

Version MJK/4

EGT3
ENGINEERING TRIPOS PART IIB

Tuesday 19 April 2016 9.30 to 11

Module 4M18

PRESENT AND FUTURE ENERGY SYSTEMS

*Answer not more than **three** questions.*

All questions carry the same number of marks.

*The **approximate** percentage of marks allocated to each part of a question is indicated in the right margin.*

*Write your candidate number **not** your name on the cover sheet.*

STATIONERY REQUIREMENTS

Single-sided script paper

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM

CUED approved calculator allowed

Engineering Data Book

10 minutes reading time is allowed for this paper.

You may not start to read the questions printed on the subsequent pages of this question paper until instructed to do so.

1 The following statements have been extracted from documents related to the East Coast 400 kV reinforcement project of Scottish and Southern Electricity, with Fig. 1 being a map of the relevant area.

“The ‘Central Belt’ of Scotland contains 3.5 million people and includes Glasgow to the West and Edinburgh to the East. Kincardine is an ancient port on the estuary of the River Forth, and is approximately half way between Glasgow and Edinburgh, a distance of around 60 km. Longannet power station is near Kincardine. Longannet power station is one of the largest coal fired stations in Europe and considered the 21st most polluting, but is now set to close in 2016. The West coast HVDC line between England and Scotland is terminated at Hunterston, which is around 50 km to the West of Glasgow. 240 km North East of Kincardine is the town of Peterhead and a large CCGT power station. Although capable of generating 2.2 GW at 57% thermal efficiency, its output was limited by the transmission system to 1550 MW. In 2015, the power station was refurbished and it is now configured to offer 400 MW of power to the grid with an additional 750 MW of power as Supplemental Balancing Reserve (SBR) meaning 750 MW of additional capacity could be called upon at any time to provide back-up over the winter period. Peterhead also has a contract to provide voltage support to the electricity grid from April 2016. The transmission line from the area around Peterhead to Kincardine is being upgraded from 275 kV to 400 kV. This is the proposed East Coast 400 kV project shown as the solid line in Fig. 1.”

Noting that the area around Peterhead is a prime location for wind power, and the majority of the Scottish population is in the Central Belt, explain carefully the choices made in planning which justify the expense of the East Coast 400 kV project at a time when gas powered generation is expensive compared to coal. Your answer should concentrate on the technical aspects and ignore government intervention.

[100%]



Fig. 1

2 Describe the scale of the challenge represented by an 80% decarbonisation of the global economy by 2050. [100%]

3 (a) Propose four contrasting means by which the greenhouse gas emissions associated with constructing new commercial buildings in the UK could be halved within 10 years. Discuss the main barriers to implementing each proposal. [50%]

(b) Explain in simple scientific terms why the energy density of nuclear fuels is a million times greater than that of fossil fuels, and why the energy density of fossil fuels is a million times greater than that of gravity fuels for hydropower. Use these ratios and any other relevant factors to explain the roles of nuclear, fossil and gravity fuels in the present global energy source mix, and the principal uses of energy as in transport, industry and heating/cooling. [50%]

4 (a) Explain how frequency control in a power system is used as a mechanism for balancing supply and demand. Discuss also the various challenges associated with its implementation. Explain what is meant by the “optimal power flow problem” and discuss its connection with frequency control. Discuss methods that could further facilitate the balancing of supply and demand in a smart grid. [50%]

(b) “Carbon capture and storage (CCS) is the only technology capable of solving the problem of global warming and it is only a matter of time before technology improves to the point where CCS can be implemented by power producers at no additional cost.” Discuss the validity of these assertions. [50%]

END OF PAPER