UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: February 2020

Module Number: ME8312 **Module Name: Energy Management**

[Three Hours]

[Answer **all questions**, each question carries **10** marks]
Clearly state any assumptions made in answering the questions.

Q1. a) What do you understand by an energy audit?

[2.0 Marks]

b) List out the **three** levels of energy audits conducted in industries and their outcomes.

[3.0 Marks]

c) Briefly describe **five** energy management measures to be considered for saving energy in the industrial sector.

[5.0 Marks]

Q2. a) With the aid of a clearly drawn sketch, explain how you can use Marginal Abatement Cost Curves (MACC) to reduce Green House Gas (GHG) emissions.

[3.0 Marks]

b) What are Abatement Cost and Abatement Potential?

[2.0 Marks]

c) A domestic roof-top solar PV installation of 3.5 kWp is planned to be installed. Find the Abatement Cost for above system by considering the following details.

- Solar PV System cost of 900,000 LKR
- Annual O&M cost of 5,000 LKR
- Solar PV System life of 20 years and no other costs
- Reference Technology Coal-based grid electricity
- GEF of 0.00089 tCO2eq/kWh
- Average cost of 16 LKR/kWh

[5.0 Marks]

Q3. a) "The key to a successful energy management program is the dedication and commitment of the top management". Discuss the significance of this statement and state **three** strategies that you will use to get the attention and support of the top management.

[3.0 Marks]

b) Discuss in brief what the ISO 50001 Energy Management System enables organisations to do.

[2.0 Marks]

Question Q3 is continued on page 2...

... Question Q3 is continued from page 1

c) Lighting for an office is provided by 20 incandescent lamps, each consuming 100 W of electricity. The lights remain switched on for 12 hours per day for a period of 300 days per year. The management of the company proposes to replace the incandescent lamps with 20 W Compact Fluorescent Lights (CFL). The following data are also given:

- Unit cost of electricity =12 LKR/kWh
- Retail price of an incandescent lamp (100 W) = 30 LKR
- Retail price of a CFL bulb (20 W) = 450 LKR
- Life of a CFL bulb = 10,000 hrs
- Life of an incandescent bulb = 1,000 hrs

As the energy manager of the company, you are requested to evaluate the following.

i) Annual energy cost of lighting for the office, if incandescent lamps are continued to be used.
ii) Annual energy cost of lighting for the office, if the incandescent lamps are replaced with an equal number of CFL bulbs.
iii) Annual savings due to the replacement of incandescent lamps with CFL bulbs.
iv) Assuming the purchase cost of CFL bulbs to be the major investment cost, calculate the simple payback period for the replacement of incandescent lamps with CFL bulbs.
v) Would you recommend or reject the proposal? Justify your answer.

[5.0 Marks]

Q4. a) In an energy audit of a coal-fired industrial boiler, below data have been recorded. Calculate the boiler efficiency by using the **direct method**.

Quantity of steam generated = 15.0 ton/hr
Pressure of steam = 12.0 barg
Temperature of steam = 220.0 °C
Temperature of feed water = 65.0 °C
Enthalpy of feed water at 65.0 °C = 272.1 kJ/kg
Enthalpy of superheated steam at 12.0 barg and 220.0 °C = 2860.6 kJ/kg
Rate of coal consumption = 3 ton/hr
Gross calorific value of coal = 20 MJ/kg

[2.0 Marks]

b) In a manufacturing plant, a boiler feeds 12 barg steam to the main steam line, which provides steam for the whole plant. One particular heating oven operates at 5 barg, using the steam obtained from a branch line connected to the main steam line. In the heating oven, steam flows in side of a heating element composed of a copper coil. The condensate produced at the coil is directed to a condensate recovery pipe line. Considering this setup, draw a schematic diagram of the steam distribution network. In the diagram, make sure to include any essential standard steam circuit components, in addition to the ones mentioned above. Name all the components in the sketch clearly.

[4.0 Marks]

c) With the aid of schematic diagrams, briefly describe **four** key methods of waste heat recovery related to a system composed of a boiler and its steam distribution network.

[4.0 Marks]

Q5. In a given manufacturing plant, a diesel-fired steam boiler operates to deliver steam to its production processes. **Table Q5** summarises data extracted from a proposal to replace the current diesel-fired boiler with a biomass-fired boiler having the same capacity to be operated in the same duty cycle.

Table Q5

Capacity of the diesel-fired boiler	8 ton/hr
Typical operation time of the boiler per day	6 hrs
No. of working days per month	20
Enthalpy of the feed water available for the boiler (50 °C , 0 barg)	210 kJ/kg
Enthalpy of the steam to be generated by the boiler (185 °C , 10 barg)	2780 kJ/kg
Efficiency of the diesel-fired boiler	75%
Calorific value of diesel	45 MJ/kg
Density of diesel	850 kg/m^3
Unit cost of diesel	120 LKR/l
Efficiency of the proposed biomass-fired boiler	67%
Calorific value of biomass to be used (firewood)	18 MJ/kg
Unit cost of firewood	25 LKR/kg
Total investment to be made if the current diesel-fired boiler to be replaced with the biomass-fired boiler	60 million LKR

By using the above information, answer the following questions.

a) Calculate the daily fuel cost for the diesel-fired boiler.

[1 Mark]

b) Evaluate the predicted daily fuel cost for the biomass-fired boiler.

[2 Marks]

c) Calculate the simple payback period and state whether the boiler replacement can be recommended or not.

[2 Marks]

d) State **four** key techniques which are used in the industry for particulate emission controlling of biomass boilers.

[2 Marks]

e) With the aid of schematic diagrams, briefly describe the concepts: Co-generation and Tri-generation in relation to a biomass boiler, highlighting their relative advantages in the context of energy management.

[3 Marks]