UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: November 2017

Module Number: EE6205   Module Name: Energy and Environment

[Three Hours]

[Answer all questions, each question carries 12 marks]

Q1. a) i)   What are the main energy supply forms available in Sri Lanka?

   ii) State three ongoing power plant projects with their contribution to the installed electricity generating capacity of Sri Lanka.

   iii) Briefly discuss why Sri Lankan government decided to recommission some of the decommissioned Independent Power Producers (IPPs) in recent years.

   iv) Describe the organizational structure which controls the energy sector in Sri Lanka.

   [6.5 Marks]

b) Briefly explain the following energy-economy indicators.

   i)   Energy intensity

   ii) Energy intensity index

   iii) Income elasticity of demand

   iv) Cross price elasticity of demand

   [2.0 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.

$$\begin{array}{c} \\ A \\ M \\ E \end{array} \begin{array}{ccc} A & M & E \\ \begin{bmatrix} 0.22 & 0.25 & 0.08 \\ 0.11 & 0.42 & 0.43 \\ 0.05 & 0.20 & 0.25 \end{bmatrix} \end{array}$$

   i)   What production plan should the economy have to satisfy a consumer demand of 85 units of agriculture, 65 units of manufacturing and 80 units of energy?

   ii) Suppose the economy is producing 205 units of agriculture, 325 units of manufacturing and 175 units of energy. How much of the production is used internally?

   [3.5 Marks]

Q2 a) i) Discuss why demand side management has become essential to handle the increasing electricity demand.

ii) State the components that can be used in a day lighting system.

iii) A 10 hp centrifugal pump with a nominal efficiency of 90% operates 1,200 hours annually at its rated speed. A throttling valve is used to regulate the flow to 50% on average. Calculate the electricity saving per year if the throttling valve is replaced with an Adjustable Speed Drive (ASD) with an efficiency of 95%. State the assumptions you make.

[6.0 Marks]

b) i) A single phase motor connected to a 220 V, 50 Hz supply draws a current of 25 A at a power factor of 0.65 lagging. In order to improve the power factor to 0.85 lagging, a capacitor bank is connected across the supply terminals parallel to the motor. The capacitor bank consists of four identical capacitors connected in series. Calculate the capacitance value of a capacitor if the capacitor bank has a power loss of 450 W.

ii) What are the types of Energy Services Companies (ESCOs) available in Sri Lanka? Briefly explain the services provided by each type.

iii) Briefly explain the difference between an energy auditor and an energy manager.

[6.0 Marks]

Q3. a) i) Briefly explain two main disadvantages caused by a variable load on a power station.

ii) Consider a power system with three generators and three loads. Rated power output of each generator is 100 MW. Power ratings of L_1, L_2 and L_3 loads are 50 MW, 90 MW and 70 MW respectively. Daily power consumption profile of the three loads for a particular day is given in the Table Q3. Calculate demand factor, load factor, diversity factor, plant capacity factor and utilization factor of the system for the given day.

Table Q3

Time Load	6.00 a.m. - 12.00 noon	12.00 noon - 6.00 p.m.	6.00 p.m. - 12.00 midnight	12.00 midnight - 6.00 a.m.
L_1 (MW)	10	20	45	5
L_2 (MW)	80	60	10	85
L_3 (MW)	40	60	50	20

iii) Show that the annual depreciation charge(q) in Sinking Fund Method can be expressed as

$$q = (P - S)\left[\frac{r}{(1 + r)^n - 1}\right]$$

Where, P is initial cost, S is the scrap value after useful life period of n years and r is the annual interest rate of the sinking fund.

[6.0 Marks]

b) i) Briefly describe two filtering mechanisms used to control the emissions related to thermal power stations.

   ii) Renewable energy transition is one possible method to reduce the pollutants released to the environment in power generation. Describe the current government policy instruments taken to promote renewable generation in Sri Lanka.

[3.0 Marks]

c) i) List the characteristics of the current economic model in Sri Lanka.

   ii) Explain why retail model cannot be implemented in Sri Lankan energy sector.

[3.0 Marks]

Q4 a) i) List the types of power plants which can be used to supply the peak power demand and state why they can be used as peaking power plants.

   ii) Describe the factors to be considered when building a hydro power station.

   iii) Explain the function of surge tank in a hydro power plant.

   iv) Explain the types of masonry dams used in hydro power stations.

   v) What are the benefits of pump storage hydro power plants?

   vi) The daily load curve of a certain area is shown in Table Q4.

Table Q4

Time	Load (MW)
12 midnight – 5 a.m.	100
5 a.m. - 8 a.m.	120
8 a.m. - 12 noon	250
12 noon - 1 p.m.	100
1 p.m. - 5 p.m.	250
5 p.m. – 9 p.m.	350
9 p.m. – 12 midnight	150

It is proposed to install a hydro power plant and a steam power plant to supply the above load. The available flow rate of the water stream is 50 m³/s and the head is 90 m. The overall efficiency of the hydro power plant is 90% and the transmission losses are assumed to be 5%. Determine the required capacity of the hydro power plant and the steam power plant.

[9.0 Marks]

b) i) What are the two nuclear reactions?

ii) How is the chain reaction controlled in a nuclear power plant?

iii) Nuclear reaction event of uranium releases approximately $3.2 \times 10^{-11} J$ of energy. 1 kg of $^{235}_{92}U$ can have 25.4×10^{23} events. Compute the mass of $^{235}_{92}U$ required to produce an average of 1 GW of thermal energy annually.

[3.0 Marks]

Q5 a) i) List the types of losses occur in a steam power plant.

ii) Explain why the thermal efficiency of a condensed type steam power plant is higher than that of a non-condensing type power plant.

iii) Differentiate the types of furnaces used in steam power plants.

iv) List the types of steam condensers.

v) What is the function of the deaerator in a steam power plant?

vi) A thermal power station has four generators of 50 MW each. The efficiency of the generator is 96% and the thermal efficiency of the station is 20%. The calorific value of the fuel is 26800 kJ/kg. The load factor is 65% and the maximum demand is 175 MW. Calculate the rating of each turbine and the coal requirement per hour.

[7.0 Marks]

b) i) Draw the schematic diagram of a closed cycle gas turbine power plant.

ii) Explain the function of the regenerator in a gas turbine power plant.

iii) What is a combined cycle power plant?

iv) What are the advantages of a combined cycle power plant?

[5.0 Marks]