

Battery Sizing for LoRa Mesh Nodes

Correctly sizing the battery for a solar-powered LoRa node prevents two failure modes: undersizing (the battery dies overnight or during cloudy periods) and oversizing (wasted cost and weight). This page walks through a systematic methodology and provides worked examples for three common node types.

Step 1 - Measure Actual Current Draw

Never rely solely on datasheet figures. Real-world current draw depends on firmware configuration, peripherals, GPS lock cycles, LoRa transmit duty cycle, and whether deep sleep is used. Measure with a USB power meter (e.g., UM25C, AT34) or an inline current shunt (e.g., INA219 module on the 3.3 V rail).

Take measurements in three states:

1. **Transmit peak:** Current during an active LoRa TX burst (typically 80 - 120 mA at 3.3 V for SX1276-based modules at +17 dBm).
2. **Receive / idle:** Firmware running, radio in RX mode, no TX. This is the *whole-node* draw (MCU + radio + regulator + peripherals), typically 30 - 80 mA on ESP32-class boards — the SX1276 radio alone is only ~11 - 14 mA in RX, the rest is the MCU and supporting circuitry. Confirm against a board-level power measurement for your platform.
3. **Deep sleep (if used):** Microcontroller and radio in lowest power state, highly design-dependent (0.01 - 10 mA). An nRF52840 board with clean power management can reach low microamps, whereas an ESP32 board with a leaky regulator may sit in the milliamp range — measure your specific board (e.g. nRF52840 vs ESP32 T-Beam) rather than assuming.

Calculate a **weighted average current** based on the fraction of time spent in each state. The example below is *illustrative*, using an assumed duty cycle rather than measured T-Beam data — substitute your own measured currents and duty cycle. For a Meshtastic router node set to 5-minute heartbeat with 20-second sleep cycles:

Illustrative example (assumed duty cycle): T-Beam v1.1 (ESP32 + SX1276 + NEO-6M GPS)
TX (0.5% of time at 120 mA) = 0.6 mA average
RX active (79.5% at 80 mA) = 63.6 mA average
Deep sleep (20% at 3 mA) = 0.6 mA average

Weighted average $\approx$ 64.8 mA

Step 2 - Calculate Daily Watt-Hours

Multiply the average current (in amps) by the system voltage and by 24 hours. Use the voltage the node actually runs at when you measured the current — for a single-cell board that is $\sim$ 3.7 V, even if the battery pack you eventually buy is a 12.8 V LiFePO4 pack. Energy (Wh) is conserved across the voltage conversion: you compute daily Wh at the node's running voltage, then later convert the required Wh to pack Ah using the *pack's* nominal voltage (Step 6). Do not mix the 3.7 V cell figure with a 12.8 V pack in the same multiplication.

$$\text{Daily_Wh} = I_{\text{avg}}(\text{A}) \times V_{\text{system}}(\text{V}) \times 24 \text{ h}$$

Example: $64.8 \text{ mA} \times 3.7 \text{ V} \times 24 \text{ h} = 5.75 \text{ Wh/day}$

If your system runs at 5 V (e.g., USB-powered node) or 12 V (e.g., Raspberry Pi gateway), substitute the appropriate system voltage.

Step 3 - Determine Required Autonomy Days

Autonomy is the number of consecutive days with no solar input (full cloud cover, snow burial, north-facing shade) the battery must sustain the node. Select based on your climate and criticality:

Deployment Type	Recommended Autonomy	Rationale
Sunny desert / Southwest US	3 - 5 days	Extended low-sun periods are rare
Pacific Northwest / Northeast US	5 - 7 days	Multi-day overcast events common Nov - Mar
High alpine / polar	7 - 14 days	Snow burial possible; winter darkness
Non-solar (mains backup only)	0.5 - 1 day	Bridge a brief power outage

Step 4 - Calculate Raw Battery Capacity

Raw_Wh = Daily_Wh × Autonomy_days

Example (5 days autonomy): 5.75 Wh × 5 = 28.75 Wh

Step 5 - Apply Derating Factors

Real batteries deliver less than their nameplate capacity due to temperature, aging, and depth-of-discharge limits. Apply the following derating multipliers. The temperature factors below are **conservative planning estimates** for a −10 °C average low, not values pulled from a specific datasheet curve — check your battery's own capacity-vs-temperature curve where one is published:

Factor	LiFePO4	LiPo	Lead Acid
Max recommended DoD	80% (use 0.80)	80% (use 0.80)	50% (use 0.50)
Temperature derating (cold climate, −10 °C avg low — conservative estimate)	0.85	0.70	0.65
End-of-life capacity (design to still work at EOL)	0.80	0.80	0.80
Combined derating factor	0.80 × 0.85 × 0.80 = 0.544	0.80 × 0.70 × 0.80 = 0.448	0.50 × 0.65 × 0.80 = 0.260

Cold-charge warning: Never charge any lithium chemistry — including LiFePO4 — below 0 °C (32 °F); sub-freezing charging causes lithium plating and permanent damage. In cold climates require a BMS with low-temperature charge cutoff or a charge controller with a battery temperature sensor. (LiFePO4 may still *discharge* down to about −20 °C.)

Required_Wh = Raw_Wh / Combined_derating_factor

Example (LiFePO4, cold climate): 28.75 / 0.544 = 52.8 Wh → round up to 53 Wh

Step 6 - Add a 20% Safety Margin and Convert to Ah

$\text{Final_Wh} = \text{Required_Wh} \times 1.20$ (20% safety margin)

$\text{Final_Ah} = \text{Final_Wh} / V_{\text{nominal_pack}}$

Example (LiFePO₄, 12.8 V nominal pack):

$\text{Final_Wh} = 52.8 \times 1.20 = 63.4 \text{ Wh}$

$\text{Final_Ah} = 63.4 / 12.8 = 4.95 \text{ Ah} \rightarrow$ use a 6 Ah pack

Worked Examples

Example A - ESP32 LoRa Repeater (T-Beam, indoor/outdoor enclosure)

Platform	TTGO T-Beam v1.1 (ESP32 + SX1276 + AXP192 PMIC)
Measured average current	65 mA at 3.7 V = 0.240 Wh/h
Daily consumption	5.76 Wh/day
Target autonomy	5 days (Pacific NW)
Raw requirement	28.8 Wh
After derating (LiFePO ₄ , cold)	$28.8 / 0.544 = 52.9 \text{ Wh}$
With safety margin	63.5 Wh $\rightarrow$ use 6 Ah at 12.8 V (76.8 Wh nominal)
Recommended battery	Bioenno BLF-1206A (6 Ah, 12.8 V LiFePO ₄) or equivalent

Example B - nRF52840 Ultra-Low-Power Node (RAK4631 + solar harvest)

Note on chemistry: the LiPo sizing below is shown only to illustrate the LiPo derating column. For an unattended outdoor or permanent solar deployment, LiPo is **not recommended** — use a LiFePO₄ (or a protected Li-ion) cell instead, per the battery-chemistry, LiFePO₄-vs-LiPo, and cold-weather pages. The 8 mA average is an assumed measurement; the duty cycle behind it (mostly deep sleep

with brief RX) must be confirmed on your own board.

Platform	RAK WisBlock Core RAK4631 + RAK12500 GPS (GPS duty-cycled off)
Measured average current	8 mA at 3.7 V = 0.0296 Wh/h (assumed, with aggressive sleep — confirm duty cycle on your board)
Daily consumption	0.71 Wh/day
Target autonomy	7 days
Raw requirement	4.97 Wh
After derating (LiPo, moderate climate — illustration only)	$4.97 / (0.80 \times 0.80 \times 0.80) = 9.71 \text{ Wh}$
With safety margin	11.65 Wh → at 3.7 V = 3.15 Ah → use a 3.5 Ah cell
Recommended battery	EEMB LP905060 3.7 V 3500 mAh (meets the 3.15 Ah requirement). Note: Adafruit #328 is a 2500 mAh cell — below the 3.15 Ah needed here, so prefer the 3500 mAh option for outdoor use.

Example C - Raspberry Pi Zero 2W + SX1302 HAT Gateway

Gateway note: a gateway is the highest-value node in an incident (it bridges to internet/MQTT), so the 3-day / no-cold-derate figures below are a desert best-case, not a default. For a gateway, use at least 5-day autonomy even in sunny climates, and do not apply a 1.00 temperature factor unless you have confirmed the battery never sees sub-freezing nights. The 620 mA average is a representative estimate (Pi Zero 2W idles ~150 - 250 mA, the SX1302 HAT adds load) — measure your own build.

Platform	RPi Zero 2W + RAK2287 SX1302 HAT + LTE modem
Measured average current	620 mA at 5 V = 3.1 W = 3.1 Wh/h (representative estimate — measure your build)
Daily consumption	74.4 Wh/day
Target autonomy	5 days (use ≥5 days for a gateway, even in sunny climates)
Raw requirement	372 Wh
After derating (LiFePO4: 0.80 DoD × 0.85 temp × 0.80 EOL = 0.544)	$372 / 0.544 = 684 \text{ Wh}$
With safety margin	821 Wh → at 12.8 V = 64 Ah → use a 100 Ah pack
Recommended battery	Battle Born BB10012 (100 Ah, 12 V LiFePO4) or 2× EVE LF50K-class packs in parallel

Rule of Thumb Quick Reference

These figures are computed from the Step 1-6 methodology (5-day autonomy, LiFePO4, with DoD/cold/EOL derate and a 20% margin). They are planning floors — run your own numbers from your measured daily Wh.

Node Type	Typical Daily Wh	Minimum Battery (5-day, LiFePO4)
nRF52840 sleepy node	0.3 - 1.5 Wh	~1 - 5 Ah @ 3.7 V
ESP32 Meshtastic router (no GPS)	3 - 5 Wh	~7 - 12 Ah @ 3.7 V (or ~2 - 4 Ah @ 12.8 V)
ESP32 + GPS always-on	5 - 10 Wh	~12 - 25 Ah @ 3.7 V (or ~4 - 7 Ah @ 12.8 V)
Pi Zero 2W gateway	60 - 90 Wh	~50 - 75 Ah @ 12 V
Pi 4 + LTE gateway	100 - 150 Wh	~80 - 120 Ah @ 12 V

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