

Energy resources and electricity supply decisions

AQA GCSE Physics 8463 and Combined Science Trilogy 8464 | Paper 1 | Foundation and Higher

Worked solutions and teaching prompts | 25 parts | 46 marks

Specification points covered

Energy resources, renewable and non-renewable sources, reliability, uses and environmental impacts: 8463 4.1.3 / 8464 6.1.3.

Power, energy transferred and time: 8463 4.1.1.4 / 8464 6.1.1.4. Interpret graphs and evaluate supplied evidence.

A coastal community is choosing an electricity supply for homes, a clinic and the harbour. Use the supplied demand, weather and cost evidence to advise the council. All case-study figures and costs are fictional.

Original PhysicsUK questions and marking guidance, not an official AQA paper. Accept valid equivalent wording, alternative calculations and consistent follow-through. The final response uses holistic levels, not six keyword ticks. Timing is an estimate after teaching.

1 Checking the resource claims

The council receives several claims from residents and suppliers.

1(a) Wind and natural gas are proposed for electricity generation. Identify the renewable resource and state what renewable means. **[2 marks]**

Answer / mark points: Wind. [1] A renewable resource is replenished as it is used / can be replenished on a human timescale. [1] Do not define renewable simply as clean, reliable or impossible to run out of.

1(b) The clinic has a diesel backup generator. Which fossil fuel is diesel made from? **[1 mark]**

Answer / mark points: Oil / crude oil / petroleum. [1] Diesel is not a renewable energy resource.

1(c) A resident says, "Nuclear fuel is renewable because it is not a fossil fuel." Explain why this conclusion is wrong. **[2 marks]**

Answer / mark points: Nuclear fuels such as uranium are finite / are not replaced as they are used. [1] Being non-fossil does not make a resource renewable; it must be replenished. [1]

1(d) A supplier proposes wood fuel for clinic heating and biofuel for harbour vehicles. Explain why calling these fuels renewable depends on how the plants are managed. **[2 marks]**

Answer / mark points: New plants/trees can be grown to replace those used for fuel. [1] Harvesting must not exceed replenishment over time / replanting and sufficient growth time are needed. [1] This does not mean burning biofuel produces no carbon dioxide.



2 Reading demand and available output

Figure 1 is a simplified profile for one day, with straight lines between marked times. Time 0 h and 24 h are midnight. Available wind output is not necessarily all used: a surplus must be stored, exported or curtailed.

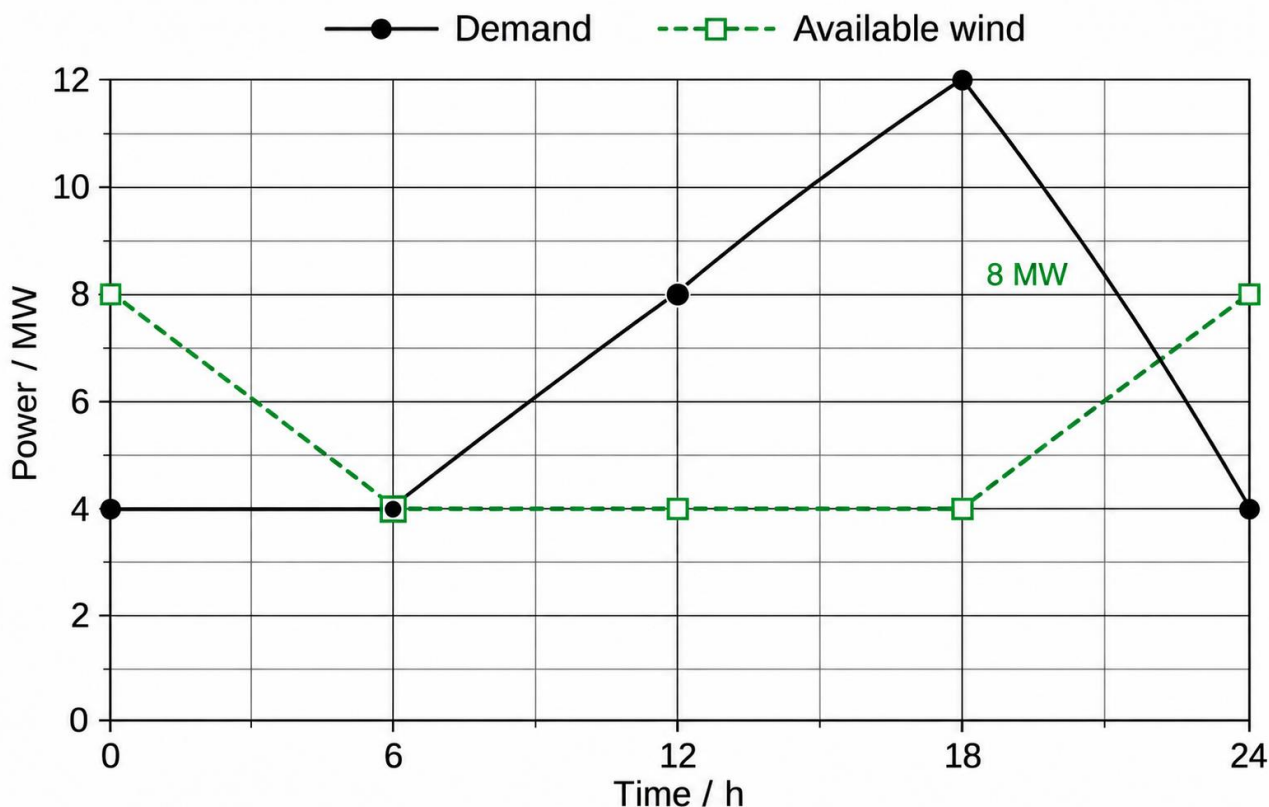


Figure 1

2(a) Use Figure 1 to state the maximum demand and the time when it occurs. [1 mark]

Answer / mark points: 12 MW at 18 h (18:00). [1 for both]

2(b) Read the available wind power at 12 h. [1 mark]

Answer / mark points: 4 MW. [1]

2(c) Calculate the extra power needed from other sources at 18 h. [1 mark]

Answer / mark points: Shortfall = demand – available wind = $12 - 4 = 8$ MW. [1] The small green 8 MW annotation on the teacher graph refers to this shortfall.

2(d) Use the straight demand line to estimate the demand at 15 h. [1 mark]

Answer / mark points: 10 MW. [1] 15 h is halfway between 12 h and 18 h; demand is halfway between 8 MW and 12 MW. Allow 9.5–10.5 MW for graphical read-off.



2 Reading demand and available output continued

2(e) Calculate the surplus available wind power at 0 h if there is no other generation. [1 mark]

Answer / mark points: Surplus = $8 - 4 = 4$ MW. [1] Available output exceeds demand; it is not an extra energy source.

2(f) Explain why having surplus wind output at midnight does not, by itself, show that wind can meet demand at 18 h. [2 marks]

Answer / mark points: At 18 h, demand is 12 MW but available wind is only 4 MW. [1] The earlier surplus cannot cover this later shortfall unless enough energy is stored and can be delivered then, or another source supplies it. [1]

Teacher prompt: Electricity supply must match demand at the time it is needed; a high output at one time is not continuous backup.

3 Planning energy and backup

Treat stated powers as constant for the specified intervals. Battery values mean usable stored energy; neglect further losses.

3(a) In a test, the clinic uses a constant 200 kW for 5.0 h. Calculate the energy used in kWh. [1 mark]

Answer / mark points: $E = P t = 200 \times 5.0 = 1000$ kWh. [1]

3(b) A harbour pump uses 6.0 kW for 90 minutes. Calculate the energy transferred in joules. [2 marks]

Answer / mark points: $P = 6000$ W and $t = 5400$ s, correctly used in $E = P t$. [1] $E = 6000 \times 5400 = 32\,400\,000$ J. [1] Accept 3.24×10^7 J (32.4 MJ).

3(c) Figure 1 shows constant available wind power from 6 h to 12 h. Calculate the energy available from wind during this interval in MWh. [1 mark]

Answer / mark points: $E = 4 \times (12 - 6) = 24$ MWh. [1] This is available energy, not necessarily all energy used by the community.

3(d) A separate clinic battery has 900 kWh of usable energy. For how long can it supply a constant 150 kW load? [1 mark]

Answer / mark points: $t = E / P = 900 / 150 = 6.0$ h. [1]

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk



3 Planning energy and backup continued

3(e) A generator supplies 36 GJ at a constant 5.0 MW. Calculate the operating time in seconds. **[2 marks]**

Answer / mark points: $t = E / P = 36\,000\,000\,000 / 5\,000\,000$. [1 for correct conversion and use] $t = 7200$ s. [1] Alternatively $36\text{ GJ} = 10\text{ MWh}$, so time = 2 h = 7200 s.

3(f) A supplier labels a generator “1 MW” and claims it therefore supplies “1 MWh every day”. Explain the error. **[2 marks]**

Answer / mark points: 1 MW is a power: the rate of energy transfer, not a fixed daily energy. [1] Energy depends on operating time: at a constant 1 MW, 1 h gives 1 MWh; 24 h gives 24 MWh. [1]

3(g) Three standby generators can each deliver 0.250 MW. Calculate their combined power and decide whether it is enough for a 0.500 MW critical load. **[2 marks]**

Answer / mark points: Combined power = $3 \times 0.250 = 0.750$ MW. [1] Yes: 0.750 MW exceeds 0.500 MW. [1] This checks power only, not how long their fuel lasts.

4 Checking local reliability

The council must consider timing and local conditions, not just whether a resource is renewable.

4(a) Local tidal output follows a predictable cycle but falls to zero at slack water. Wave output varies with the weather. Explain why tidal output can be more predictable without being constant. **[2 marks]**

Answer / mark points: The tidal cycle repeats at predictable times, unlike the less regular weather-dependent wave output. [1] Tidal output still changes during that cycle and falls to zero at slack water, so it is not constant. [1]

4(b) The council proposes using only solar panels for the clinic. Give two conditions that could reduce their output below demand. **[2 marks]**

Answer / mark points: Night/no sunlight. [1] Cloud cover/reduced sunlight during the day. [1] Accept a different specific shading condition instead of cloud; do not credit vague “bad weather” without a relevant link.

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk



4 Checking local reliability continued

4(c) The local river dries up each summer, and a survey finds no accessible high-temperature geothermal resource. Explain why being renewable does not make hydroelectricity or geothermal energy suitable here. **[2 marks]**

Answer / mark points: The seasonal river cannot provide a dependable water supply/flow for hydroelectricity throughout the year. [1] The required accessible hot-rock/geothermal resource is absent, so a local geothermal scheme is not supported by the survey. [1]

4(d) In the council's model, renewable electricity increases from 25% to 60% of the annual total. Calculate the increase in percentage points (subtract the percentages). Suggest one environmental reason for this change and explain it. **[3 marks]**

Answer / mark points: Increase = $60 - 25 = 35$ percentage points. [1] For example, replacing fossil-fuel generation can reduce carbon dioxide released [1], reducing the contribution to global warming/climate change [1]. Accept another named, linked environmental benefit. It is not a 35% relative increase; the question asks for percentage points.

5 Explaining environmental effects

Give a named cause linked to an effect. "It causes pollution" alone is not a complete explanation.

5(a) A gas-fired option burns a fossil fuel. Explain how this can contribute to climate change. **[2 marks]**

Answer / mark points: Burning the fuel releases carbon dioxide. [1] Carbon dioxide is a greenhouse gas / increases the greenhouse effect, contributing to global warming/climate change. [1]

5(b) A cheaper coal-fired option would release sulfur dioxide unless treated. Explain one environmental effect of this gas. **[2 marks]**

Answer / mark points: Sulfur dioxide can cause acid rain. [1] This can damage plants/forests or acidify lakes and harm organisms (accept erosion of limestone buildings). [1] Do not credit carbon dioxide causing acid rain or sulfur dioxide causing the greenhouse effect.

5(c) A nuclear option produces radioactive waste. Explain one reason why this waste must be managed carefully. **[2 marks]**

Answer / mark points: The waste can emit ionising radiation / remain radioactive for a long time. [1] It needs suitable containment/secure storage to prevent harmful exposure or contamination of people/the environment. [1] Do not claim all nuclear waste has the same lifetime.



6 Recommending an electricity supply

Table 1 compares complete supply options. Power ratings are maximum outputs, not guaranteed wind/solar output. Assume the gas plant has fuel and can deliver its rated power whenever required. Each fully charged battery stores 4.0 MWh of usable energy and can deliver up to 12 MW.

Table 1

Option	Generating plant	Usable battery / MWh	Capital cost / units
A	12 MW wind + 4 MW solar	4.0	80
B	12 MW wind + 4 MW solar + 12 MW gas	4.0	110
C	12 MW gas	4.0	70

6(a) Recommend the most suitable option in Table 1. The priorities are to meet demand, stay within the 120-unit capital budget and reduce fossil-fuel use when possible. A calm night gives no wind or solar output; demand can stay at 12 MW for 2.0 h. In a separate complete generation failure, the 0.500 MW critical clinic load needs 8.0 h of battery backup. Use calculations and comparisons to justify your recommendation, and explain an environmental and an economic trade-off. **[6 marks]**

Answer / mark points: Model response: B is the strongest fit to the stated priorities. The calm-night demand needs $E = 12 \times 2.0 = 24$ MWh. A has no wind/solar output then and its full battery holds only 4.0 MWh, so A cannot meet that requirement. B and C each have 12 MW of gas generation, sufficient while fuel and operation are available as stated.

The critical clinic needs $E = 0.500 \times 8.0 = 4.0$ MWh, matching each battery's usable energy. Its 0.500 MW power requirement is also below the stated 12 MW discharge limit. This is idealised backup, not proof of real-life security in every failure.

B costs 110 units, within the 120-unit budget, but costs 40 units more than C. Unlike C, B can use wind and solar when available, reducing gas use and associated carbon dioxide emissions for the same demand. It does not eliminate gas use or guarantee zero environmental impact: turbines/panels require land/materials and may affect habitats/landscape, and gas still releases carbon dioxide. Higher capital cost is weighed against reduced fossil-fuel use; no running-cost saving is quantified by these data.

Holistic levels: 5–6 for a coherent, evidence-based recommendation consistent with the priorities, covering reliability/backup with useful numerical evidence and environmental/economic comparisons. 3–4 for some linked comparisons and a supported choice but an important omission or numerical weakness. 1–2 for relevant isolated facts or a weakly supported choice; 0 for no relevant content. Choose the level first, then the mark for completeness and reasoning. Credit valid comparisons for any option; do not give full credit to A while ignoring its calm-night deficit, or to C as equally good at reducing fossil-fuel use. A list of copied values without explaining their significance is not a top-level response.

Teacher prompt: A six-mark PhysicsUK assessment-style task, not an official AQA scheme. The answer need not include every example in this model. Science quantifies effects, but cost priorities, public preferences and policy still influence decisions.

Review and improve

Ask pupils to distinguish renewable from constant/reliable, power from energy, and greenhouse-gas effects from acid rain. No resource is automatically best in every location or for every priority.

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk

