The Open University

T206/B

Course Examination 2008

ENERGY FOR A SUSTAINABLE FUTURE

Monday, 6 October 2008 **2:30 pm – 5:30 pm**

Time allowed: 3 hours

Answer **ALL** questions in **Part A** and any **TWO** in **Part B**

Each question in Part A carries 6 marks (48 marks in total) and each Part B question carries 26 marks (52 marks in total). You are advised to spend **five minutes** looking through the paper before you start. You should then spend no more than **one hour and twenty minutes** on Part A. This leaves **one and a half hours** for Part B, and **five minutes** at the end to check through your answers.

At the end of the examination

Check that you have written your personal identifier and examination number on each answer book used. **Failure to do so will mean that your work cannot be identified.**

Put all your used answer books together with your signed desk record on top. Fasten them in the top left corner with the round paper fastener. Attach this question paper to the back of the answer books with the flat paper clip.

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PART A

*Answer **ALL** questions in **Part A.***

Question 1

(a) Explain what is meant by the *energy self-sufficiency* of a country.

(2 marks)

(b) Describe and briefly explain the reason for **ONE** significant change in the energy self-sufficiency of each of the following two countries during the second half of the twentieth century.

(i) The UK

(ii) The USA.

(4 marks)

Question 2

Table 1 shows the world total electricity consumption and world total primary energy consumption for the years 2000 and 2005.

Table 1 World consumption of electricity and primary energy, 2000 and 2005

year	world consumption	
	electricity	primary energy
2000	55.44	424
2005	65.46	490

All data are in exajoules (EJ)

(a) Assuming that the average conversion efficiency of the world's power stations was 38.5% in both these years, determine the primary energy input for electricity generation in each year, in EJ.

Calculate the percentage of world total primary energy used for electricity generation in each year.

(4 marks)

(b) Show that the data in Table 1 support the view that world primary energy consumption was rising by about 3% per year during this five-year period.

(2 marks)

Question 3

A coal-fired power station might release nearly twice as much carbon dioxide per kilowatt-hour of electrical output as a combined-cycle gas turbine (CCGT) plant.

Explain **TWO** fundamental reasons for this difference.

(6 marks)

Question 4

(a) Describe what is meant by a *hydrogen economy*, and explain why a change to a hydrogen economy could be a means of reducing carbon emissions.

(4 marks)

(b) Briefly describe **TWO** obstacles to the full development of a hydrogen-fuelled system for road transport.

(2 marks)

Question 5 Briefly explaining your reasoning, identify the isotope in Table 2 that is described in each of the following cases.

(a) The isotope that is produced when polonium-212 emits an alpha particle.

(2 marks)

(b) The isotope that is produced when strontium-90 emits a beta particle.

(2 marks)

(c) A fissile isotope that is produced in a uranium reactor.

(2 marks)

Table 2 Atomic numbers and mass numbers of various isotopes

name of element	atomic number of element	mass number of isotope
krypton	36	86
strontium	38	90
yttrium	39	90
lead	82	208
polonium	84	212
radon	86	222
uranium	92	235
plutonium	94	239

Question 6 You are considering the relative merits of installing either solar thermal panels or PV modules on your south-facing roof.

The solar panels are expected to supply about 1500 kWh of heat per year. This is about half your annual demand for hot water, which is at present supplied by a natural gas boiler with an overall efficiency of 60%.

The PV system is expected to generate about 1500 kWh of electricity per year. This is about one third of your annual electricity consumption, which is at present supplied from the grid.

(a) Using the data below, compare the two systems in terms of the resulting overall reduction in carbon dioxide emissions, assuming that in each case the annual output is fully used.

Carbon dioxide emissions

The combustion of natural gas releases 0.19 kg of CO_2 per kWh of heat.

The UK grid releases an average of 0.50 kg of CO_2 per kWh of electricity.

(3 marks)

(b) Briefly discuss the factors that could affect whether or not the annual output of each system would in practice be fully used.

(3 marks)

Question 7 The electrical power output (P) in watts from a hydroelectric plant is given by the following equation.

$$P = 1000 \times \eta \times g \times Q \times H$$

(a) Identify the quantities represented by the four symbols on the right-hand side of the above equation.

(2 marks)

(b) A mini-hydro system provides power for a remote house, making use of a mountain lake which can supply water at an effective head of 40 metres. Calculate the water flow rate needed to provide 3.0 kW of power if the plant runs at an overall efficiency of 75%.

You may use the approximation $g = 10$ N kg^{-1}.

(2 marks)

(c) In an average day, the household uses 15 kilowatt-hours (kWh) of electricity. Show that this could be maintained for 10 days during a dry period if the lake held 1800 cubic metres of water at the start of the period.

(2 marks)

Question 8 (a) A combined-cycle gas turbine (CCGT) plant and a very large offshore windfarm both have the same rated output power of 200 MW. However, their average annual *capacity factors* are very different, at 80% for the CCGT plant but only 40% for the wind farm.

Calculate the annual output from each plant, expressing your answers in millions of kilowatt-hours.

(2 marks)

(b) Table 3 shows a breakdown of the annual costs of the two plants, in millions of pounds per year.

Determine the total annual cost of each plant and use this together with your results from part (a) to calculate the unit cost of electricity from each plant, in pence per kWh of output.

Table 3 Annual costs of CCGT and offshore wind plant

plant	annual capital repayment	annual O&M costs	annual fuel cost
CCGT	8.0	6.0	36.0
Offshore wind	30.0	6.0	nil

All cost data are in millions of pounds (£M) per year.

(2 marks)

(c) Table 3 shows a much greater annual capital repayment for the windfarm than for the CCGT plant. Suggest any **TWO** possible reasons for this.

(2 marks)

PART B

*Answer any **TWO** questions in **Part B**.*

Question 9

Nuclear power currently provides 18% of the UK's electricity. A number of nuclear power plants are reaching the end of their operational life and will be closed in the near future. It is proposed that these should be replaced by new nuclear plants and that the proportion of electricity generated might be expanded to 30% or more.

Write a paper of 500–600 words in which you consider the merits of this proposal in terms of its practicability, its economic and strategic implications, and the associated environmental and social issues.

In your conclusion, you may express your overall approval or opposition to the proposal, but this is not a requirement

(26 marks)

Question 10

The rising cost of oil and strategic concerns about supplies have added urgency to the discussion of alternative sources of liquid fuels. Two options under consideration for increased development are *oil-from-coal* and *liquid biofuels.*

Write a paper of 500–600 words comparing these options in terms of their environmental, economic, strategic and social consequences.

Your paper should consider the interests of the main 'consumer' countries (the major users of liquid fuels) and the probable 'source' countries (the major suppliers of the coal or biomass).

(26 marks)

Question 11

'It is widely recognised that offshore wind energy will provide the majority of the required contribution [to meet the UK target] to supply 15% of our consumed energy from renewable sources by 2020.'

Rob Hastings, director of marine estates for the Crown Estate, owners of most of the UK's near shore seabed, quoted in the *Guardian, 18 April 2008*

Write a paper of 500–600 words in which you consider whether wind power is likely to become the dominant renewable resource in the UK, and whether it might contribute, say, 10% of UK-delivered energy by 2020.

You may make use of the following information if you wish.

A 2002 study of the UK's three most accessible regions for offshore wind power estimated their total gross potential, ignoring any constraints on development, as about 700 TWh per year.

The proposed 1000 MW *London Array* in the Thames Estuary is expected to contribute 3–4 TWh per year.

(26 marks)

Question 12 The Marine Renewables Deployment Fund (MRDF) was set up by the UK government in 2006 to support full-scale wave power and tidal current projects. After nearly two years, no project had received support because none had been able to meet the MRDF requirement of having proved *full-scale operation at sea for three months.*

Write a paper of 500–600 words on **EITHER** wave power **OR** tidal current systems, which should ...

- describe the main systems that have been under development in recent years, and discuss possible reasons for their failure to meet the MRDF requirement, and
- consider why the requirement of full-scale operation for three months to qualify for major support may not be appropriate for this type of technology.

(26 marks)

Question 13 In comparison with other countries in Northern Europe, the energy efficiency of UK domestic housing stock in the UK is very poor.

Write a paper of 500–600 words in which you consider the measures that might be included in a government program to remedy this situation.

Your paper should ...

- outline the main technical measures available to improve the energy efficiency of a domestic building, comparing them in terms of their energy-saving potential and costs,
- discuss other factors that might affect the success of a program of improvement, and
- identify those measures that would in your opinion be most effective as elements of a national program of improvement, explaining your reasoning.

(26 marks)

Question 14 'The idea that Britain can meet its growing power needs through renewable energy and greater efficiency is nonsense.'

Rt Hon. John Hutton MP, Secretary of State for Business, Enterprise and Regulatory Reform, quoted in *The Sunday Times, 6 January 2008.*

Write a paper of 500–600 words explaining whether or not you agree with this opinion.

(26 marks)