Solar Panel Selection and Installation

Panel technologies, Wp ratings, geographic sizing, mounting hardware, orientation, and charge controller selection.

- Choosing a Solar Panel for LoRa Nodes
- Solar Panel Mounting and Orientation
- Charge Controllers: PWM vs MPPT

Choosing a Solar Panel for LoRa Nodes

Solar panel selection involves matching the panel's output to the node's energy needs while accounting for real-world efficiency losses, geographic location, and physical mounting constraints. This page covers panel technology, rating systems, derating factors, geographic sizing, and wiring configurations.

Panel Technologies

Technology	Efficiency Range	Temperature Coefficient	Low-Light Performance	Physical	Best Use Case
Monocrystalline silicon	17 - 22% typical (up to ~24% for premium cells)	−0.35% / °C above STC	Good	Rigid, glass-covered, aluminum frame	Fixed installations, roof/pole mounts
Polycrystalline silicon	15 - 18%	−0.40% / °C above STC	Good	Rigid, glass-covered, aluminum frame	Budget fixed installations
Amorphous silicon (thin-film)	6 - 8%	−0.20% / °C above STC	Excellent (diffuse light)	Flexible or glass, no frame	Curved surfaces, low-light climates
CIGS thin-film	12 - 14%	−0.32% / °C above STC	Very good	Flexible or rigid	Curved surfaces where efficiency matters

For most LoRa node deployments, monocrystalline panels are the correct choice. Their higher efficiency means a smaller, lighter panel for the same power output - important when mounting on a mast or in a small enclosure. Thin-film flexible panels are useful when the panel must conform to a curved surface (conduit mast, cylindrical enclosure) or when severe vibration makes rigid glass panels impractical.

Understanding Wp (Watt-Peak) Ratings

Panel power is rated in Watts-peak (Wp) at Standard Test Conditions (STC): 1000 W/m² irradiance, 25 °C cell temperature, AM 1.5 spectrum. Real-world conditions deviate from STC in several important ways:

Real-World Adjustment Factors

Most rows below are losses (values below 1.0). One row — spectral mismatch in overcast — can slightly exceed 1.0 for amorphous panels (a small gain, not a loss). Do not blindly multiply every row together as if they were all losses; apply the spectral-mismatch row only to the panel technology it describes.

Adjustment Factor	Typical Value	Explanation
Temperature (hot day)	0.80 - 0.90	Cell temp in direct sun reaches 50 - 75 °C. Monocrystalline loses ~0.35%/°C above 25 °C. At 60 °C: 1 − (35 × 0.0035) = 0.878.
Dirt / dust / pollen	0.90 - 0.97	Uncleaned outdoor panel loses 3 - 10% annually. Clean panels every 6 - 12 months.
Wiring and connection losses	0.97 - 0.99	Resistance in MC4 connectors and cable runs. Use AWG 10 - 12 for runs over 5 m.
Charge controller harvest	0.65 - 0.97	This is the fraction of available panel energy delivered to the battery, not the controller's own conversion efficiency. PWM ties the panel to battery voltage, so a 18 V (12 V-nominal) panel charging a 13 V battery delivers roughly 65 - 75% of its rated energy — the mismatch is the loss, not the controller. MPPT tracks the panel's maximum-power point and delivers ~93 - 97%, recovering more when panel Vmp is well above battery voltage and in cold or low light. See Charge Controllers page.
Partial shading	0.50 - 1.00	Even 5% shadow on a cell in a string can reduce total output by 50%+ (bypass diodes mitigate but don't eliminate).
Spectral mismatch (overcast) — can exceed 1.0	1.0 - 1.05 for amorphous; ~0.95 for mono	A gain, not a loss, for amorphous: amorphous panels outperform mono in overcast because the diffuse-light spectrum favors their bandgap. Apply only to the matching panel technology.

Adjustment Factor	Typical Value	Explanation
Combined typical derating (MPPT, clean, no shade)	**0.70 - 0.80**	Use 0.75 as a conservative planning factor

Peak Sun Hours by US Region

Peak sun hours (PSH) is the equivalent number of hours per day at 1000 W/m² irradiance that delivers the same daily energy as the actual variable irradiance. It is the single most important geographic variable in panel sizing.

Region	Example Cities	Annual Avg PSH	Winter Worst-Month PSH
Southwest Desert	Phoenix, Las Vegas, El Paso	6.0 - 7.0	4.5 - 5.5
Mountain West	Denver, Salt Lake City, Albuquerque	5.5 - 6.5	3.5 - 4.5
Southeast	Miami, Atlanta, Dallas	5.0 - 6.0	4.0 - 5.0
Midwest / Great Plains	Kansas City, Minneapolis, Chicago	4.5 - 5.5	2.5 - 3.5
Mid-Atlantic / Northeast	NYC, Philadelphia, Boston	4.0 - 4.8	2.0 - 3.0
Pacific Northwest	Seattle, Portland, Eugene	3.5 - 4.2	1.5 - 2.5 (Seattle worst-month ~1.5)
Alaska (Anchorage)	Anchorage	3.0 - 4.0	0.5 - 1.5

Always size for the **worst-month PSH**, not the annual average, to ensure year-round operation. Use a single worst-month PSH value per location across the whole book; the values here are representative and should be confirmed against NREL PVWatts for your exact site.

Panel Sizing Calculation

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Required_Wp = Daily_Wh / (PSH_worst_month × overall_derating)

Example: 5.75 Wh/day node, Seattle (1.5 PSH worst-month winter), MPPT controller (0.95), other c
 Combined derating = 0.95 × 0.85 = 0.808
 Required_Wp = 5.75 / (1.5 × 0.808) = 5.75 / 1.212 = 4.74 Wp → use a 5 Wp panel (sized for the w
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Panel Sizing by Latitude (Rule of Thumb)

Latitude (°N)	Panel Wp Required per 1 Wh/day node load	Notes
25 - 30° (South Florida, Texas)	0.5 - 0.7 Wp	Year-round high sun
30 - 37° (Southeast, Southwest)	0.6 - 0.9 Wp	Good solar resource
37 - 42° (Mid-Atlantic, Midwest)	0.9 - 1.3 Wp	Moderate winter derating
42 - 48° (New England, Northwest)	1.3 - 2.0 Wp	Poor winter sun
48 - 65° (Northern US, Alaska)	2.0 - 5.0 Wp	Size for worst month or use large battery

Wiring: 5 V USB Charging vs 12 V Systems

5 V USB Charging (small panels, direct LiPo charging)

Panels rated 5 - 6 V open-circuit (e.g., 0.5 - 2 W "USB solar panels") are designed to pair with TP4056 or CN3791 LiPo charger ICs. These work only in full sun - the panel voltage drops below the charger's minimum input at partial cloud cover. Acceptable for *supplemental* trickle charging of small nodes but not reliable primary power. Note neither the TP4056 nor the CN3791 has a low-temperature charge cutoff, so for cold-climate builds add a BMS or charge controller with low-temp protection.

12 V Nominal Systems

Panels rated 18 V open-circuit (12 V nominal, e.g., 10 W, 20 W, 40 W monocrystalline) are the standard for serious solar deployments. These pair with a dedicated charge controller (PWM or MPPT) that regulates voltage down to the battery charge voltage. MC4 connectors are the industry standard for these panels.

Series vs Parallel Configuration

Configuration	Effect on Voltage	Effect on Current	When to Use
Series (panels in series)	Voltages add (2× 18 V = 36 V)	Current stays same	Higher voltage charge controllers; longer cable runs (less current = thinner wire)
Parallel (panels in parallel)	Voltage stays same	Currents add (2× 5 A = 10 A)	Same voltage system but need more current; partial shading (each panel has independent MPPT)

For small LoRa deployments (5 - 40 Wp), a single panel in direct connection to a 12 V charge controller is the simplest and most reliable approach.

Recommended Panels for LoRa Deployments

Prices below are approximate and volatile, as of 2026-06-08; confirm against a current listing before buying.

Panel	Power	Dimensions	Best For	Approximate Cost
Voltaic P110 (monocrystalline)	2 W, 6 V	132 × 91 mm	nRF52840 trickle charge, USB-C output	$25
Newpowa NPA10-12MBK (mono)	10 W, 12 V nominal	340 × 235 mm	ESP32 nodes, primary solar	$20 - 25
Renogy RNG-100D-SS (mono, compact)	100 W, 12 V nominal	~1062 × 531 mm	Pi gateway installations	$85 - 100
Flexible mono ~50 W (verify SKU/datasheet)	~50 W, 12 V nominal	per datasheet	Curved mast mounting, marine	confirm current price
Flexible CIGS ~30 W (verify SKU/datasheet)	~30 W, 12 V nominal	per datasheet	Curved enclosures, portable	confirm current price

Solar Panel Mounting and Orientation

The mechanical installation of a solar panel is as important as the panel selection itself. A correctly sized panel pointed in the wrong direction, partially shaded, or insufficiently secured will fail to meet its energy budget. This page covers orientation rules, mounting hardware options, shading avoidance, and special-purpose installations.

South-Facing Tilt: The Fundamental Rule

In the Northern Hemisphere, solar panels produce maximum annual energy when facing **true south** (azimuth 180°) and tilted at an angle approximately equal to the installation latitude. This is not magnetic south - use a compass corrected for magnetic declination or use a sun-path tool (NREL's PVWatts, Solargis) to confirm true south orientation at your specific location. **This page is the canonical reference for panel tilt and orientation in this book.** The single rule of thumb used throughout: **optimal fixed tilt = latitude; winter-optimized tilt = latitude + 15°.** The example tilt values in the table below are approximate and should be confirmed against NREL PVWatts output for your specific site.

Latitude (°N)	Optimal Fixed Tilt	Winter-Optimized Tilt	Example Locations
25°	25°	~40°	Miami FL, Key West FL
30°	30°	~45°	Houston TX, Jacksonville FL
35°	35°	~50°	Los Angeles CA, Memphis TN
40°	40°	~55°	Denver CO, Columbus OH, NYC
45°	45°	~60°	Minneapolis MN, Portland OR
47°	47°	~62°	Seattle WA
61°	~58°	~73°	Anchorage AK

Values are approximate (fixed ≈ latitude, winter ≈ latitude + 15°) and should be confirmed against NREL PVWatts for the exact location. Above roughly 55°N the annual optimum is typically a few degrees *below* latitude, which is why Anchorage's fixed value is shown slightly under its latitude.

For fixed-tilt installations in climates with significant winter operation (Pacific NW, New England, Mountain states), set the panel at approximately latitude + 15° to capture more low winter sun. This sacrifices some summer production but improves the worst-month (winter) performance critical for battery sizing.

A ±15° deviation from true south reduces annual yield by only 2 - 3%. A ±30° deviation reduces it by about 7 - 8%. East or west orientations (90° from south) reduce yield by approximately 20%.

Fixed Tilt vs Seasonal Adjustment

Single-axis seasonal adjustment (adjusting tilt twice a year - summer and winter) improves annual yield by 5 - 10% compared to a fixed optimal tilt. For most unattended LoRa deployments, this tradeoff is not worth the maintenance visit. The exception is a high-latitude deployment (above 45°N) where winter sun angles are very low and a steep winter tilt meaningfully improves worst-month performance.

Mounting Hardware Options

Pole and Mast Mounts

Mast mounting is ideal for LoRa repeaters that are already on a mast or tripod. The same structure that supports the LoRa antenna can support the solar panel, reducing site footprint. Two common approaches:

- **Side-of-pole (SOP) mount:** A steel bracket clamps to the mast with U-bolts and holds the panel at an adjustable tilt. Generic U-bolt side-of-pole brackets (for example the Renogy Solar Panel Side of Pole Mount, which fits panels up to ~100 W) are widely available for roughly $15 - 30 (prices as of 2026-06-08). The panel faces south and the bracket tilt is fixed at installation.
- **Top-of-pole mount:** Panel mounts above the mast on a swiveling head. Larger capacity (40 - 100 Wp panels), more wind load. Several manufacturers (Unirac, IronRidge, MT Solar, Tamarack) make pole mounts; for a single small panel, Renogy's single-panel pole mount (rated for panels up to ~100 W, roughly $40 - 60 as of 2026-06-08) is a common choice. Confirm the mount's rated panel size and the current price before purchasing.

J-Mounts (Roof Rafter Mounts)

J-mounts bolt through the roof into rafters and hold the panel parallel to the roof surface, adding 2 - 4 inches of standoff for airflow. IronRidge, Unirac, and Quick Mount PV are the main suppliers. J-mounts fix the panel tilt to the roof pitch - generally acceptable for slopes between roughly 15° and 40° facing south. Note that on shallow slopes the panel sits well below latitude tilt, so annual yield is reduced compared with a latitude-tilt mount.

Flush Roof Brackets

For panels mounted flat on a low-slope roof or equipment enclosure lid, industrial hook-and-loop adhesive mounts (for example VELCRO Brand Industrial Strength or 3M VHB tape) or through-bolted HDPE brackets work for small panels up to about 40 Wp. Adequate ventilation between panel and surface is critical - at a cell temperature of 75 °C (about 50 °C above the 25 °C STC rating), a panel loses roughly 15 - 20% of its rated Wp, assuming a typical temperature coefficient of about −0.35 to −0.40%/°C.

Ground-Mount Frames

For larger gateway installations (100 - 400 Wp), commercial aluminum ground-mount frames (for example IronRidge's ground-mount / Osprey PowerRack line, or kits from MT Solar or Tamarack) provide adjustable tilt and, with proper engineering, wind resistance up to about 140 mph. The actual wind rating depends entirely on the specific anchoring, soil, and panel - do not assume the frame alone guarantees a high-wind rating; engineer the foundation for your site. Concrete ballast blocks or driven ground screws provide the foundation.

Keeping Panels Shadow-Free Throughout the Day

Shade is the single largest cause of underperforming solar nodes. A shadow covering just one cell in a 36-cell string drops the entire string's output by 50 - 70% (partial bypass diode protection reduces this but cannot eliminate it).

1. **Use the Sun Surveyor app or SOLMETRIC SunEye** to measure shade at the proposed mounting location at both 9 AM and 3 PM local solar time on the worst day (December 21). Any obstruction that casts shadow during these hours will significantly reduce winter output.

2. Trees grow. A tree 30 ft away that doesn't shade the panel today may shade it in 5 years. Add 30% to the estimated shadow cone radius when evaluating obstructions.
3. Nearby LoRa antennas, lightning rods, conduit runs, and fence posts can all cast thin shadows that track across the panel during the day. Route everything above or well to the side of the panel.

Clearing Snow

In snow climates, steep tilt angles (above 45°) allow snow to slide off naturally. Panels tilted below 30° will accumulate snow and may be buried for days. Solutions:

- Set winter tilt to 60° or greater if the installation allows adjustment.
- Mount the bottom edge of the panel at least 18 inches above the expected snow depth to prevent burial.
- Do not scrape panels with metal scrapers - use a soft brush or wait for natural sliding (the panel warms as soon as any light penetrates the snow cover).
- Black-frame monocrystalline panels absorb more heat and shed snow faster than white-back polycrystalline panels.

Bird Deterrents

Bird droppings on panels cause significant localised shading. Common solutions:

- **Bird wire / netting:** Stainless steel spikes (Daddi Long Legs, Bird-B-Gone) or polycarbonate mesh installed under and around the panel perimeter. Do not run wires over the glass surface.
- **Owl decoys:** Marginally effective for the first few weeks, then ignored.
- Regular cleaning with deionised water and a soft sponge removes existing droppings. A Rain-X solar panel coating reduces adhesion.

Marine and Boat Mounting for Floating Nodes

Floating LoRa nodes on buoys, boats, or floating platforms require stainless steel or anodized aluminum hardware throughout. Standard steel J-mounts will rust within one season in saltwater. Key requirements:

- All fasteners: 316 stainless steel (not 304).

- Tilt adjustment: Bobstay-style adjustable bracket allows panel to be angled away from most wave wash directions.
- Strain relief: Marine-grade cable glands (Blue Sea, Wiley) with EPDM seals. Cables must have enough slack to accommodate platform motion without straining MC4 connectors.
- Anti-corrosion treatment: Corrosion-X or Boeshield T-9 applied to all metal-to-metal contacts and terminal blocks annually.
- Prefer a panel with an IP67-rated, sealed junction box and conformal-coated connections for salt-spray service. Most quality terrestrial panels already use IP67 junction boxes, but in continuous salt-spray conditions confirm the J-box seal rating rather than relying on an informal "marine grade" label, which is not a formal standard.

Charge Controllers: PWM vs MPPT

The charge controller sits between the solar panel and the battery. It regulates current flow to prevent battery overcharge and manages the charging profile. Two fundamentally different control topologies are in common use: Pulse Width Modulation (PWM) and Maximum Power Point Tracking (MPPT). Selecting the wrong type typically costs 10 - 30% of available solar harvest (larger in cold or cloudy conditions, smaller when the panel's Vmp is close to the battery voltage) or can damage batteries.

How PWM Controllers Work

A PWM charge controller connects the solar panel directly to the battery through a switch (MOSFET or relay). When the battery voltage is low, the switch is fully on - the panel feeds the battery at whatever current the panel can supply at the battery's current voltage. As the battery approaches full charge, the controller begins pulsing the switch on and off at a duty cycle proportional to the difference between target and actual battery voltage. This reduces average current flow, preventing overcharge.

The critical limitation of PWM: **the panel is forced to operate at battery voltage, not at its own maximum power point (MPP).** A 12 V nominal panel has an MPP voltage (Vmpp) around 17 - 18 V but the battery sits at 12 - 14.6 V. The panel is clamped to the lower voltage, operating well off its power curve. This is the root cause of PWM's lower efficiency. PWM is well-matched only where the panel's Vmp is close to the battery voltage (e.g. a "12 V" PWM-type panel on a 12 V battery); the larger the gap between panel Vmp and battery voltage, the more an MPPT controller gains.

How MPPT Controllers Work

An MPPT controller inserts a DC-DC buck (or boost) converter between the panel and battery. The controller continuously monitors the panel's voltage and current output, computing $P = V \times I$. It then incrementally adjusts the panel's operating point (by changing the duty cycle of the converter's switching transistor) to locate and track the voltage at which the panel delivers maximum power - the Maximum Power Point.

Because the converter can step voltage down (or up) at high efficiency, the panel operates at its optimal Vmpp (~17 - 18 V for a 12 V panel) while the battery receives the current it needs at battery voltage. This voltage step-down comes with a compensating current increase, delivering more total watts to the battery.

Efficiency Comparison

Parameter	PWM Controller	MPPT Controller
Typical conversion efficiency	65 - 75% of panel STC rating	93 - 97% of panel STC rating
Panel voltage utilisation	Poor - clamped to battery voltage	Excellent - panel at MPP
Cold weather advantage	None	Significant - cold panels have higher Voc/Vmpp, MPPT captures this gain
Partial cloud benefit	None	Moderate - can still track the shifted MPP under clouds
Typical cost (5 - 20 A range)	$5 - 15	$20 - 60
Quiescent current consumption	5 - 15 mA	10 - 30 mA
Complexity / failure modes	Low - simple circuit	Moderate - switching converter can fail; firmware-dependent tracking

When the Difference Matters

Small Panels (under ~10 Wp)

For very small panels (2 - 5 Wp paired with a small LiPo and an ESP32 or nRF52840 node), the absolute watt improvement from MPPT is tiny - perhaps 1 - 2 W - and the MPPT controller's own quiescent current (20 - 30 mA = 0.07 - 0.11 Wh/h) becomes a significant fraction of the total load. For these micro-installations, a dedicated LiPo solar charger IC such as the **CN3791** (switching MPPT-style solar charger IC, ~$1) or **TP4056** (simple linear CC/CV, no MPPT, ~$0.30) is the appropriate solution. Full-featured MPPT controllers add cost, quiescent drain, and complexity with minimal return. **Note:** neither the TP4056 nor the CN3791 has a low-temperature charge cutoff - see the cold-climate warning below before using either in a build that may charge below freezing.

Medium Panels (10 - 100 Wp)

This is where MPPT begins to pay for itself. Using the efficiency figures in the table above, a 20 Wp panel with a PWM controller delivers approximately 14 W to the battery in ideal conditions (20 Wp

× 0.70). The same panel with an MPPT controller delivers approximately 19 W (20 Wp × 0.95) - about a 36% improvement. (Here "W" is the actual delivered power; "Wp" is reserved for the panel's STC rating.) Over a 5-day winter week at Seattle's 1.8 PSH average:

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PWM:  20 Wp × 0.70 × 1.8 PSH × 5 days = 126 Wh
MPPT: 20 Wp × 0.95 × 1.8 PSH × 5 days = 171 Wh
Difference: 45 Wh - roughly an extra day of autonomy

# Caveat: 1.8 PSH is an AVERAGE winter day. During a genuine multi-day
# Pacific-NW storm, harvest from BOTH controller types drops toward zero,
# so MPPT's advantage cannot be relied on to carry you through the storm.
# MPPT helps you RECOVER faster between storms; the BATTERY RESERVE - not
# the controller - must cover the no-sun stretch itself.
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Large Panels (over 100 Wp) and Cold Climates

MPPT is the only correct choice. In cold climates (below freezing), panel Vmpp rises significantly - a 36-cell panel that has Vmpp = 17 V at 25 °C may have Vmpp = 20 - 21 V at −10 °C. A PWM controller cannot exploit this; an MPPT controller captures all of it.

Cold-climate charge cutoff (critical safety item): In sub-freezing conditions, ensure the LiFePO4 BMS or charge controller inhibits charging below 0 °C (32 °F). **Never charge any lithium chemistry - including LiFePO4 - below 0 °C:** sub-freezing charging causes lithium plating, leading to permanent capacity loss and a hidden internal-short fire risk. (Discharge is fine to much lower temperatures - LiFePO4 discharges to about −20 °C.) Use a BMS with low-temperature charge protection, or a charge controller with a battery temperature sensor. Bare charger ICs such as the TP4056 and CN3791 have no low-temperature cutoff, so add external low-temp protection for any cold-weather build.

LVD Settings for LiFePO4 Packs

Low Voltage Disconnect (LVD) is the battery voltage at which the charge controller cuts power to the load, protecting the battery from over-discharge. Setting LVD correctly for LiFePO4 is critical - these batteries have flat discharge curves that make "soft" voltage warnings less useful. Two distinct thresholds matter and should not be confused: the **operating LVD** (the load-disconnect you set for longevity, ~12.0 V / ~3.0 V per cell) and the **BMS hard under-voltage protection (UVP)** (an absolute floor, ~10.0 - 10.8 V / ~2.5 - 2.7 V per cell) that should only ever trip as a last-resort safety cutoff.

Parameter	12 V LiFePO4 (4S, 12.8 V nominal)	12 V Lead Acid (12 V nominal)

Operating LVD (load disconnect)	~12.0 V (3.0 V/cell, ≈ 10 - 20% SoC remaining)	11.4 - 11.8 V (≈ 40 - 50% SoC)
BMS hard UVP (absolute floor)	10.0 - 10.8 V (2.5 - 2.7 V/cell) - last-resort cutoff only	10.5 - 11.0 V
LVD reconnect voltage (hysteresis)	12.8 - 13.0 V (well above the operating LVD to avoid relay chatter)	12.2 - 12.5 V
Absorption charge voltage	14.2 - 14.6 V (3.55 - 3.65 V/cell; ~14.4 V typical)	14.4 - 14.8 V
Float voltage	13.5 - 13.6 V (3.375 - 3.40 V/cell; use ~13.5 V)	13.2 - 13.8 V
Equalization	Do NOT equalize LiFePO4	15.0 - 16.0 V periodically

SoC-from-voltage caveat: LiFePO4's discharge curve is very flat through the mid-range, so the percentage-of-charge values mapped to each voltage above are approximate - treat them as rough guidance, not a precise fuel gauge. Do NOT float a LiFePO4 pack at 14.4 V / 3.60 V per cell: that holds the pack near 100% and accelerates aging - use ~13.5 V. The reconnect/hysteresis thresholds shown are sensible defaults; confirm against your specific charge controller's manual (e.g. Victron, Epever, Morningstar) before relying on them. (as of 2026-06-08)

Critical: Many PWM controllers sold as "12 V" ship with default lead-acid charge profiles. If used with LiFePO4, the float voltage will be too low and the absorption voltage may be set for gel/AGM lead acid (14.1 V) which undercharges LiFePO4. Always verify and configure the LiFePO4 profile. Renogy Rover, Victron BlueSolar, and Epever controllers have configurable user-defined battery profiles.

Common Charge Controllers for Small LoRa Deployments

IC-Level (for integration into custom PCBs)

IC	Type	Input Voltage	Max Charge Current	Chemistry	Cost
TP4056	Linear CC/CV (no MPPT)	4.5 - 8 V	1 A	LiPo (4.2 V cutoff)	$0.25 - 0.40

IC	Type	Input Voltage	Max Charge Current	Chemistry	Cost
CN3791	MPPT-style, switching	~4.5 - 28 V (PV)	Up to ~4 A (IC capability; typical hobby boards limit to ~2 A via the sense resistor / external FET)	LiPo (4.2 V cutoff)	$0.80 - 1.20
BQ24650	MPPT, synchronous buck	Up to 28 V	Up to 10 A	Configurable (Li, LiFePO4)	$2 - 4
SPV1040	MPPT, boost converter	0.3 - 5.5 V (per STMicro SPV1040 datasheet)	1.8 A out	LiPo, NiMH	~$1.50 - 2.50 (approx)

Notes: the CN3791's 2 A figure commonly quoted for hobby breakout boards is a board-specific limit set by the sense resistor and external FET, not the IC's maximum (the IC supports constant current up to ~4 A and a wide PV input range). SPV1040 input range and output current are per the STMicro SPV1040 datasheet; IC prices are approximate. (as of 2026-06-08)

Module-Level (drop-in for 12 V systems)

Module	Type	Panel Watts (max)	Features	Cost
Renogy Wanderer 10A PWM	PWM	120 W	LCD, LVD, USB output	$20
Epever Tracer AN 10A MPPT	MPPT	130 W	RS485 MODBUS, LCD, configurable profiles	$35 - 45
Victron SmartSolar 75/10	MPPT	145 W @ 12 V	Bluetooth, VictronConnect app, LiFePO4 profile	$55 - 65
Genasun GVB-8 (8A MPPT)	MPPT	110 W	Purpose-built LiFePO4 profiles, waterproof	$75 - 90
SRNE ML2430 30A MPPT	MPPT	390 W @ 12 V	LCD, multiple battery profiles, USB	$45 - 55

For most LoRa gateway installations (20 - 100 Wp), the **Victron SmartSolar 75/10** is the recommended choice: Bluetooth monitoring allows verifying charge behaviour remotely, and the LiFePO4 profile is well-tested. For budget-constrained multi-node deployments, the **Epever Tracer AN 10A** provides RS485 telemetry for integration with Grafana monitoring stacks.