



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2014

Module Number: EE5218

Module Name: Energy and Environment

[Three Hours]

[Answer all questions, each question carries 14 marks]

- Q1 a) i) Give the reasons why the Electrical Energy is considered as superior over other energy forms.
ii) Explain briefly the main structural behavior of the energy sector in Sri Lanka.
iii) Explain briefly the relationship between the energy and the economy. [4 Marks]
- b) i) State the main factors that affect the income elasticity of the energy demand of a country and compare that parameter for a developed country and a developing country.
ii) Some energy-economy related data of the country A is given in Table Q1. Calculate the energy consumption of the diesel and the electricity for the year 2013, if the energy demand ratio of electricity to diesel is 0.65. Take 2003 as the base year.

Table Q1

Year	Country A
2003	GDP (LKR million) = 2,880,000 Diesel (Thousand toe) = 28736 Electricity (Thousand toe) = 12736
2013	GDP (LKR million) = 5,450,100 Energy Intensity Index = 0.945

[5 Marks]

- c) i) What are the basic types of hydro power plants?
ii) Explain briefly the types of prime movers used in the hydro power plants and give an example for each.
iii) Explain briefly the advantages and the disadvantages of the hydro power plants.

[5 Marks]

- Q2 a) i) Draw the basic schematic diagram of a steam power plant. (Show the direction of the steam flow in each section clearly)
ii) Explain briefly the functionality of each section of a steam power plant.
I. Boiler
II. Super Heater

- III. Economizer
- IV. Air Preheater
- V. Condenser

iii) Briefly explain the main factors in which the thermal efficiency of a steam power plant depends on.

[8 Marks]

- b) i) Draw the schematic diagram of a gas turbine power plant in which the thermal efficiency is improved.
- ii) Draw the temperature entropy diagram for the plant in part b) i) showing the variations in each section in the diagram clearly.

[3 Marks]

c) i) A typical commercial solar cell costs Rs. 125 per watt of electricity generating capacity. A photovoltaic cell has a conversion efficiency of 9%, a performance efficiency of 0.8 and a lifetime of 30 years.

- I. How much electricity is a 10 m x 2 m cell generated based on an average solar insolation of 1700 kWh/m²yr?
- II. Estimate the cost of the panel if the daylight averages 12 hours per day.
- III. If the electricity is displaced by the solar cells costs Rs. 10/kWh in the retail market, what is the time that it takes the solar cell to pay its initial cost?

[3 Marks]

- Q3 a) i) Explain briefly how to design a daylighting system for efficient use of the electricity.
- ii) Mention the different types of automatic lighting control systems and briefly explain the disadvantages of each system.
- iii) The ABC company has a present policy of leaving its all office lights ON for the cleaning crew at night. The plant closes at 6:00 pm and the cleaning crew works from 6:00 - 10:00 pm. After a careful analysis, the company finds it can turn OFF 1000 fluorescent lamps (40 W each) at the closing time. The remaining 400 lamps provide enough light for the cleaning crew. The company also works during week days. The company pays Rs. 6.2 /kWh for the electricity. Assume the lamp ballast adds 15% to the load of the lamp.
- I. What is the saving for turning 1000 lamps OFF an extra 4 hours/day for one year?
 - II. What type of control system do you recommend for the lighting system in the plant? Explain why.

[7 Marks]

- b) i) What is the purpose of the power factor correction? State the three power factor correction methods used in the industry.
- ii) Explain briefly the methods of applying capacitors for the power factor correction.

- iii) Show that in a three phase system, the star connection requires a capacitor with a capacitance three times higher than the delta connected capacitor in order to supply the same reactive power.

[4 Marks]

- c) i) Explain why it is important to execute an Energy Audit in an organization.
ii) What are the typical work steps of a Preliminary Energy Audit?

[3 Marks]

- Q4 a) i) What are the benefits of the energy demand forecasting?
ii) What are the techniques used for the energy demand forecasting?
iii) A cement industry with an initial load condition of 5400 kVA at a power factor of 60% has a consumption of 1,920,000 units per month supplied at 33 kV. It is desired to operate the plant at a power factor of 0.96.

Consider the tariff values as below.

Demand charges = Rs. 144/kVA per month

Energy charges = Rs. 4.11 per unit

Note: If the power factor is below 90%, an additional charge of 1% from both the demand charge and the energy charge is occurred for each 1% of power factor reduction.

- I. What size of capacitor bank in kVAr is required for the power factor improvement?
- II. Calculate the cost saving due to the power factor improvement per year.
- III. Taking the cost of the capacitor bank as Rs. 2000/kVAr, the installation cost as Rs. 300,000 and the annual depreciation rate as 10%, calculate the simple payback period.

[9 Marks]

- b) A single zone heating unit is being used in a small office building. A variable air volume system retrofit is purchased and installed for a cost of Rs. 100,000. The retrofit system is estimated to save 45000 kWh per year for its economic life of 10 years. The company uses a discount rate of 10%. If the company pays Rs. 6 per kWh for electricity, and the system will have an annual depreciation rate of 25%, do you recommend to purchase the new system?

[5 Marks]

- Q5 a) i) Explain briefly the main impacts of the thermal power plants.
ii) State the main greenhouse gases and their main sources.
iii) What is meant by the carbon sequestration? State the three carbon sequestration methods.

[6 Marks]

- b) i) Explain briefly the main drawbacks of the current energy model in Sri Lanka.
- ii) Propose your own energy model for Sri Lankan energy sector and give the reasons why it is most suitable model compared to the present model.

[5 Marks]

- c) A coal-fired thermal power plant uses a coal type which consists 57.2% of Carbon, 2.2% of Hydrogen, 0.5% of Sulfur and 6.9% of Oxygen. Calculate the percentage of the air quantity required to burn the coal. Air contains 23.2% of oxygen in weight. State clearly the assumptions you use.

Hint: Mass number of Carbon = 12
Mass number of Sulfur = 16
Mass number of Oxygen = 8
Mass number of Hydrogen = 1

[3 Marks]