

EGT3  
ENGINEERING TRIPOS PART IIB

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Monday 30 April 2018 9.30 to 11.10

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**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 at the start of the exam.**

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

1 (a) Explain how supply and demand are balanced in a conventional electricity transmission grid for:

(i) fast timescales of less than half a minute; [10%]

(ii) slower timescales of more than 30 minutes. [15%]

(b) List three additional methods to those of part (a), that could assist the balancing of supply and demand in a future smart grid. Also explain the challenges associated with their large scale integration within a power grid. [25%]

(c) The UK National Grid has four HVDC *interconnector* schemes attached and 14 further schemes are at various stages in planning and construction. The UK-France FAB Link Interconnector will be 220 km long, with a planned capacity of 1400 MW. The scheme has the potential to add a HVDC station on the island of Aldernay which is 15 km from the coast of France and likely to be near offshore wind farms.

(i) Using an example in each case, describe briefly the energy, economic and environmental benefits this scheme may bring to the UK. [15%]

(ii) List three reasons why IGBT HVDC converters would be a good choice. [15%]

(iii) When planning a new HVDC link, explain briefly the technical choices which may help determine the detailed route. You may refer to the FAB Link Interconnector. [20%]

2 (a) A growing international alliance under the name Powering Past Coal Alliance, including the UK, Canada, Angola and Costa Rica, is looking to see coal vanish from the global power generation mix. But coal is a basic energy source for a majority of countries and almost every industrialized country today developed with the help of coal. Discuss whether an underdeveloped country may industrialise without relying on coal and outline any steps you may see as necessary to achieve this aim. [40%]

(b) Dwellings with electric heating systems tend to have a lower energy efficiency or EPC rating. For example, in England, 2% of dwellings with mains gas heating are 'F' or 'G' rated, compared to 14% of dwellings with electric storage heating systems, and 57% of dwellings with direct-acting electric heating systems. 25% of flats use electric heating compared to only 4% of houses. The majority of electric heating households (1.7M) use heating systems with the capability to store heat. This allows households to use cheaper electricity at night to charge the heating system, and to release heat during the day. They usually include the ability to add direct (instant) electric heating during the day as a 'top up'. There is also a small (less than 100,000) but increasing number of households that use heat pumps as their main source of heating.

(i) Noting that not all homes have a connection to gas, explain carefully why there is likely to be a correlation between EPC rating and the type of home heating. [15%]

(ii) Considering a systems approach, suggest what steps may be necessary such that electricity may be used for heating in a 'smart city'. [30%]

(iii) Making reference to electricity distribution in rural areas, how would you modify your answer to part (a) (ii) for home heating *electrically* in rural areas. [15%]

3 (a) During a recent cold night in the UK, the electricity demand was 30 GW of which 40% was supplied by coal, using all the coal fired capacity with a large part of the remainder made up of nuclear powered electricity. Noting that a large fraction of electricity is often provided by intermittent renewable energy, discuss the prospects for building a new coal fired power station in the UK. [50%]

(b) List four main technical issues which make planning upgrades to the electricity transmission grid a difficult task and identify relationships that may exist between these issues. [30%]

(c) The National Grid Future Energy Scenarios include a scenario called Two Degrees, where prosperity and 'green' ambition are both high. Describe briefly how scenarios are used to assist the process of planning the energy infrastructure, using examples particularly taking into account *consumer power* and government policies. [20%]

4 (a) By operating auctions for electricity generated from wind farms, the price per megawatt hour has dropped to around £40, making electricity generated by them cheaper than historic electricity prices. Discuss this new value of electricity generated by wind farms, making reference to the grid supply of electricity. [40%]

(b) There is a number of large offshore wind farms planned for the South East of the UK. There is also 12 GW installed capacity of solar power in the UK, although the largest solar plant is less than 100 MW. In the National Grid Future Energy Scenarios there could be as many as nine million electric vehicles by 2030. This could result in an additional 8 GW of demand at peak times. What changes might you foresee for the electrical transmission grid in the UK, shown in Fig. 1, noting that there is unused capacity in combined cycle gas turbine electricity generation? [60%]

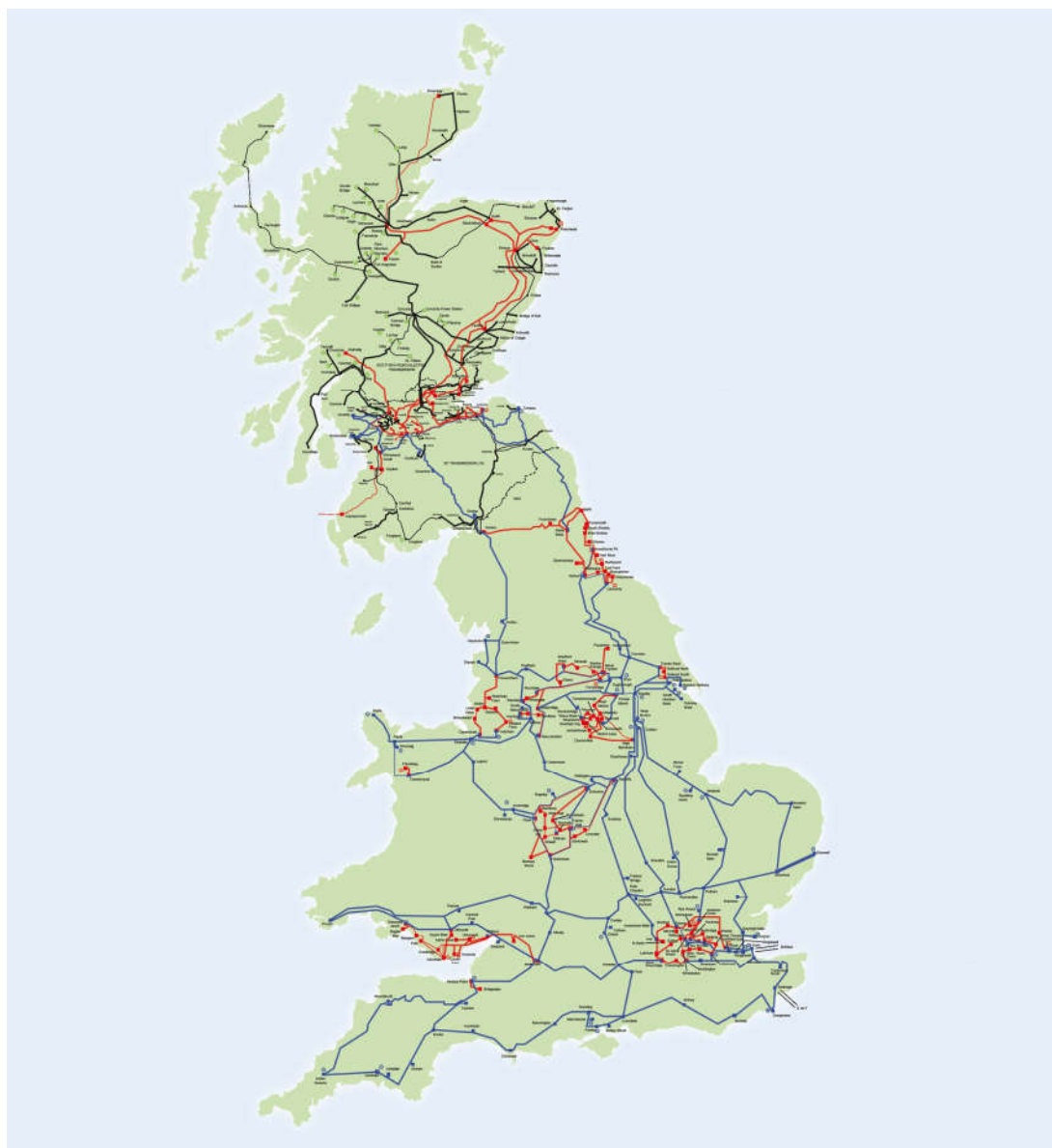


Fig. 1

**END OF PAPER**

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