Ref. No.: Ex/PG/EST/T/1210A /2024

M. TECH. ENERGY SCIENCE AND TECHNOLOGY
FIRST YEAR SECOND SEMESTER EXAMINATION – 2024

Subject : ENERGY AND ENVIRONMENT

Time: Three hours | Full Marks: 100

Use Separate Answer Scripts for Each Part

Part – I (60 Marks)

Answer **any three** questions.

1. a) What are the major sources of air pollution ? What do you mean by 'point sources', 'area sources' and 'line sources' of air pollution ? Give examples. 8

   b) Discuss on the major air pollutants that are added to the atmosphere due to energy conversion and energy use. Discuss on their effects on the environment. What is 'Thermal NO_X' and what is 'Fuel NO_X'? 12

2. Estimate stoichiometrically the emissions avoided by a solar photo voltaic power plant per unit of electricity generation taking emission factors of a coal-fired thermal power plant for 1 kWh of electricity generation as a standard data.

   Data given:

   i) 0.65 kg coal is burnt to generate one unit of electricity in a coal-fired thermal power plant;
   ii) Average elemental analysis of Indian bituminous coal:

   Carbon 50.4%, hydrogen 2.7%, nitrogen 1.0%, sulphur 0.3%, oxygen 7.6%, moisture 8.0%, and ash 30.0%.

   20

3. What is Carbon Trading ? Discuss on the three cooperative mechanism of the Kyoto Protocol – Emission Trading, Joint Implementation, and Clean Development Mechanism. 20

4. a) What is carbon sequestration ? Discuss on carbon fixation by plants through photosynthesis. 10

b) Average annual electricity generation from a coal-fired thermal power station is 7350×10^6 kWh / year. Calculate the area of plantation required for absorption of the entire CO_2 emitted by the power plant based on the following data.

Data given:

i) 1.20 kg CO_2 is emitted per kWh of electricity generation;

ii) 1 kg CO_2 is absorbed from the atmosphere for 0.55 kg of plant growth;

iii) Average plant growth rate is 6 ton / ha / year.

10

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ENERGY AND ENVIRONMENT

Time: 3 Hours (Part I + II) **Full Marks: 100**

Part II (40 Marks)

(Each question carries **20 marks**)
(*Answer any **two** questions*)

1. Capacity of a coal-fired power plant is 500 megawatts (MW). It operates 280 days per year and 24 hours per day. However, 1 ton of CO_2 is produced per megawatt-hour (MWh) of electricity generated from coal. If the coal-fired power plant is replaced with a solar PV power plant, calculate the following
   (a) Annual electricity generation of the coal-fired power plant
   (b) CO_2 emissions from the coal-fired power plant
   (c) Solar PV power plant capacity required to replace coal-fired power plant.
   (d) Net reduction in CO_2 emissions.
   Consider average daily radiation in Kolkata is 5 kWh/m²/day. Efficiency of the solar modules is 16%. The installation area of solar PV plant is 250 acres. Operational hours of PV plant are 11 hours per day. Assume solar PV produces zero direct CO_2 emissions. (1acres=4046.86 m^2).

2. What is a carbon footprint? Explain saturation of the ocean carbon sink. Describe in details different natural ocean carbon cycle processes.

3. Road transportation requirements of a particular region are catered by a fleet of 250 buses. Average half trip distance covered by a bus is 20 km. A bus having a mileage of 2 km/l completes 4 trips per day. Considering 1 liter diesel emits 2.71 kg of CO_2, 8.9 g of SO_2, and 2.9 g of NO_2, calculate the fuel consumption of the vehicle fleet and its corresponding emissions..

   If 30% of the vehicle fleet is replaced by battery operated electric bus, calculate probable energy savings and corresponding financial impact. Consider energy consumption of electric bus as 0.97 kWh/km and cost of grid electricity for charging vehicle as ₹ 7.95 per kWh. Calorific value of diesel is 38.29 MJ/l and cost of diesel is ₹ 90.76 per liter.

If battery operated electric buses are charged using electricity generated from thermal power plant, then calculate plant level emissions corresponding to fleet replacement. Consider CO_2, CO, NO_X, and $PM_{2.5}$ emissions for generating 1 kWh of electricity are 910.364 g, 0.396 g, 1.947 g, and 0.141 g respectively. Dimensionless correction factor accounting for grid transmission and distribution loss, and charging loss is 1.2 and 1.1 respectively.

4.a. A vehicle fleet has 300 vehicles. Each of these vehicles travels a distance of 160 km per day. 30% of these vehicles are to be replaced by battery operated electric vehicles. Energy consumption of a battery operated electric vehicle is 0.97 kWh/km. If energy required for battery operated electric vehicles is to be supplied by remodeling existing fuel stations with solar photovoltaic panels, then find out the number of such remodeled fuel stations needed to fulfill the energy demand. Consider average area of fuel station to be 1200 m^2 and only 25% of this area is available for module installation. The shadow area for each module is 2.082 m^2. Assume that 265 Wp modules having an efficiency of 13.8% and dimensions 1955×982×36 mm^3 may be used for this purpose. The annual average radiation received per day at this location at a tilt angle of 22.5° is 4.93 kWh/m^2.

4.b. Compare the environmental impacts of a bus using diesel fuel and a battery operated electric bus that is charged using grid electricity generated from thermal power plant.

Take necessary assumptions from Question 3 if needed.