T206 Energy for a sustainable future

PART B Questions with marking guide

The introductory part of the TMA booklet includes the following informal advice on answering Part B questions, which might usefully be borne in mind when marking.

- Do read the question carefully, and check from time to time that your answer isn't wandering off the point. This can seriously reduce your mark.
- A good paper starts with an introduction telling the reader what it is going to say, then says it, and concludes with a brief summary of what it has said.
- *Quantitative data* are an essential part of any discussion of energy systems.
- Do note the *specified length* for each question or part-question, and try to keep your text (excluding diagrams, tables, etc.) within ten percent or so of the required number of words. There are penalties in lost marks for serious breaches of the limits. (*Markers please see Word count, below*)
- Finally, do find time to read through your work before submitting it, checking especially for repetitions, or their opposite – unexplained jumps in your line of thought. (These can often result from moving sentences or paragraphs around within your answer.) And do use a spelling checker if possible.

  ***Word count**: The Part B rubric specifies answers of between 1000 and 1200 words. It has been agreed that lengths significantly outside the ±10% limit (i.e. roughly 900 – 1300 words here) should be penalised, but that the extent of the penalty will depend on the context and is at the marker's discretion.*

TMA 01, 2006

Question 9

Figures 2.9 and 2.16 in Book 1, *Energy Systems and Sustainbility*, show the variations in the types of primary energy produced and consumed in the UK and the USA over the period from 1925 to 2000.

Compare the information in these two diagrams, drawing attention to the similarities and differences between the two countries, and discussing in particular their changing patterns of resource availability and their changing patterns of demand.

(52 marks)

Q.9 Notes on answers

Answers will obviously draw on Sections 2.5 and 2.7 in Chapter 2 of Book 1, but there is also relevant material in Section 3.3 of Chapter 3 (and elsewhere in the nine chapters covered by this TMA).

Students will need to consider how to structure their answers. One obvious possibility is to take each energy source in turn, comparing the changes in its production and consumption in the two countries. Another approach might compare the relative contributions of the different fuels at different times during the period covered. Or the two aspects, production and consumption might be treated separately. In each case, a suitable introduction and a concluding summary are needed. The proposed mark scheme reflects the importance of a well thought out approach to this multi-faceted topic.

Whatever the format, the following might be regarded as important points that should be noted.

- The steeply rising **oil consumption** in both countries during the first 50 years

- The significant differences between the UK and USA in **oil production** over the period shown
- The very different patterns of **natural gas consumption and production**
- The dominance of **coal** in the UK until the 1950s, whilst oil has overtaken coal in the US by 1955
- AND/OR The striking difference in the histories of **indigenous fossil fuel** resources
- The similar growth of **nuclear power** in both countries since the 1960s.

A very good answer could also mention the changes in self-sufficiency (discussed in the text), but Figures 2.9 and 2.16 are not the easiest sources for this information.

The question asks for discussion of the changing patterns, and students need to be clear that simple description is not discussion. A reasonable answer might consider at least **four or five** of the following or similarly relevant factors that may have contributed to the changes (*no particular order here*).

- The early discovery and development of its oil resource by the US
- Coal as effectively the only indigenous fossil fuel in the UK until the late 1960s
- The development of the UK's North Sea resources: gas in the early 1970s and oil in the later '70s
- The fall in demand for coal in the UK from the late 1950s – and the even greater fall in production
- The availability of nuclear power only after its military development during WWII
- The increasing demand for transport fuel in both countries, particularly during the first 50 years
- The effect of the world oil crises of the 1970s (*discussed on p.69*)
- The growing demand for a liquid fuel for transport
- The growing demand for electricity in both countries throughout the period (*mentioned on p.81*)
- In the UK, the 'dash for gas' as the preferred fuel for power stations from the 1990s

The obvious difference between the UK and US in the quantities of energy should also be mentioned. The diagrams (and the question) offer no data on area, population, climate, etc., but a relatively brief reference to some of these factors might be expected. However, this is not the main topic and shouldn't be given undue weight at the expense of "discussing in particular" the changing patterns, as specified by the question. Similarly, economic factors and environmental issues are relevant only where they have affected the data shown in the graphs.

Q.9 Suggested mark scheme

Conformity with specification.....*4 marks*
Structure, organisation.....*10 marks*
Identification of significant similarities and differences.....*16 marks**
Discussion of reasons.....*10 marks**
Introduction and concluding summary.....*8 marks*
Mark for particular excellence: e.g. originality, numeracy******, presentation, etc. .....*4 marks*
TOTAL FOR QUESTION 9.....***52 marks***

** Some marking flexibility between these two items.*

*** For instance dates; estimates of percentage contributions, changes, etc. (There is evidence of marks lost in similar questions in examinations by answers that don't suggest even approximate dates.)*

Question 10

With an ever-growing demand for vehicle fuels, and finite oil reserves, the possibility of deriving a liquid fuel from coal or natural gas has attracted attention in recent years.

(a) Explain briefly how a liquid fuel for vehicles can be produced from natural gas or from coal, outlining one present-day method for 'oil from gas', and two different methods for 'oil from coal'.

(b) Discuss the arguments for and against the future development of the different conversion methods, considering in particular the resource implications, the present state of the technologies and the environmental consequences.

You should devote between 300 and 400 words to (a), and between 600 – 800 words to (b).

(52 marks)

Q.10 Notes on answers

Sections 7.13 – 7.15 of Book 1 (pp.266 – 278) are the main sources.

This is not an easy question. Good answers for the 'brief explanations' in (a) require an understanding of the principles of the conversion processes, whilst the 'outlines' demand skill in condensing the relatively long text accounts of the methods. The word counts (and thus the marks) have been weighted towards (b), which may be the easier part for students with limited technical background.

(a) The question directs attention fairly clearly to three possibilities discussed in the text:.

Oil from gas: a summary (*in the student's own words!*) of the essential points of Section 7.13.

Direct coal liquifaction (Bergius): the information is in the central two paragraphs of p.274.

Coal liquifaction via gasification (Lurgi + Fischer-Tropsch): a good answer will need to extract the essentials of the Lurgi process (pp.270 – 272) and then the synthesis stage (pp.274 – 275).

(b) The points listed briefly below come from several chapters of Book 1. The answer should of course be in the form of a critical discussion (not abbreviated lists!), and should include a number of these or similarly valid points. At least **2 pro and 2 con** for 'gas' and the same for 'coal' for a reasonable mark, perhaps, and more than that for a high mark.

Oil from gas

Pro:

- the present world R/P ratio is higher for natural gas than oil
- natural gas to methanol processes are already developed; methanol to ‘gasoline’ is in operation
- there is the possibility of *direct* gas to 'vehicle fuel' conversion
- net carbon emissions would be reduced with natural gas as the starting point (but not eliminated)

Con:

- natural gas is itself a valuable fuel, with many other uses
- the world natural gas R/P ratio is not hugely greater than for oil
- the complete oil-to-gasoline process is still on a fairly small scale

Oil from coal

The following two lists include some factors that apply generally to oil from coal and some that arise only with particular conversion methods.

It is possible that some answers, influenced by part (a), may also treat part (b) of the question in terms of the one oil-from-gas and two oil-from-coal methods already discussed. This could be acceptable, and the mark scheme proposed below for part (b) allows for the possibility.

Pro:

- the world coal resource is very large
- one coal liquifaction process (Sasol) is already well-established
- some of the objections below might be overcome by carbon sequestration (*see Box 1.3 on p.48, or George Bush, 2006 State of the Union message*) and other 'clean coal' technologies

Con:

- existing plant is still on a small scale in terms of world oil consumption
- net carbon emissions are necessarily high if coal is the starting point
- anything starting with coal will produce other undesirable residues (solid, liquid or gaseous)
- coal mining damages the environment, and world-wide still has a poor record of work-related illness, injury and accidental death

Q.10 Suggested mark scheme

Q10(a) Explain the processes and give examples (300-400 words)

General explantion of conversion processes.....*3 marks**

Method for oil from gas.....*4 marks*

Oil from coal, method 1.....*4 marks*

Oil from coal, method 2.....*4 marks*

Structure, organisation, use of diagrams, etc..... *3 marks*

Total for this part.....***18 marks***

** Could be split, with 1 mark to each of the next three items if that better suits the approach adopted.*

Q10(b) Pros & cons (600-800 words)

Structure, introduction, concluding summary.....*6 marks*

Oil from gas, pros and cons.....*12 marks**

Oil from coal, pros and cons.....*12 marks**

Mark for particular excellence: e.g. originality, numeracy, presentation, etc. .....*4 marks*

Total for this part.....***34 marks***

Total mark for Question 7.....***52 marks***

- *See the comment under Oil from Coal, above. A few marks might be reallocated from 'gas' to 'coal' if the answer has followed part (a) and discussed the pros and cons of two methods for coal separately.*
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TMA 01, 2007

Question 9

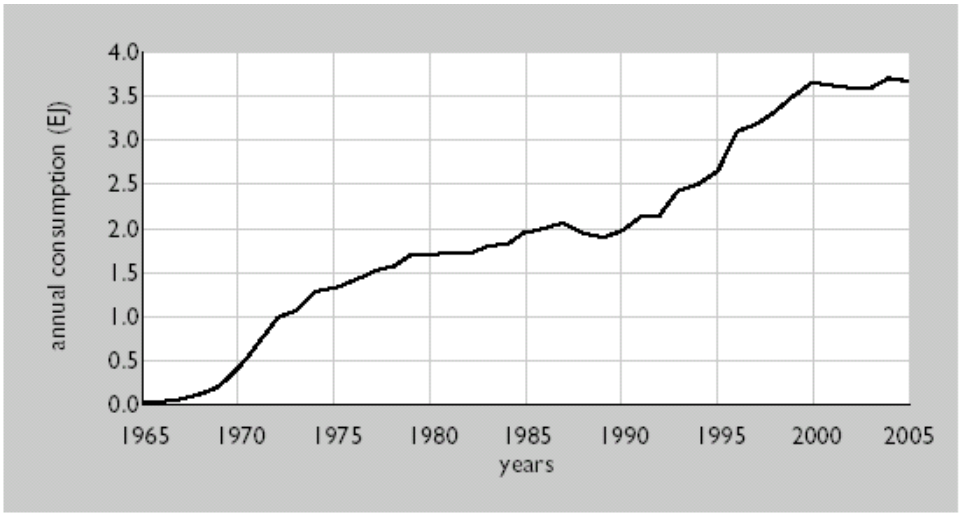

Figure 1 UK annual consumption of natural gas, 1965–2005

(a) Figure 1 shows the consumption of natural gas in the UK for each year from 1965 to 2005. Describe and explain the changes in supply and demand that led to the main features of the graph.

(b) Some writers have claimed that the 'dash for gas' was a terrible mistake. Discuss the arguments for and against this view, considering both short- and long-term effects.

(26 marks each part = 52 marks)

Q.9 Notes on answers

Sources

Fig.1, without the post-2000 period, appeared as part of Fig. 2.9(b) on p.73. There is a brief discussion there, and the production curve in Fig.2.9(a) could also be helpful, but the main accounts are in Chapter 7, with development of the UK natural gas industry on pp.235-236 and discussion of changing demand on pp.254–257. The information in Fig.7.15 (p.257) should be particularly useful (noting however that this question is concerned only with natural gas). See also page 3 of the 2007 Update Supplement for information about the post-2000 gas situation.

(a) Points that might be made in describing the graph [*quantitative items in brackets not essential, but see mark scheme*.]

- essentially zero consumption in 1965
- increasingly steep rise from late 1960s to mid–1970s [consumption triples 1970–1975]
- continuing less steep rise until late 1980s [only 50% increase in 10 years], then falls/levels off
- steep rise resumed from circa1990 to 2000 [doubling in 10 years]
- little or no growth in consumption since 2000.

Points to cover in explaining the graph:

- the situation in 1965, with gas consumption mainly domestic, using coal gas
- discovery and development of North Sea gas from mid–1960s
- nation-wide change from coal gas to natural gas, and growth of domestic central heating
- price rises and world economic problems circa 1980
- 1990–2000, 'dash for gas' for electricity generation
- post-2000, concerns about diminishing UK supplies and consequent dependence on imports

For the full marks, most of the above should be covered. (The account should of course be in essay form – not as here!).

Q.9(a) suggested mark scheme

Introduction, organisation and style of answer, brief concluding summary	*5 marks*
Description of consumption variations	*8 marks*
Explanations of variations	*10 marks*
Quantitative information (rough dates, indications of varying rates of change, etc.)	*3 marks*
Total for 9(a)	***26 marks***

(b) *The organisation of the answer is more open here. The mark scheme suggested below assumes that people are likely to follow the form implied by the question, discussing first the pros and then the cons, but this is not a requirement, and the marks may need adapting for answers organised in other equally valid ways.*

A good account might start by describing the dash for gas. What happened? Why did it happen? Where are we now?

Discussion of the 'pros' might include relatively low cost, short construction time, greater efficiency (than coal), reduced CO_2 emissions (due to efficiency plus lower combustion CO_2 from gas than coal), low particulate emissions, possible advantages of smaller local generating plant (including lower transmission losses). Also, if electricity demand continues to rise, the need for short-term solutions.

The main 'con' arises from diminishing indigenous natural gas supplies, requiring imports, which could bring economic and strategic problems in the long term, with uncertainty about future fuel costs and availability. The point could also be made that even CCGT emits CO_2 – more than nuclear plant, hydro or other potential renewable sources.

Both the pros and the cons need to be considered in comparison with other possible generating systems. However, nuclear and renewables have not yet been covered in the course, so little detail should be expected on these. There might also be a mention of the other demands for natural gas – in particular, its major role in domestic central heating.

Q.9(b) suggested mark scheme

Introduction, organisation, balance and style	*4 marks*
Arguments for	*8 marks*
Arguments against	*8 marks*
Quantitative information (efficiencies, costs, emissions, reserves, etc.)	*3 marks*
Concluding summary of main points	*3 marks*
Total for 9(b)	***26 marks***
Total mark for Question 9	***52 marks***

Question 10

The electricity consumption of a factory varies between about 80 and 100 MW. At present, the power comes from the National Grid, but the factory owners, concerned to reduce carbon emissions, are considering building a combined-cycle gas turbine (CCGT) plant on site.

As an expert in power generation, you have been asked to prepare a report on the possible advantages and disadvantages of this change. Your report should include the following.

(a) An account of the essential differences between the CCGT plant and the type of large coal-fired power station from which a substantial proportion of UK power is generated at present.

Please note that the directors of the company will not want a great deal of technical detail. Simple block diagrams of the two systems, with clear explanations of the important differences and their consequences, should be sufficient.

(b) A discussion of the advantages and disadvantages of the change. This should obviously include carbon emissions, but should also consider other aspects that might affect a final decision.

You may express a preference for one option if you wish, but this is not a requirement.

((a) 20 marks, (b) 32 marks = 52 marks)

Q.10 Notes on answers

CCGT again, but in a very different context, requiring a very different style of answer.

Sources

The main features of the two types of power station appear in various text sections. Coal boilers are described in Section 5.5 (pp.176-180), and steam turbines together with a complete coal-fired plant in Section 6.6 (pp.215-222). The CCGT is introduced in Box 9.11 and the surrounding text (pp.381-383).

Emissions from coal combustion are discussed on pp.174-175 and pp.181-182. There are several references to the combustion of natural gas. Section 4.6 (p.145) has the basic equation, and pp.381-383 mention emissions. Table 7.8 (p.259) has a useful comparison of carbon emissions from coal, oil and gas.

(a) This first part, accounting for about 40% of the mark, specifies in some detail what is required:

- *diagrams* of the two plants,
- *explanations* of the important differences…
- the *consequences* of these differences

The diagrams could be versions of Figures 6.23 and 9.42, with brief identifying labels or notes.

Differences that should be discussed include the nature of the fuel (solid or gas), the use in the CCGT of hot combustion gases and a two-stage system, the different temperatures, the difference in scale of the two types of plant under consideration, and no doubt other factors. The consequences of these differences include different plant efficiencies, emissions, flexibility in operation, methods of fuel delivery and storage, disposal of residues.

10(a) suggested mark scheme

***Note**: The question asks for a report, i.e. just one, covering (a) and (b). Marks for the introduction are therefore allocated under (a) and for the conclusion under (b). Markers may wish to be flexible where the structure differs from this.*

Introduction, organisation, balance	*3 marks*
Style appropriate to readership	*2 marks*
Descriptions of plants	*6 marks*
Important differences and their consequences	*6 marks*
Quantitative data (temperatures, efficiencies, emissions, relative sizes (outputs), etc.)*	*3 marks*
Total for 10(a)	***20 marks***

** A bright student might use her/his answer to Question 5.*

(b) This part of the question is very 'open', and discussion of any valid aspects should attract marks.

A good answer needs to stand back and consider the two very different situations. In one case, the electricity is generated in a large and probably remote coal-fired power station and delivered through the National Grid, at a price determined by the current contract. In the other case, the electricity is generated and delivered by a system installed (and maintained) locally, using gas purchased at a price determined by the current contract

Specific factors that might be considered include

- environmental effects of emissions and wastes – locally and on the wider scale
- environmental benefit of reduction in heat losses in transmission
- reliability of electricity supply – local generation versus grid supply
- reliability of gas supply (for CCGT)
- future costs of electricity and gas.*
- other 'costs' of the CCGT plant: land use, maintenance costs, etc.

** The course has not yet discussed costs in detail, but price variations have been mentioned a number of times – and are increasingly familiar to many of us! So a brief discussion might be expected.*

10(b) suggested mark scheme

Organisation and style	*4 marks*
Answer in conformity with the question	*6 marks*
Range of issues discussed	*8 marks*
Quality of reasoning	*8 marks*
Concluding discussion and summary	*6 marks*
Total for 10(b)	***32 marks***
Total for Question 10	***52 marks***