Solar Energy

Solar PV system design exercise

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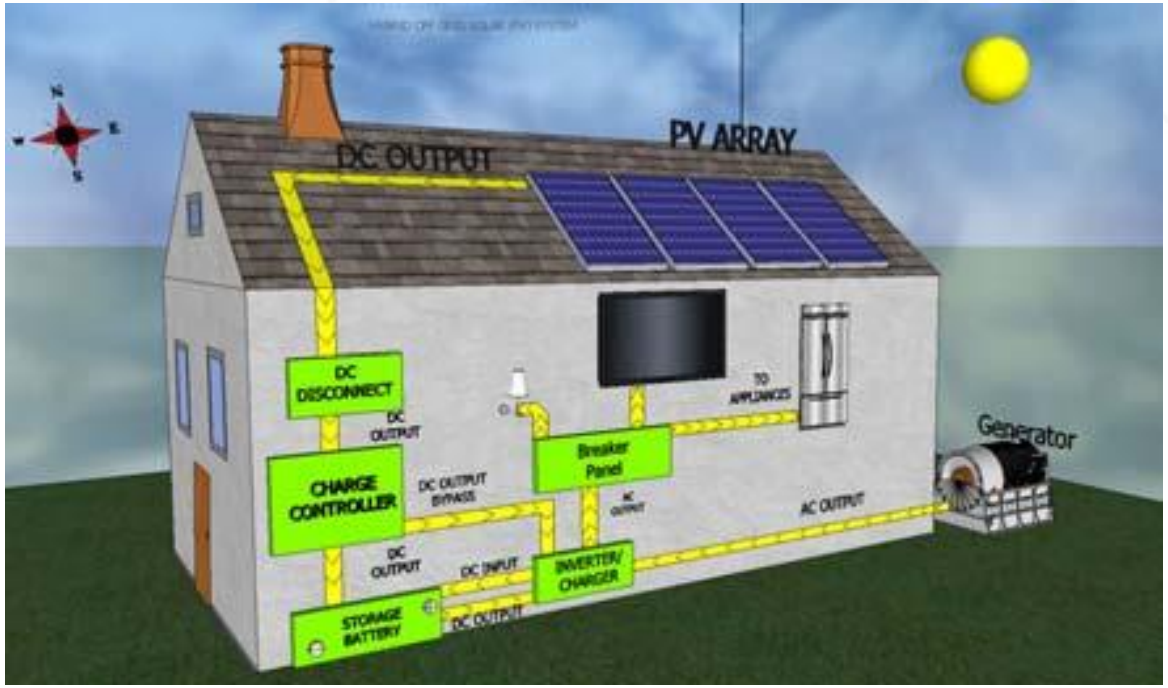
In this video you will learn:

- Review of PV design process
  - Exercise to design a PV standalone system

SESA

Design Process for Stand-Alone System

1. Load study – Total energy requirement
2. Determine the System Voltage sizing (12, 24, or 48V)
3. PV Sizing
4. Battery Sizing
5. Inverter Sizing
6. Charge Controller Sizing



SESA

Solar PV Design Exercise

A house has the following electrical appliance usage:

- Two 15 W lamp used 5 hours per day.
- Two 40 W fan used for 4 hours per day.
- One 68 W 19-in TV used 5 hours per day
- One 17 W satellite used 5 hours per day.

→ Design a solar PV standalone system to meet the load requirement

Assumptions:

- Location: Kumasi, Ghana
- PV module specification: Pm = 110 Wp; Vm = 16.7 Vdc;
- I_m = 6.6 A; V_{oc} = 20.7 A; I_{sc} = 7.5 A

Determine Total Energy demand

Appliance	Power (W)	Hours	Wh/day
Lamp	15 x 2	5	150
Fan	40 x 2	4	320
TV	68 x 1	5	340
Satellite	17 x 1	5	85
Total Energy	**195**		**895**

Determine System Voltage

High voltage:

- low current
- minimize wire loss
- More batteries in series

A guideline:

Keep the maximum steady-state current drawn below around 100 A readily available electrical hardware and wire size can be used

Suggest system voltage

Maximum ac Power	System dc Voltage
<1200 W	12 V
1200–2400 W	24 V
2400–4800 W	48 V

PV panel sizing

Rated Wp can only be produce under standard conditions
For actual generation, must consider panel generation factor to account for variations from standard conditions
This is approximately 0.62 x daily sun peak hours

$$PV\ size\ (P_{Dc}) = \frac{Total\ daily\ Energy\ (Wh)}{Daily\ peak\ sun\ hrs\ x\ \eta_{coversion}}$$

$$PV\ size\ (W_p) = \frac{895}{3.92\ x\ 0.62} = 368.3\ Wp$$

$$\text{No. of panels needed} = \frac{368.3}{110} = 3.358 = 4\ modules$$

Monthly Average Solar Global Horizontal Irradiance

Month	Clearness Index	Daily Radiation (kWh/m²/day)
Jan	0.578	5.380
Feb	0.564	5.570
Mar	0.537	5.560
Apr	0.523	5.460
May	0.507	5.170
Jun	0.459	4.580
Jul	0.420	4.220
Aug	0.381	3.920
Sep	0.390	4.030
Oct	0.473	4.710
Nov	0.541	5.080
Dec	0.556	5.050

Annual Average (kWh/m²/day): 4.89

Battery sizing

$$\text{Battery capacity (Ah)} = \frac{P_{dc} \times days\ of\ autonomy}{\eta_{battery} \times\ DoD \times V_{battery}}$$

$$\text{Battery capacity (Ah)} = \frac{895 \times 1}{0.80 \times\ 0.2 \times 12} = 466.2\ Ah$$

So the battery bank should be rated 12 V 500 Ah for 24 hrs autonomy

Inverter sizing

The inverter must have **the same nominal voltage as your battery**.

The inverter size should **be 25 - 30% bigger than total Watts of appliances**

Total Watt of all appliances = (15 x 2) + (40 x 2) + (68 x 1) + (17 x 1) = 195 W

The inverter size should be rated 12 V and about 200 W or greater

Solar charge controller sizing

The size **depends on the current and voltage capacities** of the system

The voltage of the charge controller **should match that of the system**

The current rating should be **at least 30% more** the short circuit current of the PV array.

Solar charge controller rating = (4 strings x 7.5 A) x 1.3 = 39 A

Therefore the charge controller should be rated 40 A at 12 V or greater

Summary

Procedure:

1. Determine energy requirement
2. Determine the System Voltage size
3. Determine PV Size
4. Battery Size
5. Inverter Size
6. Charge Controller Size

PV Sizing and Estimating Software

- Public Domain
  - PVWATTS: https://pvwatts.nrel.gov/pvwatts.php
  - PVGIS https://re.jrc.ec.europa.eu/pvg_tools/en/#PVP
  - SAM: https://sam.nrel.gov/

- Commercial
  - Clean power estimator: https://www.cleanpower.com/
  - PVSYST: https://www.pvsyst.com/

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