2018/19

Department of Mechanical & Aerospace Engineering

ME927 Energy Resources and Policy

Friday 07 December 2018 **1000-1200 (2 hours)**

ATTEMPT THREE QUESTIONS
ADDITIONAL QUESTIONS ATTEMPTED WILL NOT BE MARKED

Calculators must not be used to store text and/or formulae nor be capable of communication. Invigilators may require calculators to be reset.

PLEASE TURN OVER

Q.1 **(a)** Give 3 reasons why the usable renewable energy resource in the UK is likely to be substantially less than the total energy consumption.

(6 marks)

(b) Individuals hold different viewpoints on the priorities underpinning the creation of a sustainable energy supply system. Outline 3 such viewpoints and indicate how they might be in conflict.

(8 marks)

(c) Why do nuclear power plants and wind farms of the same installed capacity produce dissimilar amounts of energy in any given year?

(4 marks)

(d) Outline 3 technology challenges facing the continued use of fossil fuels at present rates and give your view on the likelihood of these challenges being tackled effectively.

(7 marks)

Q.2 **(a)** What instruments could you use to measure the global horizontal radiation and the direct normal solar radiation.

(4 marks)

(b) A developer plans to build a large solar power plant as shown in Figure Q2.

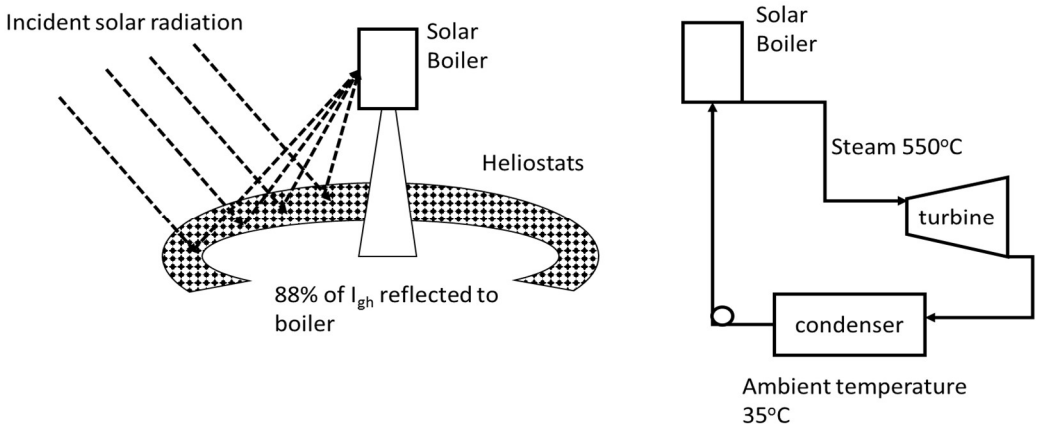

Figure Q2

(i) Calculate the maximum theoretical efficiency for this power plant;

(3 marks)

(ii) and its *realistic* efficiency.

(2 marks)

(c) The solar plant of Figure Q2 has 170,000 heliostats, which cover a ground area of 510,000m^2 and which reflect 88% of the global horizontal radiation falling on that ground area to the boiler.

Using the infomation in Table Q2 and the given equations (both over), caclulate.

(i) the direct horizontal radiation intensity (W/m^2);

(5 marks)

(ii) the total horizontal radiation intensity (W/m^2);

(2 marks)

(iii) the total radiation reflected from the heliostats to the boiler (W);

(3 marks)

(iv) assuming it reaches the realistic efficiency calculated previously, caclulate the power output of the plant (W).

(2 marks)

(d) Identify 2 advantages and 2 disadvantages of this type of solar power plant.

(4 marks)

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TABLE Q2

Hour angle	14°	Latitude	37.5°N
Declination	4°		
Direct normal solar intensity I_{dn}	786 (W/m^2)	Diffuse horizontal solar intensity I_{fh}	92 (W/m^2)
Key equations (where the symbols have their usual meaning): Direct horizontal radiation intensity: $I_{dh} = I_{dn} \sin \beta_s$ Solar altitude: $\beta_s = \sin^{-1} [\cos L \cos d \cos \theta_h + \sin L \sin d]$.			

Q.3 **(a)** The energy produced per cycle in a typical tidal barrage power plant, E, is a function of the tidal range, *2a*, the tidal basin area, *B*, the water density, ρ, and the gravitational constant, *g*. A non-dimensional energy parameter Φ_E may be produced, where

$$\Phi_E = \frac{E}{(2a)^2 Bg\rho}.$$

For a proposed tidal barrage system, the mean tidal range is 8.0 m and the basin area is 22 km^2. The annual energy produced from the plant is 544 GWh. Compute a value for Φ_E and hence estimate the annual and time-averaged outputs for the proposed system where the mean tidal range is 5.2 m and the basin surface area is 1.8 km^2. Take the water density as 1025 kg/m^3.

(7 marks)

(b) Identify 6 challenges facing the deployment of tidal stream energy conversion devices.

(6 marks)

(c) Describe 3 possible approaches to turbine sizing for power extraction from the phased operation of multiple sites over the lunar cycle.

(6 marks)

(d) In the context of wave power extraction, give an example of an oscillating water column and a relative motion device. Explain the operational principle in each case and state an advantage and a limitation of each device.

(6 marks)

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Q.4 **(a)** Biofuels are often proposed as a means to reduce the carbon emissions associated with road transport.

(i) Provide two arguments for and two arguments against the widespread use of biofuels in UK vehicles.

(8 marks)

(ii) List three potential biodiesel sources.

(3 marks)

(b) The production of heat and/or power using methane landfill gas is sometimes described as having a 'double benefit'. Briefly, explain what this means.

(4 marks)

(c) Landfill gas can be converted to heat and power in a combined heat and power (CHP) unit.

(i) Using a sketch outline the main features of small-scale, engine-based CHP.

(4 marks)

(ii) Briefly, explain the potential advantages of CHP compared to separate provision of heat and power.

(2 marks)

(iii) Briefly, explain why in the UK, CHP is becoming less effective as a carbon saving technology over time, while heat pumps are becoming more effective.

(4 marks)

Q.5 **(a)** Summarise the main features of the UK Renewables Obligation prior to the scheme's closure in 2017 and indicate the issue that the Electricity Market Reform seeks to address.

(9 marks)

(b) Summarise the main features of the Renewable Energy Feed-In Tariff.

(8 marks)

(c) Summarise the headline aspects of the 2016 Paris Climate Accord and state a principal shortcoming.

(8 marks)

END OF PAPER

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