ASSESSMENT AND DESIGN OF ROOFTOP SOLAR PV SYSTEM

Click to begin

TOPICS

Click on the ***Action Buttons*** *to directly jump to respective sections*

Solar Energy Systems

SOLAR ENERGY SYSTEMS - TYPES

Solar Energy is the most abundant energy source available and offers tremendous potential for various applications. Two major technologies to harness it are:

- **Solar Photovoltaic (PV) systems**
  - Convert sunlight directly into electricity
  - Uses PV modules made of semiconductor materials
  - Can be ground-mounted or rooftop

- **Solar Thermal systems**
  - Convert solar energy to heat
  - Convert solar energy to mechanical energy to electricity
  - Uses Collectors (flat plate, parabolic, tubular etc) to collect heat and generate energy

This training module focuses on Solar Rooftop PV systems

SOLAR ENERGY – TERMINOLOGIES

- **Irradiance:** Intensity of solar energy received per unit area i.e. instantaneous solar power falling on a unit perpendicular area. Unit is KW/square meter

- **Insolation:** Quantity of solar energy received per unit area i.e. solar irradiance integrated over time is called solar insolation. Unit is KWh/square meter. Solar Insolation is depended on location and needs to be evaluated specific to the site.

- **Peak Sun hours:** Number of hours during which the intensity of sunlight is 1,000 watts per square meter.

- **Tilt Angle:** Solar panels are most efficient, when they are perpendicular to the sun's rays. It is the angle that the panel should be tilted to derive the best incidence of solar energy. The Tilt Angle is the angle that forms between the horizontal and the long axis of the PV Module. The default value is a tilt angle equal to the station's latitude.

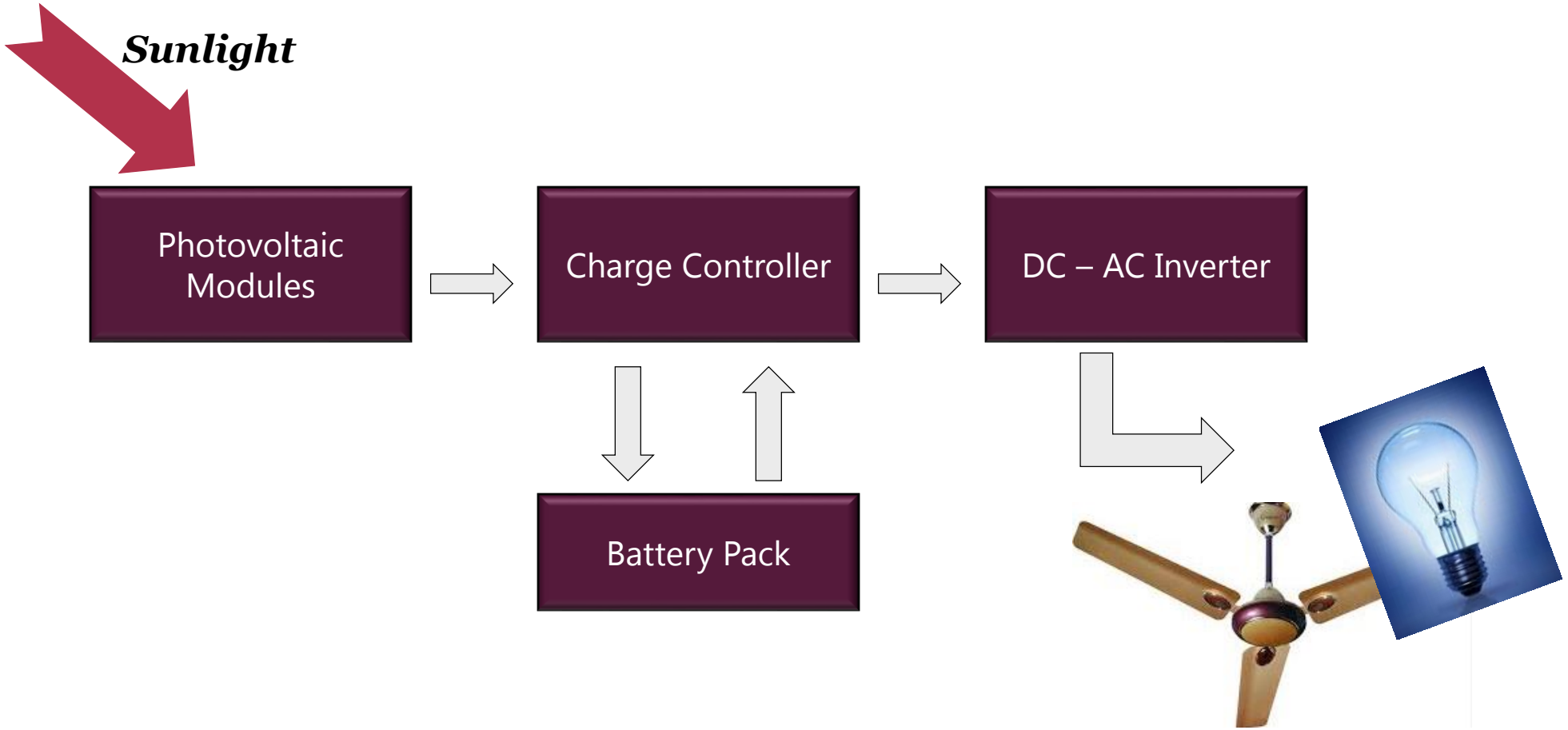
- **Azimuth Angle:** Azimuth Angle is the angle between the surface of the panel and exact south direction. For maximum performance, the azimuth angle in Indian context should be 180 degrees.

Solar PV System

TYPES OF SOLAR PV SYSTEM

- **Grid Interactive without Battery Backup**
  - Operates only when grid power is available
  - If grid power fails, in case of power outage, no power supply to equipments until power is restored
  - Inverter with Anti-islanding functionality is mandatory to avoid risk to person working on grid
- **Grid Interactive with Battery Backup**
  - No dependency on grid
  - Includes battery system to store energy
  - Support loads during grid power outage through a separate wiring system
  - Inverter with Anti-islanding functionality is mandatory to avoid risk to person working on grid
- **Off Grid – Only Battery**
  - No dependency on grid
  - Battery backup is must

SOLAR PV – SYSTEM COMPONENTS (1/3)



SOLAR PV – SYSTEM COMPONENTS (2/3)

- **Photovoltaic Modules**
  - Component that converts sunlight to electricity
  - More the number of panels, more the amount of electricity generated
  - PV modules are generally made of two types of materials: Amorphous silicon and Crystalline silicon
  - Crystalline silicon panels are preferred over Amorphous silicon panels for rooftop applications because they are more efficient and demand less space. However, these are also more cost intensive than amorphous silicon panels.
  - Life of panels can be upto 20 years
- **Charge Controller**
  - Regulates the voltage and current coming from the PV panels going to battery
  - Prevents battery from overcharging and overdischarging
  - Improves battery life
  - Improves solar panel performance

SOLAR PV – SYSTEM COMPONENTS (3/3)

- **Inverter**
  - Converts DC output of PV panels to AC for supply to appliances or feed to grid
  - Inverter selection should be done critically considering starting current requirements of motors and compressors
  - Responsible for matching the panel output voltage to reference voltage, ensuring steady supply to equipments
- **Battery Pack**
  - Stores energy to supply to appliances when there is demand
  - Operating Voltage and Energy Content (Ampere Hours) are key parameters while selecting a battery
  - Require maintenance such as cleaning of terminals, checking amount of electrolyte, charging requirements

SOLAR PANEL SPECIFICATIONS

- **Peak Power (W_p):** It is the maximum power that a solar panel can give when it is being operated in full sunlight. Higher the peak power, higher the energy output of panel.
- **Open Voltage (V_{oc}):** It is the voltage measured when panel is connected only to voltmeter and pointed to sun. The open voltage value helps to position the panel in right direction. Higher the Voc, higher the energy output of panel.
- **Short Circuit Current (I_{sc}):** It is the current measured when the panel is connected only to ammeter to measure the short circuit current. Higher the $I_{sc,}$ higher the energy output of the panel.
- **Standard Test Conditions (STC):** All the solar modules are rated under the STC i.e. maximum power output is given at standard conditions of temperature (25 degrees), irradiance (1 KW/m2), well controlled laboratory losses.
- **Peak Power (W_p) = Max. power voltage (V_{mp}) X Max, power current (I_{mp})**

Temperature	⇧	Output Voltage	⇩	Output Power	⇩
Irradiance	⇧	Output Current	⇧	Output Power	⇧

Designing a Solar Rooftop PV system

EVALUATE THE CAPACITY OF SOLAR PV SYSTEM

A household has following appliances and usage:

- 5 Lights 10W each used for 8 hours a day
- 5 Fans 20W each used for 16 hours a day
- 1 Refrigerator 250W for 24 hours a day
- Assume Panel Generation Factor (**PGF**) for India as **4**. (This needs to be evaluated specific to the site, since it depends on climate and location)
- Also assume that each solar module is **rated 100 W_p at 12V** (This is available from data sheet)

Determine the solar PV System size, No. of PV modules, Inverter size, Battery capacity

STEP 1

- **Determine the total energy demand of the household**

Lights = 10 * 5 * 8 = 400 Wh / day

Fans = 20 * 5 * 16 = 1600 Wh / day

Refrigerator = 1 * 24 * 250 = 6000 Wh / day

Total Energy Demand = 8000 Wh / day

STEP 2

- **Determine the system size and number of panels**

Total Energy Demand = 8000 Wh = 8 KWh / day

Considering 30% losses on wiring etc., Total Energy Demand = 10.4 KWh / day

Panel Generation Factor (assumed here) = 4

Total peak power demand from the panel = 10.4 / 4 = **2.6 KW_p**

Rated Power output of each module = 100 W_p at 12V

No. of PV modules required to meet demand = 2600/100 = **26**

STEP 3

- **Determine the Inverter Size**

Lights = 10 W * 5 Nos = 50 W

Fans = 20 W * 5 Nos = 100 W

Refrigerator = 250 W * 1 No = 250 W

Total Power Demand of all appliances = 400 W

Considering safety of equipments, inverter should be sized at about 30-40% of total power demand.

Inverter Size = 400 * 1.3 = **520 W**

STEP 4

- **Determine the Battery Capacity**

Total Energy Demand = 8000 Wh / day

Nominal Battery Voltage = 12 V

No of days (rainy and winter season) with no sun = 10

Battery efficiency (assumed)= 75%
Depth of Discharge (DOD) of Battery (assumed)= 40%

Battery Capacity = [8000/0.75/0.4/12] * 10 = **22,000 Ah**

Battery Rating: 12V 22000 Ah for 10 day without sunshine

EVALUATE THE ROOF AREA REQUIRED FOR ROOFTOP SOLAR PV SYSTEM

Three factors determine the roof area requirement for solar PV system:

- **Shade-free roof area:** The PV modules should be installed at locations where shadows do not form on the panel. Analysis should be conducted thoroughly to ensure that no shadows from adjacent buildings, towers, hoardings etc. form on the solar panels.

- **Panel Efficiency:** Lesser the solar panel efficiency, more space is required to set up PV modules to produce the same power output compared to higher efficient panels.

- **Rooftop type:** Load carrying capacity of the rooftop should be checked before finalizing the solar panel system.

QUIZ TIME

Lets check what you have learnt till now.

Answer the questions correctly OR

Consider revising this module … All the Best !!

NOTE: Click on the suitable option for answering the question

Q 1. Solar Insolation is defined as

1. Instantaneous solar power falling on a unit perpendicular area (KW/m2)
2. Quantity of solar energy received per unit area (KWh/m2)
3. Number of hours during which the intensity of sunlight is 1,000 watts per square meter
4. Angle that forms between the horizontal and the long axis of the PV Module

QUIZ TIME

Q 2. The **Output Power** of the solar panel is related to **Temperature and Irradiance** in which of the following manner

1. Directly to Temperature and Inversely to Irradiance
2. Directly to both Temperature and Irradiance
3. Inversely to both Temperature and Irradiance
4. Inversely to Temperature and Directly to Irradiance

QUIZ TIME

Q 3. Which of the following is **not** the function of a **Charge Controller**?

1. Prevents battery from overcharging and overdischarging
2. Converts DC output of PV panels to AC for supply to appliances or feed to grid
3. Improves battery life
4. Regulates the voltage and current coming from the PV panels going to battery

QUIZ TIME

Q 4. Which of the following aspect is **not important** while designing a solar rooftop PV system?

1. Shade free roof area
2. Panel efficiency
3. Rooftop type
4. None of the above

End of Training Module

THANK YOU

Congratulations !!

That's a correct response...

Next Question

Sorry !!

That's incorrect…

Try again

Next Question

Congratulations !!

That's a correct response…

Next question

Sorry !!

That's incorrect…

Try again

Next question

Congratulations !!

That's a correct response…

Next question

Sorry !!

That's incorrect…

Try again

Next question

Congratulations !!

That's a correct response...

Exit

Sorry !!

That's incorrect…

Try again

Go to the beginning of the section

Exit