Loughborough University

ENERGY SYSTEM ECONOMICS, MARKETS, POLICY AND RISK (DL)

(22WSP644)

Semester 2 2023 In Person Examination

This examination is to take place in-person at a central University venue under exam conditions. The standard length of time for this paper is **1.5 hours**

You will not be able to leave the exam hall for the first 30 or final 15 minutes of your exam. Your invigilator will collect your exam paper when you have finished.

Help during the exam

Invigilators are not able to answer queries about the content of your exam paper. Instead, please make a note of your query in your answer script to be considered during the marking process.

If you feel unwell, please raise your hand so that an invigilator can assist you.

Answer **ALL THREE** questions.

Questions carry the marks shown.

You may use a calculator for this exam. It must comply with the University's Calculator Policy for In-Person exams, in particular that it must not be able to transmit or receive information (e.g. mobile devices and smart watches are **not** allowed).

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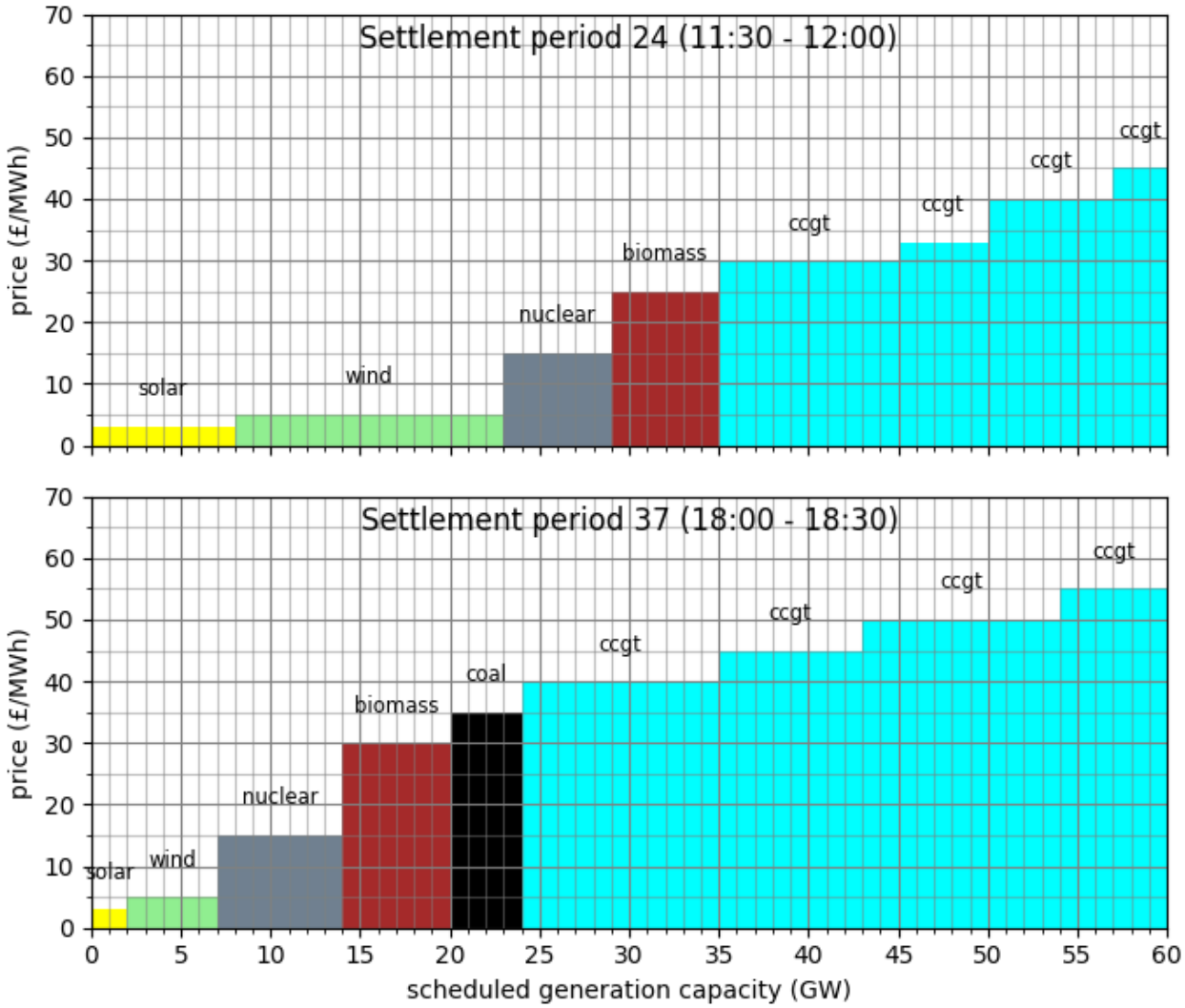
1. The charts below show the scheduled generation capacity with a system operator for different generator types for two settlement periods, 24 and 37.



a) Write a short descriptive paragraph of the above charts using and demonstrating your understanding of the following terms:

- Merit order dispatch
- Must-run generators
- Spot market or Energy Exchange
- Marginal cost of generation
- Bid offers and settlement period
- System Marginal Price
- Merit order effect of renewable energies [7 Marks]

b) Given that the average power demand for settlement period 24 was 40 GW, and for period 37 it was 48 GW, what was the system marginal price for each of these two periods? [2 marks]

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c) The marginal cost of generation for each generator class are shown in the following table. What were the profits made by the generator classes in the following table for each period per GW scheduled capacity? Show your final answers in a copy of the table. [7 Marks]

Generator class	Marginal cost of generation £/MWh	Profits During settlement period £/GW	
		24	37
Solar	3		
Wind	5		
Coal	25		
CCGT	30		

d) If a 1 GW solar farm had a Contract for Difference (CfD) with a strike price of £40/MWh, how much money would be paid to or from the low carbon contracts company in each of the two settlement periods (indicate whether the money is paid to, or from, the Low Carbon Contracts company (LCCC)? [4 marks]

2.

a) Briefly describe the use of the Energy Trilemma as a 'system or social lens' which can be used to help appreciate the complexity of the energy transition to a zero-carbon energy system. You may illustrate your answer with a rough, but carefully annotated, sketch or diagram. [5 marks]

b) As the energy system decarbonises as more new renewables are deployed on national energy systems, explain the reason for the market driven downward pressure on capacity factors of thermal generation plant such as combined-cycle gas turbine (CCGT) power plant. Contrast this with the capacity factors for renewable generators. [5 marks]

c) Such downward pressure might present plant operators with limited or even loss-making financial returns resulting in plant closures and a tightening of the capacity margin. Explain this concept and the resultant energy system risks resulting from tighter margins. Outline two energy market approaches to mitigating the tightening of the capacity margin, one being more laissez-faire and the other more interventionist. [6 marks]

d) Energy systems are becoming smarter. Discuss how smart energy systems might further mitigate the tightening of the capacity margins through price reflective charging and other specific enabling technologies. [4 marks]

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3. A UK Windfarm is rated 100 MW. The total unit cost of installation is £1.5 Million / MW installed capacity. The estimated operational expenditure is £50K (thousand) / MW installed capacity per year. It is estimated that the wind farm will generate an average 333 GWh electricity per year. The average market sale price of the generated electricity at today's prices is estimated to be £80 / MWh.

a) Write the equation for capacity factor for an energy generation technology. [2 Marks]

b) Showing your calculations, and expressing your answer to the nearest whole percent, what is the estimated annual capacity factor of the wind farm? Discuss whether this might be an offshore or onshore wind farm and give your reasoning for this. [4 Marks]

c) The equation for the simple levelised cost of energy (LCOE) calculation can be written as follows:

$$LCOE = \frac{sum\ of\ costs\ over\ lifetime}{sum\ of\ energy\ produced\ over\ lifetime}$$

Using this equation calculate the simple LCOE of the windfarm output, using an estimated average turbine lifetime of twenty-five years and assuming a net decommissioning cost of zero. Express your answer in £/MWh. [4 Marks]

d) Governments and policy makers use LCOE for the evaluation of energy systems often using more thorough LCOE evaluations incorporating a discount rate applied to both the numerator (costs) and the denominator (energy generated) as follows:

$$LCOE = \frac{I_0 + \sum_{t=1}^{n} \frac{O_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

$I_0\ initial\ investment$
$O_t\ operational\ expenditure, fuel\ etc\ year\ t$
$E_t\ electricity\ generated\ in\ year\ t$
$r\ discount\ rate$
$n\ expected\ lifetime$

Briefly Explain

- The rationale for discounting future operational expenditure in an LCOE analysis
- The rationale for discounting the energy component

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- Why LCOE is a metric favoured by policy makers
- Key assumptions made by policy makers in LCOE calculations

[[10 marks]

P.A. Leicester