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The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX6236 New and Renewable Sources of Energy**
Academic Year	:	2014/15
Date	:	02.09.2015
Time	:	0930-1230 hrs
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 08 questions. All questions carry equal marks.
3. Answer any 05 questions only.
4. Formulas are provided at the end of the each question whenever needed.

Q1

1. Define renewable energy.

2. Indicate from the following list of energy sources which are originally derived from solar energy, and explain why or why not each one is solar-derived.

   a) Crude Oil
   b) Coal
   c) Natural Gas
   d) Hydro Power
   e) Biomass
   f) Wind Power
   g) Geothermal Power
   h) Tidal
   i) Wave Energy

3. Which one of the above comes under the category of renewable energy?

4. How long would you believe non renewable energy sources exist in the world such as fossil fuel, Natural gas and coal? By 2065 what would be the main source of energy in Sri Lanka? Explain your answer with reasonable facts and figures.

Q2.

1. What are the five categories of Biomass?

2. Describe origin of each biomass and the final product of each after conversion.

3. Biomass can be converted in to useful energy source. Explain which conversion process and technologies you may use for the conversion and the final products of each process.

4. Algae is one of the biomass grow in bio reactors to produce bio fuels. What are the main advantages of algae compare with other forms of biomass? What form of bio fuels can be obtained from algae?

5. Average food waste of middle class family in the city of Colombo is expected around 0.5 kg per person a day and the sewage waste of an average person will be around 0.5 kg a day. If 2 million people live in the city and assuming all are in the middle class;

   a. What is the maximum capacity of a bio reactor (in Tons)?

   b. How much biogas (in m^3) can be produced if all food waste and sewage waste is converted to biogas in a bio reactor?

   c. If a family of four (04) people live in the city consume 0.6 m^3 of biogas per day for cooking purpose, will it produce sufficient gas to cater entire population in the city?

   d. If excess amount of biogas is produced, it is possible to install a Gas turbine run on biogas. What is the power output of the Gas Turbine (in MW)?

Data available

01 Ton of food waste produce 300 m^3 of biogas
01 on of sewage waste produce 200 m^3 of biogas
6kWh of energy is produced by one m^3 of biogas.

Q3. 1. Briefly describe the process of gasification.

2. Briefly describe the advantages of having gasification in energy conversion.

3. Name two practical applications, where gasification is a part of the energy conversion process.

4. 5 Million m^3 of log wood are available per year in a country and 3 Million m^3 of those are used for energy production in a Dendro power plant. Dry wood usually consists of 46% Carbon (C), 49% Oxygen (O) and 5% Hydrogen (H). Moisture content in wood is 15% and the density of the wood is 600 kg/m^3.

   (a) What is the lower heating value (LHV) of the dry wood?

   (b) What is the water content (w) of the wood?

   (c) Calculate the corresponding LHV of the moist wood.

   (d) What is the mass flow rate of wood in t/h, if the yield of wood was equally distributed over one year?

   (e) What is the output power of the Dendro power plant in MW if the efficiency of the plant is 50%?

$$LHV_{dry} = 0.35\,X_C + 0.939\,X_H - 0.108\,X_O \quad MJ/kg$$

(in the above formula if the carbon content is 45 % then Xc=45)

$$LHV_{moist} = LHV_{dry}\,(1-w) - h_{fg}\,w$$

enthalpy of evaporation of water h_{fg} = 2256kJ/kg

w = water content

Q4. 1. What is the main source of wind?

2. Describe in brief how wind energy is harvested using a wind turbine.

3. What are the factors that you have to take into account when you are going to install a wind turbine?

4. What is the "Belts Limit" of a wind turbine?

5. What are the main differences between a Horizontal axis Wind Turbine and a Vertical Axis Wind Turbine?

6. It has been decided to replace two identical wind turbines operated at the wind speed of 5 m/s at 50m height in at location in a rural area after 20 years of service life. New wind mill is operated at 80 m height with 8m/s wind speed. If the diameter of the blade of the new wind turbine is doubled the old turbines;

   a) Will this replacement a success or a failure?

   b) What is the minimum wind speed that requires to operate the new wind turbine to get the same power out put of the old ones?

Wind Power (P) = 1/2 C_p ρ A V^3 where ρ is the density of the air, A is the swept area of the wind, and V is the wind speed. C_p is the power coefficient of the wind turbine.

Q5. Write short notes on the following.

(i) Visual pollution
(ii) Pyrolysis
(iii) Pump storage Hydropower stations
(iv) Main advantages of Vertical Axis Wind Turbines compare with Horizontal Axis Wind Turbines
(v) Main applications of Geothermal energy

Q6. a) Describe in brief

(i) Solar declination angle
(ii) Solar altitude angle
(iii) Solar hr angle.

b) On June 21st at 10 am at 40 ^{0}N latitude (φ), Determine

(i) The direct normal extraterrestrial irradiance (I_0)
(ii) Solar declination angle (δ)
(iii) Solar hr angle (W)
(iv) Solar altitude angle (α)
(v) The extraterrestrial irradiance on a horizontal surface (H_0)
(vi) Sunrise/ Set angle (W_{ss})
(vii) Daily total radiation received on the horizontal surface ($\underline{H_0}$)

Following equations are given with their usual notations.

$I_0 = I_{SC}$ [1 + 0.034 Cos (360N/365)] where I_{SC}=1353w/m^2,

δ = 23.45 Sin [360 (284+N)/365] where N is the day number from January 01

Sin α = Sin φ Sin δ + Cosφ Cosδ Cos W , $H_0 = I_0$ Sinα , $W_{SS} = \cos^{-1}$ [tanφ tanδ]

$\underline{H_0}$ = 24/π I_0 [cosφ cosδ sin w_{SS} + π/180 W_{SS} sin φ sinδ]

Q7. Write short notes on the following

a) Spectral distribution of solar radiation
b) Thermal storages of solar energy
c) Types of solar systems – Active and Passive solar systems
d) Crystalline silicon solar cell
e) Solar systems you have seen at the NERD centre

Q8. 1. What are the advantages and disadvantages of Geothermal energy?

2. What are the possible cycles which can be used in geothermal power generation?

3. In a single flash dry steam geothermal power system, a steam turbine inlet conditions are, pressure 6.5 bar and temperature 163°C. Turbine is delivering 2 MW power output. The turbine exhaust is directly sent out to the atmosphere. The isentropic efficiency (Π_{is}) of the turbine is given as 0.82.

Data available:

From steam property tables and Mollier diagram, enthalpy of steam at turbine inlet conditions (6.5 bar/163°C) is read as 2810 kJ/kg and isentropic enthalpy at turbine exit is taken as 2490 kJ/kg.

Calculate the mass flow rate of dry steam through the turbine.

Calculation Aid:

$\eta_{is} = h_1\text{-}h_2 / h_1\text{-}h_{2s}$

$P = m(h_1\text{-}h_2)$ (kJ/kg)

Where,

η_{is} = the turbine isentropic efficiency

h_1 = steam enthalpy at the turbine inlet (kJ/kg)

h_2 = steam enthalpy at the turbine exit (pressure=1.013 bar) (kJ/kg)

h_{2s} = isentropic steam enthalpy at turbine exit (kJ/kg)

P = Mechanical power output (MW)

m = mass flow rate (kg/s)

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