EGERTON UNIVERSITY

UNIVERSITY EXAMINATIONS

NJORO CAMPUS

FIRST SEMESTER 2012/2013

FIFTH YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN AGRICULTURAL ENGINEERING

AGEN 545: RENEWABLE ENERGY SOURCES

STREAM: 2008 (Y5) B. SC. AGEN **TIME:** 2 hours

DAY/TIME: THURSDAY, 03.00 – 05.00 pm **DATE:** 17/01/2013

INSTRUCTIONS:

1. The paper contains **FOUR (4)** questions
2. Attempt **QUESTION ONE** and **any other TWO (2).**
3. Marks are shown in parenthesis at the end of each question with a total possible score of 70.
4. In case of calculations, show all the working steps as well as the relevant units and indicate any assumptions made.
5. **EACH QUESTION SHOULD BE STARTED ON A NEW PAGE.**

QUESTION ONE (COMPULSORY)

(a) With the aid of a well-labelled sketch, briefly discuss, the various "biomass energy conversion processes" highlighting the raw materials through intermediate to the end-user products. **(8 marks)**

(b) Discuss 'Renewable Energy Technologies' under the following sub-headings:

(i) Direct Solar Energy Technologies **(3 marks)**

(ii) Indirect Solar Energy Technologies **(6 marks)**

(c) A permanent stream with an annual average water flow rate of 12.5 m^3 per minute passes through a 15-m waterfall. A rural community located by the stream wishes to venture into small hydroelectric power generation using the local stream. A dam will be constructed behind which a lake will form to act as the surge tank. The system available for converting the hydropower to electric power has an overall efficiency of 80%. Determine the average electric power that can be generated for the community using:

(i) The potential energy of the water

(ii) The kinetic energy of the water **(5 marks)**

QUESTION TWO

(a) With the aid of a well labelled sketch, discuss in detail the main stages in the biogas generation process **(10 marks)**

(b) A medium scale farmer practicing mixed farming has an average daily electric energy demand of 36.5 kWh. Design for the farmer, a biogas digester to meet his energy demand, using the information provided here bellow:

- The available cow dung generated on the farm on a daily basis is 450 kg.
- Cow dung has biogas production potential of 60 l/kg
- Calorific value of biogas from cow dung equals 22.2 MJ/m^3.
- Biogas will run an internal combustion engine with 33 % thermal efficiency, and in turn, the engine will run an electrical generator with 90% efficiency
- Cow dung to water mix ratio is 1:1 and retention time is 42 days
- Density of the slurry is approximately 1000 kg/m3

In particular, determine:-

(i) Whether the daily amount of cow dung available will meet the energy needs of the farmer

(ii) The height of a cylindrical digester needed if the diameter is restricted to 3.0 m

(iii) Dimensions of gas holder to contain gas demand for half a day **(14 marks)**

QUESTION THREE

(a) Vertical wind speed gradient may be estimated by either the power or the logarithmic functions. Using the usual notations for these functions, estimate the wind speeds at heights of 6.0, 16.0 and 22 m above the ground using both functions, and given the wind speed at 10 m above the ground as 17.7 m/s. The location is an open area characterized by few surface features with the roughness coefficient equal in magnitude to the roughness length of 0.12 m. **(8 marks)**

(b) You are the Agricultural Engineer in Laikipia County most of which is semi-arid. A farmer living on a 36-ha farm has approached you to assist in the design of a wind-mill water pumping system to irrigate the land for a green-house horticulture project using a nearby permanent stream with an annual average daily water flow rate of 416 l/min. The wind speed data is given on Table Q3. The available wind turbine equipment efficiency is 15.5% and the mechanical power transmission efficiency of the system is 82.5%. The irrigation requirement for the project is 75 mm of water per month, and the irrigation efficiency is 70%. Take each month to be 30 days, and the total water pumping head to be 5.7 m. Air density of the area equals 1.115 kg/m^3.

(i) Determine the maximum area the farmer can be able to irrigate with the water available

(ii) Design the wind-mill rotor diameter for the project using;

1. Mean annual monthly power available, and
2. Minimum monthly wind power available **(15 marks)**

(iii) Briefly discuss the criteria one would use to choose between designs 1 and 2 in (ii) above. **(1 mark)**

Table Q3: Monthly wind speed data, m/s

Mon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Speed	14.2	13.4	11.8	10.5	8.4	7.7	6.9	6.3	9.3	11.6	12.6	13.2

QUESTION FOUR

(a) Briefly discuss the following terms as used in renewable energy technologies:

(i) Geothermal energy conversion technologies **(6 marks)**

(ii) Solar thermal heat exchangers **(2 marks)**

(b) Determine the water exit temperature, T_{out}, from a solar collector with an heat exchanger between the collector loop and the storage loop given the following information:

- Overall collector heat loss coefficient, U_L = 5.8 W/m^2-K
- Collector area, A = 75 m^2
- Collector cover transmissivity, τ = 0.90
- Collector plate absorptivity, α = 0.95
- Collector plate thickness, δ = 0.75 mm
- Collector plate conductivity, k = 370 W/m-K
- Collector tube spacing, W = 12 cm
- Collector bond conductance, C_B = 345 W/m-K
- Inside collector tube diameter, D_i = 12.5 mm
- Collector tube wall thickness = 0.75 mm
- Heat transfer coefficient inside tubes, h_f = 335 W/ m^2-K
- Collector water mass flow rate, $\dot{m}$ = 0.015 kg/s-m^2
- Solar radiation falling on the collector, I = 700 W/m^2
- Inlet temperature of collector fluid, T_{in} = 44.5.0 ^oC
- Ambient temperature, T_a = 23.0 ^oC
- Specific heat of water, c_p = 4.2 kJ/kg-K
- Heat exchanger factor **(16 marks)**

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