50 kW Deye Hybrid Solar Power Plant

Engineering design report, single-line diagram and bill of quantities

51.2 kWh battery storage, one battery rack

62.5 kWp	51.2 kWh	50 kW
Total PV capacity	Total battery capacity	Inverter rating

Item	Basis
PV array	100 × Jinko JKM625N-66HL4M-BDV (625 W bifacial N-type) = 62.50 kWp
Battery	Deye BOS-G Pro HV, 10 × 5.12 kWh = 51.2 kWh in 1 rack, 1 BMS box
Inverter	1 × Deye SUN-50K-SG01HP3-EU-BM4, 50 kW / 55 kVA, 3-phase 230/400 V
Mounting	Antai aluminium rail 4.5 m with mid and end clamps, 10 rows × 10 modules portrait
Supply sources	DisCo supply and standby diesel generator through an automatic changeover
Document no.	RT-50K-DR-001, Revision 0
Status	Issued for construction

Rev	Date	Description	Prepared	Approved
0	Oct 2026	Issued for construction		

1. Summary

The plant is built around one Deye 50 kW three-phase hybrid inverter fed by 100 Jinko 625 W bifacial modules, giving 62.5 kWp of PV. That is a DC/AC ratio of 1.25, which sits comfortably inside the inverter's 65 kW maximum PV input and suits Nigerian irradiance well: the array clips a little at midday in the dry season and makes up for it with stronger mornings, evenings and rainy-season output.

Storage is a Deye BOS-G Pro high-voltage battery made up of one cluster of ten 5.12 kWh packs in series, giving 51.2 kWh at 512 V nominal. The packs and their BMS control box fill one Deye BOS-A 11-layer rack.

The DisCo supply and a standby generator meet at an automatic changeover. The inverter's LOAD port feeds an essential load board that stays live through outages, while non-essential loads are fed from the main board and drop with the grid. A maintenance bypass switch lets the essential board run straight from the grid whenever the inverter is being serviced. The full arrangement is on drawing RT-50K-E-001.

Key figure	Value	Comment
Total PV capacity	62.50 kWp	100 × 625 W
Total battery capacity	51.2 kWh	10 × BOS-G-Pack5.1, 1 rack
Inverter rating	50 kW / 55 kVA	3-phase, 230/400 V
DC/AC ratio	1.25	Within 65 kW max PV input
Highest string Voc at 5 °C	673 V	Limit 1000 V
Battery output	22–29 kW	Set by the 50 A battery input
Expected yield	≈ 250–275 kWh/day	Annual average, central Nigeria
Module area / mass	270 m^2 / 3,240 kg	Modules only
Total materials cost	₦47,441,766	Incl. 7.5 % VAT; labour and accessories excluded

2. Design basis

- **Site:** central Nigeria. Design ambient 15–40 °C, minimum cell temperature for voltage checks 5 °C, maximum cell temperature 70 °C.
- **Supply:** 3-phase 230/400 V, 50 Hz, TN-C-S from the DisCo transformer, with a standby diesel generator.
- **Mounting:** 10 rows of 10 modules in portrait on Antai aluminium rail.
- **Essential load:** up to 20 kW at night on battery, with the generator taking over above that or when the battery reaches its reserve.
- **Export:** zero export. The inverter limits PV output so no power flows back to the DisCo network.

3. Equipment data

Values below are from the current manufacturer datasheets listed in Section 13.

Equipment	Data used in this design	What it means for the design
Deye SUN-50K-SG01HP3-EU-BM4	50 kW rated, 55 kVA max 4 MPPT, 2 strings each PV max 1000 V, MPPT 150–850 V, start-up 180 V 36 A operating / 55 A Isc per MPPT Max PV input 65 kW Battery 160–800 V, 2 inputs, 50 A each AC 72.5 A rated, 79.8 A max Grid pass-through 200 A Integrated DC switch, Type II DC and AC SPD, IP65, 80 kg	Two strings per MPPT is the maximum. The 50 A battery input sets the backup power available (Section 5). The 200 A pass-through lets Q2 and the grid cable be sized to the site supply rather than the inverter.
Jinko JKM625N-66HL4M-BDV	Vmp 40.88 V, Imp 15.29 A Voc 49.28 V, Isc 16.14 A Voc coefficient −0.25 %/°C Pmax coefficient −0.29 %/°C Max series fuse 35 A 2382 × 1134 × 30 mm, 32.4 kg	Low Voc coefficient (N-type) gives plenty of cold-voltage margin. The 35 A fuse rating removes the need for string fuses with two strings in parallel.
Deye BOS-G-Pack5.1, BMS box, BOS-A rack	5.12 kWh, 51.2 V, 100 Ah per pack 10 packs in series per cluster: 51.2 kWh, 512 V nominal, 440–584 V operating BMS box: 100 A nominal, DC breaker, pre-charge, CAN to inverter Rack: 11 layers (10 packs + BMS box)	Each cluster stays inside the inverter's 160–800 V battery window across its whole operating range, and fills one rack exactly.

4. PV array electrical design

4.1 String allocation

The 100 modules are wired as four strings of 12 and four of 13. Equal strings share an MPPT so each tracker works at a single operating point. The string map on drawing RT-50K-E-002 shows which module belongs to which string.

MPPT	String A	String B	Modules	DC power
PV1	12 in series	12 in series	24	15.00 kWp
PV2	12 in series	12 in series	24	15.00 kWp
PV3	13 in series	13 in series	26	16.25 kWp
PV4	13 in series	13 in series	26	16.25 kWp
Total	**4 × 12**	**4 × 13**	**100**	**62.50 kWp**

4.2 Voltage checks

Voltage is checked at three conditions: a cold clear morning (highest Voc, must stay under 1000 V), standard test conditions, and a hot afternoon (lowest Vmp, must stay above the MPPT floor). Cold correction is 1 + 0.0025 × (25 − 5) = 1.05. Hot correction uses the Pmax coefficient as a conservative proxy for Vmp: 1 − 0.0029 × (70 − 25) = 0.87.

Check	12-module string	13-module string	Limit	Result
Voc at 5 °C (worst case)	621 V	673 V	1000 V max	Pass, 33 % margin
Voc at STC	591 V	641 V	1000 V max	Pass
Vmp at STC	491 V	531 V	150–850 V MPPT	Pass
Vmp at 70 °C cell	427 V	462 V	150 V min, 180 V start-up	Pass

4.3 Current and string protection

Check	Value	Limit	Result
Operating current, 2 strings (2 × Imp)	30.6 A	36 A per MPPT	Pass
Short-circuit current, 2 strings × 1.25 (IEC 62548)	40.4 A	55 A per MPPT	Pass
Same with 20 % bifacial rear gain	48.4 A	55 A per MPPT	Pass
Reverse current into a faulted string, (2 − 1) × 1.25 × Isc	20.2 A	35 A module fuse rating	No string fuses needed

On the brightest days, bifacial gain can take operating current up to the 36 A MPPT limit. The inverter caps the current, so the only effect is a little clipping.

4.4 DC cabling and isolation

Every string is wired in 6 mm^2 H1Z2Z2-K (EN 50618) single-core solar cable, red for positive and black for negative, with MC4 connectors from a single manufacturer. At 15.3 A a 40 m one-way run drops about 0.9 % of string voltage and a 60 m run about 1.4 %, both inside the 1.5 % design limit.

DCB-01 is an IP65 enclosure near the array holding a 4-pole 1000 V DC switch-disconnector per MPPT (both strings) and a Type II DC SPD per MPPT rated Ucpv ≥ 1000 V. This gives isolation of the roof cabling

independent of the inverter's own DC switch, and surge protection at both ends of the DC run as IEC 62548 requires for runs over 10 m.

5. Battery system

5.1 Configuration

Ten Deye BOS-G-Pack5.1 modules are connected in series through the BMS control box to form a single high-voltage cluster on inverter input BAT1. The BMS box carries the DC breaker, pre-charge circuit and CAN link to the inverter. The BMS box and the ten packs fill one BOS-A 11-layer rack.

Parameter	Value
Packs	10 × 5.12 kWh, 51.2 V, in series
Total energy	51.2 kWh
Nominal voltage	512 V per cluster
Operating voltage	440–584 V (inverter window 160–800 V)
Inverter connection	BAT1, with BMS on CAN. BAT2 kept spare
Battery output	50 A × 440–584 V = 22–29 kW
Racks	1 × BOS-A 11-layer (all 11 layers used: 10 packs + BMS box)

Each battery input on this inverter is limited to 50 A, so the battery delivers 22 to 29 kW depending on its state of charge. That covers the 20 kW essential night load in the design basis. BAT2 is kept free so a second rack can be added later without rewiring.

5.2 Backup time

Usable energy is taken down to a 20 % SOC reserve with 95 % battery-to-AC efficiency, which gives about 38.9 kWh delivered to the loads.

Essential load	Backup time	Note
10 kW	≈ 3.9 h	Lighting, IT, small power
15 kW	≈ 2.6 h	
20 kW	≈ 1.9 h	Design essential load
Above 22 kW	Generator	Generator starts and carries the load

These figures are for a fully charged battery with no PV, which is the night-time case. In daylight the PV carries most of the load and the battery lasts much longer.

6. AC system and protection

6.1 How the scheme works

The DisCo supply and the generator meet at ATS-01, a 4-pole mechanically interlocked automatic changeover. Its output feeds the main LV bus (MDB), which supplies:

- the inverter GRID port through Q2, so the inverter can charge from the grid or generator and pass power through to its loads (up to 200 A);
- the non-essential board DB-NE through Q5, for loads that drop during an outage (large air-conditioners, workshop loads, water heaters);
- the bypass leg of MBS-01, so the essential board can be fed straight from the MDB while the inverter is being serviced.

The inverter LOAD port feeds the essential board DB-E through Q3, an AC SPD and MBS-01. When the grid fails, the inverter islands and keeps DB-E live from PV and battery. Three CTs on the ATS output give the inverter total site import and export for zero-export and peak-shaving control. The generator connects through the ATS so it can carry the whole site, including when the inverter is bypassed.

6.2 AC current and cable sizing

At 400 V and unity power factor, 50 kW is 72.2 A ($I = P / (\sqrt{3} \times V \times PF)$). The datasheet gives 72.5 A rated and 79.8 A maximum, and the output circuit is sized to the maximum.

Item	Calculation	Selection
Q3 output breaker	1.25 × 79.8 A = 99.8 A	100 A, 4-pole MCCB, adjustable thermal trip
Output cable rating	35 mm^2 4C Cu XLPE/SWA, clipped direct: 147 A × 0.91 (40 °C ambient) × 0.80 (grouping) = 107 A	4C 35 mm^2 Cu XLPE/SWA/PVC
Voltage drop at 30 m	1.1 mV/A/m × 79.8 A × 30 m = 2.6 V	0.66 %, inside the 3 % limit
Circuit protective conductor	Armour plus separate conductor	16 mm^2 Cu green/yellow
Q2 grid input	Sized to the site supply	4-pole MCCB, up to 200 A

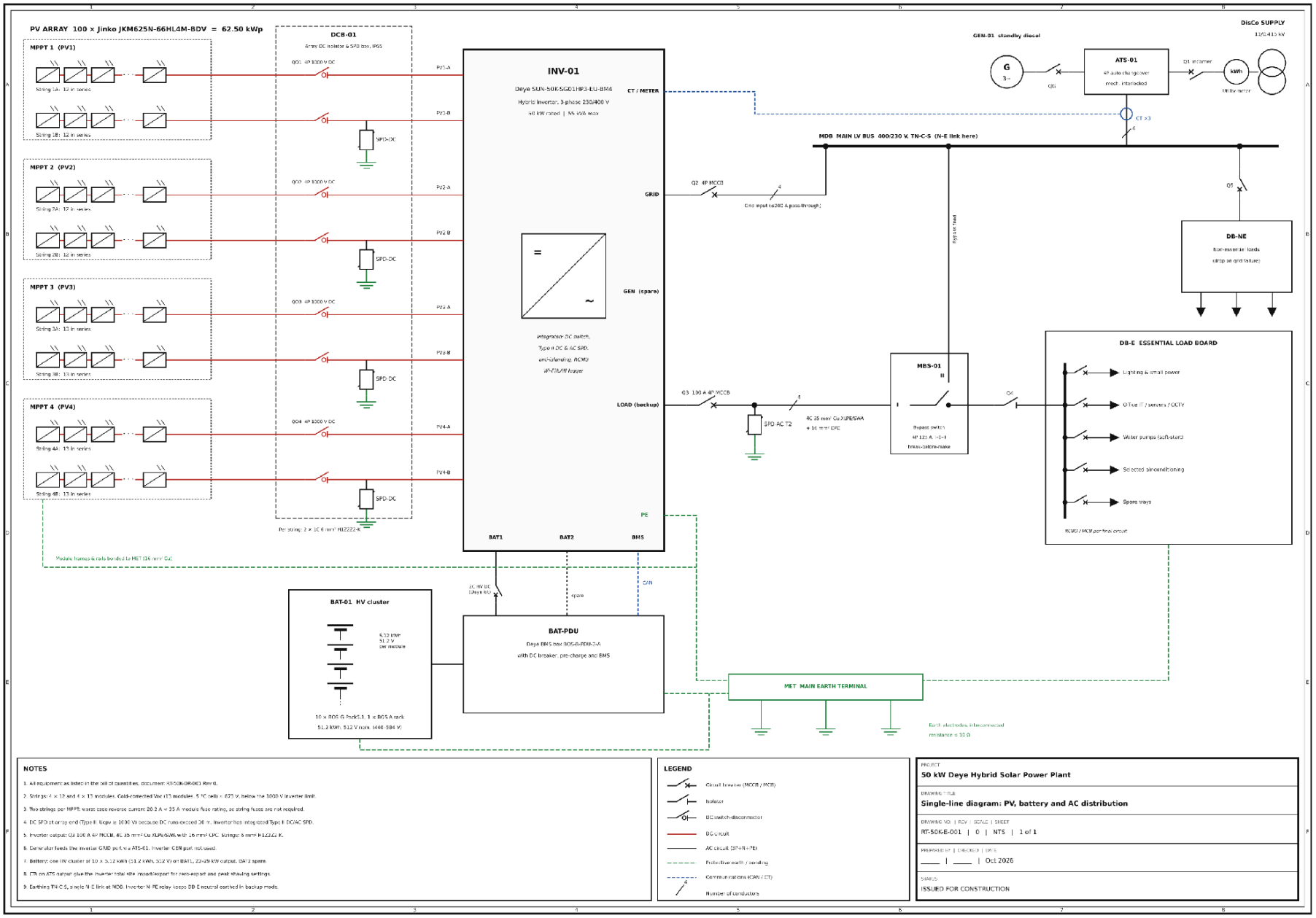
6.3 Surge protection and earthing

- **DC side:** Type II SPD in DCB-01 at the array end, plus the inverter's internal Type II.
- **AC side:** Type II SPD on the inverter LOAD output and at the MDB.
- **Earthing:** TN-C-S with a single neutral-earth link at the MDB. Module frames, rails, DCB-01, inverter, battery rack and all boards are bonded to the main earth terminal. Earth electrodes are interconnected, with a target resistance of 10 Ω or less.
- **Backup mode:** when the inverter islands, the DB-E neutral stays referenced to earth through the inverter's N-PE relay, so RCDs on DB-E continue to protect during outages.

7. Drawings

Drawing	Title
RT-50K-E-001	Single-line diagram: PV, battery and AC distribution
RT-50K-E-002	Array layout and string map, with rail and clamp set-out
RT-50K-E-003	Energy management sequence
RT-50K-E-004	Installation and commissioning sequence

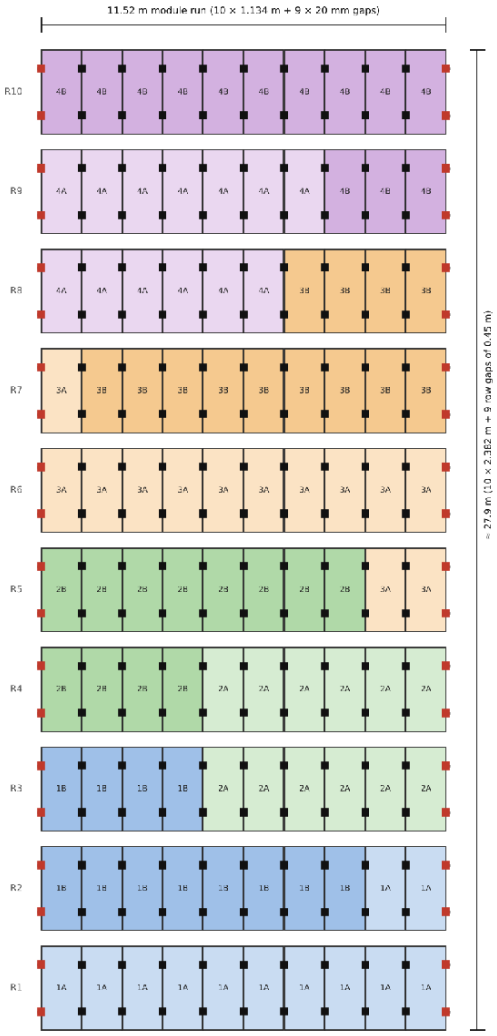
Drawing RT-50K-E-001: Single-line diagram



Drawing RT-50K-E-002: Array layout and string map

PV array arrangement, string map and rail / clamp set-out

10 rows × 10 modules, portrait. Rows numbered from the bottom.

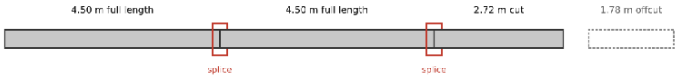


STRING SCHEDULE

String	MPPT	Modules	Vmp @STC	Voc @STC	Voc @5 °C
1A	PV1	12	491 V	591 V	621 V
1B	PV1	12	491 V	591 V	621 V
2A	PV2	12	491 V	591 V	621 V
2B	PV2	12	491 V	591 V	621 V
3A	PV3	13	531 V	641 V	673 V
3B	PV3	13	531 V	641 V	673 V
4A	PV4	13	531 V	641 V	673 V
4B	PV4	13	531 V	641 V	673 V

Cold Voc uses −0.25 %/°C. Highest string value (673 V) is well under the 1000 V inverter limit.

TYPICAL RAIL LINE (20 No.)



Rail line = 11.72 m = 11.52 m module run + 0.10 m each end for end clamps.

Three 4.5 m lengths per line × 20 lines = 60 lengths (270 m bought, ≈ 234 m installed).

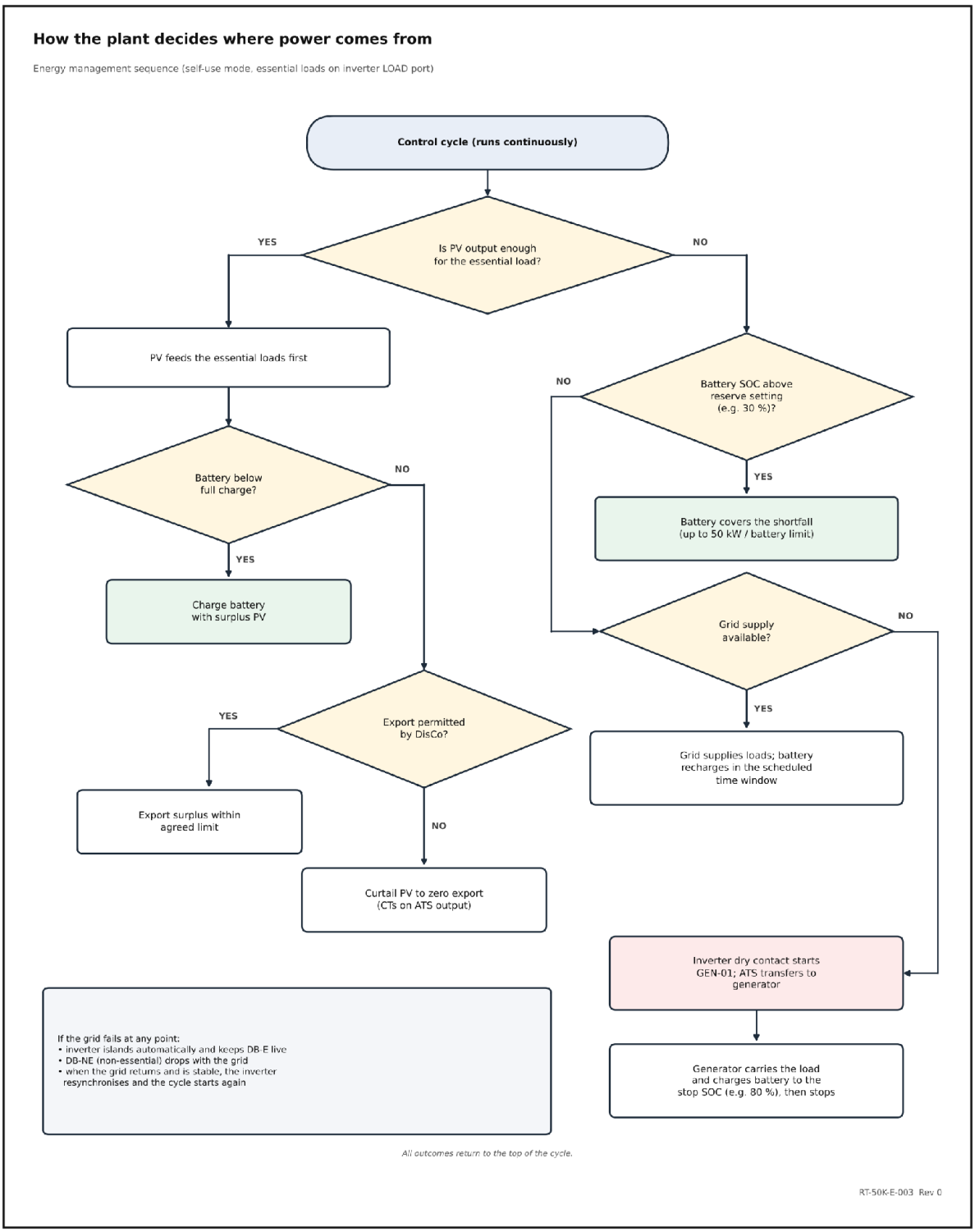
Splices must land on or near a support foot, never mid-span (Antai splice rules).

LEGEND

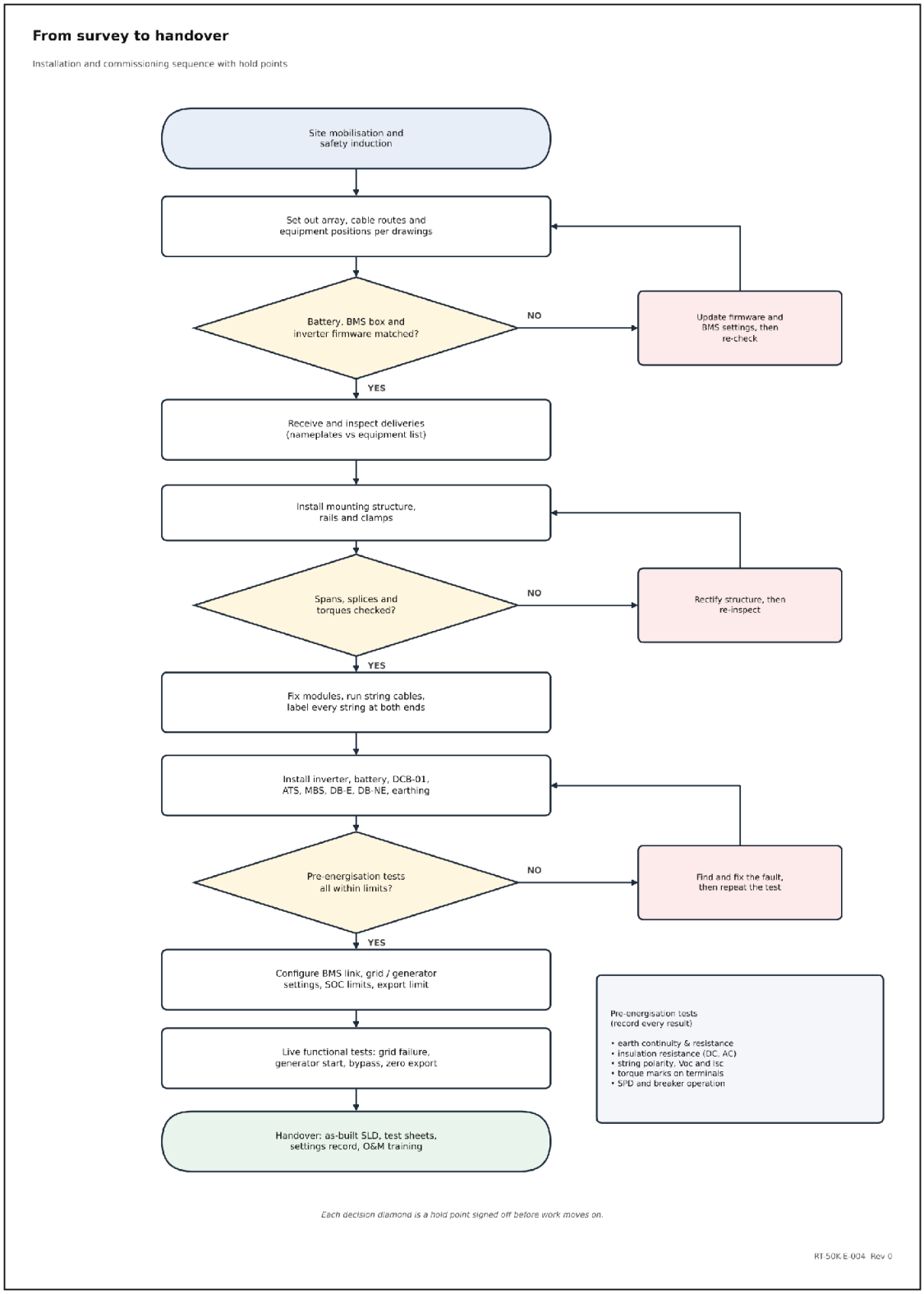
- Mid clamp (9 per rail line, 180 total)
- End clamp (2 per rail line, 40 total)
- Mounting rail, 2 per row at module clamp zones
- MPPT 1 / MPPT 2 / MPPT 3 / MPPT 4

Light shade = string A, darker shade = string B. Strings wired in a serpentine run row by row.

PROJECT	**50 kW Deye Hybrid Solar Power Plant**
DRAWING TITLE	**Array layout and string map**
DRAWING NO. | REV. | SCALE	RT-50K-E-002 | 0 | NTS
STATUS	ISSUED FOR CONSTRUCTION



Drawing RT-50K-E-003. Energy management sequence.



Drawing RT-50K-E-004. Installation and commissioning sequence.

8. Mounting take-off

Each rail line covers ten module widths, nine 20 mm mid-clamp gaps and 100 mm beyond each end module for the end clamp, giving 11.72 m. That is made up of two full 4.5 m lengths and one 2.72 m cut, so three lengths per rail line.

Item	Basis	Quantity
Module run per row	10 × 1.134 m + 9 × 0.020 m	11.52 m
Rail line length	11.52 m + 2 × 0.10 m end allowance	11.72 m
Rail lines	2 per row × 10 rows	20
Rail installed	20 × 11.72 m	234 m
Rail purchased	3 × 4.5 m per line × 20	60 lengths (270 m)
Mid clamps	9 per rail line × 20	180
End clamps	2 per rail line × 20	40
Splice kits	2 per rail line × 20	40

Splices are placed on or immediately beside a support foot, never mid-span, in line with the Antai installation instructions.

9. Expected energy yield

For a fixed array in central Nigeria at a low tilt facing south, the specific yield is about 1,450 to 1,600 kWh per kWp per year after losses. For 62.5 kWp that is roughly 90 to 100 MWh a year, or 250 to 275 kWh per day on average. Output is lowest from July to September under heavy cloud cover, and dips 5 to 10 % during Harmattan haze, when monthly module cleaning keeps yield up.

10. Bill of quantities

10.1 Materials

No.	Description	Qty	Unit	Rate (₦)	Amount (₦)
1	Deye SUN-50K-SG01HP3-EU-BM4 hybrid inverter, 50 kW, 3-phase	1	No.	6,650,000	6,650,000
2	Deye HV battery pack 5.12 kWh, BOS-G Pro series (BOS-G-Pack5.1)	10	No.	1,437,375	14,373,750
3	Deye HV battery BMS box controller (BOS-B-PDU-2-A)	1	No.	2,730,000	2,730,000
4	Deye BOS-A standard battery rack, 11 layers (DEYERACK-BOS-A-R11)	1	No.	690,625	690,625
5	Jinko JKM625N-66HL4M-BDV, 625 W bifacial N-type module	100	No.	170,750	17,075,000
6	Antai aluminium mounting rail, 4.5 m	60	Length	31,250	1,875,000
7	Mid clamp, 30 mm frame	180	Pc	3,125	562,500
8	End clamp, 30 mm frame	40	Pc	4,375	175,000
	Total materials				**44,131,875**

10.2 Summary

	Amount (₦)
Materials	44,131,875
VAT, 7.5 %	3,309,891
Total materials cost	**47,441,766**

Installation labour, cabling, switchgear, mounting accessories, earthing materials and transport are not included in this total.

11. Installation and commissioning

Drawing RT-50K-E-004 sets out the order of work and the hold points.

1. Check every nameplate against the approved equipment list before installation. Record model, serial number and firmware for the inverter, BMS box and battery packs.
2. Torque every rail, clamp and splice bolt to the manufacturer's value and mark it with a paint pen, so loose fixings are easy to spot on later inspections.
3. Label both ends of every string with its ID from the string map (1A to 4B).
4. Keep DC cables off sharp edges and hot roof sheets, support them at least every 300 mm and run the positive and negative of each string together to limit loop area.
5. Run the pre-energisation tests in the table below and record the results. DC isolators stay open until all tests pass.
6. Configure the inverter: battery type and BMS link, SOC limits (30 % reserve, 80 % generator stop), grid and generator settings, zero export and the generator start/stop signal.
7. Live tests: disconnect the grid and confirm DB-E stays up and DB-NE drops; confirm the generator starts and the ATS transfers; operate MBS-01 to bypass and back; confirm zero export with the CTs.
8. Hand over the as-built SLD, string map, settings record, test sheets, manuals and warranties, and train the client's staff on the bypass and shutdown procedure.

Test (IEC 62446-1)	Acceptance
Protective earth continuity	Continuous, low resistance on every frame, rail and enclosure
Insulation resistance, PV strings (1000 V test)	≥ 1 MΩ
String polarity	Correct on every string before connection
String Voc	Within 5 % of the expected value for the measured temperature; matching strings within 2 % of each other
String Isc or operating current	Consistent between strings of the same length at stable irradiance
Earth electrode resistance	10 Ω or less
Breaker, SPD and RCD operation	All operate as intended; RCDs tested with grid disconnected

12. Safety and standards

PV strings are live whenever there is daylight, and opening a DC isolator does not make the module side safe. The battery holds over 500 V DC with very high fault current. Work on either is done by trained personnel using isolation and lock-off, insulated tools and suitable PPE. PV connectors are never broken under load and battery terminals are never worked on live.

The installation complies with the Nigerian Electricity Management Services Agency (NEMSA) requirements for inspection and certification before energisation, the manufacturers' installation manuals, and the following standards:

- IEC 60364-7-712, low-voltage installations, solar PV power supply systems
- IEC 62548, PV arrays design requirements
- IEC 62446-1, PV systems testing, documentation and maintenance
- IEC 62305, protection against lightning
- IEC 62619 for the battery and IEC 62109-1/-2 for the inverter

13. References

- Deye, SUN-29.9-50K-SG01HP3-EU-BM4 three-phase hybrid inverter datasheet (July 2024).
- Deye, BOS-G Pro series high-voltage battery datasheet (December 2025).
- Jinko Solar, Tiger Neo JKM600-625N-66HL4M-BDV bifacial module datasheet.