UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: December 2018

Module Number: EE6205   Module Name: Energy and Environment

[Three Hours]

[Answer all questions, each question carries 12 marks]

Q1. a) i)   Name four energy resources available in Sri Lanka.

   ii) What are the current strategies used in Sri Lanka to fulfill the increasing electricity demand?

   iii) Briefly discuss the objectives of Moragahakanda Kaluganga development project.

   iv) Describe the organizational structure of the petroleum market in Sri Lanka.

[6.0 Marks]

   b) i)   Comment on the income elasticity of energy demand in a developing country with reasons.

   ii) Cross price elasticity of demand values of three products X, Y and Z referred to the price of 95 Octane petrol are given as 0, -2.2 and 1.2 respectively. Comment on the three products and name one appropriate example for each.

[3.0 Marks]

   c) Consider an economy consisting of three sectors: agriculture (A), manufacturing (M), and energy (E). Technology matrix for these three sectors is given below.

$$\begin{array}{c} \\ A \\ M \\ E \end{array} \begin{array}{ccc} A & M & E \\ \begin{bmatrix} 0.18 & 0.28 & 0.00 \\ 0.15 & 0.50 & 0.32 \\ 0.04 & 0.14 & 0.23 \end{bmatrix} \end{array}$$

   i)   Calculate the external consumer demand for each sector, if the estimated production plan is 260.89 units in agriculture sector, 389.04 units in manufacturing sector and 185.59 units in energy sector.

   ii) Determine the new production plan, if the external consumer demand in energy sector increases by 25 units.

[3.0 Marks]

Q2 a) i)   Explain two methods which can be used to reduce the energy consumption of a lighting system.

ii) State three applications where adjustable speed drives (ASDs) cannot be used for energy saving.

iii) A 20 hp centrifugal water pump with a nominal efficiency of 89% operates 900 hours annually at its rated speed. A throttling valve is used to regulate the water flow to 45% on average. Calculate the electricity bill saving per year if the throttling valve is replaced with an adjustable speed drive (ASD) having an efficiency of 90% and Rs. 30 is charged for every kWh consumed. Clearly state any assumption you make.

[5.5 Marks]

b) i)   State the IEC power factor sign convention and IEEE power factor sign convention.

ii) Two motors are connected to a 400 V, 50 Hz, 3-phase supply where one motor draws a line current of 15 A at a power factor of 0.6 lagging. The second motor develops an output of 10 hp at a power factor of 0.7 lagging and efficiency of 93%. A capacitor bank having three branches of capacitors connected in delta configuration is connected in parallel to the supply terminals. Each capacitor branch consists of four 100 V, 0.3 mF capacitors connected in series and has a power loss of 220 W. Calculate the power factor of the system

I.   before connecting the capacitor bank, and

II. after connecting the capacitor bank.

iii) Explain different levels of an energy auditing process.

[6.5 Marks]

Q3. a) i)   Briefly explain how power plants are classified as 'conventional' and 'non-conventional'.

ii) What are the three main types of water turbines used in hydro power plants in Sri Lanka? Mention one plant for each type.

iii) Draw the general arrangement of a storage type hydro power plant and name the main components.

iv) Discuss the environmental impact of a large scale hydro power project.

v)   It is proposed to install a 50 MW hydro power plant which will be operated at its rated capacity for 500 hours per annum. The water reservoir has a 40.2 km^2 catchment area with an average annual rain fall of 3550 mm. If the overall efficiency of the power plant is estimated as 85%, calculate the minimum net head required for the power plant.

[8.0 Marks]

b) i)   Briefly explain the operations of following filtering components used in coal power plants.

      I.   Scrubber

      II.   Selective catalytic reduction system

ii) A coal power plant has a plant capacity of 300 MW and a thermal efficiency of 22%. The plant has an annual plant capacity factor of 0.55 and a peak demand of 254 MW. Take the calorific value of coal as 27200 kJ/kg. Calculate the annual coal requirement and the load factor of the power plant.

[4.0 Marks]

Q4. a) i)   State three advantages of diesel power plants over other thermal power plants.

ii) Briefly explain the operations of air supply system, fuel supply system, exhaust system and starting system in a diesel power plant.

iii) What is a combined cycle power plant?

iv) Why it is advantageous to operate the condenser at the lowest possible pressure in a steam power plant?

v) State the four main operations occur inside the engine of a gas power plant.

vi) Draw the arrangement of a nuclear power plant and name the main components.

[8.0 Marks]

b) i)   Name four main greenhouse gasses.

ii) Discuss the environmental impact of global warming.

iii) Briefly explain two carbon sequestration methods.

[4.0 Marks]

Q5. a) i)   Briefly explain how variable load on a power station increases the overall generation cost.

ii) What are the factors that need to be considered when selecting base power plants and peak power plants? Briefly explain whether you agree or not with the present practice of power plant selection in Sri Lanka.

iii) The equipment in a power station cost Rs. 45 million and has a salvage value of Rs. 5 million at the end of 25 years. Calculate the annual depreciation charge for the 3rd year using diminishing value method.

[5.5 Marks]

b) The annual load duration curve of a power system is shown in Figure Q5. Three power plants P_1, P_2 and P_3 are connected to the system. P_3 is continuously operated at its plant capacity and P_2 is only used during peak periods. The ratios of number of units supplied by the plants throughout the year are 4.5 : 1.0 : 2.5. Calculate the following.

i)   The plant capacity of P_1.

ii) The operational time duration of P_2.
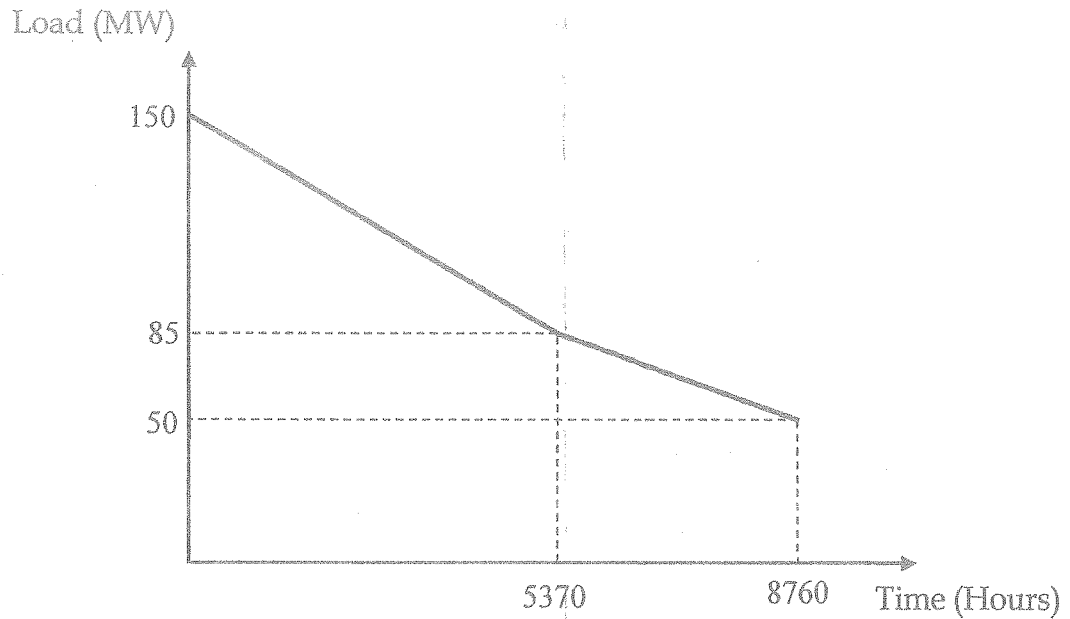
iii) Annual load factor for each power plant.

Figure Q5: Annual load duration curve

[4.0 Marks]

c) i)   What is the current economic model of the electricity sector in Sri Lanka? Justify your answer.

    ii) State four drawbacks of the economic model you mentioned in Q5 c) i) above.

[2.5 Marks]