E4.50

IMPERIAL COLLEGE LONDON

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
EXAMINATIONS 2008

EEE PART IV: MEng and ACGI

Corrected Copy

SUSTAINABLE ELECTRICAL SYSTEMS

Friday, 9 May 10:00 am

Time allowed: 3:00 hours

There are SIX questions on this paper.

Answer FOUR questions.

All questions carry equal marks.

Any special instructions for invigilators and information for candidates are on page 1.

Examiners responsible	First Marker(s) :	C.A. Hernandez-Aramburo
	Second Marker(s) :	B.C. Pal, B.C. Pal

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1. Answer the following questions.

a) Explain how the "logistics curve method" is used to estimate the availability of energy resources. Include in your explanation the following concepts: cumulative production curve (and explain its main segments), cumulative discovery curve and proven reserves curve.

[8]

b) What is the meaning of the reserve/production ratio?

[2]

c) Explain (in about 250 words) what the energy security challenges for the UK are, what risks they carry, and how these risks are being addressed in the UK according to the white papers issued since 2003.

[10]

2. A tidal generation system based on a barrage is proposed for the Severn estuary. The mean tidal range in this place is 10m and its area is approximately 70 sq. km.

a) Estimate the amount of potential energy available for tidal exploitation and the corresponding mean power.

[5]

b) Estimate the efficiency of the whole system, from the energy that can be recovered from moving water to electricity delivery.

[6]

c) If only Pelton, Francis, Kaplan and Crossflow turbine-families are under consideration, what is the most likely family to be chosen? Explain the reasoning behind your answer.

[4]

d) Briefly explain the ebb and flood strategies for tidal generation.

[2]

e) What are the advantages of tidal lagoons with respect to a barrage system?

[3]

3. Answer the following questions.

a) Why are power electronic converters needed for the connection of some types of generators to a particular load or to the grid?

[2]

b) What are the main characteristics sought in such a power converter?

[3]

c) Sketch the voltage waveforms likely to be seen at every stage of the power converter shown in figure Q3 during normal operation.

[6]

e) For a photovoltaic system, answer the following:

i) Explain why the maximum power point changes.

ii) Cite the theoretical and practical efficiencies of a crystalline silicon PV cell. Cite also the typical efficiencies for the PV cells currently found in the market.

ii) What are the components most likely to fail in a PV system?

[3]

d) Draw a block diagram of a grid-connected photovoltaic system with an MMPT strategy incorporated in it. Briefly explain the aim of each block.

[6]

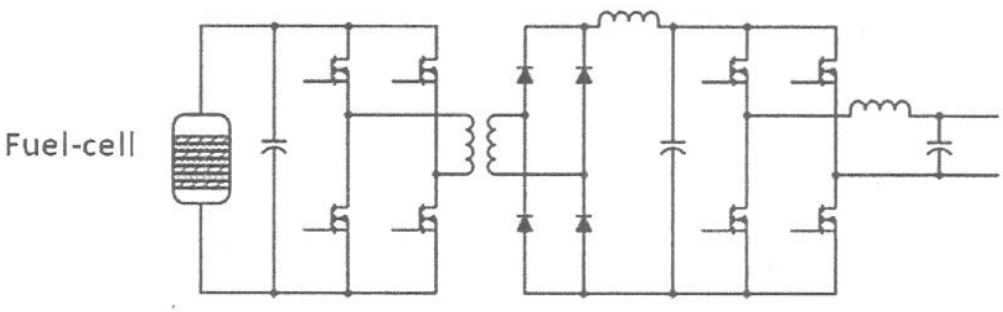

Figure Q3

4. Answer the following questions.

a) Show, from first principles, that the maximum power that a drag-only wind turbine can extract from the power available in the wind is less than 15%.

[8]

b) Estimate the CO_2 savings (in tonnes) likely to be made over one year by a 4MW-rated, horizontal-axis wind turbine installed in the UK. State any assumptions you make.

[4]

c) How can the market regulator in the electricity supply industry contribute to make electricity networks sustainable?

[4]

d) List the main parameters to assess quality of supply in the electricity supply industry.

[2]

e) List the main parameters to assess quality of service in the electricity supply industry.

[2]

5. Answer the following questions.

a) Explain how a Ringbom Stirling engine works. Include in your answer schematic diagrams of the position two pistons and a brief explanation of the thermo-dynamical phenomena occurring during each state transition.

[10]

b) Assume that the Ringbom Stirling engine has the following characteristics and operating conditions:

- Temperature of the hot and cold pistons: 700K and 300K, respectively.
- Compression ratio at the cold piston: 10 to 1
- Expansion ratio at the hot piston:1 to 10
- $\mu = 40x10^{-6}$ [kmoles]
- R = Gas constant = $8.3x10^{3}$[J/(K kmole)]
- C_V = Specific heat at constant volume = $20.8x10^{3}$ [J/(K kmole)]
- There are no losses in the regenerator.
- The losses by friction and turbulence are negligible.

Calculate the following:

i) The amount of work that the engine receives at the cold piston by compression.

[2]

ii) The amount of work done by the engine during the expansion of the hot piston.

[2]

iii) The amount of heat added to the gas during its expansion in the hot piston.

[2]

iv) The amount of heat retained and released by regenerator.

[2]

v) The efficiency of the engine.

[2]

6. Answer the following questions

a) What is the "Renewable Obligation Order"?

[2]

b) What are the targets of the Renewable Obligation order 2007/2008 and for 2015/2016?

[2]

c) What are "Renewable Obligation Certificates" and how are they issued?

[2]

d) What is the Climate Change Levy and what energy and fuel is exempt from it?

[4]

e) What is usually meant by integrating (as opposed to "connecting") distributed generation into the networks?

[4]

f) Explain what the concept of a "Virtual Power Plant" is, and its functions.

[4]

g) Explain what "capacity value" is, and describe some scenarios where distributed generators may have low and high capacity values.

[2]