

- Define load, location, inclination
- Determine irradiation
- Calculate installed power to fulfil load
- Calculate number of modules
- Define system specs

(battery, charge regulator, inverter)



Example

Stand alone system for the Algarve (37°N)

Equipment	Power	Usage	Daily load (kWh)
3 lights	100 W	3 h/day	0.90
2 lights	60 W	2 h/day	0.24
Fridge	I 50 W	10 h/day	1.50
Freezer	150 W	10 h/day	1.50
Iron	I 000 W	l h/day	1.00
TV	60 W	4 h/day	0.24
Washing machine	2.2 cycle	Twice week	0.63
Dish washer	I.9 kWh/cycle	Once a day	1.90
Total daily load			7.91

Step l

Choose least unfavourable month

Typically December, but could be September for a summer house

Step 2

Choose modules' inclination

Typically latitude + 10°, but could be latitude -10° for a summer house

Step 3

Determine irradiation (Inclination: 37° + 10° = 47°)

Month	Monthly irradiation (kWh/m ²)	Daily irradiation (kWh/m ²)
Jan	98.2	3.3
Feb	108.2	3.6
Mar	135.1	4.5
Apr	158.3	5.3
May	169.5	5.6
Jun	166.0	5.5
Jul	184.4	6.1
Aug	197.9	6.6
Sep	163.5	5.4
Oct	144.0	4.8
Nov	109.8	3.7
Dec	98.7	3.3



Step 3

Calculate irradiation PSH: Peak Solar Hours (hours @1kW/m² = kW/m²/day) Worst month: PSH = 3.3 h/day

Inverter

Load

Step 4

Cables

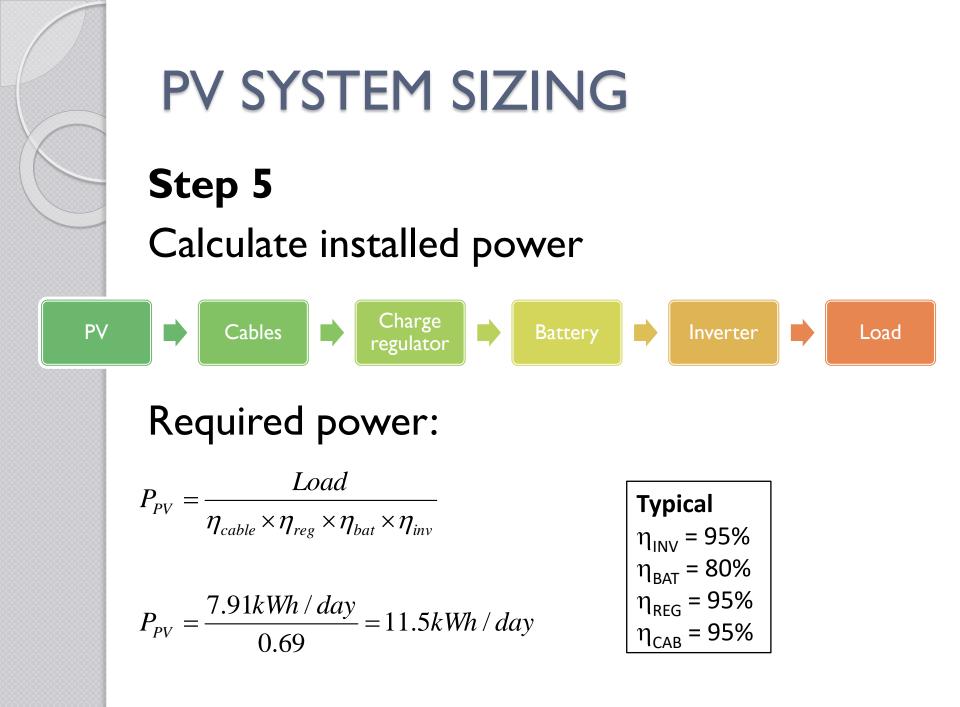
Define system configuration

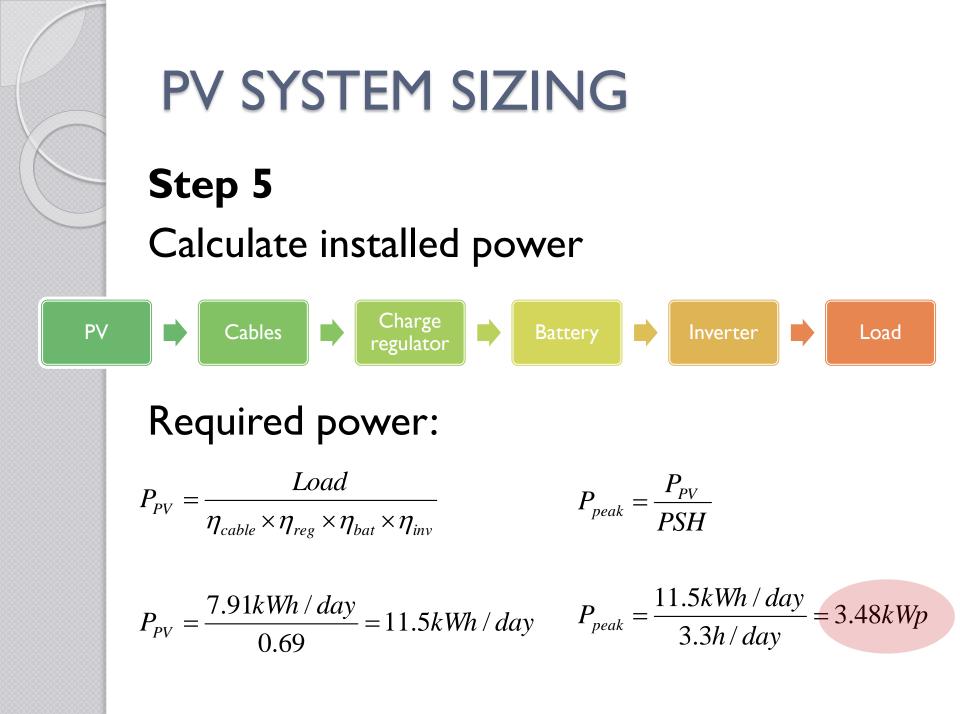
<u>Charge</u>

regulator

Stand alone requires battery

AC appliances require inverter





Step 6

Choose operating voltage V_{DC}

Typically multiple of 12V

Determine minimum section of cabling ($\Delta V < 3\%$):

 $s(mm^2) = \frac{length(m) \times current(A)}{56 \times \Delta V}$

Cheaper (thinner) cables require higher operating voltage. Let's choose V_{DC} =48V.

Step 7

Calculate string length, from the module voltage, V_m (assume 12V; string with 4 modules)

$$N_s = \frac{V_{DC}}{V_m}$$

Step 8 Calculate number of strings

(assume 50Wp module)

$$N_{p} = \frac{P_{peak}}{P_{m} \times N_{s}} = \frac{3.48 kWp}{50Wp \times 4} = 17.4 \approx 18$$

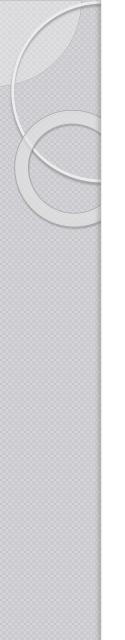
Step 9

Calculate total number of modules,

 $N = N_s \times N_p = 4 \times 18 = 72$

and its area (assume module area $A_m = 0.4m^2$)

$$A = N \times A_m = 72 \times 0.4 \approx 30m^2$$



Step 10

Determine battery capacity

Choose autonomy (n = 5 days)

$$C_{B} = \frac{n \times load}{depth}$$

$$C_{B} = \frac{5days \times \left(\frac{7.91kWh/day}{V_{DC} \times \eta_{cab} \times \eta_{bat}}\right)}{0.7} = \frac{5 \times \left(\frac{7.91 \times 0.95}{48}\right)}{0.7}$$

$$C_{B} = 1118Ah$$

Step ||

Choose charge regulator and the inverter

Relevant parameters:

•
$$V_{in} = V_{DC} = 48V$$

•
$$I_{in} = P_{peak} / V_{DC} = 3480 / 48 = 72.5 \text{ A}$$

•
$$V_{out} = V_{DC} = 48V$$

• $P_{out} = (300 + 120 + 150 + 60 + 2200) \sim 3300 W$

assuming that we won't wash and iron at the same time...

•
$$I_{out} = P_{out}/V_{out} = 3300 / 48 \sim 70 A$$

Design rules

- All strings must have the same voltage
- Minimize module mismatching
- Avoid shading
- Higher inverter efficiencies for high input voltage: maximize string length



Design rules

 minimum inverter input voltage > > MPP voltage @ +70°C

maximum inverter input voltage <

 Open circuit voltage @ -10°C

Design rules

• Power ratio between 90...110%

(= input power inverter/nominal power PV generator)

- Start at 90%
- +5% if annual yield 1200...1600kWh/kWp

(+10% if annual yield >1600kWh/kWp)

+5% if ambient temperature < 30°C

(+10% if ambient temperature < 20°C)

• +5% if single axis tracking

(+10% if dual axis tracking)