Ref. No.: Ex/PG/POW/PC/T/114/2025

M.E. Power Engineering First Year First Semester Examination – 2025

Subject: Green Energy and Sustainability
Part-I
(Use separate answer script for each part)

Full Marks: 70 **Time: 3 Hrs**

Question No.		Marks
	CO1 (Marks - 30) Answer any *Three*	
1	a. What do you understand by energy resources and energy reserves? b. What are the challenges and opportunities for future energy outlook?	5 5
2	a. Discuss briefly the SWOT of renewable energy. b. Define followings: i. Peak sun hours (PSH) ii. Air Mass	6 4
3	a. Identify and characterize different components of solar irradiance at ground level for solar PV application. b. Define and differentiate terms: Solar Radiation, Solar Irradiance, Irradiation	5 5
4	a. What is Betz' limit? Derive the Betz' efficiency. b. What is Wind power curve? Explain briefly the significance of wind power curve.	5 5
	CO2 (Marks – 30) Answer any *Three*	
5	a. Define and explain theoretical maximum efficiency of PV cells. b. Briefly explain the working principle of PV cells.	5 5
6	a. Explain with neat diagram the nature of I-V and P-V characteristics of PV array due to change in radiation, temperature, and series and shunt resistance. b. Briefly discuss the effects of partial shading on PV system and function of bypass diode.	6 4
7	What are the major components of Wind energy conversion system? Briefly explain their functionalities.	10
8	What are the different wind turbine control methods? Briefly explain each.	10
	CO4 (Marks - 10) Answer any *One*	
9	A solar cell has a reverse saturation current of I_0 = 2x10–3A and a short-circuit current of 1A at full insolation and room temperature. Given that its ideality factor is unity, determine its open-circuit voltage at full insolation and the percentage change in the open-circuit voltage if the insolation is reduced by 20%.	10
10	A PV module made from crystalline silicon has an open-circuit voltage of 21.5V and a maximum power of 120W at STC. The module has a NOCT of 45°C. Estimate the cell temperature, the open-circuit voltage, and the maximum power output for this module under insolation G = 1000 W/m^2 and ambient temperature of 30°C. Note that for crystalline silicon, the open-circuit voltage drops by 0.37%/°C and the power drops by 0.5%/°C.	10
11	A HAWT generates 110kW when the air density is 0.95kg per cubic meter and the wind speed is 12m/s. The length of each blade is 10m. a. Determine the tip speed and the speed of the turbine in revolutions per minute if the tip speed ratio is 5; b. Determine the required gear ratio if the generator needs to run at 1500 rpm; c. Determine the efficiency of the overall system	10

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Ex/PG/POW/PC/T/114/2025

Master of Power Engineering 1st Year 1st Semester– 2025
Subject: Green Energy & Sustainability (PG/POW/PC/T/114)

Time: Three hours **Full Marks: 100**

	PART-II (Use Separate answer script for each part)	**Marks[30]**
[1]	**Answer any *TEN* from this questions**	**[2×10=20]**
(a)	What is the maximum hydro plant capacity under jurisdiction of MNRE?	
(b)	State the basic difference between Impulse turbine & Reaction turbine for Hydro Power plant with examples.	
(c)	From Hydro power plant case studies comment on opportunities & challenges of low pressure hydro turbine below 5m height.	
(d)	State the basic steps of hydro power control.	
(e)	Define Sustainability.	
(f)	Comment on Renewable energy contribution to Sustainability.	
(g)	Briefly state the Sustainable Development Goals.	
(h)	State the standard emission norms (particulate matter, SO_2, NO_X, Hg in mg/Nm^3) of Thermal Power Plants (500MW & above) those are installed 1st January 2017 onwards.	
(i)	Define Energy Audit.	
(j)	Define Green Building.	
(k)	Briefly state the roles of Bureau of Energy Efficiency for energy financing.	
(l)	Briefly state the major changes in Indian power sector reform in 21st century in your view point.	
(m)	Briefly state development scopes of Renewable Energy in India for Sustainable issue.	
(n)	Draw the basic structure of wholesale competitive Electric Energy market as per Electricity (Amendment) Act 2007.	
(o)	What do you mean by Grid Code & Grid Standard?	
[2]	**Answer any *ONE* from this questions**	**[10]**
(a)	A factory has three departments (Production, Testing & Quality Control) & their details of electrical appliances & respective loading durations are shown in **Table 1&2**. Energy cost is Rs.9/unit. Working is on the basis of 6 days in week. Draw Sankey diagram along with calculate 3rd year total costing for existing setup. Finally perform energy audit with calculation of saving in rupees per Annum with payback period calculation when replacing energy efficient devices. Also calculate Star rating of building (from EPI calculation). Use data from **Table:1** (Loading topology department wise); **Table:2** (Details of normal & energy efficient devices) & those are shown in next page.	
(b)	Calculate the Green Building Index (GBI) of a specified building using the data provided in **Table: 3** & from that value conclude on the grading of the building. Assume: Gross floor area=1500m^2, service life=50Years Use following Equations: 1. GBI=(Building Hospitality Index, Q)×(Carbon Economic Index, E)/(Carbon Emission Index, C) 2. $C=\alpha\times(EC_E/EC_R)+\beta\times(OC_E/OC_R)$, where α, β are Weights of area=0.125, EC_E & EC_R=Embodied carbon emission in evaluated building & reference building in construction phase, OC_E & OC_R=Operational carbon emission in evaluated & reference building in operational & maintenance phase. 3. $Q=\sum_{i=1}^{5}(\frac{Si\times Wi}{DMi})\times\frac{1}{100}$, where Si= Score obtained in evaluated building in specific area i, DMi & Wi are allotted scores & weights for accessing carbon emission from that specific area. 4. $CE=\frac{\Delta RB}{\Delta IC}\times 100=(\frac{OER-OEE+CB}{ICE-ICR})\times 100$,where ΔRB, ΔIC are carbon emission reduction benefit & increased construction cost, OER & OEE are annual operational cost for reference building & evaluated building, ICE & ICR are initial construction cost of evaluated building & reference building, CB is carbon emission trading profit, CE is carbon economic efficiency, (E=1 if CE<4%); (E=0.05×CE+0.8 if 4%≤CE<8%); (E=1.2 if 8%≤CE)	

Table:1 Loading topology department wise (Ref. Q.2.a)

Department	Illumination Level (lumen/m^2)	Volume= Area ×height (m^2)×m	Tube Light (36W) [No./hrs loading]	Cooling requirement (Watt/m^3)	Fan (Conventional) (60W) [No./hrs loading]	Computer (150W) [No./hrs loading]	Pump (0.5h.p) [No./hrs loading]	Air condition 1.5 Ton 3 star 1926W [No./hrs loading]
Production	150	400×3	45/8	24	100/8	55/8	2/1	15/8
Testing	150	500×3	50/8	24	125/8	65/8	2/1	18/8
Quality Control	150	600×3	35/8	24	95/8	45/8	2/1	12/8

Table:2 Details of normal & energy efficient devices (Ref. Q.2.a)

Device	Investment Cost/fitting (Rs.)	Replacement cost/fitting (Rs.)	Illumination (Lumen/m^2)	Power rating (Watt)	Life (hr.)	Cooling Capacity (Watt)	Co-efficient of Utilization	Maintenance Factor
Tube light	250	50	2100	36	4000	-- ------	0.6	1
LED	550	Nil	1800	18	50000	- --------	0.6	1
Fan (Conventionally controlled)	450	75	--------------	60	80000	- --------	0.6	1
Fan (Automatic control)(reduce 3hrs operating time than conventional)	650	75	---------------	60	70000	-- -------- --	0.6	1
A.C (3 star)	24000	1000	--------	1926	70000	4200	0.6	1
A.C(5 star)	34000	1000	-------	1677	70000	4200	0.6	1

Assume:

1. **N=(E × A)/(O × CU × MF) & M = (C × V)/(CC × CU × MF)**
   Where, N & M are No. of Light fitting & Split A.C are needed respectively
   E & C are required illumination level in Lux (lumen/m^2) & required cooling level in watt/m^3 respectively
   A & V are effective area to be illuminated in m^2 or effective volume to be cooled in m^3 respectively
   O & CC are luminous flux produces per lamp in lumen & cooling capacity per A.C in watt respectively
   CU & MF are Coefficient of utilization & maintenance factor respectively
2. **Energy Performance Index (EPI) = Energy consumption/area of building/year (in kWhr/m^2/year)**
   Where EPI= 80-70 building rating: 1star; 70-60: 2 star; 60-50: 3 star, 50-40: 4 star; below 40: 5 star
3. 1st yr annual costing=investment charge+ 1st yr energy charge; 2nd yr total costing=previous year costing+ 2nd yr energy charge; 3rd yr total costing=previous years' total costing +3rd yr energy charge+ replacement of fitting charge

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Table: 3 Details of Green building parameters (Ref. Q.2.b)

GBI Range	Grade	**Carbon Emission Index parameters**	**Building hospitality index parameters**	Wi	DMi	Si	**Carbon Economic Index Parameters** (Cost /unit area in USD/m^2)		
		Embodied & operational Carbon Emissions/unit area (Kg/m^2)					Parameters	Evaluated Building	Reference Building
GBI≥4	Green 1st	EC_E=450.5	Ecology	21	32	22.5	Initial construction cost	ICE=360.2	ICR=250.4
3≤GBI<4	Green 2nd	EC_R=670.5	Health	20	45	33.0	Annual operational cost	OEE=5.6	OER=10.1
2.5≤GBI<3	Green 3rd	OC_E=1170	Function	33	33	27.0	Annual carbon emission trading profit	CB=0.7	CB=0.0
2≤GBI<2.5	Green 4th	OC_R=2650.6	Energy Efficiency	26	36	26.0			
GBI<2	Out of Grade		Resource Efficiency	22	27	30.05			