GCSE

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SCIENCE B

UNIT 1: Space, Energy and Life

A.M. THURSDAY, 14 January 2016

Resource Folder (Pre-Release Article)

For use with:

GCSE Science B (UNIT 1) **Section B** of the Foundation Tier

GCSE Science B (UNIT 1) **Section A** of the Higher Tier

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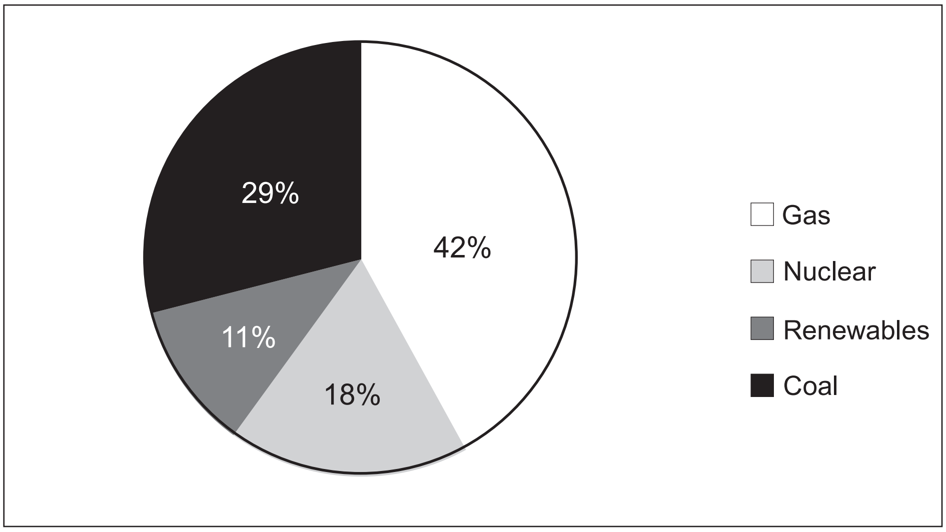
Pre-Release Article – Electricity generation

The energy sources used for electricity generation in 2010 are shown in **Diagram 1** below.

Diagram 1



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Since 2010, electricity has come increasingly from renewable sources. This will compensate for the phasing out of nuclear energy and help to reduce the number of fossil fuel-fired power plants.

For example, one study recommended that, by 2050, over 90% of the electricity produced in the UK should come from renewable energy sources.

Table 1 shows how supply from different renewable technologies in the UK could change between 2010 and 2050.

Table 1

	2010	2020	2030	2040	2050
	Electricity generated (GW)				
Hydro	2	2	3	3	3
Biomass	0	1	1	2	2
Wind	2	5	8	12	18
Geothermal	0	1	1	1	1
PV	1	3	4	4	5
Ocean energy	0	1	1	2	2
Total	**5**	**13**	**18**	**24**	**31**

1 GW = 1000 MW
1 MW = 1000 kW
1 kW = 1000 W

Biomass

Sources of biomass are shown in **Diagram 2** below.

Diagram 2

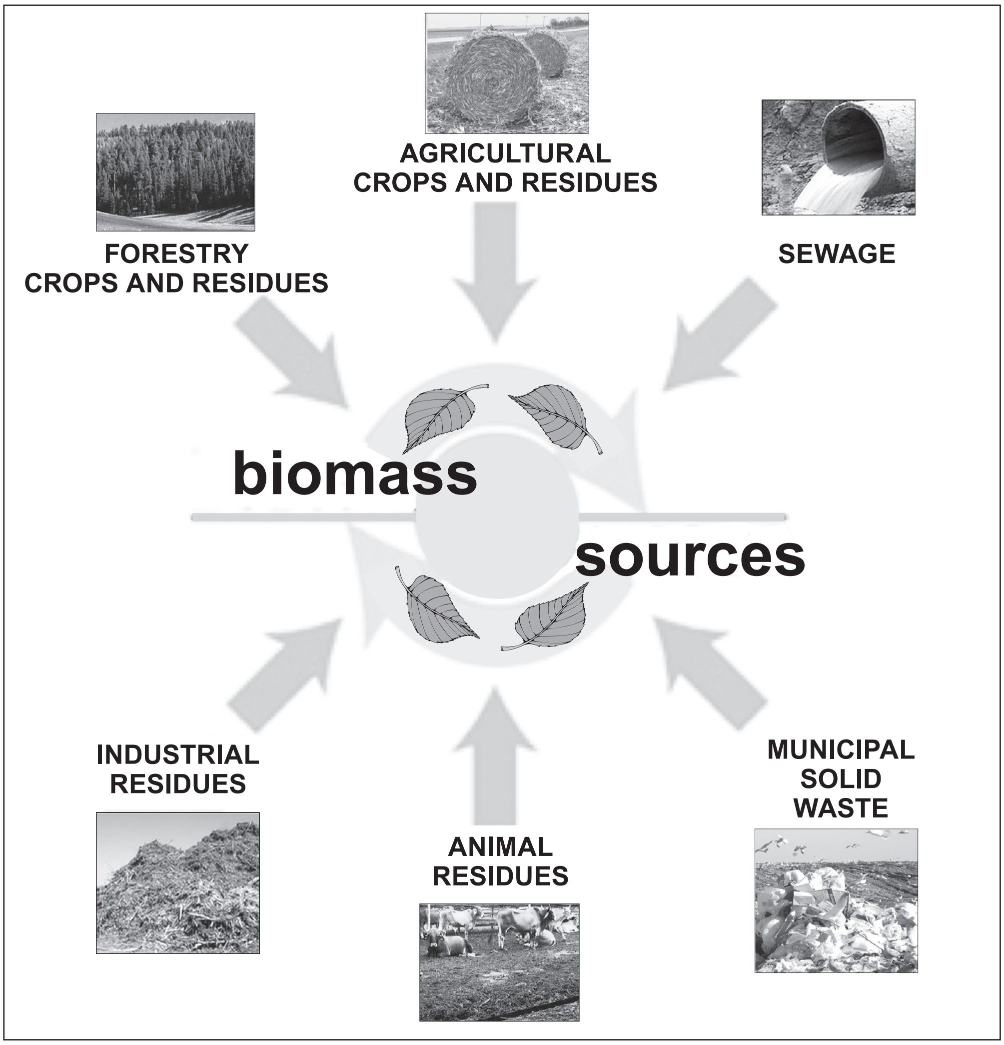


Table 2 shows information about some plants that could be used to make pellets. These pellets can be burned instead of fossil fuels to heat water in a biomass generator for the production of electricity.

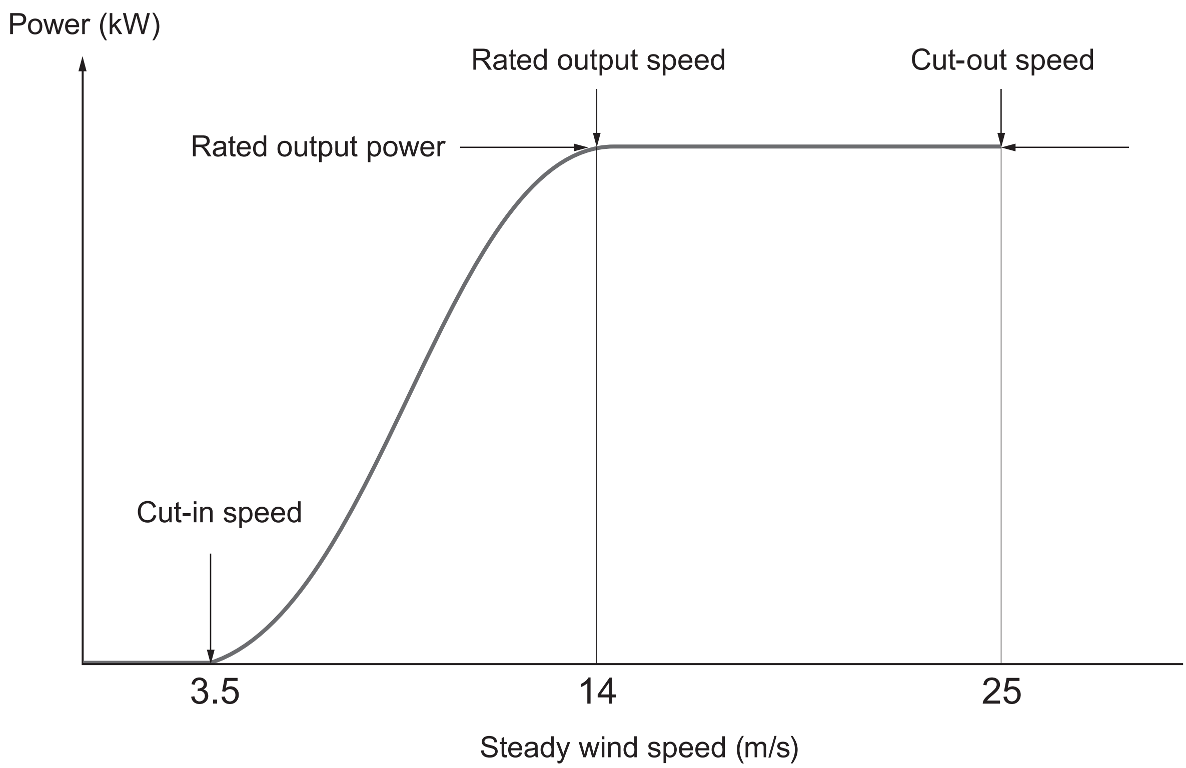
Table 2

Crop	Crop yield in a year from each km^2 of land (tonnes)	Energy content (units/tonne)
poplar	8	18
willow	15	20
grass	5	16

Wind

Diagram 3 below illustrates how the power output from a wind turbine varies with steady wind speed.

Diagram 3



Cut-in speed

This is the speed at which the turbine first starts to rotate and generate power. It is typically between 3 and 4 m/s.

Rated output power and rated output speed

As the wind speed rises above the cut-in speed, the level of electrical output power rises rapidly. However somewhere between 12 and 17 m/s, the output power reaches the maximum limit. This limit is called the **rated output power** and the wind speed at which it is reached is called the **rated output speed**.

Cut-out speed

As the speed increases above the rated output wind speed, the forces on the turbine structure continue to rise and, at some point, there is a risk of damage to the rotor. As a result, a braking system is employed to bring the rotor to a standstill. This is called the **cut-out speed** and is usually around 25 m/s.

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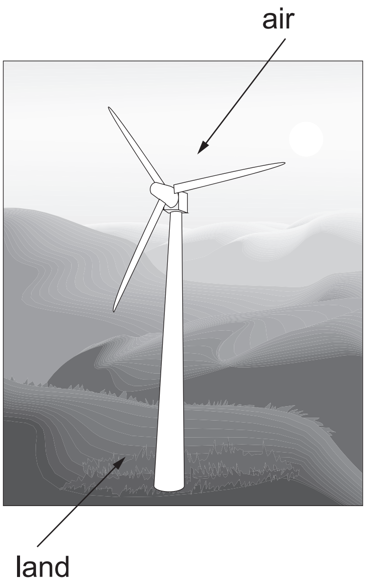
Turbines

Electricity can be generated using either tidal water turbines or wind turbines. **Diagram 4** shows the typical construction of these two types of turbine.

Diagram 4

tidal water turbine



wind turbine

Some differences between tidal water turbines on the seabed and wind turbines on land are shown in **Table 3**.

Table 3

	Tidal water turbine	Wind turbine
Speed of water or wind (m/s)	5	14
Density of water or air (kg/m^3)	1 000	1
Length of blade (m)	10	35
Area swept out by blade (m^2)	314	3 850
Power output at this speed (MW)	2.9	1.5

Comparing wind and nuclear power

Table 4 gives information about generating electricity from wind and nuclear power.

Table 4

	How they compare	
	A wind turbine	A nuclear power station
Overall cost of generating electricity (p/kWh)	5.6	2.8
Maximum power output (MW)	2	1800
Lifetime (years)	15	45
Waste produced	None	Radioactive waste
Lifetime carbon footprint (g of CO_2/kWh)	4.64 / 5.25 (onshore/offshore)	5
Commissioning cost (£ million)	3	4000

How much electricity can I generate with solar panels?

The standard solar panel has an input rate of 1000 watts per square metre. However, at present it only produces 200 W of electricity in good sunlight.

You may work out your expected output from the solar panels on your home as shown in the example below.

Take the number of square meters of solar panel on your property and multiply this by 200; then multiply the answer by the number of sun hours in your area in a day. This will give you your watt hours (Wh) per day.

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Answer **all** *questions in the spaces provided.*

Use the information in the separate Resource Folder to answer the following questions.

1. *(a)* Use the information in **Table 1** to answer the question below.

Calculate the drop in the power generated by non-renewable sources from 2010 to 2050. Assume that the maximum power generated remains at a constant 34 GW. [2]

Drop in power generation by non-renewable sources = ... GW

(b) (i) Use the information in **Table 2** to answer the following questions.

A 10 MW power station needs 60 000 tonnes of willow crop per year.

I. Calculate the area of land needed to grow this amount of willow crop. [1]

area .... km^2

II. Calculate the energy content of 60 000 tonnes of willow crop. [1]

energy content = ... units

(ii) Explain why burning biofuels is more environmentally friendly than burning fossil fuels. [2]

....

....

....

....

....

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(c) Use the information about wind power on **page 5** to answer the following question.

Complete the table by ticking (✓) the correct column for each steady wind speed.

One has been completed as an example. [3]

Steady wind speed (m/s)	Zero power output	Rated output power	Between zero and rated output power
2.9	✓		
27.2			
19.6			
12.2			

(d) Describe the advantages of tidal water turbines compared to wind turbines using your knowledge and the information in **Table 3**. [3]

....

....

....

....

....

....

....

12

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2. Compare the use of wind power and nuclear power to generate electricity using the information in **Table 4** and your own knowledge. [6 QWC]

Include in your answer, details about:

- cost effectiveness;
- effect on the environment;
- reliability.

6

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3. Use the information about solar panels on **page 7** to answer the questions that follow.

(i) Calculate the efficiency of a solar panel using the equation: [2]

$$\text{percentage efficiency} = \frac{\text{useful output power}}{\text{total input power}} \times 100$$

percentage efficiency = ...

(ii) Household voltage is 230 V. Calculate the maximum current that can be drawn from a solar panel of area 1 square metre, using the equation: [2]

$$\text{current} = \frac{\text{power}}{\text{voltage}}$$

current = ... A

(iii) Calculate the energy (Wh) produced by a 5 square metre solar panel in 6 hours of good sunlight. [2]

energy = ... Wh

6

END OF PAPER

GCSE MARKING SCHEME

JANUARY 2016

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<table>
<tr><th>Question</th><th>Marking point</th><th>Marks</th></tr>
<tr><td>1 (a)</td><td>Reduction from 29 to 3 (1) = 26 (GW) (1)
or
31 – 5 (1) = 26 (GW) (1)</td><td>2</td></tr>
<tr><td>(b) (i)</td><td>I. Area = (60 000/15) = 4000 (km^2) (1)
II. Energy content = (60 000 x 20) = 1200000 (units) (1)</td><td>2</td></tr>
<tr><td>(ii)</td><td>CO_2 released during burning (1)
= CO_2 absorbed during growing / photosynthesis (1)
so carbon neutral (1)
Any two points
The points must be correctly and coherently connected to be awarded two marks</td><td>2</td></tr>
<tr><td>(c)</td><td>1 mark for each correct point
<table>
<tr><th>Steady wind speed (m/s)</th><th>Zero power output</th><th>Maximum power output</th><th>Between zero and maximum power output</th></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>27.2</td><td>✓</td><td></td><td></td></tr>
<tr><td>19.6</td><td></td><td>✓</td><td></td></tr>
<tr><td>12.2</td><td></td><td></td><td>✓</td></tr>
</table></td><td>3</td></tr>
<tr><td>(d)</td><td>smaller, larger power output, more reliable, less of an eyesore</td><td>3</td></tr>
</table>

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Question	Marking point	Marks
(2)	Indicative content • power output one nuclear power station is equivalent to 900 wind turbines • nuclear power stations last 3 times longer / in the lifetime of one nuclear power station equivalent 2 700 wind turbines. • cost wind turbines more than double the cost of a nuclear power station / nuclear option cheaper per unit produced • wind power is less reliable • radioactive waste more detrimental to the environment since it has to be stored safely for long periods of time / danger of leakage into the ecosystem. **Marking bands** **5 - 6 marks.** The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar. **3 - 4 marks** The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar. **1 - 2 marks** The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar. **0 marks** The candidate does not make any attempt or give a relevant answer worthy of credit.	6

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Question	Marking point	Marks
(3) (i)	200/1000 (1) x 100 = 20 (1)	2
(ii)	Current = 200/230 (1) = 0.87 / 0.9 (A) (1)	2
(iii)	5 x 200 x 6 (1) = 6000 (Wh) (1)	2

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