Power Fundamentals

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Current Draw & Power Budgets

Current Draw & Power Budgets

Understanding how much power your node consumes is the starting point for sizing batteries and solar panels. LoRa mesh nodes have variable current draw depending on what they are doing at any given moment.

Typical Current Draw by State

State	Current Draw	Notes
Deep sleep (nRF52)	2 - 20 µA	Heltec Wireless Paper: ~20 µA; T-Echo: ~2 - 5 µA
Deep sleep (ESP32)	10 - 100 µA (bare MCU); often hundreds of µA to a few mA at board level	Bare-module figures; real ESP32 Meshtastic boards draw far more (community measurements show up to ~2.7 mA) due to regulators/peripherals
Idle / listening	nRF52: ~10 - 30 mA; ESP32: ~40 - 80 mA	Radio on, waiting for packets; display off. ESP32-based boards (e.g. Heltec V3) draw considerably more than nRF52 boards (e.g. RAK4631, T-Echo)
Active with display	30 - 60 mA	OLED adds ~10 - 20 mA; e-ink adds ~0 mA between refreshes
Transmitting	Radio/PA ~50 - 120 mA; whole device commonly 150 - 330 mA at 22 dBm	The ~80 mA figure is radio-only on efficient boards (RAK nRF52840 ≈ 88 mA); full-board TX current at 22 dBm reaches ~163 - 332 mA depending on board (MCU + PA + regulator). Representative — measure your own

State	Current Draw	Notes
Transmitting (Station G2, 36.5 dBm)	~800 - 1200 mA (estimate)	36.5 dBm (≈4.46 W) RF output is the manufacturer spec; the current draw is an estimate (the vendor notes consumption does not scale strongly with PA output). Requires a 15 V PD supply (≥20 W). Note: 4.46 W EIRP/conducted may exceed license-free power limits in your band/jurisdiction — verify the legal limit before transmitting at full power

Average Current for a Repeater Node

A repeater node running MeshCore is mostly in idle/listening mode, with brief transmit bursts when relaying traffic. Typical average:

- **Idle listening:** ~10 - 15 mA most of the time for an nRF52-class board (e.g. RAK4631); ESP32 repeaters idle considerably higher (~40 - 80 mA). Representative values — measure your own
- **Transmit duty cycle:** Low (a few percent in typical mesh traffic)
- **Average current:** ~10 - 15 mA for a lightly-loaded nRF52 repeater; an ESP32 repeater (Heltec V3) averages ~40 - 80 mA. These are representative figures from community measurements — measure your own board

Calculating Daily Energy Use

Daily energy (Wh/day) = Average current (A) × Voltage (V) × 24 hours. Equivalently, Wh/day = average current (mA) × 24 h × system voltage (V) ÷ 1000. (Current in mA × hours gives mAh/Ah; you must multiply by voltage to get watt-hours.)

Example for an nRF52 (RAK4631) repeater:

- Average current: 12 mA = 0.012 A (representative nRF52 figure — measure your own)
- Battery voltage: 3.7V (nominal LiPo/Li-ion)
- Daily energy: 0.012 × 3.7 × 24 = **~1.07 Wh/day**

An always-on ESP32 board (e.g. Heltec V3) averaging ~50 mA would instead consume 0.050 × 3.7 × 24 ≈ **4.4 Wh/day** — roughly four times as much. Always size to your specific board.

This is the baseline figure used in solar sizing calculations. A Room Server running with active connections may draw more - budget 3 - 4 Wh/day for a heavily used Room Server node.

Power Budget Worksheet

Parameter	Your Value	Notes
Average current draw (mA)	___	Measure with a USB power meter or estimate from table above
Supply voltage (V)	3.7	Standard LiPo/Li-ion nominal voltage
Daily energy (Wh/day)	___	= current(A) × 3.7 × 24
Days of battery reserve needed	___	General outdoor solar nodes: 3 - 5 days. Emergency-comms nodes: 5 - 7+ days (panels do not help during multi-day overcast)
Battery capacity needed (Wh)	___	= daily energy × reserve days ÷ (usable fraction × cold derate × end-of-life derate) × 1.2 safety margin. For a warm-climate LiFePO4 node the usable fraction alone is ~0.80; for a cold-climate node the *combined* derate is roughly 0.58, so the battery must be substantially larger. Do NOT size on 0.80 alone in freezing climates — see the Battery Sizing page for the full method (this worksheet's simple 0.80 divisor undersizes a winter node by ~40%)
Worst-case peak sun hours	___	Look up your location's worst-month (December) value from NREL PVWatts — do not assume a flat 4 PSH year-round. Northern-US winter is ~1 - 2.5 PSH (e.g. Seattle/Portland ~1.5, Chicago ~2.5)
Solar panel needed (W)	___	= daily energy ÷ (peak sun hours × 0.75). The 0.75 overall system derate covers controller, wiring, temperature and soiling losses. Use your location's worst-month (winter) peak sun hours from NREL PVWatts — northern-US winter is ~1 - 2.5 PSH, not a flat 4

Measuring Real Current Draw

For accurate power budgeting, measure actual current with a USB power meter (for 5V USB-powered nodes) or a multimeter in series with the battery lead. A USB meter like the UM25C gives real-time current and accumulates energy over time. Log over a 24-hour period under typical traffic conditions for the most accurate average.

Reducing Power Consumption

- Disable unused peripherals (OLED display off when not needed)

- Use nRF52-based boards (T-Echo, T114, RAK4631, Wio series) instead of ESP32 for lower idle current
- Reduce TX power if the node is within range with lower power - every 3 dB reduction halves transmit current
- Enable deep sleep between transmit windows for infrequent sensor nodes

Battery Chemistry Guide

Battery Chemistry Guide

Choosing the right battery chemistry for your deployment is critical. The wrong choice leads to shortened battery life, safety hazards, or a node that fails in cold weather.

Li-ion 18650 Cells

The 18650 is the workhorse battery for DIY LoRa nodes. Named for its dimensions (18mm × 65mm), it is widely available, well-understood, and supported by most mid-range device designs with a holder.

Warning: Most 18650 cells sold on Amazon are counterfeit. The highest-capacity genuine 18650 cells on the market are roughly 3500mAh; anything advertised far above that (for example a 6000mAh cell from an unknown brand) is physically impossible and counterfeit. Buy from reputable electronics retailers only.

Recommended 18650 Cells

Prices below are approximate and volatile (as of 2026-06-08). Capacity and current ratings are from each manufacturer's datasheet.

Cell	Price	Capacity	Max Continuous	Notes
Samsung 35E Protected	$10	3500mAh	8A	Good all-around; protected circuit prevents overdischarge. 8A continuous per Samsung SDI INR18650-35E datasheet
Molicel M35A Protected	$12	3450mAh typ (3500mAh rated)	10A	Slightly higher max current than Samsung 35E (per Molicel datasheet)

Cell	Price	Capacity	Max Continuous	Notes
Panasonic NCR18650GA	$14	3450mAh	10A	Excellent quality; established brand (3450mAh / 10A per Panasonic NCR18650GA datasheet)

All three options are equivalent for LoRa node use. Typical node average draw is <200 mA; brief TX bursts can reach several hundred mA momentarily but still far below the cells' 8 - 10A ratings, so any of these cells will work well. Buy protected cells - the protection circuit prevents over-discharge which can damage the cell - unless the device or holder already provides over-discharge protection (for example a DW01-based module), in which case unprotected cells are fine and fit holders better.

21700 Cells

21700 cells are slightly larger (21mm × 70mm) and offer higher capacity. Fewer devices have 21700 holders but they can be used in custom builds or with adapter sleeves.

Cell	Price	Capacity	Max Continuous
Samsung 50S	$8 (as of 2026-06-08)	5000mAh	25A
Molicel P50B	$11 (as of 2026-06-08)	5000mAh	45A continuous (60A max)

LiPo Packs

Lithium polymer packs in various capacities with JST connectors are the standard battery choice for devices without 18650 holders (Heltec V3, many LilyGo boards). Match the connector type carefully.

Pack	Price	Capacity	Connector	Fits
3000mAh JST SH 1.25	$11	3000mAh	JST SH 1.25mm	Heltec V3, V4 (verify LilyGo board connector separately)
3200mAh JST	$15	3200mAh	JST (verify pin count against RAKwireless datasheet)	RAK19026
Rokland LiPo Packs	$10 - $20	Multiple sizes	Micro JST 1.25	Various; check listing for exact connector

LiPo caution: LiPo cells can swell, catch fire, or vent if overcharged, over-discharged, punctured, or charged at low temperatures. Use only with a proper charge controller. Never charge below 0°C

- this 0°C charge floor applies to every lithium chemistry, including LiFePO4. For unattended outdoor deployments in cold climates, prefer Li-ion 18650 or LiFePO4 over LiPo, and use a BMS with a low-temperature charge cutoff regardless of chemistry.

LiFePO4 (Lithium Iron Phosphate)

LiFePO4 is strongly preferred for outdoor and cold-weather deployments. Key advantages over Li-ion/LiPo:

- **Temperature tolerance:** Discharges at much lower temperatures (down to ~ - 20°C). Like all lithium chemistries, it must NOT be charged below 0°C - charging below freezing causes lithium plating, permanent capacity loss, and a hidden internal-short fire risk. For cold climates use a BMS with low-temperature charge cutoff or a charge controller with a battery temperature sensor.
- **Safety:** Much less prone to thermal runaway and far more abuse-tolerant than LiPo/NMC, but not fireproof - severe overcharge or puncture can still cause a fire. Still use a BMS and proper fusing.
- **Cycle life:** 2000 - 4000 cycles vs. 300 - 1000 for standard Li-ion (cycle life varies widely with depth of discharge)
- **Discharge curve:** Flat 3.2V nominal vs. 3.7V for Li-ion - verify your device supports 3.2V operation

Trade-off: Lower energy density than Li-ion. A LiFePO4 pack of the same physical size will have less capacity than a Li-ion pack. At - 40°C (which equals - 40°F) plan for roughly 40 - 60% capacity loss even with LiFePO4 - this loss is temporary and recovers as the cells warm - and size accordingly.

Battery Chemistry Comparison

Note: all lithium chemistries below share the same 0°C charge floor. The "Cold Weather" rating reflects discharge/survival performance and thermal stability, not a difference in charge temperature - LiPo's disadvantage is its lower thermal stability and the rarer availability of a low-temperature-cutoff BMS, not a different minimum charge temperature.

Chemistry	Nominal Voltage	Cold Weather	Safety	Cycle Life	Best For
LiPo	3.7V	Poor	Moderate	300 - 500	Indoor, portable, attended deployments
Li-ion 18650	3.7V	Moderate	Good (protected)	500 - 800	General purpose; most DIY builds

Chemistry	Nominal Voltage	Cold Weather	Safety	Cycle Life	Best For
LiFePO4	3.2V	Excellent	Excellent	2000 - 4000	Outdoor permanent, cold climate, unattended