specifications and safe operation standards

---

🧠 Additional Installer Notes

- Ensure ATS/MTS is rated for:
  - Voltage (typically 230/400 V)
  - Current (generator output)
  - Break-before-make logic
- Avoid using **standard DB isolators** as transfer switches.
- If generator auto-start is used:
  - Configure **delay-on-start** and **voltage/frequency thresholds**
  - Ensure inverter does not auto-synchronize unless approved.

◇ 7.7 Final AC Testing

📘 Source References

Clause / Standard	Application
SANS 10142-1 Clause 8.1	Initial verification of completed installation
Clause 8.2	Testing procedures for LV systems
Clause 6.7.5	Earth Leakage Device (RCD) testing
Clause 8.3	Documentation and test reports
Clause 712.61	PV-specific commissioning requirements
Annex B & D	Test methods and optional test forms

✅ Purpose of AC Testing

Before switching on the AC output of the inverter, the installer must verify that all wiring, protection, and bonding complies with the required safety and operational standards.

🧪 Required AC Tests Before Commissioning

Test	Requirement / Pass Criteria
1. Earth Continuity Test	All exposed conductive parts must show continuity to earth bar (≤ 1 Ω)
2. Insulation Resistance	≥ 1 MΩ between L–N, L–E, and N–E (measured with 500 V insulation tester)

Test	Requirement / Pass Criteria
3. Polarity Check	All switches, breakers, and outlets must have correct polarity (L on line side)
4. Earth Electrode Resistance	≤ 200 Ω (general); < 6 Ω recommended for effective SPD and inverter grounding
5. RCD Trip Test	≤ 300 ms at rated current (IΔn); ≤ 40 ms at 5 × IΔn
6. Functional Device Test	All isolators, MCBs, RCDs, changeover switches must operate correctly
7. Voltage & Frequency Check	Output = 230 V ± 10%, Frequency = 50 Hz ± 1%; Confirm 3-phase rotation if used
8. SPD Check	Visual indicator or test button status; replace if tripped

---

⚙️ Testing Procedure Summary

🔧 1. Continuity of Protective Conductors

- Test from every metallic enclosure/component back to main earth bar
- Acceptable resistance: **≤ 1 Ω**

🔧 2. Insulation Resistance

- Use 500 V DC test
- Test between:
  - Line to Neutral
  - Line to Earth
  - Neutral to Earth
- Acceptable value: **≥ 1 MΩ**

🔧 3. Polarity Verification

- Ensure single-pole devices interrupt **line**, not neutral
- Check:
  - Sockets
  - Isolators
  - MCBs
- Especially important in 3-phase and split DB layouts

🌍 4. Earth Electrode Resistance

- Required if earthing uses rod or mat
- Acceptable values:
  - **≤ 200 Ω** for general installations
  - **< 6 Ω** for PV systems with SPD/inverter bonding

⚡ 5. RCD Testing

- Use ramp test and push-button method
- Acceptable results:
  - ≤ **300 ms** at IΔn (rated current)
  - ≤ **40 ms** at 5 × IΔn
- Document trip time and leakage current

🔁 6. Functionality of Switching Devices

- Operate all isolators and contactors:
  - AC breakers

    - Bypass switches
    - Changeover switches
    - Generator ATS
- Must switch cleanly and fully isolate when off

🔍 7. Voltage and Frequency Measurement

- Measure at inverter output terminals and main DB
- Acceptable output:
    - Voltage: **230 V ± 10%**
    - Frequency: **50 Hz ± 1%**
- Confirm **correct phase rotation** if system is 3-phase

⚠️ 8. SPD Verification

- If SPD includes test button or visual flag, confirm:
    - “Green” or “OK” indicator is visible
- Replace SPD if “Red” or “Tripped” shown

📜 Documentation Requirements

Required Fields	Notes
Test Results	Include all readings and observations
Pass / Fail Indicators	Clearly mark compliant and non-compliant results
Inspector Name & Signature	Must be signed by the responsible electrician or engineer
Date of Testing	Match commissioning and CoC documentation
DB & Circuit Reference Numbers	Link each test to the correct DB, circuit ID, or inverter label
Comments / Actions Taken	Note any corrections, replaced components, or re-tests performed

---

🧰 Installer Checklist

- All wiring terminated and torqued
- Labels and DB schedules are complete
- Safety signs and isolators are accessible
- Test report completed and filed
- CoC form ready for handover to client

◇ 7.8 Certificate of Compliance (CoC)

✅ Legal Requirement for Commissioning

Requirement	Detail
Governing Law	General Safety Regulation 5 of the **Occupational Health and Safety Act**
Applicable Standards	Not in SANS 60364-7-712 directly, but referenced in **SANS 10142-1**
Issued by	Only a **registered person** (per Electrical Installation Regulations)

Requirement	Detail
Purpose	Certifies that the installation complies with safety standards and is safe
When Required	For new installs, modifications, or embedded generators (PV/inverter/gen)

🪪 Who May Issue a CoC?

Only the following persons are authorised:

Type	Registered With	Responsibility
Wireman's License	Department of Employment and Labour (DEL)	May sign for single-phase work
Master Installation Electrician	Department of Employment and Labour (DEL)	May sign for 3-phase and complex embedded generation systems

⚠️ The **registered person** must perform **physical inspection and testing themselves** before signing the CoC.

📋 Required Items on the CoC

Per Annex I of SANS 10142-1, a valid Certificate of Compliance must contain:

Field	Description
Site Address	Exact location where the system is installed
Installer Details	Full name, contact details, and registration number
Installation Description	Clearly state: "Solar PV – Embedded Generation – AC Tie-In"
Inverter & Battery Specs	Include serial numbers, ratings, models
Distribution Board Layout	Indicate inverter tie-in, essential loads, changeover switches
Surge Protection	Confirmation of SPD installation if required
Earth Test Readings	Measured values (earth loop, electrode resistance, etc.)
Test Results	From Section 7.7 – continuity, insulation, voltage, RCD trip times
Installer Declaration	Statement confirming compliance with SANS 10142-1
Signature	Must be signed by the responsible registered person
Date	Date of inspection and test

📘 Reference Clauses

Clause / Regulation	Application
Clause 8.3	Final test documentation
Clause 7.12.3	Requirements for embedded generation systems
Annex I	Sample CoC layout and checklist
OHSA GSR 5	Legal mandate for Certificate of Compliance
Electrical Installation Regulations	Defines who may issue and under what circumstances

---

🔍 What Must Be Verified Before Issuing

The registered person must confirm the following **before signing off**:

- ✅ Full compliance with **SANS 10142-1** (LV electrical installations)
- ✅ All **AC test results** pass thresholds (see Section 7.7)
- ✅ Earthing and bonding are installed correctly
- ✅ Surge protection devices (SPDs) installed if applicable
- ✅ Load segregation (essential/non-essential) is labelled and wired correctly
- ✅ Proper isolation and labelling of circuits and components
- ✅ Client is informed of operational limitations and maintenance responsibilities

---

📁 Documentation and Record-Keeping

Copy Must Be Kept By	Purpose
Installer / Contractor	For warranty and liability purposes
Client	Proof of legal compliance and safety
Municipality / Authority (if required)	Upload to relevant portal (e.g., City of Cape Town embedded generation)

Attach all **test results**, inverter serial numbers, panel IDs, and diagrams to the CoC file.

🔴 Important Notes for Solar PV Systems

- 🟡 If retrofitting to an existing DB, a **partial CoC** may be issued:
  - Must **reference the existing CoC number**
  - Must state that this CoC applies to “Solar PV Tie-in Only”
- 🔴 If the **AC DB was modified** (e.g., isolators added), CoC **must cover the entire modified section**
- 🟢 A CoC **does not apply to DC wiring** unless the DC wiring forms part of the AC-side enclosure or crosses into the DB

8. Remote Monitoring & Plant Setup

◇ 8.1 System Types & Monitoring Platforms

This section covers how to set up, configure, and hand over **remote monitoring systems** for inverters, batteries, and hybrid systems.
It ensures that both the **client** and your **support team** can monitor and troubleshoot the system remotely.

📱 Common Monitoring Systems

Brand	Monitoring Portal	Notes
Sunsynk	Sunsynk Portal	Cloud-based; supports battery SoC and load control
Victron	Victron VRM Portal	Advanced portal; GX devices like Cerbo required
LuxPower / Voltronic	RS485 Toolsets	Typically local monitoring via PC or app
GoodWe	SEMS Portal	Real-time inverter monitoring with smart analytics
Huawei	FusionSolar Portal	Suitable for residential and commercial installations
Growatt	ShineServer	Installer and user login; mobile-friendly

Brand	Monitoring Portal	Notes
SMA	Sunny Portal / Sunny Places	Grid-compliant and commercial-ready
Tesla	Tesla App	Fully integrated solar + battery + EV experience

---

🧭 Monitoring Categories

System Type	Description
Local Monitoring	Accessed via inverter screen or LAN interface (e.g., IP/webpage on local Wi-Fi)
Cloud-Based Monitoring	Data pushed to server; accessible anywhere via portal or app
Hybrid Systems	Support offline logging + sync once internet restores

All systems follow these **core setup steps**:

1. Enable communication
2. Create user account
3. Register the device
4. Configure data permissions and alerts

📘 Standards and Regulations

Standard	Application
IEC 61724-1	Defines monitoring classes: A (high accuracy), B (medium), C (basic)
SANS 10142-1	Requires: – Performance logging – Documentation of faults/alarms – Integration into client handover file

---

📊 Monitoring Platform Types

1. **Manufacturer-Integrated Systems**
   - Tied to specific hardware brands
   - Seamless data access, often inverter- and module-level
   - Examples: Victron VRM, SolarEdge, Enphase Enlighten
2. **Installer-Neutral / Add-On Monitoring**
   - Hardware-agnostic, tracks solar generation and home consumption
   - Examples: Sense, Solar Analytics, Emporia
3. **Smart Home / EMS Platforms**
   - Combines solar, battery, EV, loads
   - Centralized dashboard and energy automation
   - Examples: SolarEdge ONE, Tesla App, Home Assistant integrations

---

🏅 Major Brand Platforms Summary

Platform	Key Features
SolarEdge	Panel-level tracking, fleet tools, alerts, and 25-year warranty support
Enphase	Microinverter tracking per module, clean UI, detailed alerts

Platform	Key Features
Sungrow	Built-in Wi-Fi, battery analytics, mobile/web dashboards
SMA	Stable and compliant, moderate analytics, Sunny Portal and Sunny Places
Fronius	Real-time generation/consumption, good smart meter integration
GoodWe	Simple portal; supports mobile alerts and smart overlays
Tesla	Sleek mobile app for solar + battery + EV (no desktop access)

🧩 Monitoring Comparison Table

Feature	SolarEdge	Enphase	Sungrow	SMA	Fronius	GoodWe	Tesla
Module-level tracking	✓	✓	Limited	✕	✕	✕	✕
Fleet management	✓	❌	Limited	❌	❌	❌	✕
Mobile & Web Dashboards	✓	✓	✓	✓	✓	✓	Mobile only
Battery integration	✓	Limited	✓	✓	✓	✓	✓
Alerts & Diagnostics	Advanced	Good	Good	Basic	Basic	Basic	Basic
Warranty Support	Up to 25 yrs	25 yrs	10 yrs	5 yrs	Variable	10 yrs	10 yrs

---

✅ Platform Selection Guidelines

Need	Recommended Option
Module-level performance & panel analytics	SolarEdge, Enphase
Value-focused, strong performance	Sungrow, GoodWe
Commercial-grade grid compliance	SMA, Fronius
Smart lifestyle integration (solar + EV + home)	Tesla
Independent energy use tracking (whole home)	Sense, Emporia, Curb

◇ 8.2 Monitoring Hardware Requirements

✅ Minimum Setup Checklist

Ensure the following before enabling any monitoring platform:

- ✅ **Wi-Fi or Ethernet** internet connection at the site
- ✅ **Dongle**, datalogger, GX device, or LAN module installed
- ✅ Device **powered on** and physically connected to inverter
- ✅ **Remote access enabled** in inverter settings (if applicable)
- 🔲 *Optional:* Include a QR code in the client handover pack for easy portal access

---

🔌 Typical Monitoring Hardware

Component	Use Case
Wi-Fi/Ethernet Dongle	For basic monitoring (Growatt, Solis, LuxPower)
RS485 / CAN Communication	For inverter-to-battery or CT meter communication
Data Logger	Required for logging and portal upload (Victron, Solarman)

Component	Use Case
Energy Meters / CT Clamps	Grid export limit, load profiling, generator detection

⚠️ Not all inverters include built-in communications—external modules may be required.

🧩 Core Monitoring Components

A complete system typically includes:

1. **Inverter-integrated data loggers**
2. **External energy meters (CTs/PTs)**
3. **Weather sensors** (irradiance, temperature – optional)
4. **Communication gateways** (Wi-Fi, RS485, GSM/4G)
5. **Cloud platforms** for analytics, alerts, data retention

✅ 1. Inverter Data Loggers

Brand	System
SolarEdge	mySolarEdge via Ethernet or cellular
Enphase	Envoy gateway with microinverters (Ethernet/Wi-Fi)
Sungrow	iSolarCloud + COM modules (COM100E etc.)
SMA	Sunny Home Manager + Portal
Fronius	Solar.web (Ethernet, USB LTE, or Wi-Fi)
GoodWe	SEMS Portal via RS485 or Wi-Fi
Tesla	Tesla Gateway for solar, battery, EV monitoring

✅ 2. External Energy Meters & CTs

Brand / Product	Purpose
Sungrow DTSU666-20	Dual-CT metering for inverter and grid
Solar Analytics / Sense / Emporia	Circuit-level energy use tracking
Compliance	IEC 61850-7-420 standard for smart sensor integration

📌 Ensure CT orientation is correct (grid-side) for accurate readings, especially in grid-limiting setups.

✅ 3. Weather Monitoring (Optional)

- **Irradiance sensor**: Measures sun intensity
- **Ambient/module temperature sensor**: Detects overheating and shading
- **Standard**: IEC 61724 performance compliance
- **Use Case**: Yield tracking, PR ratio diagnostics, fault alerts

---

✅ 4. Communication Gateways

Protocol / Hardware	Used For
RS485 (Modbus RTU)	CT meters, BMS, battery comms (Fronius, Sungrow)
Wi-Fi / Ethernet	Internet-based monitoring (SolarEdge, SMA, GoodWe)
GSM / 4G routers	Remote rural sites without landline internet
Protocols	Modbus RTU/TCP, MQTT, SunSpec, IEC 61850

✅ 5. Cloud Platforms & Analytics

Platform Type	Examples
Manufacturer Platforms	SolarEdge, SMA, GoodWe, Sungrow, Enphase, Tesla
Third-Party / Neutral	Solar Analytics, Sense, Emporia
Commercial / SCADA	Supports IEC 61850, Modbus, DERMS integration

---

✅ System Size vs Hardware Requirements

System Size	Recommended Setup
Small (≤ 10 kW)	Native inverter platform + optional CT meter for load profiling
Medium (10–100 kW)	Panel-level monitoring (e.g. SolarEdge) or add external energy meters
Commercial (>100 kW)	Full metering (CT/PT), weather sensors, SCADA/DERMS remote control (IEC 61850/Modbus)

◇ 8.3 Step-by-Step Setup Process

📶 WiFi Setup

- Connect via mobile app to inverter/dongle
- Select local Wi-Fi network and enter password
- Confirm **“Connected to Internet”** status before proceeding

---

🔧 Portal Registration

- Create a new **site profile** on the inverter’s monitoring portal
- Register the inverter serial number (SN) or dongle SN
- Link the system to your **installer account** (if supported)

⚙ System Naming Convention

- Recommended format:
  ClientName_Location_Date
  (e.g., "Ngobeni_JHB_2025-06")
- Include optional notes in the portal setup:
  - Inverter model
  - Number of panels
  - Battery size/specs

- Grid type (single/three-phase)

🛠 1. Pre-Installation Preparation

- **Obtain installer credentials**
  (e.g. SolarEdge requires installer registration for full access)
- **Choose communication method early**:
  - Wi-Fi
  - Ethernet
  - RS485

👣 2. Mount and Connect Monitoring Hardware

- **Sungrow DTSU666-20 Meter**:
  - Mount meter on 35 mm DIN rail
  - Clip CTs on grid feed (arrow points to inverter/load)
  - Wire RS485 A/B to inverter RS485 terminal
  - Add load-break isolator adjacent to grid meter
- **SolarEdge Power Optimizers (if used)**:
  - Install within 25 mm of panel frame
  - Bond using star-ground washer (torque 9.5 Nm)
  - Pair optimizers before energizing

🌐 3. Inverter Communication Setup

- Designate **one inverter as RS485 master**
- Use **CAT5 or CAT6** cable with ground wire
- Add 120 Ω termination resistors at both ends of RS485 loop
- Connect external CT meter via RS485 port for load tracking

🔁 4. Platform Activation & Site Mapping

🟠 **Sungrow iSolarCloud:**

- Auto-detects inverter and meter via RS485
- Update firmware via the platform before commissioning

🔵 **SolarEdge mySolarEdge / SetApp:**

- Register as an installer on the platform
- Scan QR code to add inverter
- Use **Site Mapper** to assign panels to optimizers

✅ 5. System Verification & Commissioning

- Confirm:
  - Internet connectivity
  - Remote access and live data
  - Communication between inverter, meter, logger
- Check:
  - Generation values
  - Consumption via CT readings
  - Alerts: undervoltage, string errors, comms failures
- Simulate:
  - Grid failure or transfer switch test
  - Battery charge/discharge behavior

👤 6. Client Training & Handover

- Create a **client login** on the portal
- Show client how to:
  - Access data (daily/weekly/monthly)
  - Identify and respond to alerts
  - Share access with installer (if desired)
- Provide the following:
  - Printed **quick start guide**
  - **Login credentials** and QR code
  - Monitoring platform overview

🛠 Physical Setup Summary

Step	Key Actions
Logger Installation	Mount securely near inverter (not inside metal DBs)
Internet Connectivity	Use Wi-Fi or hardwire to router (test signal strength)
RS485 / CAN Wiring	Correct polarity, termination resistors as per spec
Device Power-Up	Confirm all comms modules are live
Inverter Configuration	Set RS485/Ethernet mode, Modbus ID, baud rate (e.g., 9600)
Wi-Fi Login	Scan network, enter password, test connection
Account Creation	Register SN/QR on manufacturer platform
Installer Dashboard	Link to customer profile and record final commissioning

◇ 8.4 Testing the Monitoring Setup.

Before final handover to the client, the entire monitoring system must be fully verified for accuracy, data integrity, responsiveness, and safety alerts.

✅ Basic Checks Before Handover

- Confirm inverter and logger show as **“Online”** on cloud platform
- Data updates **every 1–5 minutes**: power, voltage, SOC, etc.
- Battery % and inverter output readings must match local inverter display
- Trigger **live events** (e.g. turn load on/off) and confirm data graph changes
- Check for alerts or alarms upon inverter shutoff or disconnection

- Remote control functions (if allowed) should respond correctly

---

📋 Test Matrix: Monitoring Verification

Test / Action	Pass Criteria
Inverter Online Status	Cloud platform confirms “Online” + shows live data
Data Refresh Interval	Updates visible every 1–5 minutes for key metrics (voltage, power, SOC)
Alert Functionality	Alerts trigger when inverter powered off or faults simulated
CT / Energy Meter Validation	Solar production and consumption graphs match expected values
Remote Control (if supported)	Toggling loads/export limiting works via app or portal
Firmware Display	Inverter model + firmware version correctly shown in portal

📌 *Tip: Use a phone hotspot for temporary setup if no internet is available on site.*

🔍 1. Communication Verification

- **Data Connectivity**
  - Confirm inverter and external meter are listed and synced on the portal
  - RS-485 devices must display real-time data and system health
  - Internet latency: Live readings should update within 60 seconds
- **CT Meter Check**
  - Ensure CT clamp arrow points **toward the load**
  - Grid import must show as **positive consumption**
  - Confirm **both import/export** CT values register correctly (real/reactive power)

🧬 2. Data Integrity Tests

- **Live Event Triggers**
  - Turn on/off high-wattage devices (e.g., kettle or geyser)
  - Observe system response time on dashboard
- **Simulated Solar Day**
  - Compare panel array specs with observed generation at midday
  - Check for dips, shading effects, or unexpected low values
- **Alarm Testing**
  - Switch off inverter or unplug logger to simulate disconnection
  - Observe if platform shows “Offline” or sends alert/email
- **Voltage Fault Simulation**
  - Use inverter’s built-in test mode to trigger over/under voltage
  - Ensure system logs this and generates alarm notification

🔋 3. Battery & Backup Validation (if installed)

- **Backup Mode Activation**
  - Simulate a grid failure to confirm switchover to backup load
  - Verify system maintains power to essential circuits
  - Measure reconnection time to grid after restoration

- **Battery Monitoring**
  - Observe charging and discharging cycles over a test period
  - SOC must change logically based on usage or solar input
  - Compare logged battery data with real-time inverter readings

---

⚡ 4. Surge Protection Checks

- **DC & AC SPD Status**
  - View SPD status in inverter menu (where available)
  - Should display “Green” / “Normal”
  - If no monitoring exists, conduct a **visual inspection** of SPD LED indicators
- **Labelling and Access**
  - Ensure SPD warning labels are present and intact
  - Visually inspect enclosure or combiner boxes

📈 5. Historical Data Review

- Allow system to run for **24 hours** before full verification:
  - Plot generation vs. panel rating and expected irradiance
  - Track household load vs. solar contribution
  - Identify energy balance and mismatch zones
  - Establish a baseline **Performance Ratio (PR)** for long-term comparison

---

📁 6. Final Documentation

Include the following in the **Client Handover Pack**:

- Screenshots of:
  - Solar generation graphs
  - Load consumption
  - Battery activity and state of charge
  - Alert log (if applicable)
- Completed Monitoring Setup Checklist:
  - Meter installation date/time
  - CT orientation verified
  - Communication confirmed
  - Alerts tested and verified
  - Installer signature and client signature

🔷 8.5 Client Training & Access

✅ Objective:

To ensure the client is confident in using the monitoring platform and understands basic operation, safety, and fault handling.

🧭 Training Goals

- Empower clients to **monitor system performance** and identify issues early.
- Ensure clients understand **basic functionality**, **safety procedures**, and **support channels**.
- Provide access details in a **secure, user-friendly** format (paper, SMS, or email).

✅ 1. Setup Client Access

- Create a **client user account** (not installer/admin level) on the selected platform:
  - SolarEdge
  - iSolarCloud
  - GoodWe SEMS
  - Fronius Solar.web
  - Sunsynk App
- Provide:
  - Username & password (written or emailed)
  - Web login link and mobile app download info
  - QR code if supported
  - Instructions to reset password or change login details

✅ 2. Walkthrough of Key Monitoring Features

Feature	Training Demonstration
Live data view	Show real-time solar generation, grid import/export, and load consumption
Historical graphs	Navigate daily, weekly, monthly and annual views
Alerts & notifications	Explain error types and how to respond (e.g., contact support)
Battery status	Explain State of Charge (SoC), charging/discharging, backup readiness
Export performance	Show how to generate/download CSV or PDF logs
Panel-level display	(If applicable) Show output per panel and identify any module faults

---

✅ 3. Mobile App Usage

- Help client install and open the relevant mobile app
- Demonstrate:
  - How to view **live data** and interpret **color-coded charts**
  - How to **set daily goals** or receive **push alerts**
  - How to **share access** with other household members or service teams
  - Refresh, sync, or force reconnect functions (if needed)

✅ 4. Troubleshooting Basics

Check	What to Do
Internet/Wi-Fi	Ensure router is working and inverter is in range
Inverter display/lights	Confirm inverter is powered, check for warning LEDs
Data not showing	Verify CT meter is powered and RS485/Comms cable is connected
Lost connection	Try toggling AC isolator or restarting the monitoring app
Persistent errors	Take screenshot of app/inverter screen and send to installer

📘 *Provide a printed or digital copy of a Quick Troubleshooting Guide.*

✅ 5. Safety Instructions

- Instruct the client **not to touch** any inverter wiring, DB boards, or battery terminals.
- If needed, only switch off:
  - The **inverter AC isolator**
  - The **DC isolator** (if advised)
- Show them the **emergency shutdown procedure** (location and label of switch)
- Provide **warning stickers** with contact details for:
  - Installer
  - Electrician
  - Emergency shutdown

✅ 6. Documentation Handover

Client receives a full **Monitoring & Access Pack**, including:

- Monitoring platform **login instructions**
- System name and serial number
- QR codes or app download links (no passwords on printed forms)
- Diagrams showing:
  - System flow
  - Where to shut off safely
- Support contacts:
  - Warranty contact
  - Installer support number or WhatsApp
  - Manufacturer tech support (if applicable)

✅ 7. Post-Training Sign-Off

Checklist Item	✅ Confirmed
Client received login details	
Client installed and logged into app	
Live view and history data explained	
Fault response and alerts demonstrated	
Safety procedures discussed and explained	
Quick guide and support info provided	
Client understood and signed handover sheet	

- Sign handover log:
  - Include **date**, **client signature**, and **installer/trainer name**
  - Store a copy with the job documentation and handover folder

◇ 8.6 Monitoring Tips for Installers

🎯 Purpose:

To ensure the long-term success, reliability, and client satisfaction of solar PV systems through proactive monitoring, proper documentation, and data-driven insights.

✅ Key Reminders

- Enable alerts for **communication loss**, **battery issues**, **shutdowns**, or **inverter faults**.
- Never allow clients to change inverter settings unless trained.
- Check system performance online **48 hours post-commissioning**.
- Use installer-level access (if available) to run diagnostics and apply updates.
- Document all device **serial numbers**, **firmware versions**, and **client login information** in your project file or CRM.

✅ 1. Optimize Data Connectivity

- Prefer **Ethernet** or **dual-band Wi-Fi (2.4 GHz + 5 GHz)** for better stability.
- If Wi-Fi is weak or unreliable:
  - Use **4G LTE dongles** or **GSM modules**.
- Surge-protect all RS485/CAN communications lines.
- Label cables and devices clearly:
  - CT clamp direction
  - RS485 A/B channels
  - Gateway port

✅ 2. Keep Firmware Up-to-Date

- Always install the latest firmware for:
  - Inverters
  - Battery modules
  - Gateways or dongles
  - CT meters (e.g., Sungrow DTSU666)
- Document current version and update dates in a **firmware log**.
- Schedule updates when system is generating power (daylight hours) to confirm reconnection.

✅ 3. Enable Alerts & Remote Diagnostics

Set automatic platform alerts for:

Event	Recommended Action
Inverter offline > 10 min	Check comms, AC isolator, or power feed

Event	Recommended Action
Battery SoC < 10% or 100% idle	Check charger/controller settings
Grid voltage/frequency error	Check utility supply or update inverter limits
DC overvoltage / SPD fail	Inspect SPD fuses, DC isolators, or lightning risk
CT meter communication error	Verify RS485 wiring and terminator resistors

Enable **remote access** (VPN or cloud) on compatible platforms (e.g., SMA, SolarEdge, Fronius).

✅ 4. Daily / Monthly Performance Monitoring

- Track **Performance Ratio (PR)**:
  - If PR < 75% → investigate shading, inverter config, or dirty panels.
- Use irradiance/weather data (IEC 61724) to benchmark expected output.
- Investigate:
  - Sudden dips (>10%) in energy
  - Abnormal temperature readings
  - Reactive power issues in hybrid setups

✅ 5. Use Monitoring to Detect Hardware Faults

Use analytics to flag:

Indicator	Possible Root Cause
Uneven panel voltages	Module mismatch or shade issues
High cable temperatures	Loose lugs, thin cables, or faulty terminations
Drop in string current	Disconnected panel or diode issue
Negative power flow	CT clamp reversed

Log any patterns that suggest **panel degradation** or **BMS/inverter communication delays** for warranty claims.

✅ 6. Preventive Maintenance Integration

- Schedule **annual inspections**:
  - Inverter & combiner box check
  - Retighten lugs and torque breakers
  - Earth-bond continuity & insulation test
- Use historic data trends to:
  - Identify **earthing resistance changes**
  - Flag **insulation faults** (e.g., water ingress)

📋 Attach completed inspection sheets to the system's **CoC folder**.

✅ 7. Support Client Communication

- Provide clients with simplified **annual performance reports**:
  - Total kWh generated
  - Money saved vs. grid costs
  - System health snapshot
- Recommend upgrades like:
  - **EV charging integration**
  - **Time-of-use battery scheduling**
  - **Smart geyser or load shifting relays**

✅ 8. Backup Monitoring & Handover Planning

- Prepare a fallback plan in case of failures or support issues:
  - Provide platform access to both client and installer
  - List inverter manufacturer support contacts
  - Recommend **remote check-ups** every 3–6 months

📂 Installer Monitoring Checklist (Annex – Optional Template)

Item	✅ Completed
Inverter & logger serial numbers	
Firmware version recorded	
RS485/CAN cable routing labelled	
CT clamps installed & oriented	
Remote monitoring active	
Alerts enabled and tested	
Installer portal linked to site	
Client trained and logged in	

9. Emergency Shutdown Procedure

🛑 9.1 When to Trigger Emergency Shutdown

This section outlines what to do **immediately** in the event of fire, arcing, electric shock, system failure, or equipment overheating. It protects lives, property, and equipment — and must be understood by **every installer and client**.

✅ **Post a Shutdown Label** near the inverter or DB board, including:

- Step-by-step shutdown instructions
- Emergency contact details:
  - Installer / Technician
  - SAPS / Fire Department
  - Local Municipal Fault Line

Emergency shutdown **must be performed immediately** if any of the following occurs:

⚠️ Scenario	✅ Action Required
🔥 **Burning smell or visible smoke**	Cut AC and DC isolators, evacuate area, call fire services
⚡ **Sparks or electrical arcing** from cables, DBs, batteries, or inverter	Perform full system shutdown and isolate system
🚷 **Electric shock** (even minor)	Stop all work, shut down system, seek medical help
🔥 **Overheating** of inverter or batteries	Shut down and allow to cool, notify installer
🧯 **Water ingress or flooding** in DBs or inverter	Isolate main breaker and DC switchgear
⚡ **RCD or Earth Leakage not tripping** during a fault	Manually shut down to prevent electrocution risk
📉 **Sudden inverter/battery faults or unusual behaviour**	Isolate system, report to technician
🛠 **Mechanical damage** (hail, tree fall, structural collapse)	Isolate system, secure area, contact installer
🔓 **Tampering, cable theft or intrusion**	Shut down, secure, and report incident
🏢 **Utility company request** (e.g., maintenance, emergency)	Comply immediately with shutdown instructions

⚠️ **Important**: Even if the inverter shuts down automatically, always perform a **manual shutdown** to safely isolate both DC and AC circuits.

▽ 9.2 Shutdown Sequence (All System Types)

⚙️ **Follow this exact order** to safely shut down **any PV system** — whether grid-tied, hybrid, or off-grid.

📉 DC Side Shutdown:

1. Turn **OFF** the **PV combiner box isolator** (string isolator).
2. Turn **OFF** the **battery DC isolator or breaker**.
3. Turn **OFF** the **DC isolator on the inverter**.

⚡ AC Side Shutdown:

4. Turn **OFF** the **AC output breaker** from the inverter.
5. Turn **OFF** the **main AC isolator** feeding the inverter.
6. If required, **isolate essential/non-essential DBs**.
7. Lastly, turn **OFF** the **main grid breaker** (only if a full site shutdown is required).

✅ **Emergency Shutdown Options** (if available):

- Firefighter switch (external shutdown button)
- Remote disable relay (installer-controlled)

🛠 Hybrid System Notes:

- Use brand-specific shutdown steps (e.g. Victron, Sunsynk, LuxPower).

- For Victron GX or Multiplus:
  → Use screen or VRM portal to set inverter to “Off”
  → Then proceed with DC/AC isolator shutdown

✅ **Reminder**:
Always shut down the **DC side first**, then the **AC side**.
This prevents **back-feed hazards** and ensures safe isolation.

📋 9.3 Emergency Contact Sheet (Post Near System)

🔴 **This sheet must be printed, laminated, and mounted near the inverter, main DB, or battery cabinet — at eye level and in waterproof covering.**

📄 Contact Directory

Role	Name / Company	Contact Number
Site Supervisor	(Insert name)	0X0 123 4567
Installer / Technician	(Insert name or company)	0X0 987 6543
Fire / EMS	Emergency Services	10111 / 112 (cell)
System Owner / Client	(Insert name)	0X0 111 2222
Utility Provider	(Eskom / Municipality)	(Insert number)
Equipment Supplier	(e.g. Victron, SolarEdge)	(Insert support line)

📜 System Details

Item	Information
Installer Name	SolarTech Solutions
System Type	Hybrid Solar – Sunsynk 8 kW + FreedomWon
Last Maintenance Date	14 April 2025
Next Scheduled Checkup	14 April 2026
Shutdown Instructions Summary	1. PV Isolator → 2. Battery Isolator → 3. AC Breakers

---

🚀 Instructions:

- Mount this contact sheet **in clear waterproof plastic**.
- Ensure it is placed **close to the inverter or DB board**.
- Replace annually or if any contact details change.

🕮 9.4 Client Emergency Quick Guide

🔒 **Purpose:** Provide the client with a simple, laminated A5 card or sticker near the inverter/DB for quick emergency action.

🚨 EMERGENCY SOLAR SHUTDOWN

Follow this exact order to shut down the solar system:

Step 1: Turn OFF all DC Isolators

- 🔴 PV Combiner Box / DC Isolator
- 🔋 Battery Breaker / Battery DC Switch
- 🟡 Inverter DC Isolator (if present)

Step 2: Turn OFF AC Power

- ⚡ Inverter AC Output Breaker
- 🚨 Main AC Isolator
- 🏠 Main Grid Breaker (if total shutdown is required)

🧯 When to Use This Guide

Scenario	Action
🔥 Fire or Burning Smell	Turn off all isolators, evacuate, and call emergency services
⚡ Electrical Arcing/Buzzing	Isolate system immediately and call the installer
💡 Abnormal System Behavior	(e.g. flickering lights or overheating wires) – shut down and report
💥 Loud Alarm or Flashing Light	Shut down and report fault to installer

---

⚠️ DO NOT:

- Touch any **burnt, melted, or damaged** wiring.
- Attempt to reset the system **unless advised** by the installer.
- Use water on electrical fires. Use only **CO_2 or Dry Powder** extinguishers.

📱 Contact Details (Insert):

- **Installer Emergency Line:** 0X0 987 6543
- **Fire/EMS:** 10111 / 10177
- **Client Support Contact:** 0X0 111 2222

🔗 Optional Additions:

- Attach a **QR Code** linking to a shutdown video or PDF guide.
- Place near the main DB or inverter **at eye level**.
- Include icons for:
  - 🔥 Fire
  - ⚡ Shock
  - 💥 System Fault

📌 **Keep this guide in:**

- The CoC file folder
- Near the inverter or main DB in **laminated, waterproof format**

👷 9.5 Installer Protocol After Emergency

Purpose: Outlines the required actions an installer must take after being notified of a system emergency (fire, electric fault, shutdown, or damage).

☑ *Step-by-Step Installer Response Checklist*

1. **Initial Safety Measures**
   - Confirm **all AC and DC isolators are OFF**
   - Secure the area: restrict access to damaged equipment
   - Check for:
     - Smoke, burnt smell
     - Exposed wiring
     - Heat damage or water ingress
2. **Detailed Visual Inspection**
   - Open and inspect:
     - ☐ PV Combiner Box (check string fuses and terminals)
     - ☐ Battery and Inverter Enclosures
     - ☐ Cable routing and glands (for signs of melting or arc marks)
   - Look for:
     - Burnt connectors
     - Melted plastic components
     - Rust or corrosion from moisture
3. **Electrical Testing**
   - Use an insulation resistance tester on:
     - DC strings (PV side)
     - AC output cables
     - Battery leads
   - Confirm:
     - No short circuits
     - No reverse polarity
     - Correct voltage readings after isolation
4. **Logging & Evidence Gathering**
   - Take timestamped photos of:
     - Affected components
     - Damage or error screens
   - Record inverter or battery **fault codes**
   - Download device logs (if USB or cloud tools are available)
5. **Fault Assessment & Report**
   - Identify source: e.g., lightning, overload, water damage, installation error
   - Write a formal **Emergency Incident Report**:
     - Date and time of incident
     - Nature of issue
     - Inspection findings

        - Corrective actions taken
6. **Rectification & Sign-Off**
    - Replace:
        - Fuses, isolators, damaged SPD units
        - Cables or breakers if required
    - Re-test the full system using the pre-commissioning test procedure
    - Only **restore power** if:
        - Fault has been fully rectified
        - A qualified person signs off on safety
        - Any updated CoC documents (if rewiring occurred) are issued

---

Required Documentation for Handover

Document	Description
Emergency Response Log	Summary of visit, actions, and site status
Inspection Photos	Clear images of before/after
Electrical Test Results	IR, continuity, voltage checks
Fault Code Report (if available)	Inverter/BMS download logs
Sign-off Sheet	Signed by supervisor or electrician-in-charge
Updated CoC (if applicable)	For any changes made to wiring/isolation

---

📌 **Tip:** Always retain backup copies of emergency reports for at least **5 years** (for CoC traceability and insurance purposes).

10. Commissioning, Testing & Handover

◇ 10.1 Pre-Commissioning Checklist (Before Power-Up)

Before any system is energized, confirm the following:

✅ Visual Inspections

- All wiring is secure, labelled, and terminated correctly
- All isolators are OFF
- No loose cable strands or untorqued lugs
- All panels are clean and secured
- Batteries are properly mounted, cabled, and fused
- Earth wire is properly connected at all points

✅ Tools Needed

- Multimeter
- Clamp meter
- Torque wrench
- Insulation tester (Megger)

- Earth resistance tester
- Load (test light or 2kW+ appliance)

Before energising the system, perform a full visual and mechanical inspection:

Mechanical & Wiring Checks:

- All panel connectors are secure (MC4 or compatible) and polarity-checked
- No sharp edges or stress points on cables
- Proper gland seals installed on all enclosures
- AC and DC isolators correctly labelled and accessible
- All trunking and conduit properly terminated
- CT clamps (if present) are oriented correctly and secured

Equipment Verifications:

- Inverter securely mounted and torqued
- Battery cabinet/stack securely fastened with correct spacing
- Combiner boxes labelled with string configuration
- DC/AC cable terminations torqued to spec
- Surge protection devices installed and bonded (if required)

Documentation & Labeling:

- Warning signs and operating instructions posted near inverter
- All DBs and combiner boxes labelled
- Breaker schedules and string maps printed and laminated

⚠️ This inspection must be completed and signed off by the installer before any power-up or electrical testing is performed.

📗 **Based on:**

- SANS 10142-1 (Ed. 3): Clause 8.1 – Initial Verification, Clause 8.2 – Visual Inspection, Clause 8.3 – Testing before energizing
- SANS 60364-7-712: Clauses 712.61, 712.62, 712.63 – PV-specific tests

---

✅ **Purpose**

To ensure electrical safety, system integrity, and standard compliance before applying power to any part of the PV system.

📋 **Required Checks Before Power-Up**

Area	Specific Requirements
Mechanical Completion	- All modules, batteries, inverters, combiners mounted securely - No loose fixings
Cable Routing & Protection	- All cables installed per design: protected, sleeved, no sharp bends - Correct glands used
Labeling & Signage	- All DBs, isolators, wireways, and batteries labeled per SANS - Fire safety and emergency labels applied
Wire Identification	- Cables clearly marked: L, N, E, +, – - Colour coding consistent and compliant
Bonding & Earthing	- Bonding of PV frames, DC/AC enclosures, surge devices checked - Earth continuity confirmed
Isolators & Breakers	- All isolators rated and installed correctly, with visible ON/OFF positions - SPD units connected and earthed
Cable Terminations	- Terminals torqued to spec, no damaged strands, ferrules used where required
DC & AC Polarity Check	- Verified using multimeter BEFORE closing isolators (never energize in reverse)
Visual Defects	- No damage, exposed conductors, gaps, or non-compliant routing
Documentation Available	- System layout, SLD, battery config, datasheets, monitoring info ready for records

---

📌 **Notes:**

- Use a physical or digital checklist signed off by the installer and reviewed by a qualified electrician.
- Any deviation must be corrected before proceeding to **Section 10.2**.

◇ 10.2 DC Side Tests

✅ **Required Tests:**

- **Polarity test** (from each panel string to combiner)
- **Voc check** (verify total string voltage before inverter connection)
- **Insulation resistance test** (Megger between + and – to earth)
- **Continuity check** on all string cables
- **Earth continuity** (PV frame to earth spike/bar)
- **Surge protection check** (SPD test button or LED indicator)

📝 Record all values on the job card or commissioning checklist.
These are **required by SANS 60364-7-712.61** and **Annex B** for compliance and safety documentation.

📗 **Standards Reference:**

- **SANS 60364-7-712:2018** – Clauses 712.61 to 712.63
- **SANS 10142-1:2020 (Edition 3)** – Clause 8.3: Testing before energising

---

✅ **Purpose:**

To confirm that the PV DC circuits are:

- Properly wired

- Safe to connect to the inverter
- Free from faults such as reverse polarity, insulation failure, or loose earthing

---

📋 Required DC Tests and Acceptance Criteria

Test	Description / Procedure	Acceptable Result
Polarity Test	Use a DC voltmeter at the DC isolator or combiner to confirm string polarity	Correct positive and negative orientation. **No reverse polarity allowed**. Confirm at each string.
Open Circuit Voltage (Voc)	Measure voltage of each string (disconnected from inverter) at combiner or isolator	Must be **within ±10%** of expected Voc under current temperature and irradiance. **Must not exceed inverter's max DC input voltage**.
Insulation Resistance	Use **500V or 1000V megger** between +ve to earth, –ve to earth (MPPT/inverter disconnected)	Minimum **≥ 1 MΩ per string** (per SANS). Higher values preferable.
Continuity of Protective Earth	Measure from PV frame and SPD body to main earth bar with continuity tester or multimeter	Resistance must be **≤ 0.5 Ω** (best practice) or ≤ 1 Ω (per standard).
Short Circuit Current (Isc)	If safe and sunlight is strong, clamp meter around + or – at combiner or isolator	Value must match datasheet short-circuit current (±15%). Only done if system supports safe testing (never under load).
Surge Protection Devices (SPDs)	Visually inspect LED or indicator; press test button if available	SPD status must be "OK" (e.g., green light). If red/faulty, **replace before commissioning**.

⚠️ Important Testing Safety Notes:

- **Do not connect the inverter** until all tests are successfully passed.
- Always use **insulated DC test probes**.
- Use **appropriate PPE**, including gloves and eye protection when working on live circuits.
- If an abnormal value is found, **stop work and investigate** before continuing.
- Log all test results and serial numbers in the site handover file or commissioning report.

◇ 10.3 Battery & Inverter Tests

✅ Required Tests:

- Measure **battery voltage per bank** and **total system voltage**
- Verify **series/parallel configuration** is correct
- Confirm **voltage at inverter terminals** on DC side
- Perform **polarity check** at inverter DC inputs
- Test **battery fuse or breaker** for continuity and rating
- Torque all **DC cable terminations** to manufacturer specifications
- Power up **inverter with no loads** — monitor LCD/app for self-check, faults, or status messages

---

🔋 Battery Testing (Where Applicable)

- Measure individual **battery bank voltages** before connecting inverter
- Check **BMS communication** via RS485, CAN, or app
- Confirm **State of Charge (SOC)** using interface or BMS readout

- Look for **error LEDs, alarms, or warning codes**
- Inspect cables, fuses, terminations for tightness and compliance

---

⚙️ Inverter Testing

- Torque **DC input/output terminals** as per user manual
- Confirm **firmware version** is current and compatible with battery brand
- Configure inverter for correct **battery chemistry** ($LiFePO_4$, Lead Acid, etc.)
- Ensure **communication established** with monitoring app or portal
- Set and verify **grid-tie parameters** (if applicable)
- Complete **CT or external meter setup** for zero-export or grid feedback

---

📗 Standards Reference:

- **SANS 10142-1:2020 Ed. 3** – Clause 8.3 (Testing before energising)
- **Manufacturer datasheets and inverter user manuals**

📋 Battery Test Procedures

Test Area	Procedure	Criteria / Notes
Battery Identification	Confirm battery type ($LiFePO_4$, AGM, etc.), capacity, and voltage	Must match inverter specs and config menus
Wiring & Polarity	Use voltmeter to check terminal polarity before connecting to inverter	Positive-to-positive, negative-to-negative — no reversals allowed
Battery Voltage	Measure resting voltage after pre-charge (if applicable)	Must fall in correct range (e.g., 48V bank = 51V–54V typical full)
SOC Reading	Confirm via BMS/app or interface	Should match known condition — e.g., 90% SOC at install
BMS Communication	Verify inverter detects battery comms (RS485, CAN, etc.)	No inverter warning/error related to battery communication
Battery Fuse/Breaker	Inspect physical device, test continuity	Rated ≥ battery max current × 1.25 for safety (e.g., 100 A × 1.25 = 125 A fuse)

⚡ Inverter Test Procedures

Test Area	Procedure	Criteria / Notes
DC Voltage Input	Measure DC voltage at inverter terminals BEFORE energizing	Must be within inverter's MPPT voltage range; log for records
Inverter Polarity Check	Use multimeter or visual inspection for PV +/– and battery +/–	Strictly no reverse polarity (can cause permanent damage)
Grounding & Bonding	Test inverter earth terminal to main earthing bar	< 1 Ω resistance — confirms proper protective earth continuity
Isolation Resistance Test	Optional: Use 500 V insulation tester between inputs and earth	≥ 1 MΩ required per SANS 10142. Inverter must be disconnected during test

Test Area	Procedure	Criteria / Notes
Firmware Version	Check firmware via screen or app	Must be compatible with battery BMS or inverter features
Parameter Settings	Confirm: battery voltage, charging limits, LVD, HVD, PV input range	Use manufacturer's recommended settings
Communication Protocols	Confirm inverter sees: battery, grid, PV input, BMS	No "comms error" or fault lights; inverter should show "Ready" or "Idle"
LED/Display Indicators	Check for normal status lights, warnings, or system messages	Must display "No Fault," "Normal," or "Standby" — NOT red, fault, or alert

---

🛡 **Safety Notes:**

- Do **not connect AC side** or enable loads until inverter passes all checks
- Use **insulated tools and gloves** when working with battery terminals
- Take note of **firmware versions** and **serial numbers** — store with commissioning documents
- If any test fails or shows abnormality, **halt the process** and troubleshoot before proceeding

◇ 10.4 AC Side Tests

✅ **Required Tests:**

- Voltage test at **inverter AC output terminals**
- **Continuity test** for Live, Neutral, and Earth
- **Earth loop impedance** from inverter DB to main DB
- **RCD trip test** at 30 mA (must trip within 300 ms)
- **Phase rotation** test (for 3-phase systems)
- **Load test** with known resistive or inductive load to confirm supply integrity

📋 *All results must be logged on the commissioning and CoC sheet.*

⚡ **AC Side Tests – Overview**

Performed both **before** and **after startup** (inverter energised):

Test	Description	Expected Result
Polarity	Confirm correct Live–Neutral–Earth orientation	L = Live, N = Neutral, E = Earth – no reversals
Earth Loop Impedance (Zs)	Measure loop impedance from each DB or outlet	Within limits per SANS 10142-1 Table 8.7
Voltage Levels	Measure grid and inverter output voltages	Within ±6% of nominal (e.g. 230V or 400V ±6%)
Continuity of Conductors	Confirm full continuity on L, N, and E wires	Confirmed – no open circuits
Insulation Resistance	Test between L–E, N–E, and L–N	≥ 1 MΩ per SANS 10142-1

✍ *Use an auto-sequence tester if available. Record per DB and inverter.*

📗 Standards Reference:

- **SANS 10142-1:2020 Ed. 3**
  - Clause 8.3: Pre-energisation tests
  - Clause 8.5: Verification of protection
  - Annex D: DB labelling
- **Manufacturer Specifications** for SPDs, RCDs, and inverters

---

📋 AC Wiring & Protection Checks

Test Area	Procedure	Criteria / Notes
Continuity of Conductors	Use continuity tester to verify line, neutral, and earth connections	Full continuity confirmed; no open ends or reversed connections
Insulation Resistance	Test L–E, N–E, and L–N using 500 V insulation tester	Must be ≥ 1 MΩ per SANS 10142-1 Clause 8.5.2.1
Earth Loop Impedance	Use loop tester to measure impedance from inverter DB to earth bar	Compare results to Table 8.7 in SANS 10142-1 – confirms breaker/fuse effectiveness
Polarity Test	Check sockets, DB outputs, and inverter connections for correct orientation	L = Live, N = Neutral, no swaps
Voltage Test	Use voltmeter on grid input and inverter output	Single phase: ~230V; Three phase: ~400V ±10%
SPD Testing	Check visual indicators (MOV lights) and test continuity	MOV/LED indicator must be green or show “OK” – red indicates replacement required
RCD Testing	Use calibrated tester to inject 30 mA fault current	Must trip in < 300 ms; test both RCDs and earth leakage breakers
DB Labeling	Check all DB circuits are clearly and correctly labelled	Use permanent labels – mark solar, grid, backup, essential loads separately

---

🔁 Functional Tests (After Startup)

Test Area	Procedure	Criteria / Notes
Inverter Output Transfer	Monitor inverter AC output when loads connect (auto/manual)	Seamless switchover for hybrids; transfer delay per specs
Essential Load Switching	Confirm correct switching to essential/non-essential groups	Loads behave according to design – test outage simulation
Generator Interface (if any)	Simulate grid loss; test auto/manual generator start and handover	Generator starts, inverter accepts or isolates as per programmed logic
DB Thermal Inspection	Optional: Perform thermal scan after 10 mins of load	Detect hot spots or loose terminals not visible to eye

---

🛡 Safety Notes:

- Do not perform **live tests** unless you are a qualified technician using full PPE
- **Energise AC side only after full DC and inverter testing is passed** (Sections 10.2 and 10.3)
- Record all results including **pass/fail status**, **technician initials**, and **date**
- Upload photos of readings to project record (if digital CoC platform is used)

◇ 10.5 Firmware & Settings Verification

✅ What to Check:

- Inverter firmware version
- Battery model auto-detection or manual configuration
- Charging current and voltage limits
- MPPT scan completed
- Generator settings (if applicable)
- Inverter comms sync (parallel addresses, status)
- Remote monitoring portal is online and logging data

📱 Firmware & Settings Verification – General Procedure

Before enabling **inverter output**, the following checks must be completed:

- Confirm inverter firmware is the latest **stable version**
- Ensure compatibility of inverter with:
  - Battery brand/model (e.g. FreedomWon, Pylontech, Hubble)
  - Remote monitoring system (e.g. Solarman, Sunsynk Portal, VRM)
- Complete MPPT scan to detect PV strings (if not automatic)
- Verify parameters such as:
  - **Battery cut-off/recovery voltages**
  - **Max charge/discharge currents**
  - **Export limit and CT calibration**
  - **Generator priorities and relays**
  - **Scheduling/time-of-use settings**

⚙️ Purpose

To ensure all firmware and inverter/battery settings are:

- Correctly applied according to system design and local regulations
- Compatible with site components (grid, battery, PV)
- Stable and prepared for live power output and remote supervision

---

📋 Step-by-Step Settings Checklist

Setting / Function	Description / Checkpoint	Notes
Firmware Version	Confirm latest stable firmware is installed on inverter and BMS	Use official portal (VictronConnect, Sunsynk App, etc.)
Region/Grid Profile	Select correct grid code (e.g. NRS 097-2-1 for South Africa)	Incorrect grid code may cause inverter rejection by utility
Nominal AC Output	Confirm output voltage and frequency (e.g. 230V / 50Hz)	Must match utility/grid or DB specs
Battery Chemistry	Select battery type (LiFePO4, AGM, Lead Acid)	Affects SOC, charge voltage, and comms

Setting / Function	Description / Checkpoint	Notes
Charge/Discharge Current	Set maximum charging/discharge current per battery specs	Exceeding limits causes faults or BMS cutoff
Float/Absorption/Equalize V	Enter manufacturer voltage thresholds	Especially for lead-acid banks
SOC Sync	Confirm BMS-reported SOC is correct or perform a cycle for calibration	Prevents false “empty/full” readings
CT / Smart Meter Setup	Check CTs are oriented correctly and mapped to correct inputs	Essential for export limiting and load monitoring
Time-of-Use / Schedule	Configure off-peak vs peak charging, load supply, or grid use	Important for cost-saving TOU tariffs
Auto Restart / Black Start	Set automatic reboot logic on power return	Black start should be disabled unless site requires it
Load Priority Settings	Define supply priority (PV > battery > grid or custom rule)	Affects performance under load shedding or grid interruption
Relay Output Settings	Set logic timers for generator start, fans, or alarms	Match to wired automation configuration
Communication Ports	Confirm RS485, CAN, Ethernet/Wi-Fi ports are working and online	Check on local LCD or app (no comms errors should show)

⚠️ Important Notes

- **Backup all settings** before any firmware updates — some models reset settings after update
- **Firmware should only be updated** when:
  - Batteries are fully charged
  - Grid is stable
  - System is idle (not under high load)
- Re-apply configurations if reset after update
- **Log all parameter values**, firmware version numbers, and timestamp of update

---

📲 Firmware & Monitoring Portals by Brand

Brand	Firmware & Configuration Tool
Victron	VictronConnect + VRM Portal
Sunsynk	Sunsynk App / Sunsynk Web Portal
Growatt	Shine Server
ATESS	ATESS USB Update Tool + Web Monitoring
Deye	Smart ESS App / Deye Installer Portal
LuxPower	LuxPower App
GoodWe	SEMS Portal
SMA	Sunny Explorer

◇ 10.6 System Startup

✅ Once All Tests Pass:

1. Turn **ON** battery breaker or isolator
2. Power on **inverter**
3. Turn **ON** DC isolator (panel input)

4. Turn **ON** AC isolator to DB or load
5. Monitor inverter startup and confirm **no errors**
6. Confirm **battery charging or discharging**
7. Observe **PV power flow** and **active loads**

🔴 **If any fault code appears, isolate immediately and investigate.**

🔌 **10.6 System Startup – Step-by-Step Sequence**

📜 **Startup Sequence (In Order):**

1. **Switch ON battery breakers**
2. **Wait for inverter** to boot and detect battery communication
3. **Switch ON PV string isolators** (DC side)
4. Monitor voltage rise at **MPPT trackers**
5. Inverter will **auto-start generation** if:
    - Battery voltage is within safe range
    - Grid voltage is present (for grid-tied systems)
6. Confirm inverter **starts power output**
7. Observe display or remote platform for:
    - Input voltages
    - Output power
    - Battery charge/discharge status

⚠️ **Monitor the system for 15–30 minutes under load** before finalising commissioning.

⚡ **10.6 System Startup – Sequence & Safety Checks**

🔄 **Objective:**

To **energize the system safely** in a controlled sequence, prevent damage, and verify correct startup behaviour under real conditions.

✅ **Safe Startup Sequence (Hybrid / Off-Grid / Grid-Tied)**

Step	Procedure	Notes
1	Final Visual Inspection	Confirm cabling, gland seals, labels, bonding completed
2	Ensure All Isolators Are OFF	PV input, battery, AC input/output should be OFF
3	Activate Battery System	Turn ON BMS and battery breaker/isolator
4	Power Up Inverter (DC Only)	Inverter boots from DC power – no PV yet
5	Check Battery-Inverter Comms	SOC, voltage, current should be accurate; no error codes
6	Turn ON PV Input	DC isolator ON → MPPT detects voltage/current
7	Turn ON AC Output to Load	Energize load side (if isolated from grid)
8	Turn ON AC Grid Input	For grid-tied/hybrid: enable grid supply to inverter
9	Check Grid Synchronization	Voltage, frequency, and phase match confirmed
10	Check Display & Monitoring	Ensure no faults and all values are visible online/app

---

🔍 Key Indicators After Startup

Item	What to Look For
Inverter Display	Status = “Inverting”, “Charging”, “Grid-tied” (depending on mode)
Battery Status	SOC, voltage, and current values correct
PV Input / MPPT	Input voltage close to design Vmp, and current flow in sun
Grid Parameters	Grid voltage within ±10%, frequency 49.5–50.5 Hz
Load Output	Output stable at 230V or 400V (single/three-phase)
No Fault Codes	No beeps, red LEDs, or blinking fault icons
Monitoring Platform	Values appear on mobile/web platform (live sync)

⚠️ Notes:

- Always **energize the DC side first** (battery, then PV), before turning ON any AC isolators.
- Never apply PV voltage unless **DC isolator is engaged** to protect inverter inputs.
- If any startup fails or errors occur, **isolate immediately** and perform full re-inspection.

◇ 10.7 Final Sign-Off & Client Handover

✅ What to Do:

- Show client how to:
  - Read the inverter display
  - Switch the system OFF/ON safely
  - Use the remote monitoring platform (app/portal)
  - Identify basic system warnings or error codes
- Explain the following:
  - System specifications (solar kW, battery kWh, inverter kVA)
  - Backup vs non-backup loads
  - Warranty terms and coverage
  - Service and support contact details
  - What **not** to do (e.g., don’t modify wiring, reset errors blindly, overload inverter)
- Provide client with:
  - A **copy of the Certificate of Compliance (CoC)**
  - A **system-specific emergency shutdown guide**
  - All **warranty documents** (inverter, panels, battery)
  - Remote monitoring **login details**
  - A **signed handover form**

✍ Client **must sign** to confirm understanding and acceptance of the system in good condition.

✍️ Final Sign-Off – Administrative Tasks

📌 Final Steps Before Handover:

- Complete the internal installation checklist.
- Print and sign the following:

    - ✅ Commissioning Sheet
    - ✅ Electrical Test Report
    - ✅ Compliance Declaration (if required for municipality or SSEG)
- Provide the client with:
    - ✅ System diagram and Single Line Diagram (SLD)
    - ✅ QR codes or links to apps and remote portals
    - ✅ Site-specific Emergency Shutdown Instruction Guide
    - ✅ Warranty cards and service plan booklet
    - ✅ Final signed Certificate of Compliance (CoC)

📁 Suggested Optional Forms for Annexures:

(Not included in this manual; to be customised per installer/company)

- DC Testing & Polarity Log Sheet
- Battery BMS Setup Confirmation
- Inverter Firmware & Settings Checklist
- Pre-Startup Inspection Sheet
- Customer Handover Acknowledgement Form
- Commissioning Photos Index Sheet

✅ Purpose:

To formally conclude the PV installation process, verify the system operates correctly under real-world conditions, and ensure the client is trained and equipped to manage the system safely and efficiently.

📋 Final Installer Sign-Off Checklist

Area	Tasks Completed
✅ DC Side	Final string tests passed; polarity confirmed; insulation resistance within limits
✅ Battery	Correct configuration; BMS online; no error indicators
✅ Inverter	All settings confirmed; inverter synced (or in off-grid mode); no faults
✅ AC Side	Functional RCDs/SPDs; earth continuity; load circuits tested
✅ Monitoring	App/portal configured; real-time values streaming correctly
✅ Labelling	All components labelled: DBs, isolators, inverter, combiner, battery, etc.
✅ Wiring & Clean-up	Cables neatly tied; no exposed conductors; trunking sealed

---

📂 Documents to Provide the Client

Document Type	Description
Certificate of Compliance (CoC)	As required by Electrical Installation Regulations (mandatory legal document)
Commissioning Form	Internal document recording all test results and commissioning data
Warranty Cards or Slips	For all major components (inverter, battery, solar panels)
SSEG Registration Confirmation	Proof of registration or municipal approval for grid-tied systems
System Layout Diagram	Visual overview of system layout and wiring
Load Chart (if applicable)	Breakdown of circuits per DB (essential vs non-essential)
Monitoring Login Credentials	Login info for app/web dashboard (setup assistance given on-site)
Emergency Contacts	Installer, tech support, fire/EMS contacts, etc.

📦 Client Walkthrough – Key Topics to Cover

Topic	What to Explain
Basic Operation	System modes: grid-tied, charging, backup, battery priority, etc.
Safe Shutdown	How to isolate PV, battery, inverter, and AC for maintenance or emergencies
Fault Notifications	How to identify fault codes or LED alerts and what to do next
Routine Maintenance	Panel cleaning frequency, visual checks, when to call for service
Monitoring Platform	Dashboard overview: PV production, battery level, power flow, errors

11. Recording of Equipment (Asset Logging)

🔢 11.1 When to Record Serial Numbers (SNs)

📌 Purpose:

Recording all **serial numbers (SNs)** and **key specifications** is a **non-negotiable** requirement for every solar installation. This step is critical for:

- Warranty tracking
- Theft recovery and insurance claims
- Commissioning verification
- Remote monitoring registration
- Maintenance and future replacements
- Compliance with **SANS 60364-7-712** and audit requirements

---

✅ **Mandatory Recording Points:**

When	Reason / Benefit
At delivery to site *(optional but ideal)*	Confirms that correct equipment was delivered
During unpacking / staging	Matches serial numbers to delivery and purchase orders
Before installation	Avoids mismatch if equipment is swapped after installation begins
During pre-commissioning	Verifies that all installed equipment is the same as recorded
During final walkthrough before handover	Ensures clean documentation for the client and installer records
At time of fault, warranty claim, or service	Essential for component identification and proof of warranty

---

📝 **Industry Standards & Best Practice:**

- **SANS 60364-7-712** and most international codes require traceability of all major system components.
- This includes:
  - PV modules (each panel SN)
  - Inverters
  - Batteries (if applicable)
  - MPPTs, BMS units, and combiner boxes (where SN is available)
- Serial numbers should be recorded on a **centralised Asset Register**, ideally both digitally and in hard copy form.

💡 **Tips:**

- Take **photos** of serial number labels on-site — this provides easy backup for data entry errors.
- Label string groups and DB circuits to match asset list (e.g., “PV String A – Panel SN1234 to SN1240”).
- Use a spreadsheet or commissioning app with **time stamps** and **GPS location tags** if available.

🔢 11.2 What Equipment to Record

📌 Objective:

To ensure all critical components of the solar PV system are uniquely identified, traceable, and documented for future maintenance, warranty, or audits.

🪜 Required Equipment Categories & Details:

Equipment Category	What to Record
Inverter(s)	Serial Number, Model, Firmware Version
Battery System	Serial Numbers for each module and BMS unit (if modular)
Solar Panels	At least one serial number per string, panel wattage, number of panels per string
MPPT Controllers	Serial Number (only if external; e.g. Victron BlueSolar)
Combiner Boxes	Internal label reference + installer initials
CT Clamps / Smart Meters / Dongles	Serial Numbers, Device Type (e.g., Solarman CT, Victron Cerbo), SIM/IMEI (if GSM)
Charge Controllers	External units only (off-grid or modular systems)
Monitoring Devices	Gateways, loggers, portals (e.g., Sunsynk Logger, SMA Gateway)
Communication Hubs	RS485, Wi-Fi bridges, LAN dongles, RS232 serial ports, etc.
SPD Devices (optional)	Label, replacement date cycle (if trackable SNs exist)

📷 Photo Logging:

- Take clear photos of each **serial number sticker** (inverters, batteries, panels, MPPTs).
- Save into the job folder, naming each according to the site and component.
- **File Naming Format** (for photos or scanned sheets):
  ClientName_Site_SNRecord_YYYY-MM-DD

📌 Optional Best Practice:

- Record **firmware versions** for the inverter and battery BMS to simplify tech support later.
- Where SNs are hard to access once installed (e.g., behind batteries), take the photo before final wiring.

📝 11.3 How to Record Equipment

✅ Acceptable Recording Formats:

Method	Details
Manual Forms	SN checklist printed and completed by installer on-site
Label Sheet	Pre-filled template added to job card or commissioning form
Digital Forms	Google Form, Microsoft Forms, or company app during install
Photo Log	Folder of images stored in digital job file
Excel Log	Tabular asset register with columns: Category, Brand, Model, SN, Location

---

📁 Example File Naming Convention:

SmithFarm_Limpopo_SNRecord_2025-07-13.xlsx

🛠 Labeling and Redundancy:

Practice	Purpose
Duplicate internal label	Place inside inverter/battery door in case SN gets rubbed off
Company sticker on device	Add sticker with client name + install date to inverter/BMS devices
Use barcode/QR scanner	Speed up data entry and reduce input errors (if using mobile apps)

📄 11.4 SN Record Sheet Example

📌 Purpose:

To provide a structured template for installers to record all relevant asset serial numbers (SNs) and component details. This record is crucial for warranties, system maintenance, remote monitoring setup, and compliance documentation.

✅ Example SN Record Table (Quick Reference)

Item	Brand	Model	Serial Number	Notes
Inverter 1	Sunsynk	8kW Hybrid	SUNX240112345	Master inverter
Battery 1	Hubble	AM2 5.5kWh	HBL220090123	Top of stack
Panel 1	JA Solar	545W Mono	JA23SM456789012	String A
Combiner Box	Custom	DC 4-in/1-out	N/A	Labelled on cover

📑 Detailed SN Logging Template – For Annexure Use

Include a formal version of this sheet in the **project file** and **client digital handover pack**.

Component Type	Brand / Model	Serial Number	Location Installed	Date Installed	Notes
PV Module	Canadian Solar 455W	CS45520230887	Roof North 1	2025-07-09	Group 1 of 10
Inverter	Victron Multiplus II	MP-II-48-3000-INTL	Backroom	2025-07-09	Firmware 2.94
Battery	FreedomWon Lite Home 10/8	FW230000456	Inverter Room Wall	2025-07-09	SOC Sync Confirmed

Component Type	Brand / Model	Serial Number	Location Installed	Date Installed	Notes
CT Clamp	Solarman RS485 CT	CT485-2025-00322	Main DB	2025-07-09	Correct orientation confirmed
Logger	Deye Logger V2	DLOG-20250709-001	Near inverter	2025-07-09	LAN connection tested

---

📂 **Fields to Include in a Custom SN Form (Structure Only)**

Your internal job card or annexure form should contain the following fields:

- **Project Name / Client Name**
- **Client Address / Site Location**
- **Installer Name**
- **Date of Installation**
- **Equipment Category** (e.g., Inverter, Battery, PV Module, Combiner Box)
- **Brand and Model Number**
- **Full Serial Number**
- **Physical Location on Site** (e.g., Roof South, Backroom Wall)
- **Notes** (e.g., string position, firmware version, CT direction)

🗁 **11.5 Where SN Records Are Stored**

✅ **Purpose:**

To ensure serial number (SN) records are securely stored, easily retrievable for service or warranty purposes, and accessible by both installers and clients.

🕳 **Installer Master Copy**

SN records must be filed together with all commissioning and compliance documentation. Recommended locations:

- **CRM or job folder system** (e.g., Papertrail, Monday.com, SolarCRM)
- **Local digital archive** (company computer or hard drive)
- **Cloud storage** (Dropbox, OneDrive, Google Drive) for backup

🔒 Always back up to at least two separate locations (e.g., one local, one cloud) for disaster recovery.

📄 **Client Copy**

- Provide the client with a **printed or PDF version** of the SN list.
- Include with the:
  - User manual pack
  - CoC document set

    - Warranty documentation
- Optional: email a digital version post-handover

📋 Compliance & Insurance Requirements

In certain regions or under specific insurance policies, SN records may be required for:

- **Warranty claims**
- **Fire or surge insurance claims**
- **Grid-tied system inspections**
- **Product recalls**
- **Performance guarantee reviews**
- **SSEG compliance inspections**

📦 *Best Practice:* Physically **label the system enclosure** (e.g., inverter door, battery rack) with key SNs for quick reference by service teams.

📲 Monitoring Portal Integration

- Some platforms require SNs for setup (e.g., Victron, Solarman, Sunsynk)
- Others auto-import SNs via QR/NFC scan (e.g., SMA Sunny Explorer)
- Always verify SNs recorded in the portal match the physical hardware

---

📁 Summary Table: Where SN Records Are Stored

Storage Location	Best Practice Description
Project Job Card	Paper or PDF file in the commissioning folder
Digital Cloud System	Dropbox, Google Drive, CRM or solar management platform
Client Handover Pack (Optional)	Include printed or emailed list of SNs for client reference
Monitoring / Remote Portal	Auto-sync or manual SN entry for tracking and warranty
On-site Labeling	SNs labelled on inverter, battery, or DB door for technician access

12. Photographic Proof Requirements

◇ 12.1 Importance of Photo Documentation

Photos are a **non-negotiable compliance requirement** in every solar PV installation. They serve multiple critical functions:

- ✅ **Proof of quality workmanship**
- ✅ **Evidence of code and safety compliance**
- ✅ **Support for insurance or warranty claims**
- ✅ **Client satisfaction and transparency**
- ✅ **Protection against disputes and false claims**
- ✅ **Record for future maintenance or audits**

📁 *Photos must be submitted with the job's final documentation pack before client handover.*

🕐 12.1 When to Take Photos

Photos should be taken systematically at **all key phases of the project**. The following points are mandatory:

Stage	Required Photo Content
Before Installation	Site condition, roof integrity, existing DBs, layout of work area
Panel Mounting (Mid-Install)	Panel frames, roof anchors, roof penetration sealing, mounting spacing
Cable Routing & Labeling	Trunking open with routed wires, labeled conductors, bonding clamps
DC Combiner Build	DC fuses, SPD installation, busbar wiring, gland sealing
Battery Installation	Full battery bank view, terminal layout, bonding & earth connections
Inverter Setup	Inverter position, clean wiring, CT clamps, communication ports
AC Combiner / DB Wiring	Wiring terminations, RCDs, SPD, MCBs labelled, cable gland entry
Testing Phase	Multimeter/tester readings, insulation tester screen, loop test values
Commissioning & Monitoring	Inverter LCD display, mobile app screen, portal values and alerts
Final Site Overview	Whole installation, labels, SLDs, cleanup, CoC displayed if mounted

---

🗓️ Best Practices for Photo Capturing

- ✅ Use a **mobile device with high-resolution camera**
- ✅ Ensure **good lighting** and no obstructions
- ✅ **Focus** on connections, labels, and test results clearly
- ✅ Always **time-stamp photos** (enabled in camera settings or via app)
- ✅ Take **wide-angle** views and **close-ups** where needed
- ✅ If possible, include a **whiteboard or paper sheet** with job number and date in frame

---

📂 Storage & File Naming Convention

Organize all images in the **project folder**, sorted by stage:

Copy code

```
ClientName_Project_YYYYMMDD/
│
├── 01_Before_Install/
├── 02_Mounting/
├── 03_DC_Wiring/
├── 04_AC_Wiring/
├── 05_Battery_Inverter/
├── 06_Testing/
├── 07_Monitoring_Screenshots/
└── 08_Final_Handover/
```

📁 *Tip:* Convert final job photo set into a PDF “Photo Evidence Report” for archiving or handover pack.

🔷 12.2 Required Photos (Checklist)

Photos taken throughout the installation must be **clear, labelled, and stored** systematically. The list below outlines the **essential photographic documentation** needed for compliance, warranty, and audit purposes.

📋 Required Photo Types & Descriptions

Photo Type	Description
Panel Overview	Full view of all mounted panels on roof or ground (centered and clear)
Panel ID Tag	Close-up of at least one serial number or label per string
Trunking/Conduit	Entry/exit points, bends, and sealed covers; cables neatly routed
DC Combiner (Open & Closed)	Neat wiring, fuses, labels, SPD if present; then lid closed with label visible
Earth Spike & Bonding	Spike driven into ground, bonded to structure, with green/yellow cable visible
Inverter (Front & Side)	Mounted position, airflow spacing, cable entries clearly shown
Battery Bank	Top and side view; clear orientation of cables and terminals
Serial Numbers	One photo each of inverter, battery, panels (if visible), and dongles
AC Combiner DB	Open view showing labeling, breakers, surge protection
Main DB Connection	Where system ties into client's distribution board
Testing	Multimeter/tester readings (e.g. Voc, AC volts, earth loop impedance)
Final System Shot	Wide angle photo showing full installed system in context of environment
Clean-Up	After photo: clean site, no packaging or tools left behind

🧭 Photo Checklist by Area

🟢 General Site

- Building exterior showing panel position
- Roof structure showing anchoring (brackets, bolts, tile hooks)

🔴 DC Side

- Rear of PV panels showing string layout and SNs
- DC cable route (trunking, conduit)
- DC combiner (lid open for fuses, SPD, labels; lid closed for finish)
- Earthing: panel frame bonding, spike connection
- DC test photo (e.g., Voc string voltage test)

🔵 Battery & Inverter Area

- Full view of battery cabinet or rack (front/top)
- Inverter wiring: DC and AC terminals clearly visible
- All earthing and busbar connections
- All isolators: open with internal wiring, labels applied
- Final enclosure or board view (neatness, trunking closed)

🟡 AC Side

- AC tie-in point at DB or changeover switch
- Essential vs non-essential DB layout (if split)
- Generator interface and protection setup (if used)

🟣 Final Labels & Handover

- Stickers on isolators, combiner boxes, battery/inverter
- Shutdown instruction sheet displayed
- Client contact and emergency sticker (if required)
- Labelled SNs and printed test results (in photo frame or binder)

📲 Optional (Highly Recommended)

- Screenshots of:
  - Inverter LCD display showing real-time data
  - Monitoring portal dashboard (battery %, solar kW, grid connection)
  - Commissioning logs or settings export

◇ 12.3 How to Submit Photos

Proper submission and naming of installation photos is essential for **quality assurance**, **compliance**, **warranty claims**, and **client satisfaction**. Photos should be **clear, labelled, and submitted in the correct format** before the final handover.

✅ Acceptable Submission Methods

Submission Channel	Description
Cloud Upload	Upload to a dedicated shared folder (e.g., Google Drive, Dropbox, OneDrive)
WhatsApp to Admin/Supervisor	For smaller projects or quick handovers – ensure admin logs them properly
Commissioning Checklist Attachment	Printed or digital job card with embedded photo references or thumbnails
PDF Report Integration	Embed photos in final report or test sheet (recommended for high-end projects)

👣 Recommended File Naming Convention

All photo files must follow a consistent, traceable format:

Copy code
ClientName_Project_Location_Item_YYYYMMDD.jpg

🇿🇦 **Example**:
Ngobeni_Site1_JHB_Inverter_SN_20250610.jpg

This helps with:

- Easy retrieval during warranty claims or inspections
- Sorting per system component or install phase
- Linking to commissioning or job tracking systems

🚚 Submission Per Stakeholder

🔧 Installer Team (Internal)

- Upload to company's shared drive, CRM, or structured job folder
- Use the following structure:

  swift
  Copy code
  /ClientName/SiteLocation/YYYY-MM-DD/
  ├── DC/
  ├── AC/
  ├── Battery/
  ├── Handover/

- Include photos in:
  - Digital job pack
  - Internal quality review process

👩‍💼 **Clients**

- Provide selected photos:
  - Full system overview
  - Panel layout
  - Inverter and battery view
  - Shutdown guide photo
- Via:
  - Email
  - USB drive
  - Cloud download link
  - Printed photo sheet (optional)

🖨️ **Finance, Municipality or Compliance Body**

- Follow the method required by the party:
  - Portal upload (e.g., SSEG)
  - WhatsApp to verifier (include site ID and install date)
  - Shared folder with index sheet
- Always label photos by:
  - Site reference number
  - Installer initials
  - Date of commissioning

📌 *Important: All photos must be time-stamped and clearly focused. Blurry or poorly labeled photos may delay approval, claims, or payment.*

🔷 12.4 Photo Guidelines

Photos are only useful if they are clear, accurate, and usable. Follow these best practices to ensure your photos meet installation and compliance standards.

✅ **Do:**

- Use a clean camera lens
- Ensure good lighting conditions (use flash if needed)

- Keep images focused and stable (no motion blur)
- Include **equipment labels** (e.g., isolator labels, panel SNs) clearly in frame
- Step back far enough to show **component context** (e.g., inverter in room)

❌ **Don't:**

- Submit **blurry**, **cropped**, or **tilted** photos
- Cut off serial number tags or labels
- Take photos with **hands, fingers, or tools** blocking the view
- Skip photos of **dirty work areas**, untidy wiring, or unlabelled components

---

📷 **Quality Guidelines Table**

Photo Rule	Description
Resolution	Use a camera of at least **8 megapixels**; do not submit low-quality images
Label Clarity	Zoom in on important labels (DBs, isolators, SNs, inverter screen)
Framing	Capture **entire components** – not half a panel or cropped isolator
Lighting	Use flash in low-light areas (inside DBs, garages, etc.)
Avoid Obstruction	No fingers, screwdrivers, or debris in shot
Serial Numbers	Ensure stickers are readable, no blur or reflection
Tidy Wiring	Only take final photos **after** cable ties and labelling are complete
Wide Shots	Include full system view and room context where possible

---

◇ 12.5 Why This Matters

📌 Why photo documentation is non-negotiable:

Purpose	Benefit
✅ Quality Assurance	Confirms that the work was completed to standard
✅ Warranty Claims	Supports claims by showing proof of proper installation
✅ Legal Protection	Defends against accusations or disputes post-install
✅ Compliance	Required for insurance audits, SSEG submissions, and municipal approvals
✅ Training & Reviews	Allows new staff to learn from real-world examples
✅ Client Trust	Shows professionalism and builds confidence in your team

Golden Rule:
"If it's installed — photo it!"
Do not rely on memory or assume someone else got the picture.

13. Site Handover Procedure

🕐 13.1 Handover & Timing

Why?

The **final step** in any solar PV installation is the formal **site handover** to the client. This process ensures:

- ✅ The client understands their system's function and safety features
- ✅ They are trained in **basic operation**, safe shutdown, and system care
- ✅ All documents, passwords, and compliance certificates are given
- ✅ The installer is protected from future claims such as “you never showed me”

🔒 **This handover is mandatory before leaving site. It is a critical legal and safety requirement.**

🗓️ **When Must Handover Take Place?**

Only after the following tasks are fully complete:

Pre-Handover Task	Reference Section	Status Required
Final Testing and Functional Verification	✅ Section 10	All startup, power flow, and alarms verified
Monitoring Setup Completed	✅ Section 8	Remote platform connected and visible
Serial Numbers & Photos Logged	✅ Sections 11 and 12	SNs matched, photos uploaded
Certificate of Compliance (CoC) Issued	📄 Internal Compliance	Signed by Qualified Electrician
Final Walkthrough Ready	This Section (13)	System off-grid/on-grid but stable

---

⚠️ **Important Safety & Legal Note:**

DO NOT energise or activate “Auto” / full normal operation mode until:

- All handover documentation is signed
- The client walkthrough is complete
- Safety signage and shutdown instructions are posted

🔺 **Partial handovers** (e.g., before testing is complete) are **not allowed** and pose a **legal and liability risk** for both the installer and the client.

✅ 13.2 Client Walkthrough Checklist

A **complete system handover** requires a guided, **in-person walkthrough** with the client to ensure they understand:

- How their system works
- Where critical safety components are
- What actions to take in an emergency
- What responsibilities they carry (warranty, monitoring, safe operation)

📋 **Walkthrough Checklist – Key Topics to Cover**

Topic	What to Explain
🔋 **System Summary**	- Inverter brand, model, and kVA size pgsql Copy code - Battery bank size (kWh) and chemistry

- Number of panels and total solar watts
- Whether system is off-grid, grid-tied, or hybrid
- What the system powers (load limitations) |

| 🔴 **Shutdown Procedure** | - Location of PV, battery, and AC isolators
- Proper shutdown sequence in case of emergency
- Where to find QR sticker or printed emergency card |
| ⚙️ **Basic Operation** | - How to check inverter status (battery %, PV input, grid supply)
- What warning lights or icons mean
- What to do if there's an alarm (call vs wait) |
| 🌐 **Monitoring Access** | - Provide login info for app or web portal
- Assist with login on client phone/device
- Confirm client can see live status graph before leaving |
| 🛠️ **Warranty & Service** | - What is covered (inverter, battery, panel durations)
- Actions that void warranty (tampering, overloads, DIY changes)
- Recommended servicing timeline (filter clean, firmware updates) |
| 📦 **Load Management** | - Explain essential vs non-essential circuits
- If changeover/generator: demonstrate operation and safety limits |
| 🚨 **Emergency Plan** | - Walk through contact sheet and posted instructions
- Show physical safety signage and posted shutdown steps |
| 📚 **Documentation** | - Provide CoC, warranty card, system layout, and emergency sheet
- Optional: USB or printed copy of SN photos, test results |

🔁 **Additional Guidelines:**

- Repeat key points to another adult if more than one person lives at the site
- Demonstrate both **shutdown and restart procedure** clearly
- Show how to **access and interpret** monitoring platform (app or dashboard)
- Remind client not to tamper with cabling or inverter settings
- Encourage client to call for support if unsure

📌 The walkthrough must be signed off by the client on the Handover Acknowledgement Form (Annexure).

📄 13.3 Documents to Provide Client

At the time of handover, the installer must supply the client with a complete documentation pack. This protects both parties and ensures the client has everything needed for safe, informed system use and future support.

🧳 **Client Handover Pack – Required Documents**

Document	Description
✅ **Certificate of Compliance (CoC)**	Signed and dated by the registered electrician. Required for legal operation and grid approval.
✅ **System Overview Sheet**	Visual layout of inverter, battery, panels, loads, and essential/non-essential circuits.
✅ **Shutdown Procedure Sheet**	Step-by-step guide for emergency shutdown; also posted near system.

Document	Description
✅ **Login Credentials**	App name, platform link, QR code (if used), and full client login info.
✅ **Warranty Information**	Terms and durations for panels, inverter, battery, and monitoring devices.
✅ **Serial Number Record**	From Section 11 – all SNs for inverter, battery, panels, dongles, etc.
✅ **Test Report Summary**	Summary of critical results for DC voltage, AC wiring, insulation resistance, earth continuity.
✅ **Maintenance Advice Sheet**	Basic schedule for cleaning, safety checks, and service calls.
✅ **Client Handover Acknowledgement**	Signed confirmation that walkthrough and document transfer were completed.

📁 **Optional (Recommended for Professionalism)**

You may also include:

- 🔹 USB flash drive with install folder
- 🔹 Download link (Google Drive, Dropbox, etc.) containing:
  - Installation photos (Section 12)
  - Firmware files (if applicable)
  - User manuals for inverter, battery, app
  - Test report PDFs
  - System diagrams

📌 Keeping a copy of this full pack in your installer CRM or archive folder is highly recommended for future warranty or service reference.

14. Installation Do’s and Don’ts

☑ 14.1 General Workmanship – DO

All installation work must be completed to a professional, code-compliant standard. Below are critical workmanship requirements that must always be followed:

This section provides clear visual and practical examples of what is acceptable versus what is unacceptable in a solar installation. Even experienced installers benefit from regular reminders of these best practices.

✔ **General Requirements**

- Use the correct size lugs and ferrules for all terminations.
- Terminate cables cleanly and apply proper torque to terminal screws (check spec sheet).
- Route cables neatly through trunking or conduit, secured with UV-rated cable ties.
- Label all wires, isolators, and DBs using weatherproof, legible labels.
- Separate AC and DC wiring in all conduits and cable trays (SANS requirement).
- Close and seal all trunking, junction boxes, and combiner boxes after wiring is completed.
- Use proper tools — no screwdrivers for crimping, use a ratchet or hydraulic crimper.
- Clean panels and wipe inverters before leaving site.
- Take photos after each major phase for job card evidence.

- Wear full PPE at all times (gloves, helmet, eye protection, flame-resistant clothing).

✔ Follow Manufacturer Instructions

- Always install equipment according to manufacturer datasheets and user manuals.
- Torque values, spacing, fuse sizing, and polarity instructions must be followed without exception.
- Never assume or improvise when installing unfamiliar brands — read the guide first.

✔ Use Only Approved Components

- Ensure all installed components meet international standards:
  - PV Modules: IEC 61215, IEC 61730
  - Inverters: IEC 62109
  - Batteries: IEC 62619 or equivalent
- Reject counterfeit or unverified products — only use approved suppliers.

✔ Ensure Professional Appearance

- Cables must be neat, straight, and uniformly secured.
- Trunking and conduits must run parallel or perpendicular to surfaces, not diagonally.
- No exposed insulation or dangling wires.
- Maintain consistent layout across all DBs and enclosures.

✔ Maintain Clearance and Access

- Leave sufficient clearance around:
  - Inverters: min. 300 mm sides and 1 m front
  - Batteries: spacing per datasheet
  - DBs and isolators: must be reachable without tools
- Ensure equipment is accessible for servicing.

✔ Secure All Cabling

- UV-resistant ties for outdoor cables
- Cable cleats or saddles for tray or wall-mount installations
- Prevent mechanical strain — provide slack loops where needed

---

✔ System Earth Continuity

- Bond all metallic frames (panel mounting, DB enclosures, rails)
- Ensure equipotential bonding between AC, DC, and structural elements
- Earth rods must be properly driven and tested (SANS 10142: ≤ 25Ω preferred)

✔ Test as You Build

- Use a multimeter and insulation tester during wiring:
  - Polarity checks
  - String voltage confirmation
  - Insulation resistance tests
  - Earth resistance test
- Don’t wait until the end to discover faults — test every stage.

✔ Use Proper Cable Ratings

- DC cables: PV1-F or equivalent, double insulation
- AC cables: Suitable for expected load and environment
- Fire-resistant cable (e.g., LSZH) in areas required by SANS 10142-1 (e.g., fire routes)

✔ Respect Bending Radius & Tray Fill

- General rule: Bending radius ≥ 6 × cable diameter
- Avoid sharp bends or kinks
- Do not exceed cable tray fill capacity

✔ Install SPDs Where Required

- If the site is prone to lightning or surges, install SPDs in:
  - DC Combiner Box
  - AC DB
  - Battery or inverter circuits
- Required per SANS 60364-7-712 when overvoltage category risk is moderate to high.

✔ Follow Local Regulations

- Adhere to local authority requirements, including:
  - Certificate of Compliance (CoC) rules
  - Small-Scale Embedded Generation (SSEG) submissions
  - Inspection or sign-off rules
  - Distance from boundaries, DB height restrictions, etc.

✔ Photographic Documentation

- Take clear, timestamped photos of:
  - PV structure
  - Combiner box wiring

- Inverter & battery installs
- Serial numbers
- Completed DBs

- These are required for client reports, insurance claims, and dispute resolution.

❌ 14.2 General Workmanship – DON'T

This section outlines **unsafe**, **non-compliant**, or **unprofessional practices** that must be strictly avoided on all solar installations. These points align with **SANS 10142-1**, **SANS 60364-7-712**, and best installation standards. Failure to comply can result in insurance rejection, system damage, legal exposure, and reputational harm.

🚫 Major Compliance & Safety Violations

Violation	Description
Mixing AC & DC cables	Do not run AC and DC cables in the same conduit or trunking unless fully insulated and separated — SANS 10142-1 Clause 6.1.6.1.
Using unapproved cables	Never use twin-flex, speaker wire, or non-solar-rated cables. Only use PV1-F or TUV/IEC-certified types.
Sharp edges or burrs	De-burr all trunking ends, DB cutouts, and entry holes to prevent insulation damage — SANS Clause 6.2.6.
Loose/dangling cables	Support DC cables every 300 mm, AC every 500 mm. Vertical cables may need tighter intervals.
Reusing lugs or glands	Reuse is strictly prohibited. Always use new compression lugs and glands to maintain mechanical and waterproof integrity.
Incorrect IP ratings	Outdoor equipment must be at least IP65. Never use indoor enclosures outdoors unless protected.
Exposed or hot routing	Cables must not pass over sharp edges, hot equipment, or unshaded roofs unless rated UV and heat-resistant.
Improper fasteners	Don't use random screws or self-tappers. Use stainless steel or approved fasteners for the roof type.
Open DBs or exposed wiring	All terminations must be enclosed, labelled, and sealed. SANS requires complete enclosure.
Buried cables without conduit	Underground cables must be inside rigid conduit, buried ≥300 mm, with warning tape — SANS Clause 6.14.
Skipping installation tests	Never omit insulation, polarity, or continuity tests. Test and log every stage.
Overfilling trays	Trunking and cable trays must not exceed 40–50% fill to avoid overheating.
Crowding equipment	Respect inverter/battery spacing per datasheet. Poor airflow = heat buildup.
Dirty work sites	Always clean the work area. Offcuts, tools, and trash must be removed daily.

⚠ Workmanship & Behavioural Mistakes

- Do **not** twist wires together — always use correct ferrules or crimp lugs.
- Do **not** leave slack or excess cable inside DBs — trim neatly and terminate correctly.
- Do **not** skip ferrules on stranded wire — this causes loose contact and overheating.
- Do **not** leave isolators unlabelled — clearly mark AC, DC, and battery isolators.
- Do **not** use incorrect colour coding — follow SANS:
  - Red/Black for DC
  - Brown/Blue for AC
  - Green/Yellow only for Earth
- Do **not** use silicone sealant as a permanent fix for cable glands — use proper compression glands.
- Do **not** walk or kneel on solar panels — this causes microcracks and voids warranties.
- Do **not** leave tools or rubbish behind on-site — always do a final sweep.
- Do **not** forget to torque terminals — under-torqued lugs cause hot joints and fires.
- Do **not** install in dusty, wet environments without IP-rated enclosures.
- Do **not** energise the system unless all compliance tests are passed and signed off.
- Do **not** use uncalibrated or low-voltage-rated test tools on PV circuits.
- Do **not** allow unqualified team members to terminate or commission the system.
- Do **not** leave handwritten or incomplete labels on any part of the system.
- Do **not** skip earth continuity tests — never assume bonding is intact.

☑ 14.3 Panel Mounting – DO

Proper panel mounting is essential for **system performance**, **safety**, and **durability**. This section outlines **best practices** to ensure compliance with **SANS 10160**, **SANS 60364-7-712**, and manufacturer guidelines.

✓ Structural & Mechanical Guidelines

Task	Description
Use Approved Mounting Structures	Use aluminium or galvanized steel frames that are corrosion-resistant and certified for local wind loads. Waterproof all roof penetrations using UV-stable flashing or seals.
Proper Tilt & Orientation	Panels should face **true north** in the Southern Hemisphere and be mounted at an optimal tilt angle of **25°–35°**, unless adjusted for seasonal yield or roof constraints.
Uniform Alignment	Panels must be straight, level, and evenly spaced. Misalignment affects airflow, loading, and visual quality.
Allow Ventilation	Maintain at least **100 mm** between the back of the panels and the mounting surface to reduce heat build-up and improve efficiency.
Use Stainless Steel Fasteners	Only use stainless or corrosion-resistant fasteners — including mid and end clamps, bolts, and washers.
Secure DC Cables	Route all cabling beneath panels in conduit or UV-stable clips. No cables may rest on roof sheets or tiles.

Task	Description
Fix to Rafters or Purlins	All bolts and lag screws must anchor into structural timber or steel (not just roof sheeting or tiles). Confirm locations before drilling.
Label Structures Where Required	Attach UV-rated or aluminium tags to mounting structures where needed for inspection or maintenance purposes.
Inspect After Weather	After first rain or weather exposure, re-check all mountings and torques to ensure settling has not caused loosening.
Maintain Walkways	Leave a **300–600 mm gap** between rows or array edges to allow for cleaning, inspection, and safe movement.

🛠 Installation Best Practices

- ✅ Use **torque wrench** on rails and clamps – follow manufacturer specs.
- ✅ Ground all frames with **green/yellow bonding cable** or approved clips.
- ✅ Apply **string labels** directly beneath panels – UV-resistant and legible.
- ✅ Mount panels with **visible serial numbers**, or photograph before installation.
- ✅ Install clamps correctly — **end clamps at edges**, **mid clamps between panels**, evenly spaced.
- ✅ Avoid roof contact by keeping cable loops tidy and clipped.
- ✅ Ensure rafter spacing aligns with **rail layout** – adapt if needed.

❌ 14.4 Panel Mounting – DON'T

- Poor panel mounting can **void warranties**, **cause system failure**, and **create safety hazards**. Below are key mistakes to avoid — every item reflects a real issue seen in the field.
- ---

- ⚠ Structural & Installation Mistakes to Avoid

❌ Mistake	⚠ Reason
Using tek screws through panel frame	Damages panel integrity and voids warranty. Only use manufacturer-approved clamps.
Leaving uneven panel rows	Impacts airflow, causes mounting strain, and looks unprofessional.
No panel grounding	Violates SANS 60364-7-712 and is dangerous in fault conditions.
Overtightening clamps	Can crack the glass or deform frames. Always torque to spec.
Mounting in shaded locations	Even partial shade drastically reduces array performance.
Using rust-prone or DIY brackets	Leads to corrosion and failure. Use only certified, tested systems.
Drilling holes in panel frame	Unless permitted by manufacturer, this voids warranty and weakens the frame.
Routing DC cables over sharp edges	Can wear through insulation and cause shorts or fires. Use grommets or conduit.

❌ Mistake	⚠ Reason
Tightly bundling DC cables	Prevents heat dissipation; increases fire risk. Allow airflow.
Skipping earth continuity test	Leaves system non-compliant. Every frame must be bonded and tested.
Leaving loose panels on-site overnight	Dangerous in wind, and a theft or injury risk. Always complete mounting same day.
Installing directly onto IBR or tile without rafters	Causes roof leaks, structural instability, and may fail wind tests. Use flashed, rafter-anchored systems.
Using incorrect torque on fixings	Over- or under-tightening causes system degradation or collapse.
Ignoring panel spacing or height levels	Uneven layouts reduce airflow and make cleaning or maintenance difficult.
Not accounting for thermal expansion	Rigid systems crack or bend under heat. Use floating rails where needed.
Leaving unused holes unsealed	Causes water leaks and corrosion over time. Seal all unused racking or roof holes.
Exposing cables to rubbing or chafing	DC faults are dangerous. Secure and insulate all cable paths.
Installing on a damaged roof	A poor substrate reduces system lifespan and may void insurance. Inspect first.
Assuming visual alignment is enough	Use levels and tape — misalignment leads to strain, uneven loading, and poor aesthetics.

- ---
- ✅ Always follow SANS 10160 and SANS 60364-7-712, and refer to the **panel and racking manufacturer's installation manual**.

☑ 14.5 Inverter & Battery – DO

- Correct inverter and battery installation is critical for system safety, performance, and warranty compliance. This section summarises all best practices, referencing both **SANS 10142-1**, **SANS 60364-7-712**, and **manufacturer guidelines**.
- ---
- 🔧 Best Practices for Inverter and Battery Installations

✅ Task	✓ Explanation
Mount on non-combustible backboard	Required by SANS. Use concrete, fireboard, or brick. Avoid wood and PVC boards.
Maintain clearance between devices	300–500 mm spacing around inverters and batteries allows proper ventilation. Follow datasheets.
Use proper anchoring for batteries	Heavy lithium or AGM batteries must be secured with steel brackets or bolted shelves — no adhesive or loose stacking.
Weather protection if outdoors	If installed outside, the inverter and battery must be housed in an IP54-rated or higher enclosure with shading.

✅ Task	✓ Explanation
Label all devices clearly	Include shutdown instructions, voltage, inverter model, battery type, and earthing labels.
Install fuses and disconnects near batteries	Battery-side protection (fuse or DC breaker) is essential — install as close as possible to the positive terminal.
Protect battery terminals	Use insulated covers, enclosures, or plastic caps to prevent accidental contact or short circuits.
Use correct cable sizing	Match cable gauge to manufacturer spec and system load. Use ferrules, properly crimped lugs, and correct insulation ratings.
Tighten terminals to torque spec	Loose DC connections can lead to fires. Always use a torque wrench per datasheet.
Set BMS and inverter communication	Ensure CAN bus or RS485 connections are secure and configured before switching on.
Allow technician access space	Keep minimum 300 mm front clearance for serviceability and fuse changes.
Check battery orientation and venting	Vented batteries must be upright and ventilated per SANS 10142 and IEC 62485-2. Lithium units may have different needs — check manuals.
Bond DC screens and racks	Earth battery racks and cable screens as required by SANS 712.544.4.
Document everything	Photograph final setup, label serials, and ensure inverter and battery firmware versions are recorded.

- ---
- 📌 **Tip:** Never energise the battery or inverter until all fuses, isolators, cables, and communication links are verified and the configuration is complete.

❌ 14.6 Inverter & Battery – DON'T

- Improper inverter and battery installation can lead to fire hazards, warranty voids, and long-term system failure. The following practices are specifically **prohibited** under **SANS 10142-1**, **manufacturer specifications**, and **basic electrical safety principles**.
- ---
- ⚠ Dangerous or Non-Compliant Practices

❌ Don't	🚫 Why It's a Problem
Mount on wooden boards or drywall	Fire risk — these are combustible materials. Use concrete, brick, or certified fire-rated backboards only.
Install inverters and batteries with no breathing space	Causes overheating and performance loss. Always follow manufacturer air gap specs.
Place batteries directly on floor	Moisture, pests, and impact risks. Use steel brackets, plinths, or non-absorbent mounts.

❌ Don't	🚫 Why It's a Problem
Block access to isolators or fuses	Violates SANS — isolators must be easily accessible for emergency shutdown or maintenance.
Mix different battery types or brands	Results in charging imbalance, reduced capacity, possible fire or thermal runaway.
Expose system to moisture, steam, or fine dust	Conductive particles or humidity can cause arcing, corrosion, or insulation failure.
Use plastic ties on battery terminals	Insecure and unsafe. Use proper bolted lugs, washers, and torque according to spec.
Ignore structural load limits for battery banks	Can lead to collapse or floor cracking. Lithium batteries are especially heavy — verify with an engineer if unsure.
Omit DC fuses, breakers, or surge protection	Major safety hazard. DC protection is essential near the battery and PV inputs.
Run battery cables through unsafe paths	Sharp metal edges or unprotected holes can cause insulation cuts and dangerous shorts. Always use grommets/trunking.
Mount batteries in unventilated or damp locations	Reduces battery life and increases corrosion/fire risk. Choose well-ventilated, dry, shaded areas.
Use mismatched battery cables or reused lugs	Causes voltage drops, poor conductivity, and overheating. Always use new, size-matched cables and connectors.
Bypass fuses or breakers	Never acceptable. Compromises system and life safety.
Install above ceilings, geysers, or in kitchens	High risk of water/steam exposure and fire. Follow site layout and environmental guidelines.
Ignore BMS warnings or lights	Indicates unsafe conditions. Investigate and correct faults before continuing operation.

- 📌 **Remember:** Inverter and battery safety violations can lead to insurance claim rejection, installer liability, and criminal negligence under South African electrical law.

☑ 14.7 DBs & Trunking – DO

Correct distribution board (DB) wiring and trunking practices are essential for safety, serviceability, and compliance with **SANS 10142-1** and **SANS 60364-7-712**.

🔧 Best Practices for DBs & Trunking

✅ Action	🛠️ Description
Use flame-retardant and UV-rated trunking	Use PVC trunking indoors and UV-stable, flame-resistant trunking or conduit outdoors. SANS requires all containment systems to be non-combustible.
Secure trunking properly	Mount with appropriate saddles, clips, or wall anchors to prevent sagging or loose runs.
Label all DBs clearly	Include labels like: "AC Distribution Board", "DC Combiner", circuit names, PV warning stickers, dual supply notices, earth/neutral bar markings.
Install accessible isolators	Place AC and DC isolators where visible and serviceable. Clearly label each isolator. Keep AC and DC isolators separate per SANS rules.
Separate AC and DC wiring	Within trunking or DBs, use separate compartments or conduits for AC and DC. No mixed cable runs without barriers are permitted.
Use correct cable colours and sizes	Follow industry-standard colour codes: Red = DC+, Black = DC−, Brown = AC Live, Blue = Neutral, Green/Yellow = Earth. Match cable size to load specs.
Gland all entries	Fit every DB, junction box, or trunking entry with glands or bushings to protect insulation and prevent ingress of moisture or dust.
Allow cable slack for future work	Leave extra length neatly looped for maintenance or DB changes, avoiding strain on terminals.
Install SPDs	Add surge protection devices (SPDs) where required — especially at inverter AC output and DC combiner inputs — and label them clearly.
Apply bonded busbars correctly	Earth busbars must be sized correctly and bonded to the main earth bar. All metal enclosures and racks must be earthed.

💡 Additional DOs

- Keep DB wiring flat and grouped by function.
- Clean all offcuts and wire trimmings out of DBs after work.
- Use label printers or durable ferrules — no hand-written tape labels.
- Follow clause **712.536.3.2.2** for AC/DC enclosure separation.
- Maintain neat cable tie spacing inside trunking.
- Confirm all connections are torqued and mechanically secure.

✅ This level of DB and trunking discipline reduces fire risk, improves diagnostics, and passes inspections with confidence.

❌ 14.8 DBs & Trunking – DON'T

Improper practices with distribution boards (DBs) and trunking pose fire, shock, and long-term reliability risks. The following are **strictly prohibited** under **SANS 10142-1**, **SANS 60364-7-712**, and good solar industry practice.

⚠️ **Common Mistakes to Avoid**

❌ Don't	🚫 Why It's Unsafe or Non-Compliant
Mix AC and DC cables without barriers	Violates SANS 712.52.5. Causes electromagnetic interference and risks during maintenance. Always separate or use partitioned trunking.
Install DC breakers in an AC DB or vice versa	Devices are rated for specific current types. Incorrect usage can lead to arcing or failed disconnection.
Reuse random breaker slots	Never repurpose old AC breakers or unused DB slots for PV without full compatibility and labelling.
Leave wires unlabelled or with loose strands	Leads to dangerous troubleshooting and risk of contact with stray wires. Use ferrules and permanent labels.
Route wires diagonally or tangled	Makes fault tracing impossible and leads to overheating or physical damage. Keep wire runs straight and grouped.
Use oversized breakers	Protection devices must match the cable's ampacity. Overrated breakers will not trip, causing heat buildup and fire risk.
Mount DBs on wood or flammable surfaces	Non-combustible surfaces only (e.g., brick, cement board, metal). Wood poses a fire risk.
Leave DB or trunking glands open	Exposes wires to dust, insects, and water. Always seal entries with compression glands or bushings.
Install isolators inside inaccessible DBs	Emergency disconnects must be accessible. Never place behind locked doors, ceilings, or inside sealed units.
Ignore bonding of metal DBs	SANS requires all metal enclosures to be earthed. Failure to bond is a serious safety violation.
Run wires across hot or sharp surfaces	Heat and abrasion degrade insulation over time. Use protective sleeving, grommets, or reroute.
Oversize or underfill trunking	Leads to messy installation or unventilated bunching. Trunking should fit cable bundle size with managed spacing.
Skip SPDs when required	Surge protection is mandatory for sensitive electronics and compliance in grid-tied systems.
Use trunking for bare wires	All conductors must be sleeved or sheathed — never run unsheathed cables even inside trunking.
Overcrowd DBs	Minimum spacing is required to ensure heat dissipation and safe service access. Don't cramp terminals.
Cross conductors unnecessarily	Increases risk of interference and poor heat flow. Organise wires by circuit and voltage.

✅ Following proper DB and trunking discipline is critical for long-term safety, inspection approval, and professional credibility.

15. Technician Section Sign-Offs

📋 15.1 Phased Sign-Off Structure

Every major installation phase must be **signed off by the team leader responsible** for that section. This ensures:

- ✅ Work is completed to standard

- ✅ Required tests have been conducted
- ✅ Responsibility is clear — no one is blamed for faults they didn't cause
- ✅ A clean, documented handover between teams

This practice is essential for quality control, safety compliance, and warranty protection.

To maintain high standards and reduce the risk of system failure or regulatory non-compliance, each phase must be reviewed and signed off before proceeding.

Phase	Responsible Team	When to Sign Off
✅ **DC Install Complete**	**DC Team Leader**	After all of the following: panel mounting, cable routing, trunking installed, DC combiner wired, stringing done, insulation & polarity tests passed
✅ **Battery + Inverter Wired**	**BESS / Inverter Team Leader**	After inverter is mounted, battery banks connected and configured, comms cables installed, isolators and fuses in place, ferrules and crimps completed
✅ **AC Side Connected**	**AC Team Leader**	After tie-in to main DB, essential/non-essential load split, AC combiner wired, breakers installed and tested
✅ **System Commissioned**	**Installer Supervisor**	After all commissioning tests (DC, AC, BESS), firmware and settings verified, monitoring system activated, and client walk-through completed

---

⚠️ Sign-Off Rules

- 🚫 **No team may begin unless the previous phase is fully signed off** and documented.
- 🚨 **Any risk or non-compliance must be flagged immediately** — no "carry on" without resolution.
- 📸 **Photos and digital forms must be uploaded** to the site job folder before the next team proceeds.
- 📝 Sign-off checklists must be completed, scanned, and filed digitally alongside test reports and commissioning records.

❗ 15.2 What This Prevents

A structured **phased sign-off system** is not just about admin or paperwork — it directly prevents common and costly mistakes in solar PV installations by enforcing clear accountability, technical verification, and safety protocols.

🚫 Problem	✅ Prevented by
Missed earth bonding	DC Team Leader verifies all panel bonding before BESS work begins
Poor trunking layout affecting battery cable routing	BESS Team flags poor DC routing during their phase sign-off
Inverter settings incorrect or firmware skipped	Commissioning Team confirms all settings, firmware versions, and logs before handover
Overlooked SPDs or isolator installation	Each team inspects previous DB/combiner layout for compliance before proceeding

🚫 Problem	✅ Prevented by
Finger-pointing or blame	Every phase has a named sign-off — no room for “we didn’t do that” excuses
Voided warranty due to incorrect stringing	DC phase includes photo and document record of string layout and polarity testing
Unsafe energisation or sequence	System cannot be powered until all phases are signed off and test results are logged

---

🛡 Key Benefits of This Process:

- Ensures **legal and safety compliance** with SANS 10142 and SANS 60364.
- Creates a clear **accountability chain** between teams.
- Prevents **installation gaps** and **untested system components**.
- Protects your **company’s reputation**, the **client’s property**, and any **warranty claims**.

16. End-of-Day Clean-Up Procedure

☑ 16.1 Why Clean-Up Matters

Clean-up is not a favour — it’s part of the job.

Clients may not remember every wire you installed or how neatly you torqued a clamp — but they *will* remember if you left the site clean or in a mess.

A clean and organised worksite is essential not only for **presentation**, but also for:

- Safety
- Professionalism
- Productivity
- Inspection readiness
- Client satisfaction and trust

🛠 This procedure must be followed at the end of *every* workday — not just on handover day.

- ✅ Shows respect for the client’s home or premises
- ✅ Prevents theft or loss of tools and components
- ✅ Avoids injuries from sharp debris (e.g., lugs, screws, cut wires)
- ✅ Keeps site safe and ready for co-trades or inspections
- ✅ Protects your team’s reputation and company image

☑ 16.2 Daily Clean-Up Checklist

Item	Completed (✓)	Notes
Panel glass wiped clean (remove dust/fingerprints)		
Inverter and battery casings wiped (inside & out)		
All wire offcuts, lugs, cable ties picked up		
Packaging and boxes removed or neatly stored		
Tool stickers and price tags removed		
Plastic wrap off isolators, panels, and batteries		
Tools counted, returned to toolbox or vehicle		
DB and trunking covers re-attached securely		
Floors swept / dust wiped off walls if needed		
Rubbish placed in bag or bin, ready for disposal		

🧹 Additional Daily Tasks by Zone

Zone	Action Required
Cables & Offcuts	Pick up all loose wire, lugs, insulation, zip ties
Tools	Count, clean, and return all tools and meters
Packaging	Flatten boxes, stack neatly or dispose
Panels	Do not leave panels loose or half-mounted on roof
Open Ducts / Trenches	Cover or barricade temporary openings
Walkways	Clear all access paths of obstructions and tools
Unterminated Wires	Cap, insulate, and label — especially DC cables
Distribution Boards	Re-attach covers and label if installation not yet complete
Battery / Inverter Room	Clean up all ends, foam bits, and cable pieces
Scaffolding & Ladders	Secure, collapse or move off pedestrian routes

---

📸 **Tip:** Take a daily photo of the work area at knock-off time and store it with the job file or commissioning folder. This protects your team and shows pride in your work.

☑ 16.3 End-of-Install Final Clean-Up (Project Handover)

Before the final client handover and walkthrough, perform a **deep clean** to ensure the site reflects the quality of your work. First impressions matter, especially at the end.

🧼 Final Clean-Up Tasks:

- ✅ Wipe down inverter face, battery cabinets, DBs, isolators
- ✅ Remove all packaging, tools, wire reels, and leftover conduit
- ✅ Clear roof of plastic wrap, cable offcuts, fasteners, or debris
- ✅ Sweep or vacuum battery rooms, garages, inverter areas
- ✅ Wipe panel glass if dusty or soiled from drilling
- ✅ Remove temporary signs, warning tape, or placeholder labels
- ✅ Verify all stickers/labels are:
  - Neat and straight
  - Not peeling
  - Clear and visible (e.g. DC Isolator, PV supply present, etc.)

📸 **Final "AFTER" Photos to Take:**

- ✅ Solar panels (from the ground — full view of array)
- ✅ Inverter and battery installation area (clean, no cables exposed)
- ✅ AC and DC distribution boards (with labels visible)
- ✅ Tie-in at main DB (showing quality, labelling, protection)

💬 **Tip:** These photos go in the final client report folder. They also protect your team in case of later damage or disputes.

☑ 16.4 Site Sign-Off

Before officially leaving the site for the last time, the following steps **must** be completed:

🧹 **Site Exit Checklist:**

Action	Person Responsible	Notes
Full site walk-through	Team Leader / Supervisor	Ensure no areas skipped
Confirm zero waste/tools left	Team Leader	Nothing left in garage, roof, yard, DBs
Job card: "Clean-Up Complete" ticked	Supervisor	Tick-off and initial on job folder or app
Final photos taken	Team Leader / Supervisor	See 16.3 photo checklist above

⚠️ **Important Rule:**

If **any** debris, packaging, or tools are left behind, the **supervisor must FAIL the handover**, and the team must return immediately to correct it.

This is non-negotiable — it protects both your **reputation** and the **client's safety**.

☑ 16.5 Notes on Shared or Public Sites

When working in **shared environments** such as schools, hospitals, businesses, apartment blocks, or estates, additional care is required to ensure **public safety**, maintain a **professional image**, and avoid liability.

🛑 **Key Safety Rules:**

- ❗ Do **not** use client or public bins for any construction waste
- ❗ Remove **all** sharp offcuts, screws, tie ends, or exposed cable ends
- ❗ **Never** leave tools, ladders, or panel crates accessible overnight
- ❗ Avoid causing puddles or wet floors — dry up any water used

🛡 **Additional Requirements:**

- ✅ Tape off active work zones with **hazard tape or cones**
- ✅ Clearly mark open trenches or exposed conduits
- ✅ Sweep walkways and wipe railings at the end of each day
- ✅ Secure scaffold towers, ladders, or loose material with cable ties or locks
- ✅ Store gear in a **locked room or vehicle** — no unsecured overnight storage

🐥 You are responsible for the safety of **all persons on-site**, even if they are not part of your crew. Assume children, clients, or the public may enter after hours.

17. Material Check-In Sheet

✅ 17.1 When to Use the Check-In Sheet

A **Material Check-In Sheet** is a vital tracking tool used to ensure that **all components and equipment arrive on site as expected**, and that there is a clear **handover of responsibility** from delivery to the installation team.

Using a check-in sheet helps to:

- ✅ Confirm all items were received in full and in good condition
- ✅ Prevent disputes or claims of missing stock ("It never got here")
- ✅ Track damaged, missing, or stolen materials
- ✅ Assist with warranty claims by recording serial numbers and condition
- ✅ Improve project costing and leftover material tracking

📍 Event or Timing	✓ Use the Check-In Sheet
On-site delivery from supplier	✅ Yes
Day 1 of mobilisation	✅ Yes
Return to site after a delay (e.g. rain or permit issue)	✅ Yes
When additional materials/tools arrive during the project	✅ Yes
Project closeout and clean-up	✅ Yes (to log unused items)

📋 **Skipping this step leads to untraceable losses and installation delays.**

✅ 17.2 Who Fills It In

Person	Responsibility
Delivery Driver	Signs off at handover confirming what was dropped off
Installer or Technician	Helps unpack and verify, but does not sign off unless acting as lead
Team Leader or Foreman	Completes the form, confirms condition, and signs off
Project Administrator	Files the signed form (scanned or physical copy) into the job folder

📝 The person accepting the delivery becomes **responsible for the items listed**.

✅ 17.3 What to Include

Your material check-in sheet should include these **minimum fields** for each item:

Item Description	Qty Delivered	Qty Used	Condition (OK / Damaged)	Installer Initials	Notes
PV Panels – JA Solar 550W	12	12	OK	TL	All serials logged
Inverter – Sunsynk 8kW	1	1	OK	TL	Box opened & tested

Item Description	Qty Delivered	Qty Used	Condition (OK / Damaged)	Installer Initials	Notes
Batteries – Hubble AM2	2	2	OK	TL	Setup with correct firmware
DC Cable 6mm (Roll)	1 roll	¾ used	OK	AJ	Remaining stored on-site
Trunking – 25mm, 3m lengths	5	4	OK	MK	1 returned to store
MC4 Connectors – Pairs	6	6	OK	AJ	Pre-crimped
AC SPD Type 2	1	1	OK	MK	Installed in AC DB
DC SPD	1	1	OK	MK	Fitted near combiner
Label Pack	1	1	OK	AJ	Labels applied
Misc (Breakers, Ferrules, Screws)	—	—	OK	AJ	Per use

✅ 17.4 What Types of Materials to Track

Item Category	Examples
PV Panels	Brand, wattage, serial numbers
Inverter & Batteries	Make, model, kW/kWh rating, serials
Mounting Structures	Rails, clamps, bolts, hooks, tile brackets
Wiring & Protection	DC cable rolls, trunking, glands, isolators, fuses
Labels & Signage	UV-rated labels, warning signs, CoC kits
Tools & Consumables	Ferrules, lugs, screws, drill bits (job-specific)
PPE Issued (if applicable)	Gloves, safety glasses, harnesses (if site provides)

🧿 **Tip:** Open boxes on delivery — not later. Photograph and log any damaged items or missing contents **immediately.**

✅ 17.5 Handling Damaged or Missing Items

When receiving materials, it is critical to respond immediately to **missing, damaged, or incorrect items** to avoid liability and installation delays.

❌ Problem Type	🔧 Action Required
Missing Item	Log immediately, mark on sheet, and call the supplier/logistics contact
Damaged Item	Take clear photographs, describe damage on check-in sheet
Wrong Spec	Set item aside, do **not** install. Mark as “incorrect” and notify admin
Partial Delivery	Note what was received and what is still pending
Critical Shortage	Pause the affected section of installation until resolved

🚫 **Never install damaged or non-compliant parts** to “just make it work”.
Once installed, it becomes **your liability**, **voids warranties**, and may breach **SANS standards**.

✅ 17.6 Digital & Paper Copies

Maintaining proper documentation is crucial for warranty claims, project audits, and internal tracking.

Format	Procedure
Printed Triplicate Pads	Use carbon copy pads on site – one for supplier, one for project file

Format	Procedure
Photos	Take a photo of the signed sheet daily and submit to project group or admin
Scanning	Scan and save to shared cloud storage (e.g. Google Drive, Dropbox)
Backup	Store a digital version in your internal project folder for long-term records

📸 A daily photo of the check-in sheet is highly recommended, especially if multiple teams or suppliers are involved.

✅ 17.7 Final Site Inventory (Optional but Recommended)

At project closeout, perform a **Final Inventory Report** to log leftover or returned materials. This can reduce waste and help future planning.

Final Report Should Include:	Examples
✅ Items Installed	E.g. 12 panels mounted, 3 rolls of DC cable used
✅ Leftover Stock	1 extra isolator, 2m spare trunking
✅ Damaged or Unused	1 broken MC4, unopened label kit
✅ Returned to Store or Client	Cable reels, hardware, unused DBs
✅ Tool or Equipment Damage	Damaged crimp tool, drill batteries

🖇️ Helps track **costing**, supports **warranty queries**, and avoids **over-ordering** on future jobs.

18. Permitting & SSEG Compliance

☑ 18.1 What Is SSEG?

Before any grid-connected solar PV system is switched on, it **must comply with local municipal regulations**. These typically require:

- **Registration** as a Small-Scale Embedded Generator (SSEG)
- **Permission to connect** to the municipal grid
- **Compliance** with NERSA and national grid codes
- **Approved inverters**, tested and certified for grid compatibility
- **Safety documentation**, including electrical CoC, test reports, and commissioning photos

Failure to register a system can result in:

- **Disconnection of power**
- **Fines** or penalties for both client and installer
- **Voided insurance cover** in case of fire or electrical failure

SSEG stands for **Small-Scale Embedded Generation**. It refers to **electricity generation systems** (typically **under 1 MW**) that are installed at a **customer's premises** and are **connected to the municipal or Eskom grid**.

These systems may:

- **Export energy** to the grid (e.g. via net metering)
- Be **hybrid** (e.g. grid + solar + battery)

- Be **connected for self-consumption only**, with no feedback to grid

⚡ **Common SSEG Systems Include:**

- Grid-tied solar PV systems
- Hybrid solar-battery systems
- Small-scale wind turbines
- Biogas or micro-hydro generators (less common)

💡 **Key Characteristics of SSEG Systems:**

Feature	Typical Specification
Power Rating	Less than 1 MW
Location	On customer premises
Purpose	Self-use and/or grid export
Control Equipment	Smart inverter or hybrid controller
Registration	Required by most municipalities

🛠 **Why Registration Matters**

- Ensures **grid safety** and **technical compatibility**
- Protects **municipal workers** during outages
- Enables **export** if allowed by your local utility
- Avoids illegal installation or penalties
- Enables **official sign-off** on municipal building compliance

📌 **Note**: Even if your system is not designed to feed back into the grid, **municipalities still require registration** if there is any physical connection to the main DB or grid supply.

☑ 18.2 When Is Registration Required?

SSEG registration is required in most municipalities when your solar system interacts with the grid in any way — even if it does not export power.

🚦 **Registration Is Required When:**

- The inverter is **connected to the grid** (hybrid, grid-tied, or AC-coupled).
- The inverter is **capable of synchronising with the grid**, even if export is set to zero.
- The system has **anti-islanding protection** but could energise the grid if misconfigured.
- The **municipality requires SSEG approval** before CoC can be submitted.
- The **system exceeds a certain size threshold** (often 3.5 kW, but varies by area).
- **Municipal grid stability, worker safety**, and **national grid compliance** are at stake.

📍 Even non-exporting hybrid inverters usually still require registration.

⚠ **Registration Is NOT Required When:**

- The system is **100% off-grid**, with **no physical connection** to any DB that connects to the grid.
- The system is a **backup-only inverter** with no grid synchronisation and **true zero-export** configuration.
- The system is **temporary or mobile** (e.g. trailer-based solar).
- The system supplies **DC-only loads** and has **no AC-side interaction** with the grid.

☑ 18.3 What Needs to Be Submitted?

To legally register a Small-Scale Embedded Generation (SSEG) system, most South African municipalities require a formal application pack. The following documents are typically required:

📑 Core Submission Documents

Required Document	Description
✅ SSEG Application Form	Official municipal or utility form detailing the system type, size, property location, owner, and installer information.
✅ Single Line Diagram (SLD)	A clear electrical drawing showing PV panels, inverter, DBs, protection devices, grid tie-in, and earthing layout.
✅ Commissioning Test Report	Test results confirming system integrity (e.g., insulation, polarity, voltage checks).
✅ Inverter Specification Sheet	Manufacturer's datasheet confirming compliance with **NRS 097-2-1** and anti-islanding capabilities.
✅ Certificate of Compliance	Issued by a **registered electrician**, confirming that the system complies with **SANS 10142-1**.
✅ Engineer Sign-Off (if req.)	Some metros require a **Pr. Eng** or **Pr. Tech Eng** sign-off for systems >100 kVA or rooftop structures >350 kW.

📦 Additional Supporting Documents (as required):

- Load profile or energy audit (for larger systems)
- Structural engineer sign-off (for roof mounting)
- Property owner's approval (if rented)
- Proof of registered installer or wireman's licence
- Earth loop impedance test
- Surge protection confirmation
- Zero-export limiter settings (if relevant)

📎 Always confirm requirements with the local authority — missing documents may delay approval by weeks.

☑ 18.4 Registration Platforms by City

Each municipality handles SSEG registration individually. Below are the most common platforms or submission methods as of 2025:

🏙 Major Metros & Platforms

City / Municipality	Registration Platform or Submission Email
City of Cape Town	Smart Installations Portal: www.capetown.gov.za/SolarPV
City of Johannesburg	Submit via email to: **ssegapplication@citypower.co.za**
Ekurhuleni (CoE)	Email submissions to: **SSEGregistration@ekurhuleni.gov.za**
eThekwini (Durban)	Contact via: **sseg@durban.gov.za** (new online portal pending)
Tshwane (Pretoria)	Use the downloadable form; submit via **electricityapplications@tshwane.gov.za**
Nelson Mandela Bay Metro	Paper-based or digital email submission: **electricity@mandelametro.gov.za**
Stellenbosch, George, Mossel Bay	Submit to **sseg@stellenbosch.gov.za** or via municipal electricity/building department

🔍 **Important Notes:**

- Always check your municipality's **official website or electrical engineering department** for the latest forms.
- **Follow up every 7–10 working days** if no feedback is received.
- ⚠️ **Never connect** an SSEG system to the grid before formal approval — it can result in fines or disconnection.

☑ 18.5 Compliance Benefits

- Registering your Small-Scale Embedded Generation (SSEG) system is not just paperwork — it provides **critical legal, technical, and business benefits** to both the client and the installer.

- ⚖ Legal and Regulatory Benefits

Benefit	Description
✅ Legality	Operating a grid-connected PV system without registration is illegal in most metros. Registration ensures compliance.
✅ Avoids Fines/Disconnection	Unregistered systems may be disconnected by the municipality or fined.
✅ Feed-in Tariff Eligibility	Only registered SSEG systems may be allowed to export and earn credit for surplus electricity.
✅ Insurance Validity	Many insurers require SSEG registration and CoC for fire, surge, or damage claims to be honored.

- ⚙ Technical and Safety Benefits

Benefit	Description
✅ Grid Safety	Anti-islanding protection prevents PV systems from energizing the grid during outages, protecting utility workers.
✅ Workmanship Standards	SSEG approval enforces compliance with **SANS 10142-1** and **NRS 097-2-1**, ensuring safe and legal installs.
✅ Reduced Fire Risk	Mandatory inspections catch poor wiring, overloaded components, or thermal hazards early.

- 💼 Business and Installer Benefits

Benefit	Description
✅ Professional Credibility	Registered and compliant systems enhance installer reputation and open doors to more commercial work.
✅ Repeat Business & Referrals	Compliant installs lead to satisfied clients and future job opportunities.
✅ Access to Incentives	Some municipalities offer rebates, net metering, or carbon credit programs for registered SSEG systems.

- 🖇️ **Bottom line:** Registration protects everyone — your client, your team, and your business.
-

☑ 18.6 SANS & NRS Documents That Apply

- A compliant PV system must meet several key South African standards and utility codes:

Document / Standard	Scope & Use
SANS 10142-1	**Wiring Code** – General electrical installation requirements, DBs, bonding, circuit protection
NRS 097-2-1	**Inverter Grid-Tie Standard** – Covers voltage limits, anti-islanding, export limits
SANS 60364-7-712	**PV-Specific Standard** – Covers layout, voltages, rooftop safety, and labelling requirements
Municipal SSEG Policies	City-specific rules regarding feed-in limits, metering, CoC processes, or structural sign-offs

- 📚 Installers should keep updated copies of these standards and follow local municipal guidance for additional rules or amendments.

To ensure **legal and technical compliance** for Small-Scale Embedded Generation (SSEG) systems, all installers must be familiar with the applicable **South African National Standards (SANS)** and **National Rationalised Specifications (NRS)**. These standards form the **minimum technical framework** required by municipalities and supply authorities.

🔳 Primary SANS Documents

Standard	Description
SANS 10142-1:2020 (Edition 3)	*The Wiring of Premises – Low-Voltage Installations*. Governs all AC/DC low-voltage wiring.
SANS 10142-1-2 (Draft)	Add-on to SANS 10142-1. Specifies additional requirements for embedded generation systems.
SANS 60364-7-712:2018 (Edition 2)	*Solar PV Power Supply Systems*. Regulates safe PV layout, voltages, labelling, and rooftop safety.
SANS 60947-1 & -3	Standards for isolators, switches, and DB components used in combiner/distribution boxes.

🔳 Primary NRS Documents

Standard	Description
NRS 097-2-1:2017	National interface standard for grid-connected inverters. Defines anti-islanding and safety specs.
NRS 097-2-3	Simplified connection criteria for SSEG <100 kVA. Basis for type-approved inverters in SA.
NRS 048	*Quality of Supply*. Ensures embedded systems don't create harmonics, voltage flicker or surges.

📌 Installer Notes

- Keep **updated digital and printed copies** of the relevant standards on file.
- Be prepared to **present evidence** of compliance during SSEG applications or audits.
- Some municipalities may **request proof** that installations meet SANS and NRS requirements.
- **Anti-islanding certificates** (based on NRS 097-2-1) are usually supplied by **inverter manufacturers**.

☑ Summary Table: Key Documents and Uses

Document	Use
NRS 097-2-1	Inverter grid interface and protection (anti-islanding, voltage/frequency limits)
NRS 097-2-3	Simplified SSEG connection criteria for <100 kVA grid-tied systems
SANS 10142-1	Wiring code – required for all CoC-compliant electrical installations
SANS 10142-1-2	Extra rules for embedded generation (where adopted)
SANS 60364-7-712	PV-specific rules for design, voltages, safety, and rooftop conditions
Local Municipal Guidelines	City-specific application rules and additional technical submissions

☑ 18.7 Installer Responsibility

As a **registered solar installer or qualified electrician**, you carry both **legal** and **technical responsibility** for every Small-Scale Embedded Generation (SSEG) system you install — especially when the system connects to any municipal or Eskom infrastructure.

This includes:

- Grid-tied systems
- Hybrid systems with grid fallback
- Multi-inverter or high-capacity setups (typically ≥5 kW)

👷 Key Responsibilities by Area

Area	Responsibility
⚖️ **Legal Compliance**	Ensure full compliance with **SANS 10142-1**, **SANS 60364-7-712**, **NRS 097-2-1**, and any **municipal by-laws**.
📄 **Registration & Approvals**	Submit accurate and complete SSEG applications. Follow up regularly (approval can take 2–6 weeks).
🧪 **Testing & Commissioning**	Conduct all required tests: insulation resistance, polarity, voltage checks, and earth loop impedance.
🛡 **Protection Configuration**	Ensure proper protection: anti-islanding, surge protection, overcurrent devices, isolators, and correct ratings.
📁 **Documentation**	Maintain job records: inverter serial numbers, commissioning forms, test results, CoC, and photos.

Area	Responsibility
👩‍🏫 **Client Education**	Explain shutdown/startup procedure, inverter display, mobile monitoring apps, and registration status.

📌 Mandatory Installer Duties

- Advise the client **early** if their system needs registration
- **Assist** or handle the entire SSEG submission process
- **Configure** the inverter to match export rules (e.g. Zero Export setting if required)
- Never bypass or delay registration "just to finish the job"
- **Track and confirm** that final approval was received — and store the documentation

---

⚠️ Risk of Non-Compliance

Failing to register or commission a system properly can lead to:

Risk	Impact
❌ Disconnection	Municipalities may forcibly isolate the system and remove the meter
❌ Insurance Rejection	Insurers may reject claims for surge/fire if SSEG and CoC are not valid
❌ Installer Penalties	You may face fines or lose your **wireman's licence / PV GreenCard**
❌ Property & Personal Risk	Non-compliant systems can result in shock, fire, or grid backfeed injuries

---

✅ Summary

🔒 **It is your legal and professional duty** to ensure that each system you install is:

- Safe
- SANS-compliant
- Correctly protected
- Registered with the municipality (if required)
- Fully documented with a valid CoC

19. Case Studies – Failures & Lessons Learned

Why:

This section shares real incidents from the field. The purpose is not to assign blame, but to educate the team, build awareness, and prevent future mistakes through reflection and system improvements.

Each case includes:

- 🔥 **What went wrong**
- ❌ **Why it happened**
- 💰 **What the damage was**
- ✅ **How it was prevented going forward**

⚠ Case Study 1: Blown Inverter Due to Reverse Polarity

🔥 **What Happened:**
A 10 kW inverter was destroyed immediately on power-up. The DC input cables were connected in reverse — positive to negative and vice versa.

❌ **Why:**

- No polarity test was done before connection
- Technician skipped checklist
- No +/– labels inside the combiner box

💰 **Damage:**

- Inverter destroyed before commissioning
- R35 000 financial loss (not covered by warranty)
- Project delayed 4 days

✅ **Prevention Measures:**

- Section 5.8: Polarity test required at DC combiner
- Mandatory labelling of string input polarity
- No DC connection allowed without signed checklist

⚠ Case Study 2: Burning AC Isolator

🔥 **What Happened:**
A main AC isolator melted after load shedding due to internal arcing and contact failure.

❌ **Why:**

- Underrated isolator (20 A on 8 kVA system)
- No surge protection installed
- Terminals were not torqued correctly

💰 **Damage:**

- Isolator destroyed
- Combiner board was at fire risk
- Full AC rewire needed

✅ **Prevention Measures:**

- Use isolators rated at 125% of full load
- Include SPD in all AC combiners (now mandatory)
- Introduced torque-check form in Section 10

⚠ Case Study 3: Earth Spike Not Bonded

🔥 **What Happened:**
A lightning surge damaged several household appliances. Earth resistance was 110 Ω — ineffective.

❌ **Why:**

- Earth rod was installed but not bonded to the inverter or DB
- Wire used for bonding was 1.5 mm² (too thin)
- No earth continuity test done

💰 **Damage:**

- Wi-Fi router, TV, and fridge damaged
- Loss of approx. R18 000
- Installer was liable for insurance excess

✅ **Prevention Measures:**

- Updated procedures in Sections 5.3 and 6.5
- Earth resistance test is now on every job card
- Minimum bonding conductor is 6 mm²

⚠ Case Study 4: CT Clamp Facing Wrong Direction

🔥 **What Happened:**
System showed zero solar export and batteries never charged. Client assumed the system was faulty.

❌ **Why:**

- CT clamp installed in reverse orientation
- No monitoring check done after commissioning
- Installer left without confirming power flow

💰 **Damage:**

- Client nearly cancelled contract
- R700 call-out and 3 hours lost
- 4 days of production lost

✅ **Prevention Measures:**

- CT orientation diagram added to Section 6
- Section 8 requires full monitoring verification
- Mandatory 48-hour remote check after handover

⚠ Case Study 5: Loose DC Lug Causes Fire

🔥 **What Happened:**
A DC cable lug at the inverter smoked and nearly caught fire.

❌ **Why:**

- Lug not torqued with correct tool
- Crimp joint was not visually inspected
- Cable insulation damaged during install

💰 **Damage:**

- DC cable, inverter terminal, and lug destroyed
- R7 000 in losses
- Project delayed 2 days

✅ **Prevention Measures:**

- Torque wrench now required for all DC lugs
- Lug torque record form included in Section 10
- Cable sleeving and pull technique now part of training

📋 Summary of Lessons Learned

Failure Cause	Now Prevented By…
Skipped polarity test	DC test sheet added in Section 10
Underrated/cheap isolator	Minimum AC specs table added in Section 14
Poor earth bonding	Earth bonding checklist in Sections 5 & 6
CT clamp installed backwards	Commissioning flow test (Section 8)
Loose or untorqued lug	Lug torque record introduced (Section 10)

20. Annexures

🔧 20.1 AC & DC Cable Sizing Tables

Cable Size (mm²)	Max Current (Amps)	Typical Use
2.5 mm²	20 A	Small AC circuits
4 mm²	25–30 A	Inverter AC output (≤5 kW)
6 mm²	30–40 A	Battery interconnects / DC cabling
10 mm²	45–60 A	PV panels to combiner (long runs)
16 mm²	70–80 A	Medium to large battery banks
25 mm²+	100 A	Large-scale or parallel inverter arrays

⚠ Always consider voltage drop, installation method (e.g. conduit vs. open), and derating for temperature or bundling.

🏷 20.2 Labelling Examples

Item	Label Example
Inverter AC Output	“INVERTER AC OUT – 230V LIVE”
DC Combiner Box	“DC COMBINER – PV STRING 1–4”
Battery Breaker	“BATTERY ISOLATOR – 48VDC”
AC DB Main Breaker	“MAIN FEED FROM INVERTER”
Earth Bar	“MAIN EARTH TERMINAL”
PV Strings at Combiner	“STRING 1 +” / “STRING 1 –”

✅ Use **UV-stable vinyl** or **laser-printed heat shrink** for durability.

📋 20.3 Commissioning Checklist Template

Test Performed	Passed (✓)	Notes
DC polarity & Voc checked		
Insulation resistance test (Megger)		
Combiner wired correctly		
Earth resistance under 10 Ω		
Inverter firmware updated		
Battery voltage confirmed		
CT clamp tested (correct orientation)		
Monitoring portal functional		
Load test performed		

📎 Attach this checklist to the final job card or commissioning pack.

🧰 20.4 Tools & PPE Checklist (Per Team)

Team	Essential Tools	Required PPE
DC Team	MC4 crimper, Megger, multimeter, heat gun	Gloves, helmet, goggles, FR jacket
AC Team	Loop tester, RCD tester, label printer	Gloves, hard hat, steel-toe boots
Inverter Team	Comms cables, torque wrench, laptop for config/monitoring	Same as AC team + ESD wrist strap

---

📝 20.5 Risk Assessment Template (Basic)

Hazard	Severity	Control Measure
Working at height	High	Fall harness, ladder tie-off
Live DC circuits	High	PPE, isolate before handling
Battery fire/explosion	High	Fire extinguisher nearby
Sharp trunking edges	Medium	Gloves, proper tool use
Trip hazard (loose cables)	Medium	Cable trays, tape, cable tie-offs

✅ Fill out at the start of every job. Retain in the job file.

📸 20.6 Photographic Proof Checklist

Item	Photo Taken? (✓)	Notes
Panels mounted & aligned		
Combiner box (open & closed)		
Inverter installed (overall view)		
Battery stack with cable layout		
Distribution Boards (labelled)		
Earth rod and bonding wire		

📎 Include these in the digital job file and handover pack.

📄 20.7 Signature Forms & Templates

The following forms should be included in your company's installation pack:

- ✅ Technician Section Sign-Off Sheet (See Section 15)
- ✅ Client Handover Confirmation Form (See Section 13)
- ✅ Subcontractor Code of Conduct & Responsibility Agreement *(Optional)*
- ✅ Daily Toolbox Talk Register *(For long/multi-day projects)*

🚨 20.8 Emergency QR Sticker (Sample Layout)

css
Copy code
⚠ EMERGENCY SHUTDOWN INSTRUCTIONS

1 – TURN OFF BATTERY ISOLATOR
2 – TURN OFF SOLAR ISOLATOR
3 – TURN OFF MAIN AC ISOLATOR

🔗 Scan QR Code for Emergency Video

☎ Installer: 0X0 123 4567
☎ Emergency Services: 112 / 10111

📌 **Print this on a vinyl sticker** and affix near the inverter/battery area.

📁 20.9 Folder Structure – Digital Job File (Backup & Client Handover)

Folder Name	Contents
01_Project Photos	Site progress, final install, panel layout
02_Serial Numbers	Inverter, battery, panel serial numbers + summary sheet
03_Job Card & Commissioning	Completed checklists, polarity test, insulation test
04_Client Documents	CoC, warranties, municipal approval, handover sheet
05_Monitoring Info	Portal login, screenshots, app config
06_Municipal/SSEG	SSEG form, SLD, approval emails, CoC copy

🖱 Keep all files organised and backed up for 5+ years (depending on local regulations).

21. Additional Sections / Add-on (REV 2)

21.1 General fault finding

21.2 General Flow of all aspects of installations

21.3 General commercial installations (to be added to relevant sections)

21.4 Photos and example diagrams (to be added to relevant sections)

21.5 All relevant annexures to be added or links to them.

21.6 Single vs 3phase section