Course: B.Tech
Sub_Code: REL5D005

6th Semester Regular/Back Examination: 2024-25
SUBJECT: Renewable Power Generation Systems
BRANCH(S): AE, BIOTECH, CIVIL, ECE, ELECTRICAL & C.E, ELECTRONICS & C.E, ETC
Time: 3 Hours
Max Marks: 100
Q.Code: S228
Answer Question No.1 (Part-I) which is compulsory, any eight from Part-II and any two from Part-III.
The figures in the right hand margin indicate marks.

Part-I

Q1   **Answer the following questions:**   (2 x 10)
   a) A 250 W photovoltaic module comprises 60 cells connected in series, divided into three equal strings of 20 cells each. Under standard test conditions (1000 W/m² irradiance), the module operates at its rated capacity. If one string (20 cells) experiences partial shading, reducing its irradiance to 300 W/m², while the other two strings remain fully illuminated, estimate the new maximum power output of the module.
   b) State two advantages of using solar-powered lighting systems in outdoor applications.
   c) What are the four stages of solar battery charging, briefly explain.
   d) What are heliostats? Briefly explain.
   e) Find the wind power density and convert it to kW/m². Given that Wind speed = 10 m/s, Air density = 1.225 kg/m³.
   f) List two differences between induction and synchronous generators used in wind turbines.
   g) State any two methods used for reactive power compensation in wind energy systems.
   h) What is anaerobic digestion, and how is it used in biogas production?
   i) List any two differences between combustion and pyrolysis in biomass conversion.
   j) List any two advantages of a Wind-PV hybrid system.

Part-II

Q2   **Only Focused-Short Answer Type Questions- (Answer Any Eight out of Twelve)**   (6 x 8)
   a) Explain the concept of distributed energy systems and dispersed generation (DG). Discuss their advantages and challenges in the context of renewable energy integration.
   b) Photovoltaic cells with an overall average conversion efficiency of 10% and total area of 5 m² are placed in the following locations: I) Mumbai, India; II) London, England; III) Chennai, India; IV) Bhubaneswar, India; V) Jaisalmer, India and VI) New York, USA. Determine the total amount of electricity, in kWh, produced annually in each location. The Average Solar Irradiance (kWh/m²/day) by Location (Typical Estimates) are 5.5, 2.5, 5.8, 5.6, 6.0, and 4.0 respectively. The performance value can be assumed to be 0.8.
   c) Explain about Solar Cell, Solar PV Module, Solar PV Panel, and Solar PV Array.
   d) A thermal solar power plant uses 1,300 heliostats, each one with an area 25 m². The annually averaged peak insolation in the area is 700 W/m². The thermal solar energy collection efficiency of the plant is 56% and the efficiency of the cycle is 38%. Determine the annually averaged peak power produced by this power plant.
   e) Describe the different types of solar collectors used in thermal systems. Discuss their performance characteristics and typical applications.
   f) Explain the aerodynamic principles governing wind rotor operation.

g) Determine the maximum power a wind turbine may produce at the following wind speeds: 1, 5, and 10 m/s. Assume Betz limit as 0.593 and air density (approximately 1.225 kg/m³ at sea level).

h) Compare and contrast grid-connected and self-excited induction generators in wind energy systems.

i) Describe the process of biomass pyrolysis.

j) What are its key products and how do they differ based on process conditions (temperature and residence time)?

k) What do you mean by pitch angle? How pitch angle can be controlled in wind energy conversion system?

l) Compare the technical features of hybrid electric vehicles (HEVs) and battery electric vehicles (BEVs).

Part-III

Only Long Answer Type Questions (Answer Any Two out of Four) (16 x 2)

Q3 a) Explain, what is maximum power point tracking (MPPT) in PV system? **(6 + 10)**

b) A photovoltaic (PV) module operates under standard test conditions (STC) with the following specifications: Open-circuit voltage (V_{oc}) = 21.6 V, Short-circuit current (I_{sc}) = 5.0 A, Maximum power point voltage (V_{mpp}) = 17.0 V and Maximum power point current (I_{mpp}) = 4.7 A. The module is connected to a resistive load through a DC-DC buck converter equipped with an MPPT controller utilizing the Perturb and Observe (P&O) algorithm.

    I) Calculate the maximum power (P_{max}) the PV module can deliver under STC.

    II) Determine the optimal load resistance (R_{opt}) that should be connected to the PV module to extract maximum power.

    III) Explain how the P&O algorithm adjusts the operating point to achieve maximum power delivery.

    IV) Discuss one potential drawback of the P&O algorithm under rapidly changing irradiance conditions.

Q4 a) Explain in detail the layout and working of wind electricity generation power plant. **(10 + 6)**

b) A wind turbine with a rotor diameter of 50 meters operates at a wind speed of 10 m/s in a location where the air density is 1.2 kg/m³. The power coefficient (C_p) is 0.4. Calculate: (i) The swept area of the rotor. (ii) The available power in the wind. (iii) The mechanical power extracted by the turbine.

Q5 Describe in detail the various methods of biomass conversion into useful energy. **(4 x 4)**

    a) It must include the principles of combustion, fermentation, and anaerobic digestion.

    b) Working of a wood gasifier.

    c) Applications of biogas, biodiesel, and biomass combustion engines

    d) Advantages and limitations of biomass energy systems

Q6 a) Explain with a neat schematic the working of a Diesel - PV hybrid system. **(8 x 2)**

b) A remote village is powered by a Diesel-PV hybrid system. The daily energy demand of the village is 120 kWh. The solar radiation data suggests that the PV system can generate 5 kWh/day per kW of installed PV capacity. The system includes: A PV array with 10 kW installed capacity, a diesel generator with a fuel consumption rate of 0.3 liters/kWh, Diesel cost: ₹90 per liter, then Calculate:

    I) Daily energy contribution from the PV system.

    II) Remaining energy to be supplied by the diesel generator.

    III) Daily diesel consumption (in liters).

    IV) Daily cost of diesel to meet the energy shortfall.