Index Number:	

UNIVERSITY OF COLOMBO, SRI LANKA

FACULTY OF TECHNOLOGY

LEVEL II EXAMINATION IN TECHNOLOGY – Semester I – 2019

IA 2002 – Non-conventional Energy Sources & their Applications

Answer **All Questions**
Time: **Two (02) hours**
No. of Pages: **16**
Total **100 marks**

Important Instructions to Candidates

- This paper consists of 04 questions. Answer all questions.
- If a page or a part of this question paper is not printed, please inform the supervisor immediately.
- Enter your Index Number on all pages in the answers script.
- **STRUCTURED ESSAY TYPE: Write the answers to these questions in the space provided in the question paper.**
- Electronic devices capable of storing and retrieving text, including electronic dictionaries and mobile phones are not allowed.

Question	Marks
1	
2	
3	
4	
Total	

Index Number:

1. a). (i). Define “Energy”, and list down the different forms of energy.

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(2 marks)

(ii). Compare and contrast conventional and non-conventional energy sources.

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(2 marks)

(iii). What are the prime potentials of non-conventional energy sources?

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(2 marks)

b). "Photovoltaic (PV) devices are proper alternatives to exhausting fossil fuels". Discuss.

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(3 marks)

c). (i). What is the main function of a PV device?

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(2 marks)

(ii). A Solar cell is a PV device. Describe the process inside the typical Si based p-n junction solar cell upon the illumination of sunlight.

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(3 marks)

(iii). Charge controller and inverter are major components of a typical PV system. What are the main functions of them?

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(2 marks)

d). (i). Draw the I-V characteristic curve for a typical solar cell and label the following points on it.

- Short circuit current (I_{sc})
- Open circuit voltage (V_{oc})
- Maximum power point (MPP)
- Maximum current output (I_{mp})
- Maximum voltage output (V_{mp})

(3 marks)

(ii). How to find the fill factor of a typical solar cell using its I-V characteristic curve?

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(2 marks)

(iii). Draw the I-V characteristic curve for 3 identical solar panels (V_{oc} = 0.6 V and I_{sc} = 15 mA cm^{-2}) which are in series connection to form a solar array.

(2 marks)

(iv). What are the factors affecting the conversion efficiency of a solar panel?

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(2 marks)

2. a). (i). What are the factors that influence the production of wind energy?

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(3 marks)

(ii). "Offshore wind turbines are more beneficial than onshore wind turbines". Discuss.

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(4 marks)

(iii). State the basic parts of a wind turbine except the rotor blades.

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(2 marks)

(iv). Compare and contrast single-, two-, three-blade wind turbines.

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(3 marks)

b). (i). Complete the block diagram shown in Figure 2.1 which is relevant to the power electronic frequency conversion of a wind turbine.

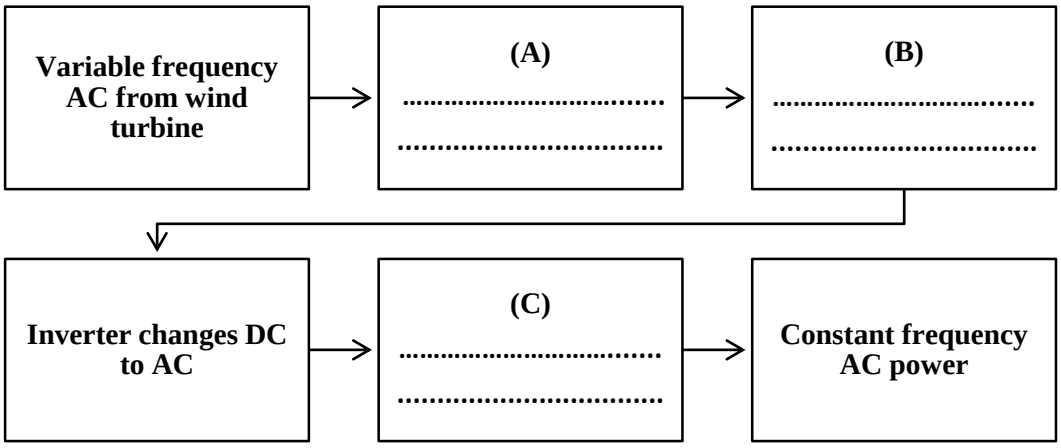

Figure 2.1

(3 marks)

(ii). Write down three traditional vertical axis wind mill types.

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(3 marks)

c). (i). Using the first principles derive the following equation to find the power output of a wind turbine.

$$P_{tur} = \frac{1}{2} A \rho_a v_w^3 C_{tur}$$

Where;

$P_{tur} -$ power out of the turbine, in W

$A -$ area swept by turbine, in m^2

$\rho_a -$ density of the air in wind, in kg m^{-3}

$v_w -$ velocity of the wind, in m s^{-1}

$C_{tur} -$ the efficiency of the turbine or maximum power coefficient

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(3 marks)

(ii). Determine the output power of a wind turbine whose blades are 20 m long, when the wind speed is 5 m s^{-1}, air density is 1.2 kg m^{-3}, and maximum power coefficient for this wind turbine is 0.30.

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(4 marks)

Index Number:

3. a). (i). What are the three main processes through which biomass can be converted into biofuels (or bioenergy)? Give one example for each process.

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(3 marks)

(ii). What are the main differences between direct combustion and pyrolysis?

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(2 marks)

(iii). What is the main difference between dry-milling and wet-milling in ethanol production?

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(1 mark)

(iv). It is possible to directly use vegetable oils in most diesel engines. However, there are two main issues related to vegetable oils which make them less desirable to be directly used in diesel engines. What are these two issues?

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(2 marks)

(v). Briefly explain what happens in the 'phase separation stage' of biodiesel production.

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(1 mark)

b). (i). Write down four factors that determine the growth rate of algae.

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(1 mark)

(ii). Briefly explain the 'raceway pond' used in algae production and draw a simplified diagram of a raceway pond.

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(3 marks)

(iii). Write down two advantages of a 'photobioreactor' compared to a raceway pond.

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(1 mark)

(iv). Write down three methods of extracting algae from water and two methods of extracting oils from algae.

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(2.5 marks)

c). (i) Compare and contrast Aerobic digestion and Anaerobic digestion.

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(3 marks)

(ii) Briefly explain the batch digester used in biogas generation and draw a simplified diagram of a batch digester (part names should be included in the diagram).

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(2.5 marks)

(iii) What are the two main physical phenomena behind the formation of ocean tides?

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(1 mark)

(iv) Briefly explain the tidal barrage and how electricity is generated by tidal barrages.

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(2 marks)

Index Number:

4. a). (i) What is the natural process that generates most of the geothermal heat?

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(1 mark)

(ii) Write down four applications of geothermal energy.

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(2 marks)

(iii) Briefly discuss the disadvantages of geothermal energy.

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(2 marks)

b). (i) Draw simplified diagrams depicting the main parts of a dry-steam plant and a binary-cycle plant used in geothermal power generation. Indicate the flow directions and name the parts.

(6 marks)

(ii) What is the main difference between a dry-steam plant and flash-steam plant in geothermal power generation?

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(2 marks)

(iii) What is the difference between a flash-steam plant and double flash-steam plant in geothermal power generation?

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(2 marks)

c). The rated capacity of a wind power plant is 5 MW. The annual capacity factor of the power plant is 48%. The capital cost of the power plant is Rs. 125,000 per kW. Annual operational and maintenance costs of the plant is Rs. 2,000,000. The plant has zero fuel costs. The plant has a lifetime of 30 years. The capital is provided by the government at 0% interest rate. The capital needs to be repaid in equal annual amounts over the plant lifetime.

(i) What is 'annual capacity factor' (ACF) of a power plant?

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(1 mark)

(ii) Calculate the annual electricity generation of the power plant in Wh.

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(2 marks)

(iii) Calculate the total capital cost of the power plant.

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(2 marks)

(iv) Calculate the total annual costs of the power plant.

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(3 marks)

(v) Calculate the cost of generating 1 kWh of electricity in the power plant.

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(2 marks)