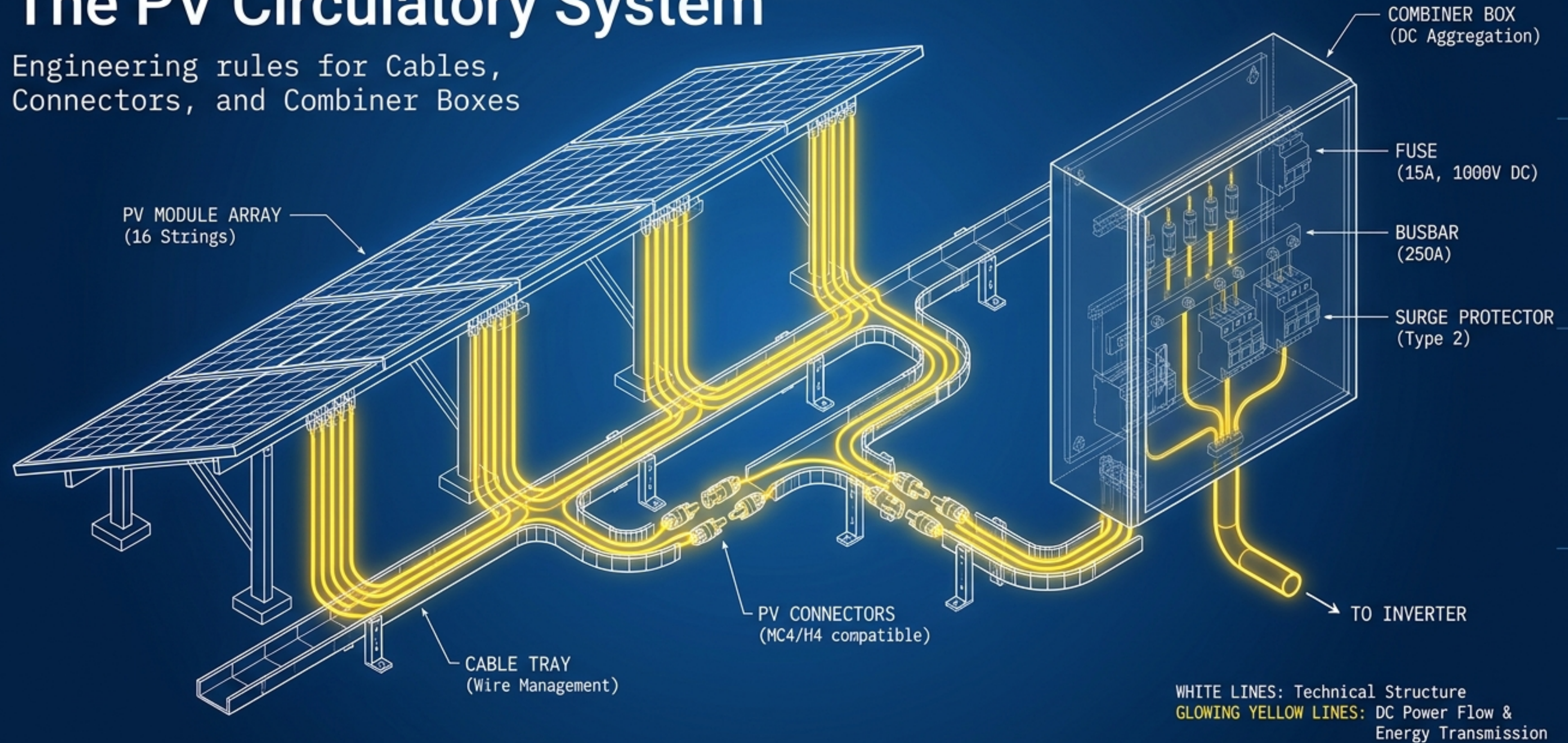


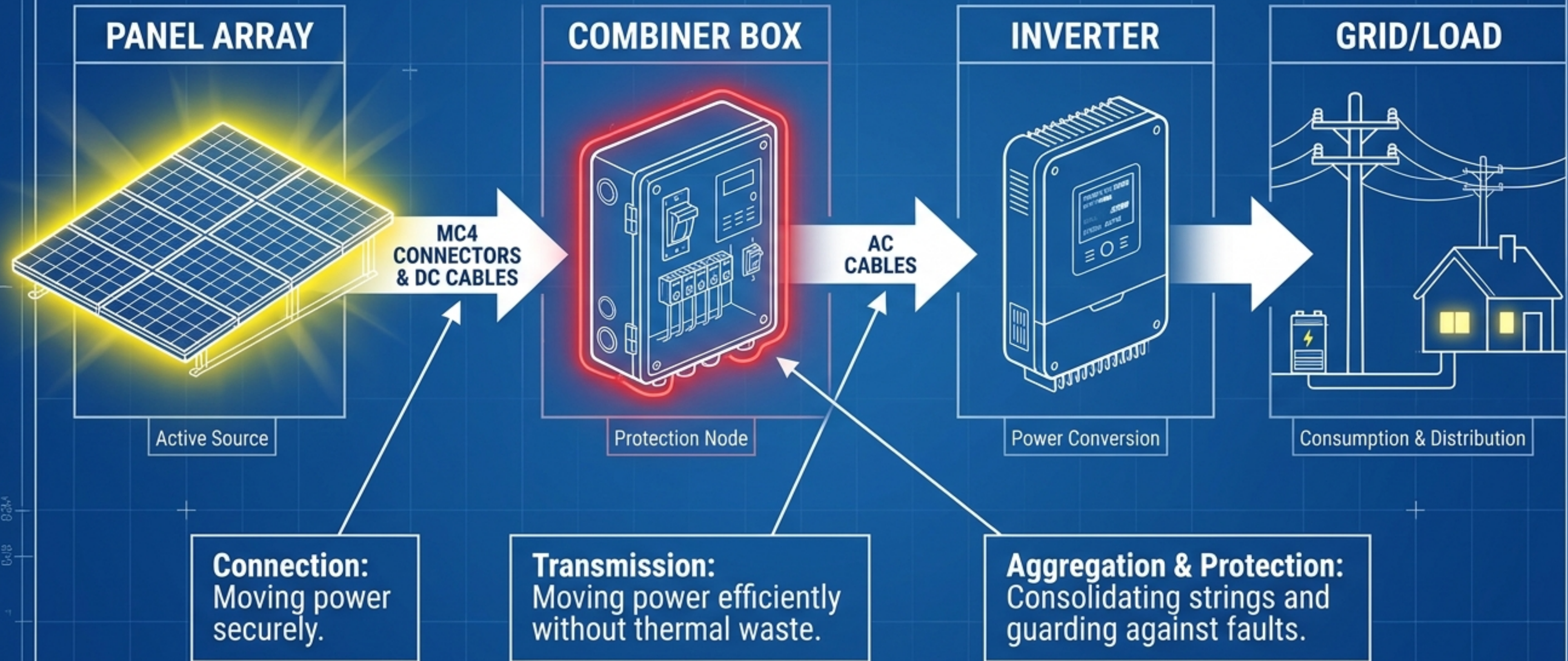
Lesson 2.5

The PV Circulatory System

Engineering rules for Cables,
Connectors, and Combiner Boxes



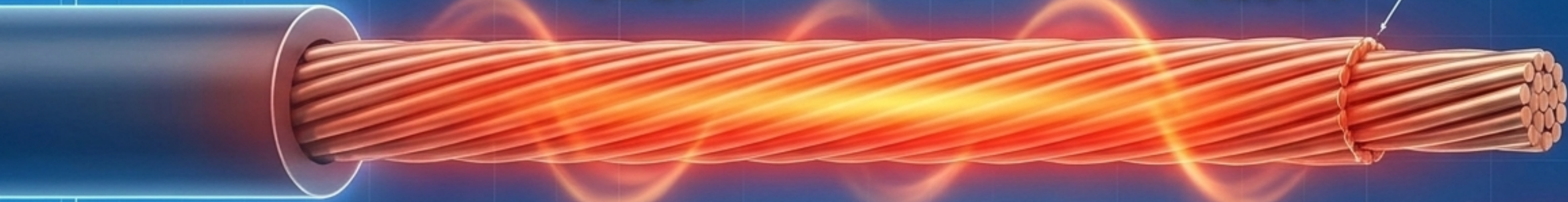
THE THREE CRITICAL NODES OF PV TRANSMISSION



THE PHYSICS OF THERMAL LOSS

Why cable sizing matters.

$$P_{\text{loss}} = I^2 \times R_{\text{cable}}$$



Resistance in cables creates Joule heating. Because P_{loss} is proportional to the square of the current (I^2), doubling the current quadruples the thermal loss.

1x Current (I)

1x Heat

Callout: Modern PV modules connect in series to boost voltage and keep current low, specifically to minimize this I^2R thermal loss effect in the cabling.

4x Heat!

THE GOLDEN RULES OF VOLTAGE DROP

DC SIDE (GENERATOR TO INVERTER)

Limit: $\leq 2\%$ MAXIMUM VOLTAGE DROP

Environment: Extreme UV exposure, temperature fluctuations.

Risk: Exceeding this limit throws away expensive solar generation as waste heat before it ever reaches the inverter.

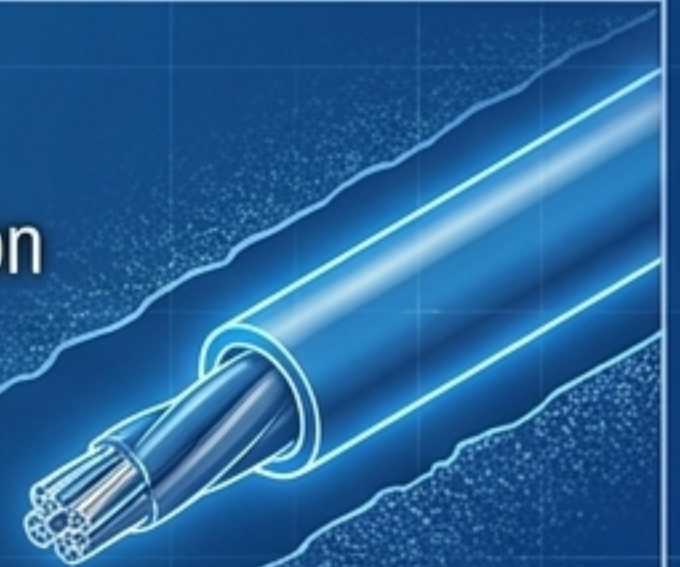


AC SIDE (INVERTER TO GRID/LOAD)

Limit: $\leq 3\%$ MAXIMUM VOLTAGE DROP

Environment: Protected, buried, or in conduit.

Risk: High line resistance causes grid synchronization failures and inverter shutdown.



CABLE SPECIFICATIONS IN THE FIELD

Minimum requirement:
UV-resistant

Rated up to 1,000V
DC (or 1,500V)

Cross-section:
Typically 4mm² or 6mm²
for standard string wiring

Color coding:
Red (+) and Black (-)

PV DC CABLE

Blue
(Neutral)

Green-Yellow
(Protective Earth)

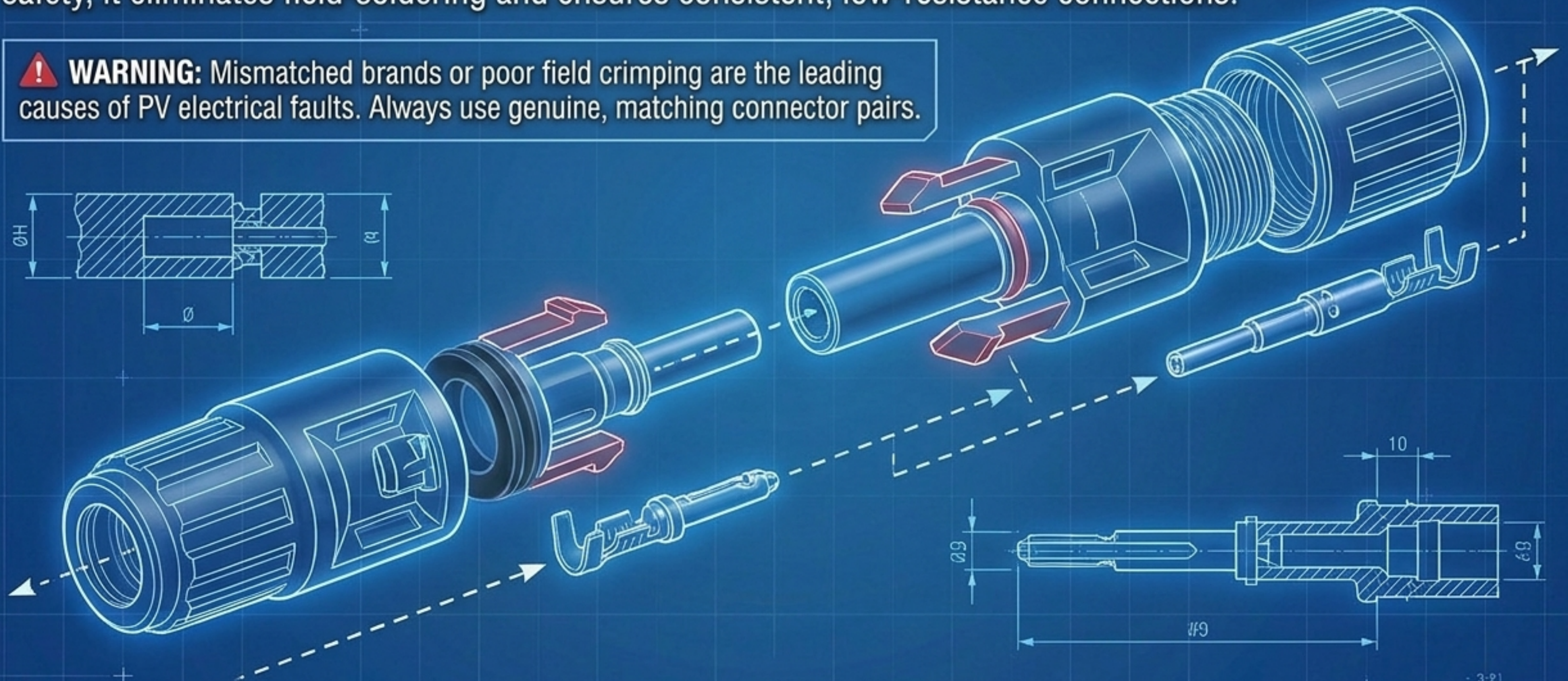
Brown/Black/Grey
(Live Phases)

STANDARD AC CABLE

The Critical Link: MC4 Connectors

The MC4 (Multi-Contact 4mm) is the universal joint of modern solar. Designed for snap-in safety, it eliminates field-soldering and ensures consistent, low-resistance connections.

⚠ WARNING: Mismatched brands or poor field crimping are the leading causes of PV electrical faults. Always use genuine, matching connector pairs.



Decoding Weatherproofing: IP65 and IP67

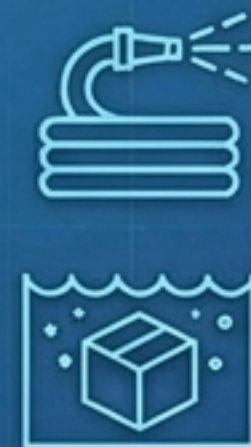
True weatherproof connections require at least an IP65 or IP67 rating.
Moisture ingress destroys DC systems, causing rapid corrosion and highly dangerous sustained arc faults.



IP Rating Breakdown



First Digit (6):
100% Dust-tight.



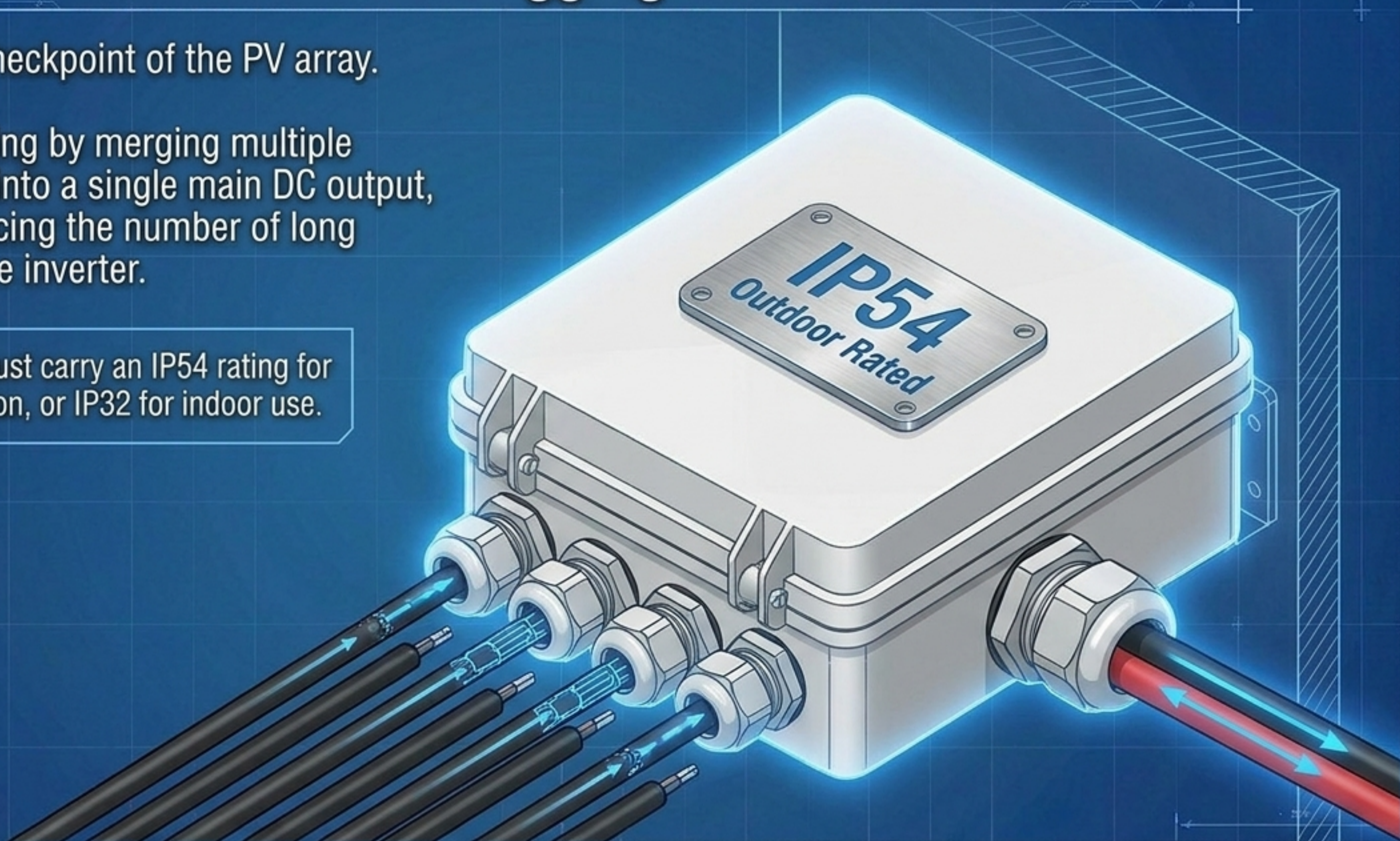
Second Digit (5/7):
Withstands low-pressure
water jets (5) or temporary
full immersion (7).

The Combiner Box: Aggregation & Protection

The electrical checkpoint of the PV array.

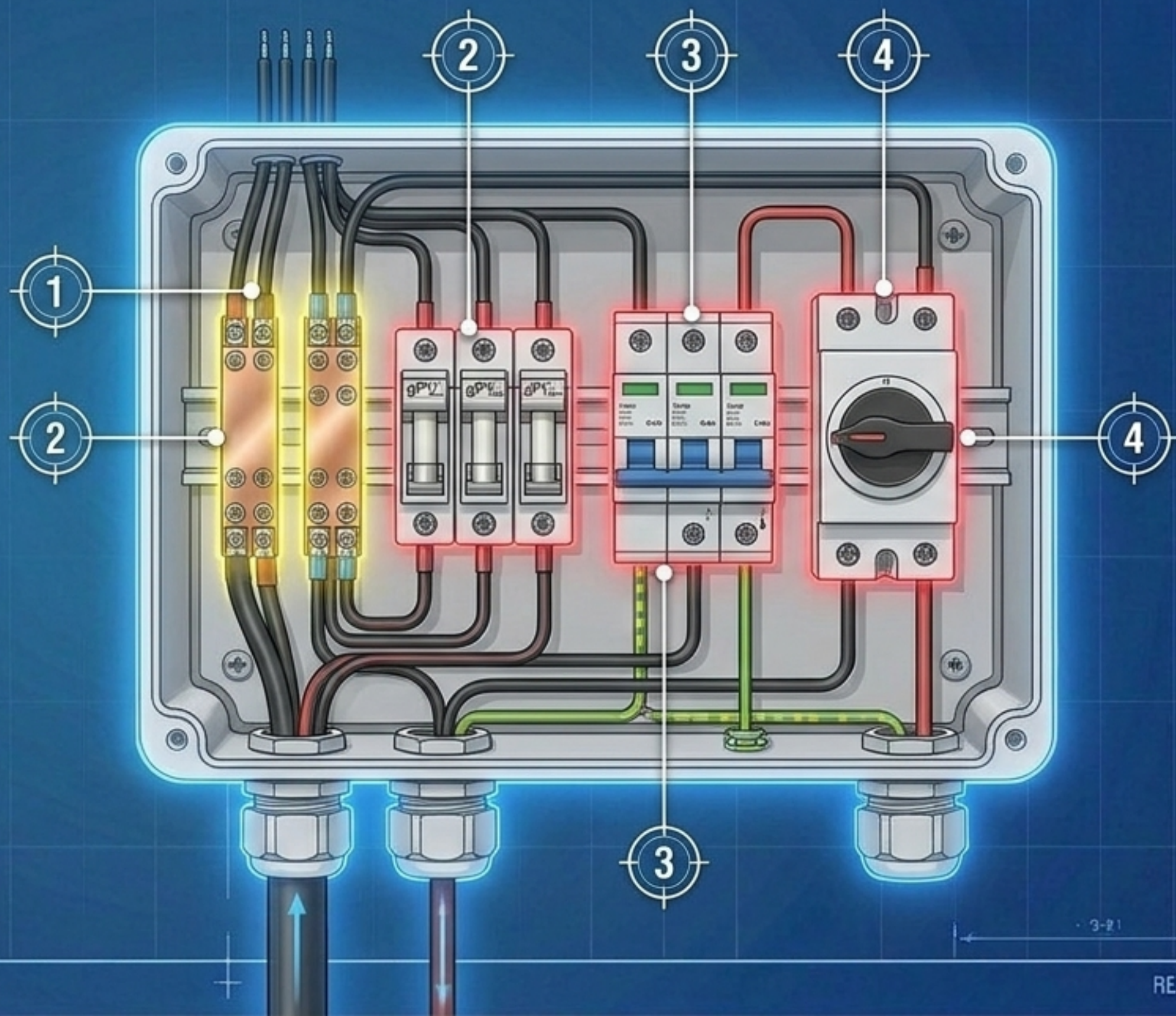
It simplifies wiring by merging multiple parallel strings into a single main DC output, drastically reducing the number of long cable runs to the inverter.

Specification: Must carry an IP54 rating for outdoor installation, or IP32 for indoor use.



Anatomy of the Hub

1. **Positive/Negative Busbars:** Merging parallel string current.
2. **gPV String Fuses:** Overcurrent & reverse current protection.
3. **SPD (Surge Protection Device):** Overvoltage and lightning defense.
4. **DC Isolator Switch:** Manual load-breaking safety disconnect.



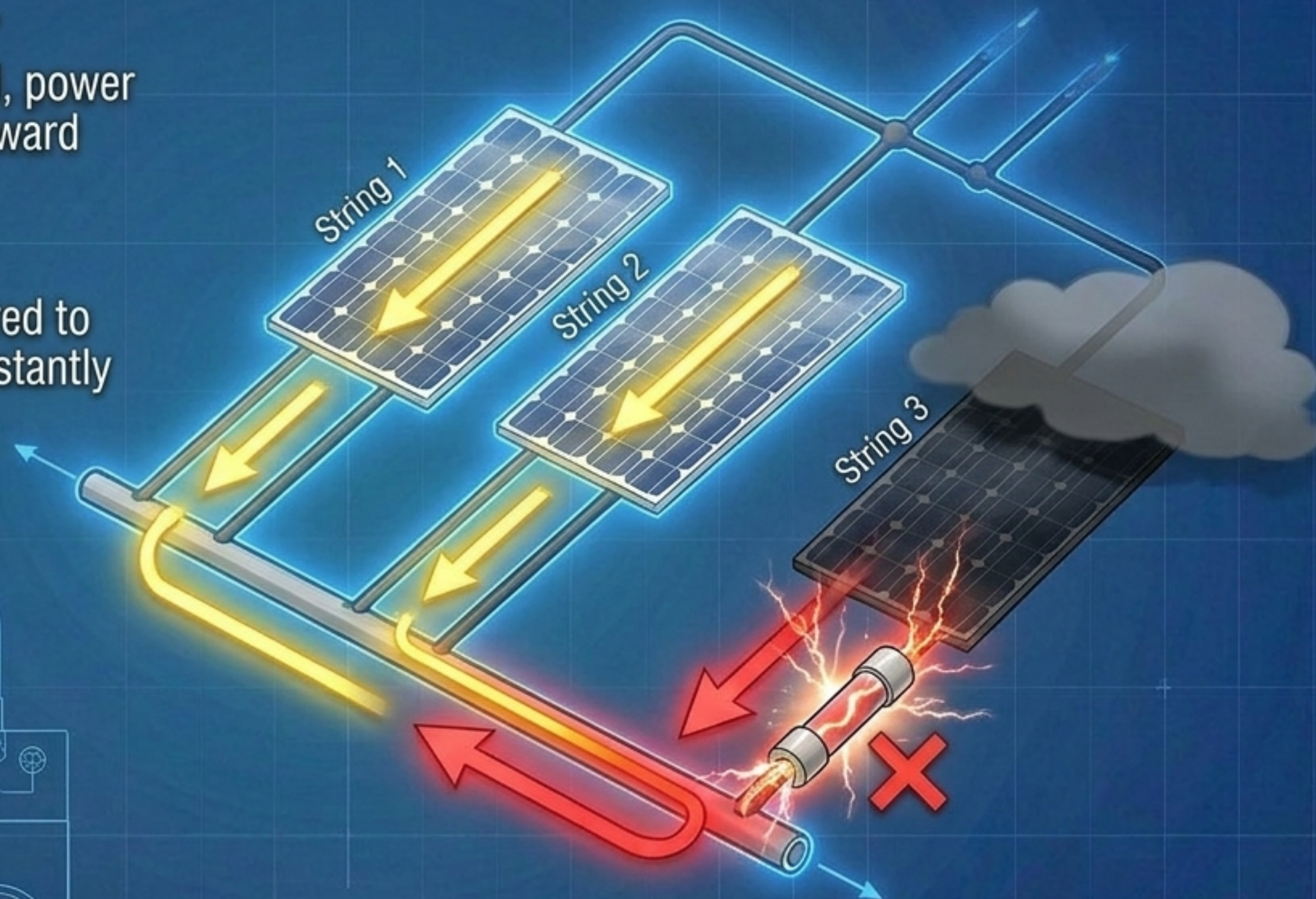
Protection Node 1: gPV String Fuses

Guarding against reverse current.

If one string is shaded or damaged, power from parallel strings will flow backward into it, risking panel fires.

Standard AC fuses are too slow.

gPV fuses are specifically engineered to clear low-level DC fault currents instantly to protect photovoltaic modules.

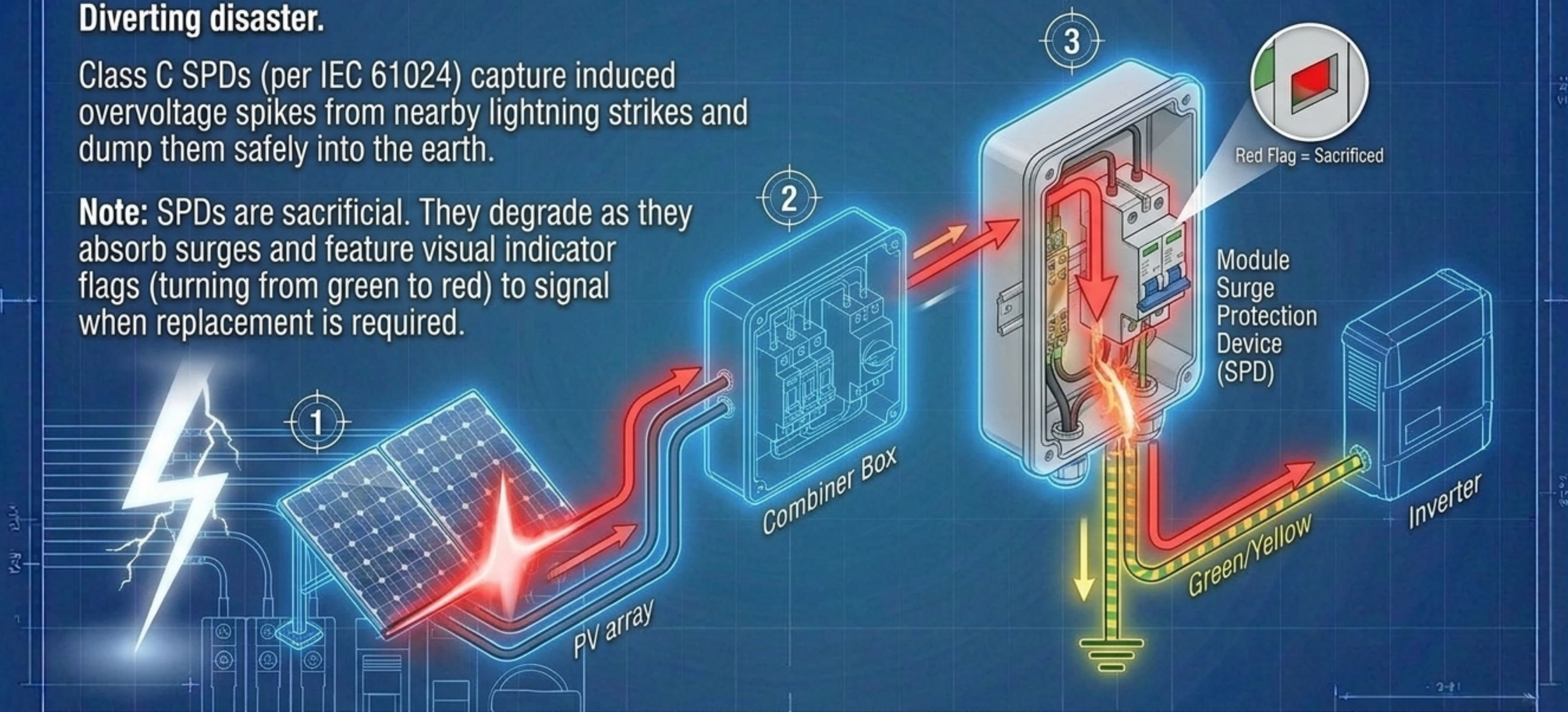


Protection Node 2: Surge Protection (SPDs)

Diverting disaster.

Class C SPDs (per IEC 61024) capture induced overvoltage spikes from nearby lightning strikes and dump them safely into the earth.

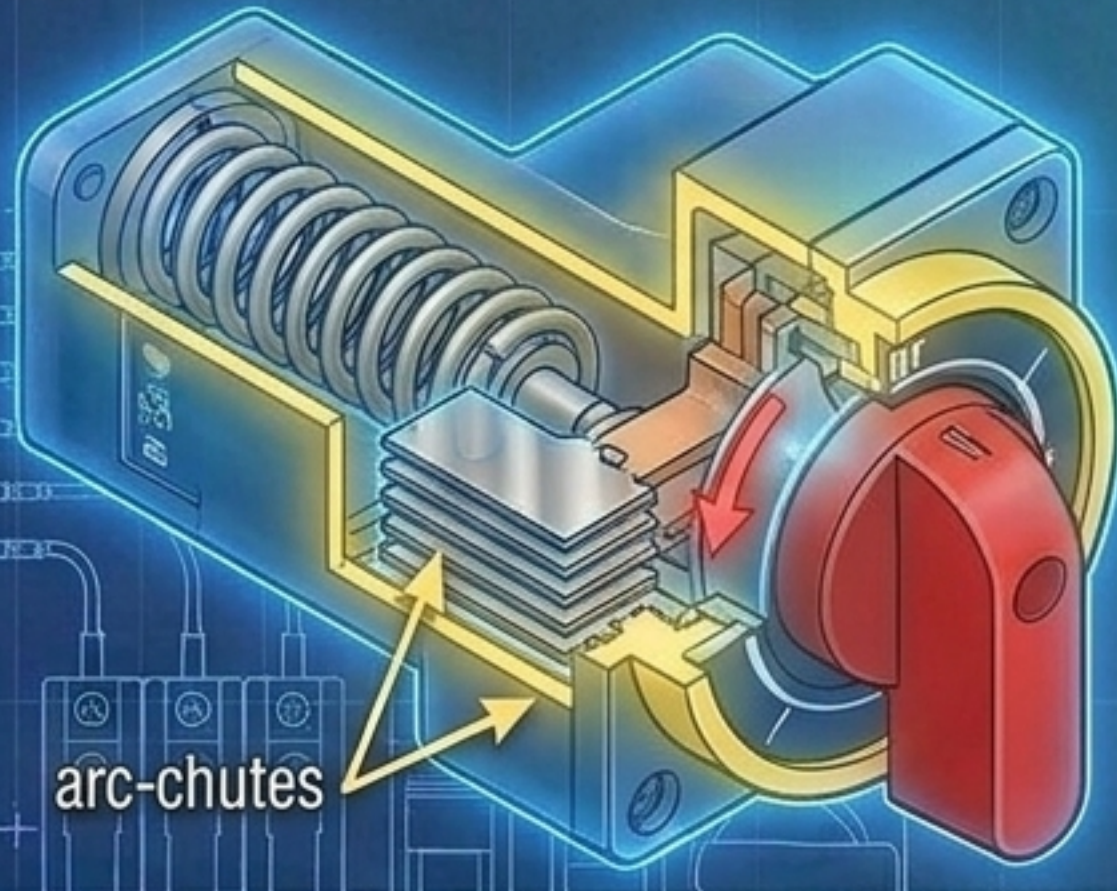
Note: SPDs are sacrificial. They degrade as they absorb surges and feature visual indicator flags (turning from green to red) to signal when replacement is required.



Protection Node 3: The DC Isolator

The ultimate kill switch.

- DC electricity does not pass through zero volts, meaning it can sustain a dangerous, high-heat arc across an open gap.
- DC Isolators utilize specialized arc-chutes and rapid spring-loaded mechanisms to instantly break the circuit, allowing safe maintenance downstream.



AC Current

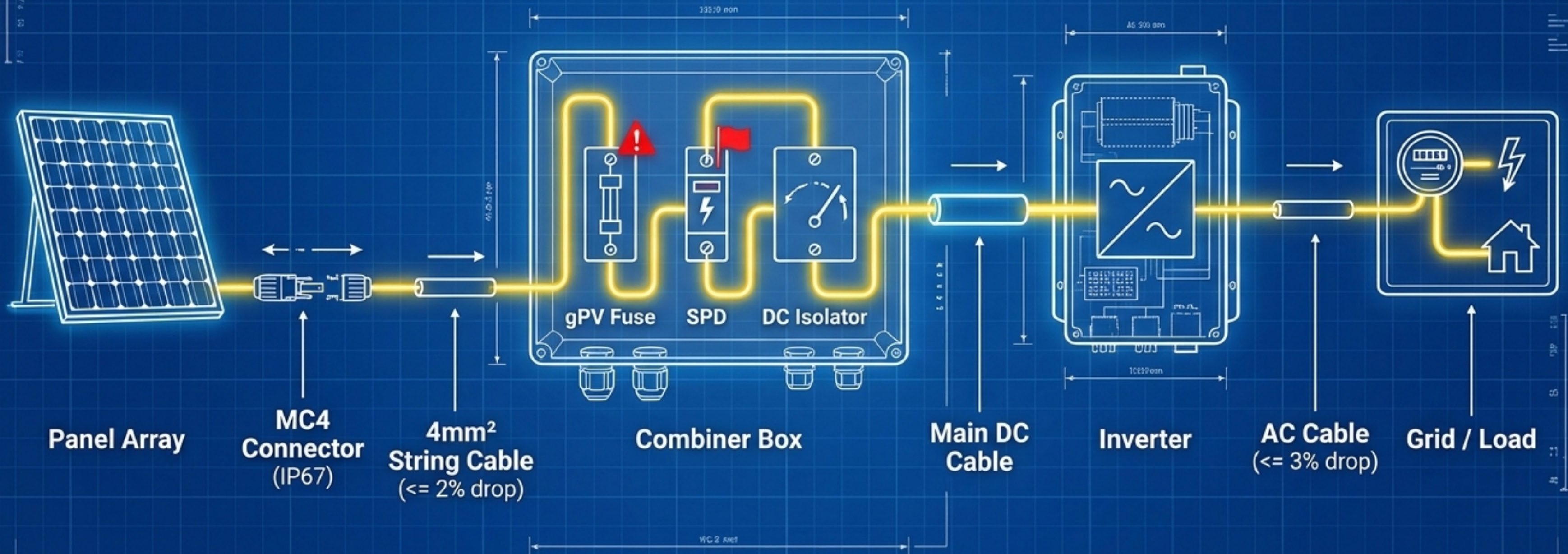


DC Current



System Synthesis: The Complete Wiring Ecosystem

A properly engineered PV system balances mathematical efficiency limits with rigorous, specialized physical safety protocols at every single node.



The Engineer's Quality Assurance Checklist

