TUTORIAL 1: SOLAR ENERGY – PV SYSTEMS

Renewable Energy Systems

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Tutorial

WHAT YOU WILL LEARN

Sample: Performing the tasks outlined below will help you acquire the following skills and proficiencies:

1. Basic understanding of calculations involving photovoltaic systems and solar cells;
2. Underpin knowledge of electric solar panels;
3. Have an insight into power ratings of PV systems based on sunlight availability.

YOUR TASK

Answer the following questions. Additional recourses (especially on-line) may be used to review technology and find specific calculation techniques.

1. Fig. 1 illustrates the direct sunlight intensity incident normally on a PV panel versus time in Sydney in January (summer). The average value of this distribution over a 24 hour period is 280 W/m^2. The area of the PV panel is 1 m^2.

   (a) What is the total amount of electricity in one day in kWh and in MJ the PV panel can produce?

   (b) How is this energy altered if sunlight falls at an angle of 30° to the normal to the surface of the panel?

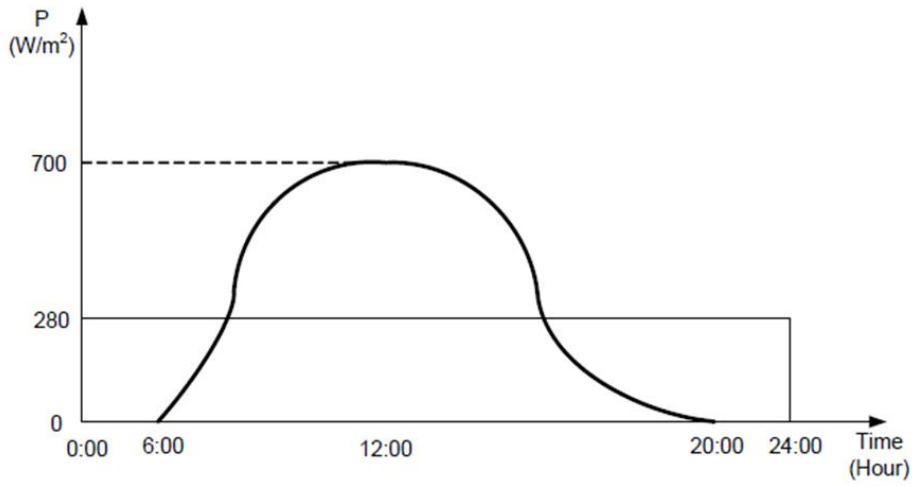

Fig. 1. Direct Sunlight intensity incident normally on a PV cell versus time in Sydney in January.

2. Assume 1000 kWh was consumed to manufacture the PV panel in Problem 1, and this panel can produce 150 kWh/year. What is the energy payback time?
3. What are the advantages and disadvantages of single crystal compared with thin film solar cells?

4. A PV cell has a saturation current of 2×10^{-12} A, a short circuit current of 30 mA, and an area of 1 cm^2. Find the maximum power output and fill factor. What resistance is required to give the maximum output power?

5. A solar panel is made up of 40 silicon cells in series each of area 0.01 m^2, open circuit voltage 0.6 V, and fill factor 0.7. The short circuit current density of a panel under AM1.5 illumination is 400 A/m^2. In the UK there is about 750 kWh/m^2/year of solar radiation. If an area of 8 m^2 is available on a house, estimate the amount of energy per year that could be provided by solar panels.

6. A silicon PV cell has an area of 4 cm^2 and is illuminated normally with AM1.5 solar radiation. The short circuit current is 160 mA and the saturation current is $4x10^{-9}$ mA. Calculate the maximum power output and the corresponding load resistor. What is the output power when the load resistor is 10 % higher than the optimum value?

7. A household uses 4000 kWh of electricity in a year. Estimate what area of solar panels of the PV cell in question 6 would be required to produce 1000 kWh of electricity in a year. The insolation is 800 kWh/m^2/year.

8. A 30 cell silicon solar panel has a saturation current density $J_s = 10^{-7}$ A/m^2. Show that this panel could be used to charge a 12 V battery by calculating the peak power voltages V_m for insolation values of 0.2, 0.4, 0.6, 0.8 and 1.0 kW/m^2. An insolation of 1 kW/m^2 gives a short circuit current density of 400 A/m^2.