

ME: What does usable DoD mean?

CHATGPT: DoD = Depth of Discharge

It's the fraction of a battery's total rated capacity that you can safely use without damaging its lifespan.

- Rated capacity: what the manufacturer states (e.g., 100 Ah at 48 V = 4.8 kWh).
- Usable DoD: how much of that you can actually pull out regularly.
- Remaining fraction: must stay in the battery to protect its chemistry.

Examples

- Li-ion (LiFePO_4) \rightarrow Usable DoD \approx 80–90%
- A 100 Ah LiFePO_4 battery gives you \sim 80–90 Ah usable.
- You leave \sim 10–20% charge inside as a buffer.
- Lead Acid (AGM/GEL) \rightarrow Usable DoD \approx 50%
- A 100 Ah SLA battery really gives only \sim 50 Ah usable.
- Draining more shortens life drastically.

Why it matters in your project

When we sized your battery (Step 4), we took the energy needed for 3 days and then divided by the Usable DoD.

That ensures the battery bank is large enough so that even after using the safe fraction, it still covers the load.

👉 Formula:

$$\text{Battery Wh (rated)} = \frac{\text{Required Wh}}{\text{Usable DoD}}$$

So if your IoT node needs 2,000 Wh for 3 days:

- Li-ion (DoD 0.8) $\rightarrow 2,000 / 0.8 = 2,500$ Wh rated.
- Lead Acid (DoD 0.5) $\rightarrow 2,000 / 0.5 = 4,000$ Wh rated.

That's why Li-ion packs are smaller for the same usable energy.

ME: I've chosen a power systems project to size a 48V solar battery pack for a remote IoT node. including a load profile, 3 days autonomy and cable loss

First explain in simple terms what I need to do to achieve this. Explain what a load profile is and 3 days autonomy

Then draft two alternate ten step plans with inputs, outputs and tests.

Include file names, units and a target plot. Don't make it too complex, I want to be able to

understand and explain it to someone.

CHATGPT: Simple explanation — what you need to do

1. Measure or estimate how much energy your remote IoT node uses each hour (this is the load profile).
2. Convert that energy into daily Wh (watt-hours).
3. Multiply by 3 days (autonomy) and add losses (cable losses, converter/inverter inefficiency, battery depth-of-discharge limits) to get the required battery energy.
4. Choose a 48 V battery capacity (Ah) that meets that energy requirement.
5. Design the solar charging (PV) and cable sizing so the battery is charged reliably and cable losses are acceptable.
6. Document everything and test with real or simulated data.

What is a load profile? What is “3 days autonomy”?

- Load profile: a list of the device’s power draw over time (typically in watts or amps, per minute or per hour). Example: at 00:00–06:00 the node sleeps at 2 W, 06:00–07:00 it wakes and transmits at 10 W, etc. Summing the profile over 24 hours gives daily energy (Wh/day).
- 3 days autonomy: the battery must supply the node for 3 full days without any solar input (e.g., bad weather for 3 days). So if the node needs 1,000 Wh per day, a 3-day autonomy implies storage for at least 3,000 Wh plus losses and safety margins.

Key formulas (simple)

- Energy per period: $E = P \times t$ ($W \times \text{hours} = \text{Wh}$)
- Daily energy: $E_{\text{day}} = \sum \text{hourly } P \times 1\text{h}$ (Wh/day)
- Battery required (Wh, before margins): $E_{\text{batt_nominal}} = E_{\text{day}} \times \text{autonomy_days}$
- Account for usable fraction (DoD) and system efficiency (η):

$\text{Battery_Wh_required} = E_{\text{batt_nominal}} / (\text{DoD_fraction} \times \eta_{\text{system}})$

Example: DoD_fraction = 0.5 (50% usable), $\eta_{\text{system}} = 0.9$ (90% round-trip)

- Convert Wh to Ah at 48 V: $\text{Ah} = \text{Wh} / 48$
- Cable power loss (DC): $P_{\text{loss}} = I^2 \times R$ where $I = P / V$, $R = \text{resistivity} \times \text{length} / \text{area}$ (or use conductor tables).

Worked example (simple numbers so you can explain it)

Assume you estimate the node uses 576 Wh/day (this is just an example — replace with your measured profile).

1. $E_{\text{day}} = 576 \text{ Wh}$
2. $\text{autonomy_days} = 3 \Rightarrow E_{\text{batt_nominal}} = 576 \times 3 = 1,728 \text{ Wh}$

3. Assume DoD = 50% (0.5), $\eta_{\text{system}} = 90\%$ (0.9):

Battery_Wh_required = $1,728 / (0.5 \times 0.9) \approx 3,840$ Wh

4. Convert to Ah at 48 V: Ah = $3,840 / 48 = 80$ Ah

So you'd specify a 48 V, 80 Ah battery pack ($\approx 3,840$ Wh) in this example.

Cable loss example: if the system current under average load is $I = P/V = 576 \text{ Wh/day} \div 24 \text{ h} \div 48 \text{ V} \approx 0.5 \text{ A}$ (small), but peak transmit may cause higher currents. For higher currents, use $P_{\text{loss}} = I^2 R$ to check heating and choose conductor area.

Target plot (what to show visually)

Filename: target_plot_soc_vs_time.png

Plot to create/attach: State of Charge (SoC) vs Time for a 7-day window showing:

- Day 0: full charge
- Days 1–3: consumption without solar (SoC falling to the autonomy limit)
- Day 4+: charging resumes (solar) and SoC recovers

Axes & units

- X axis: Time (days)
- Y axis: Battery State of Charge (%) or Battery Energy (Wh)

Short checklist for field tests

- Verify load_profile.csv with a meter for 24–72 hours.
- Confirm daily Wh matches estimation within $\pm 10\%$.
- Disconnect PV, run 3 days: battery SoC should remain \geq chosen minimum DoD.
- Check cable temperature & voltage drop under peak.
- Verify PV recharges battery in expected time.