Solar Power System Design Guide Example

Part 1: Load & Battery Storage Capacity Sizing

Step 1: Determine your typical daily power consumption in Watt-Hours (Wh), note that 1000Wh is equal to 1kWh (Kilo Watt-Hour).

If you already have a power meter installed, just monitor the daily difference in electricity units consumed, or better yet get the weekly or monthly power consumption and find the daily average by dividing the total units consumed by the number of sampled days (7 days for a week, 30 days for a month).

You can also estimate daily power usage by finding the power rating of appliances used and multiplying by the number of hours run per 24hr period, then summing up all the appliances in the household.

Example:

Appliance	Power Rating (Watts)	Hours Used per day	Daily Watt-Hours Consumption
Laptop	60	10	600
Electric Kettle	2000	0.16	332
LED Bulbs (6pcs)	12	6	432
Refrigerator	150	5	750
Phone Charger	37	1.5	56
Smart TV	60	6	360
Wi-Fi Router	18	24	432
Sound System	65	10	650
Inverter (Standby)	15	24	360
TOTAL DAILY WATT HOUR CONSUMPTION			3972Wh

For this example, let's assume a daily power consumption of 4kWh or 4000Wh.

Step 2: <u>Determine the battery Chemistry and Capacity.</u>

Typically, there are Lead-Acid and Lithium based batteries commonly used. For Lead, you can use Flooded Lead-Acid batteries or Sealed AGM (Absorbed Glass Mat) batteries.

For a Lithium based battery, just use LiFePO4 (Lithium Iron Phosphate) battery.

LITHIUM VS. LEAD-ACID COMPARISON

FEATURE	FLOODED LEAD-ACID	AGM	RELiON LiFePO4
Cycle Life	300 - 400 cycles	300 - 400 cycles	3,500
Max Usable Capacity	50%	50%	85%
Discharge Efficiency	50-90%	50-90%	99%
Maintenance	High	Medium	None
Charge Time	6 - 12 Hours	6 - 12 Hours	1 - 5 Hours
Partial Charging Capable	No	No	Yes
Weight Comparison	100%	100%	50%
Charge Efficiency	80%	85%	99%
Cost	$	$$	$$$

Its clear Lithium based battery storage for off-grid solar systems is relatively more expensive upfront but ends up being much cheaper in the long run. Lead acid-based battery storage is cheaper to install but due to the low lifespan and low depth of discharge, it's advisable to install Lithium iron phosphate batteries for future savings. However, if on a budget just use Flooded of AGM lead acid batteries which are more affordable upfront. A lead acid-based battery will need to have a much larger capacity to have the same usable capacity as a lithium-based battery.

Days of autonomy is the number of days the battery system can continue delivering power even in the absence of sunlight, its usually between 2 and 5 depending on your location.

It's good practice to add about 20% more battery capacity to the final calculated value to cater for various system losses and gradual battery capacity degradation due to charge-discharge cycles.

For LiFePO4 battery system:

Use Depth of discharge of 80%, 2 days of autonomy, Temperature compensation factor of 1.1 for the lowest temperature of about 16 degrees Celsius, and inverter efficiency of 90%

Battery capacity required =

$$\frac{Daily\ Power\ Usage}{Discharge\ \ efficiency * Depth\ of\ Dischage} * 1.1$$

$$= \frac{4000Wh}{0.99 * 0.8} * 1.1 = 5555 \text{ Watt hours}$$

Divide this value by 0.9 to cater for inverter conversion efficiency

5555/0.9 = 6173Watt hours

Note this is the minimum battery capacity required ignoring future battery degradation and system losses such as cable resistance, standby consumption etc.

Divide by battery voltage to get capacity in Amp hours (Ah)

For 12V battery;

Capacity = 6173/12 = 515Ah

Double this value for 2 days of autonomy

Final battery Capacity = 1030 Amp hours

Note: The higher the battery voltage you use, the more efficient your system will be due to reduced electrical losses.

A 24Volt battery string (Two 12V batteries in series) will work with half the final Amp hours value, while a 48Volt battery string (Four 12V batteries in series) should work with a quarter of this value.

Note It's usually a good idea to round up, to help cover inverter inefficiencies, voltage drop and other losses. Think of this as the minimum battery bank size based on your typical usage.

Battery banks are typically wired for either 12 volts, 24 volts or 48 volts depending on the size of the system.

Note: It's recommended to use no more than 2 parallel battery connections. You can add as many batteries in series as possible, but ensure you use matched batteries for optimal performance.

For Lead Acid based battery system:

Use Depth of discharge of 50%, 2 days of autonomy, Temperature compensation factor of 1.1 for a lowest temperature of about 16 degrees Celsius, and inverter efficiency of 90%.

$$\text{Battery capacity required} = \frac{Daily\ Power\ Usage}{Discharge\ efficiency * Depth\ of\ Dischage} * 1.1$$

$$= \frac{4000Wh}{0.99 * 0.5} * 1.1 = 8889 \text{ Watt hours}$$

Divide this value by 0.9 to cater for inverter conversion efficiency

8889/0.9 = 9877Watt hours

Divide by battery voltage to get capacity in Amp hours (Ah)

For 12V battery;

Capacity = 9877/12 = 823 Amp hours

Double this value for 2 days of autonomy

Final battery Capacity = 1646 Amp hours

A 24Volt battery string (Two 12V batteries in series) will work with half the final Amp hours value, while a 48Volt battery string (Four 12V batteries in series) should work with a quarter of this value.

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