



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: February 2020

Module Number: EE6205

Module Name: Energy and Environment

[Three Hours]

[Answer all questions, each question carries 12 marks]

- Q1. a) i) Name four forms of energy supply in Sri Lanka.
ii) What are the three major hydro power complexes in Sri Lanka? Name two power plants in each complex.
iii) Briefly discuss three strategies recently used or proposed by the government of Sri Lanka to reduce the cost and environmental impact of electricity generation.
iv) Write a small note about Uma Oya hydro power project. [6.0 Marks]
- b) Explain the following energy-economy indicators.
i) Energy intensity index
ii) Self-price elasticity of demand
iii) Income elasticity of demand [2.0 Marks]
- c) i) What is a non-conventional power plant?
ii) State three non-conventional power plant types used for electricity generation in Sri Lanka.
iii) Explain the operation of a Proton-Exchange Membrane (PEM) fuel cell. [4.0 Marks]
- Q2. a) i) Briefly discuss how Demand Side Management (DSM) plans are being served in Sri Lanka.
ii) State the factors to be considered when implementing a day lighting system.
iii) A 15 hp centrifugal water pump operates 1000 hours annually at its rated speed. A throttling valve is used to regulate the water flow to 40% on average. An annual electrical energy saving of 8703 kWh was achieved when the throttling valve was replaced with an Adjustable Speed Drive (ASD) having an efficiency of 92%. Determine the efficiency of the pump if the motor is properly sized for the application with a load factor of 75%. Clearly state any assumption you make. [6.0 Marks]

- b) i) What is a walk-through energy audit?
- ii) Name two types of Energy Service Companies (ESCOs) registered with Sri Lanka Sustainable Energy Authority (SLSEA) and briefly explain the services provided by each type.
- iii) A 400 V, 50 Hz, 3-phase AC generator supplies power to following loads.
- *Load 1:* Pure resistive 3-phase load of 3 kW
 - *Load 2:* 3-phase induction motor drawing a line current of 15 A at 0.67 lagging power factor
 - *Load 3:* 3-phase synchronous motor consuming 2 kW power at 0.9 leading power factor

A capacitor bank having three branches of capacitors connected in delta configuration is connected in parallel to the supply terminals. Determine the required capacitance in a branch to improve the system power factor to 0.95 lagging. Neglect the power loss of the capacitor bank.

[6.0 Marks]

- Q3. a) i) State three advantages of an interconnected grid system.
- ii) Briefly explain the difference between spinning reserve and non-spinning reserve of a power system.
- iii) The equipment in a power station costs Rs. 20 million and has a salvage value of Rs. 2.5 million at the end of 25 years. Determine the depreciated value of equipment at the end of 15th year using sinking fund method for an annual interest rate of 10%.

[4.0 Marks]

- b) A total connected load of 350 MW with 60% annual demand factor can be supplied by either a hydro-electric power plant or a thermal power plant. Utilization factor of the power plant with the above demand should be 70%. The estimated costs are as follows:

Hydro-electric power plant:

Capital cost = Rs. 500,000 per kW installed

Operating cost = Rs. 3.50 per kWh

Thermal power plant:

Capital cost = 150,000 per kW installed

Operating cost = Rs. 9.00 per kWh

Annual interest rates on capital cost for hydro-electric power plant and for thermal power plant are 7% and 10% respectively. Calculate the minimum annual load factor above which the hydro-electric plant will be more economical. Assume total annual cost is equal to the sum of annual interest on capital cost and annual operating cost.

[4.0 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.

| | | | |
|---|------|------|------|
| | A | M | E |
| A | 0.15 | 0.20 | 0.00 |
| M | 0.12 | 0.43 | 0.20 |
| E | 0.10 | 0.30 | 0.13 |

- i) Calculate the external consumer demand for each sector, if the estimated production plan is 200 units in agriculture sector, 250 units in manufacturing sector and 180 units in energy sector.
- ii) Determine the new production plan, if the external consumer demand in agricultural sector increases by 40 units.
- iii) Calculate the internal consumption in ii).

[4.0 Marks]

- Q4. a)
 - i) Name three types of dams commonly used in hydro-electric power plants in Sri Lanka and give an example for each type.
 - ii) Briefly explain the operation and application of a pumped storage type hydro-electric power plant.
 - iii) A hydro-electric power station is to be operated at a mean head of 210 m and it is supplied from a reservoir having a catchment area of 800 km². The average annual rainfall in the area is 1300 mm and 85% from the rainfall is available for power generation. The expected plant factor is 70%. Allowing a head loss of 7 m and assuming efficiency of the turbine and the generator to be 92% and 90% respectively, calculate a suitable MW rating for this power station. Suggest the type of turbine suitable for this power plant.

[6.0 Marks]

- b)
 - i) Describe the arrangement of the fuel system of a diesel power plant.
 - ii) Explain the difference between turbocharger and supercharger associated with diesel engines.
 - iii) State three merits of a gas power plant compared to other combustion power plants.
 - iv) A nuclear power plant has a plant capacity of 400 MW and a thermal efficiency of 28%. The plant has an annual plant capacity factor of 0.65 and a peak demand of 300 MW. Nuclear reaction event of uranium releases approximately 3.2×10^{-11} J of energy. 1 kg of uranium can have 25.4×10^{23} events. Calculate the annual uranium requirement and the load factor of the power plant.

[6.0 Marks]

- Q5. a) i) State three advantages of a combined cycle power plant.
ii) Briefly describe two types of condensers used in steam power plants.
iii) Briefly explain the operations of economizer, super heater, pre-heater and re-heater in a steam power plant.

[4.0 Marks]

- b) i) Describe two filtering mechanisms used to control the emissions in coal power plants.
ii) Discuss the environmental impact of a large hydro-electric plant. Give two real life examples.

[4.0 Marks]

- c) i) What is green-house gas effect?
ii) Briefly explain two methods to reduce global warming.
iii) Describe the retail economic model for electricity sector.
iv) State why retail economic model is difficult to be implemented in Sri Lankan electricity sector.

[4.0 Marks]