Energy Resources, Economics & Environment
Revision Paper-1

1. Write true or false and explain the reason for your answer. Marks will be given only if the reasoning is correct
   a) The Human Disruption Index for CO_2 is 0.0005

   b) ONGC Videsh acquired natural gas mines in Kazakhstan, This results in an improvement in India's energy security.

   c) The cost of saved carbon for a grid connected 1 MW PV plant (exactly same technical configuration and characteristics) will be the same for a location in Kerala as it is for a location in Chhattisgarh,

   d) Solar radiation is a form of secondary energy

   e) The carbon dioxide emission factor of a thermal power plant will remain the same even if its energy efficiency is increased.

   f) It is not possible for a country with a lower electricity consumption per capita than the world average to have human development index (HDI) greater than any country that has electricity consumption that is more than 120% of the world average [2×6= 12]

2. A country had an annual production of coal in 2018 of 600 million tonnes. The production of coal in 2013 was 500 million tonnes. The proven reserves is 140,000 million tonnes.
   a) Calculate the static R/P ratio. [1]

   b) Considering the compound annual growth rate during 2013-18 as the growth rate for an exponential growth model, calculate the number of years that the coal will last. [2]

   c) The coal production data has been fitted and a S shaped logistic curve(Pearl Curve) fitted for an ultimate reserve of 140,000 million tonnes
   $Q_p = 140000/(1+600\ e^{-0.06t})$ where Q_p is the cumulative production of coal and t=0 is 1960. Calculate the time when the peak production is reached and the time when 90% is exhausted. Compare the three estimates of time duration of coal in a,b,c. [2]

   d) What are the limitations to the Hubbert's model (as in c)? Are there any other approaches possible? [1]

3. Diesel engine-generators are commonly used as backup power supply. A company (with a discount rate of 30%) has a diesel engine generator (DG set) of rating 25 kW for its outlets as backup supply with the normal electricity supply coming from the grid. In 2018 the diesel engine generator was operated for a total of 800 hours with a total electricity generation of 12000 kWh. The capital cost of the diesel engine-generator is ₹ 4 lakhs (life of DG set 10 years). The non-fuel operating and maintenance cost annually in ₹ 25,000. The diesel engine generator efficiency is 35%. The fuel used is Light diesel oil (LDO) with a calorific value of 41 MJ/kg and a price of ₹ 50/kg (Carbon percentage 84% by weight).

   a) Calculate the annual amount of LDO used and the annual fuel cost [2]

   b) Calculate the annualised life cycle cost and the cost of generated electricity [2]

   c) Compute the carbon dioxide emission factor for the DG set and the annual carbon dioxide emissions [2]

There is a proposal to replace the DG set with a solar PV module of rating 10 kW (module life 25 years) Price ₹ 6 lakhs , and a battery rating of 30 kWh Price ₹ 2.4 lakhs (life 5 years), balance of system (power electronics, controller- ₹ 1 lakh, life 10 years). Assume that the final electricity supplied by the system from the battery is the same as the DG.

   d) Calculate the initial cost and the simple payback period [1]
   e) Calculate the annualised lifecycle cost and the cost of generated electricity. Compare this with b) for a new installation. [2]
   f) Should the company opt for the PV- battery? Assuming that there is no carbon dioxide emissions for the PV-battery case. Calculate the cost of saved carbon [2]

4. The data for Sweden for 2010 and 2016 is given below (from the IEA statistics)

Table 1. Overall Data for Sweden

	2010	**2016**
Population (million)	9.3	9.9
GDP (Market Exchange Rate) Billion 2010 US $	488	560
GDP (Purchasing Power Parity Rate) Billion 2010 US $	391	448
Total Primary Energy supply (PJ) TPES	2132	2048
Electricity consumption (TWh)	140	137
CO_2 emissions (Million tonnes)	46	38
Net Energy Imports(PJ)	20	17

Table 2. Overall Indicators for India and the World 2016

	India	**World**
TPES/capita	19 GJ	77 GJ
TPES/GDP $_{MER}$	14.6 MJ/US$	7.4 MJ/US$
TPES/GDP $_{PPP}$	4.6 MJ/US$	5.3 MJ/US$
CO_2/TPES	57.6 kg/GJ	56.2 kg/GJ
CO_2/capita	1.6 tonnes	4.3 tonnes

i. Compute the GDP/ capita. What is the difference between GDP based on market exchange rate and GDP based on purchasing parity? Which should be used for inter-country comparisons? In the case of Sweden the GDP$_{PPP}$ is lower than GDP $_{MER}$? Is this also true for India? [2]

ii. Compute the per-capita electricity consumption and per capita primary energy use for Sweden in 2016? Comment on these values vis-à-vis India and the world. How do these link with development [2]

Table 3. Sweden Electricity sector 2016

	Hydro	Nuclear	Wind	Solar	Total (including thermal)
Installed capacity(MW)	16181	9075	6520	175	40,125
Generation(TWh)	61.7	60.5	15.5	No data	152.3

(Source: https://www.energimyndigheten.se/en/facts-and-figures/statistics/)

iii. Compare the capacity factor of the wind and nuclear power plants for Sweden. Compare the carbon intensity of Sweden's energy sector with India. Comment on the emissions intensity of Sweden's power sector as compared to India. [2]

iv. Using the Kaya identity comment on the changes in the carbon intensity of energy, energy intensity of the economy for Sweden during 2010-2016 [2]

v. Compare the energy intensity with the energy intensity of India .What does the energy intensity reflect? Does a lower energy intensity imply a more energy efficient economy? [2]

vi. Comment on the differences in perspectives and strategies for Sweden and India vis-à-vis the global Climate Change negotiation [1]

(Peta =10^{15}, Tera – 10^{12},Giga = 10^{8}, Mega -10^{6})