Britain's Energy Sources

Contents: A data analysis exercise concerning the costs and contributions of different energy sources in Britain.

Time: Homework plus two periods or more, depending on number of parts attempted.

Intended use: GCSE Physics, Chemistry and Integrated Science. Links with work on energy, fuels, energy sources, electricity generation, efficiency of energy conversion.

Aims:

- To complement work on energy and energy sources.
- To develop awareness of different energy sources, their uses and costs.
- To develop awareness of patterns of energy use in Britain.
- To provide opportunities to practise data-handling skills.

Requirements: Students' worksheets No. 403. If possible, the current UK Energy Statistics card (see 'Further resources' below).

This unit is in four parts. There is no need to use all four parts, though Parts 1 and 2 are fairly closely linked.

Part 1 Energy in your home
Part 2 Comparing the costs of energy sources
Part 3 Why is electricity more expensive?
Part 4 Who are the big energy users?

Part 1 should preferably be done at home, perhaps for homework preceding the lesson in which the rest of the unit is to be tackled. It will be necessary to go over the results to correct mistakes, fill in gaps and discuss discrepancies (see note on question 4 below). Students should not be given Part 2 until they have completed Part 1.

Part 2 The prices given in Table 2 are average domestic prices for 1985. Teachers may prefer to replace them with more up-to-date local prices, consistent with those in Table 1. Industrial energy prices are usually considerably cheaper.

Part 3 The figures in Table 5 are for Drax Power Station. Similar figures can be obtained from most CEGB power stations.

Part 4 The figures in Table 6 are taken from the UK Energy Statistics Card for 1984, and they relate to 1983. It is recommended that the teacher update the figures using the latest edition of the card (see 'Further resources'). Able pupils could retrieve data directly from the cards, but this is made difficult by the variety of units used. For simplicity, all energy values in this topic are given in megajoules (MJ).

Useful conversion factors:

1 million tonnes coal	$= 2.64 \times 10^{10}$ MJ
1 million tonnes oil	$= 4.48 \times 10^{10}$ MJ
1 million therms	$= 1.06 \times 10^{8}$ MJ
1 TWh (terawatt-hour)	$= 3.59 \times 10^{9}$ MJ

Any figures less than 25 in Table 6 have been ignored. Non-energy uses are included in the table: this is particularly significant in the case of oil, where the non-energy uses are included in the figure for Industry. Significant quantities of coal are used to make coke and other smokeless fuels: the figures for this use are included in Other Uses.

It may be worth reminding students that oil needs to be refined before it can be used. The figures given for oil in Table 6 include all the various petroleum products.

Notes on some of the questions

Q.4 The costs of similar fuels may vary according to quality and calorific value, the time of year, the quantity bought and the geographical location.

Q.5 The figures (1985 prices) are:

Coal	249 MJ for £1
Oil	207 MJ for £1
Gas	283 MJ for £1
Electricity	72 MJ for £1

Thus the prices of coal, oil and gas are all quite similar. This reflects government pricing and taxing policy rather than the intrinsic cost of the fuel.

Q.9 The efficiency of the power station is 37 per cent. Most of the rest of the energy is lost as waste heat through the cooling water. There are of course further losses on transmission of electricity from the power station to the user.

Q.10 A typical breakdown of the cost of generating a unit of electricity is as follows:

	%
Fuel	50
Salaries	16
Depreciation	11
Interest	8
Rates	3
Other	12

Thus fuel costs account for about half the total cost of electricity generation.

Qs 12 and 13 Most of the energy used in the domestic sector is for heating. Gas is both cheap and convenient for this purpose. Electricity, while highly convenient, is more expensive.

Q.14 In order to avoid counting twice, Table 6 omits figures for fuel use in electricity generation. The majority of coal is used for this purpose (2150 billion MJ in 1983).

Q.15 Nuclear power is missing from the table. In 1983, about 17 per cent of Britain's electricity was generated from nuclear power.

Q.16 Lubricants, bitumen, wax and petrochemicals might all be mentioned. Note that natural gas is an increasingly important petrochemical feedstock.

Q.17 This is a highly speculative area. It is likely that less oil and gas, and more coal, will be used in twenty years time. Nuclear power may also become more important, and perhaps alternative sources such as tidal power and wind power.

Further activities

Teachers will no doubt be able to devise other activities based on the data in this unit and in the UK Energy Statistics Card.

It is interesting to extend this survey to a comparison with energy use in other parts of the world. BP's *World Energy Statistics* are useful in this connection (see 'Further resources').

Further resources

A wealth of resource material is available relating to energy, much of it free. The major oil companies, British Gas, the National Coal Board and the Electricity Council all have extensive resource catalogues.

The following are useful sources of statistics:

The *UK Energy Statistics Card* is available free, in single copies or class sets, from: Department of Energy, Information Division, Thames House South, London SW1P 4QJ.

The *Handbook of Electricity Supply Statistics* is available free from: Secretary's Department, The Electricity Council, 30 Millbank, London SW1P 4RD.

BP produce a useful pack, *World Energy Statistics*, containing worksheets and overhead projector transparencies as well as comprehensive statistical information. Available from: BP Educational Service, Britannic House, Moor Lane, London EC2Y 9BU.

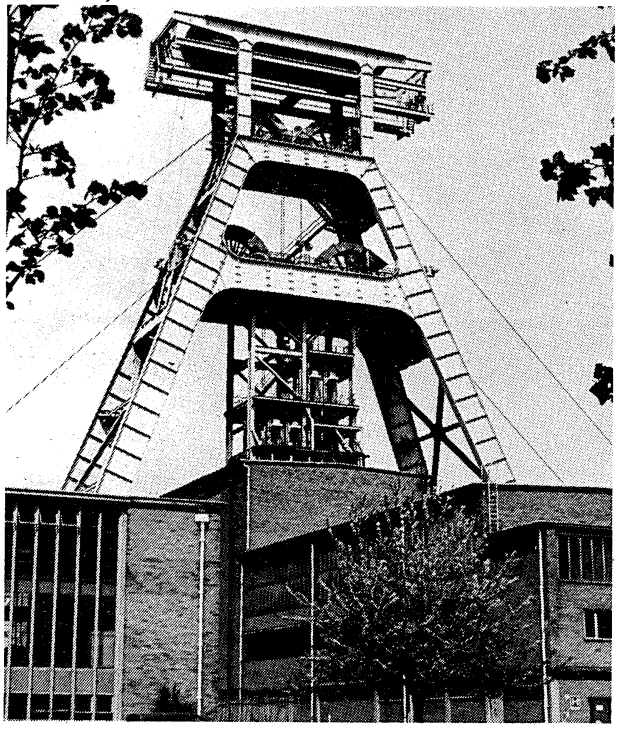
Acknowledgements Photographs in Figure 1 supplied by the National Coal Board, British Gas Corporation and British Petroleum.

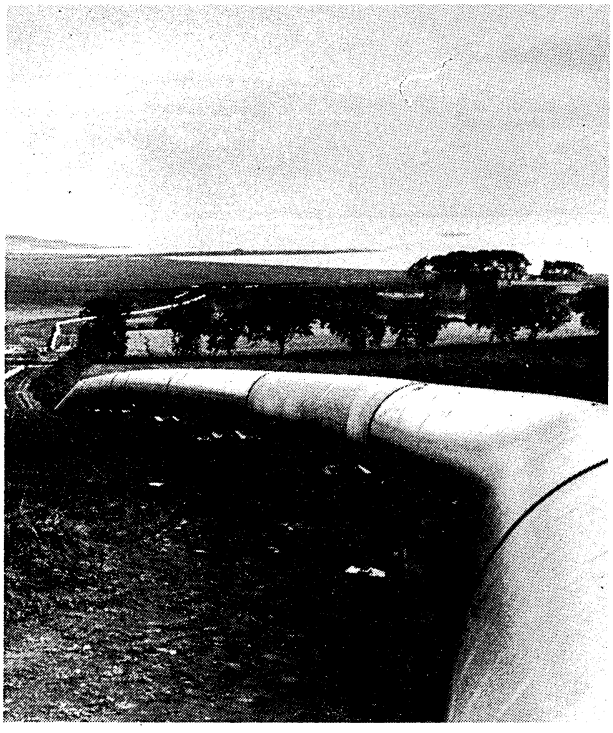
BRITAIN'S ENERGY SOURCES

Where does Britain get its energy, and how is it used? These are the questions we will be asking in this unit. We will be looking at some major types of energy source.

The unit is in four parts:

Part 1 Energy in your home
Part 2 Comparing the costs of energy sources
Part 3 Why is electricity more expensive?
Part 4 Who are the big energy users?





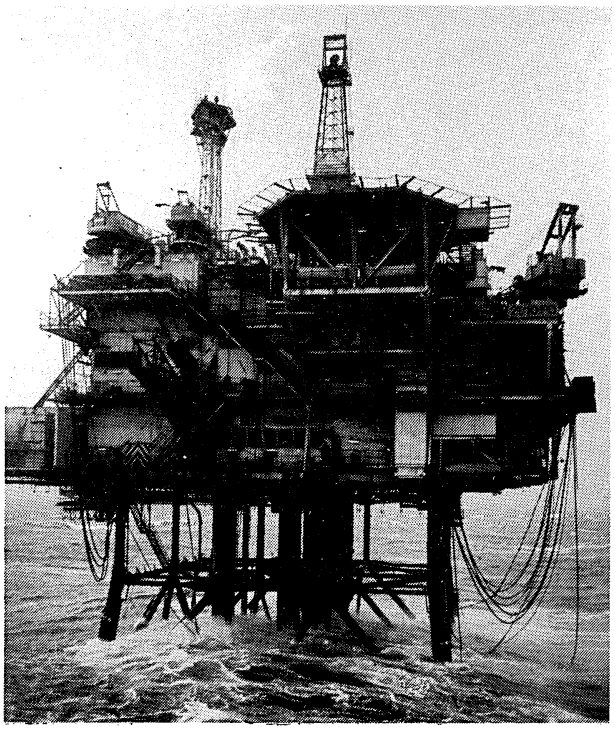


Figure 1 Coal, gas and oil production.
Above left: *Hem Heath Colliery near Stoke-on-Trent, from which coal is transported to power stations by 'merry-go-round' rapid load trains.*
Above right: *Part of the metre diameter pipeline laid down the east coast of Britain to handle supplies of gas from the North Sea. Here the pipeline is strung out before being buried underground.*
Below left: *Production platform in BP's Forties oilfield in the North Sea.*

Part 1 Energy in your home

A and **B** are to be done at home. **C** will be done in class afterwards.

A Find out which energy sources are used in your home. Draw up a table like Table 1, and write the names of the energy sources in the first column of the table.

Table 1

Name of energy source	*Units in which you buy it*	*Cost of one unit*
Coal	tonnes	£120

B In Part 2 we will be comparing the costs of the different energy sources. But unfortunately different sources are sold in different units. Try to find out what unit each energy source is sold in. Put this information in the second column of Table 1. Try to find out also the *cost* of one unit. You might be able to find this out from fuel bills. Put the cost in column 3. An example, 'Coal', has been filled in already.

C Before going on to Part 2, compare your results with other members of your class. Fill in any gaps in your table, and correct any mistakes. Add any energy sources you did not include.

Questions

1 *What is the energy source used in the largest number of homes of people in the class?*

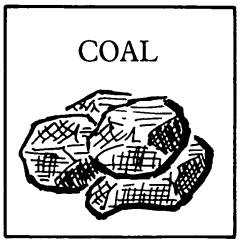
2 *What is the least used energy source?*

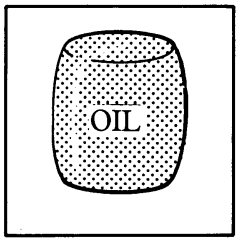
3 *Why is it impossible to compare the costs of the different energy sources using Table 1 alone?*

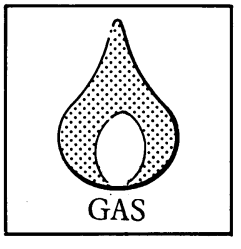
4 *You have probably found that different people pay different prices for the same energy source. Suggest reasons for this.*

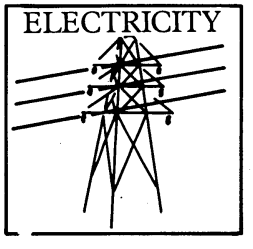
Part 2 Comparing the costs of energy sources

In this part we will concentrate on four major energy sources.









Apart from electricity, all of these energy sources are **fuels** — substances which burn in air to release heat.

Table 2 gives the units in which they are sold, the price per unit and the amount bought for £1. Compare Table 2 with your own Table 1. The prices are only averages, because they vary according to quality, the time of year and the amount you buy. They are 1985 prices, and you may like to replace them with your own, up-to-date local prices.

Table 2 Costs of different energy sources

Energy source	*Unit in which you buy it*	*Cost of one unit*	*Amount bought for £1*
Coal	tonne (1000 kg)	£120	8.3 kg
Fuel oil	litre	£ 0.18	5.6 litres
Mains gas	therm	£ 0.37	2.7 therms
Electricity	kilowatt-hour (kWh)	£ 0.05	20 kWh

Which is the cheapest? Of course, you cannot tell, because these figures are not very helpful when it comes to comparing fuels. If you want to know which fuel is cheapest, you need to know whether, say, 1 kWh of electricity represents more or less energy than 1 litre of oil.

To make comparisons possible, we need to have the prices of all the energy sources in the same unit. Since they are all energy sources, it makes sense to use energy units. A convenient energy unit is the megajoule (MJ). 1 MJ = 1 million joules.

Table 3 shows the number of megajoules that can be obtained from the various energy sources.

Table 3 Converting energy sources to megajoule units

Energy source				
Coal	1 kg coal	=	30	MJ
Fuel oil	1 litre fuel oil	=	37	MJ
Gas	1 therm	=	105	MJ
Electricity	1 kilowatt-hour	=	3.6	MJ

Questions

5 *Draw up a table like Table 4 below and put your answers in it.*

6 *Which energy source is the cheapest?*

7 *Which is the most expensive?*

Table 2 showed you how much fuel you can buy for £1. Table 3 shows how many MJ you get from different quantities of fuel. From these two sets of figures, you can work out for each fuel how many MJ you get for £1.

Table 4

Energy source	*Energy in MJ bought for £1*
Coal	
Fuel oil	
Gas	
Electricity	

Part 3 Why is electricity more expensive?

Unlike coal, oil and gas, electricity is a **secondary energy source**. This means it can only be made from another, **primary energy source** — such as coal, oil or nuclear power.

Most electricity is generated by burning coal in a power station (Figure 2). Heat produced by burning fuel is used to turn water to steam. The steam then drives turbines, which in turn drive electrical generators. But not all the energy in the fuel is converted to electricity. A lot escapes in hot air from the cooling towers and chimney of the power station.

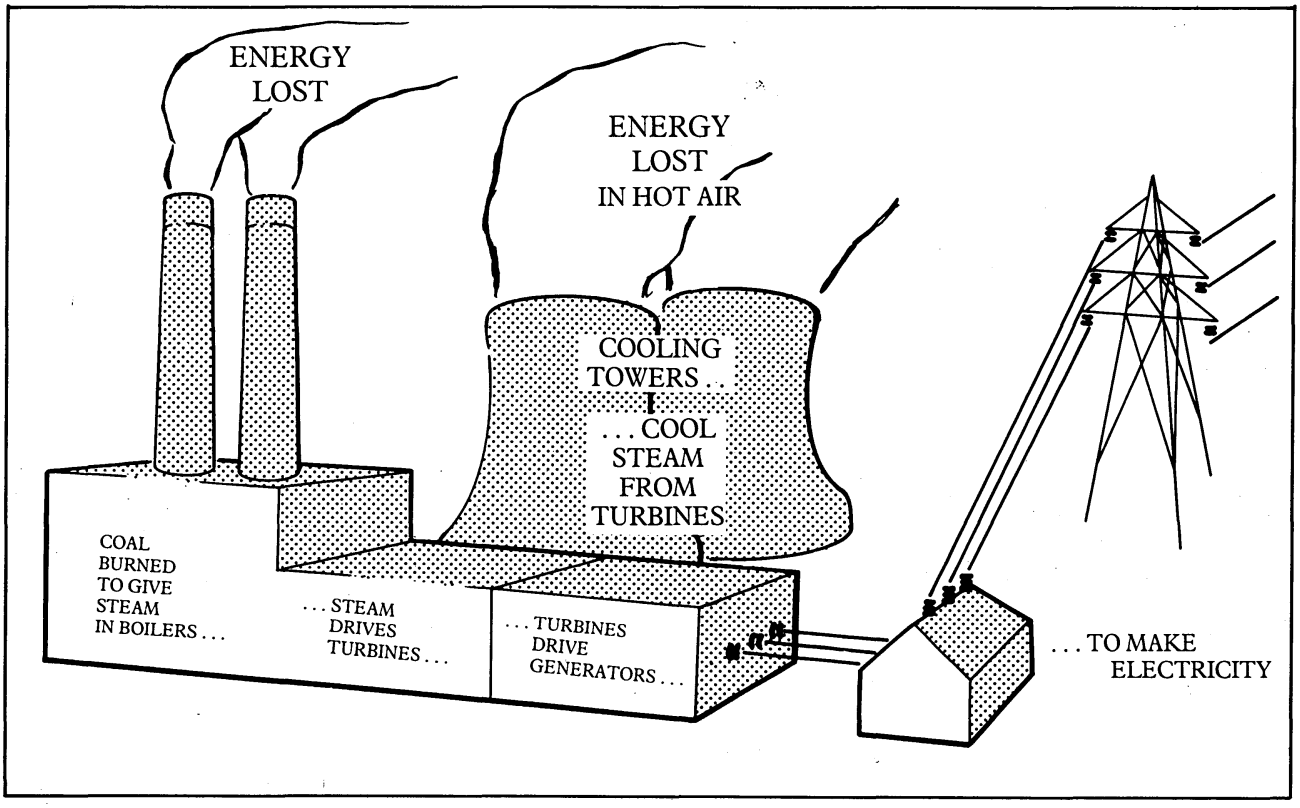


Figure 2 Generating electricity in a coal-fired power station

Table 5 gives data for a big coal-fired power station. Look carefully at the data, then answer questions 8 to 10.

Table 5 Energy use in a major coal-fired power station (the figures are in thousands of megajoules per hour)

Input energy		*Output energy*	
Energy input from burning coal	6073	Energy output:	
		Electricity	2250
		Heat lost to cooling water	3078
		Heat lost up chimney	516
		Other losses	103
		Electricity used in running power station	126
		Total output	6073

Questions

8 Where does most *of the input energy go to?*

9 The percentage efficiency of a power station is given by

$$\frac{\text{Useful energy output as electricity}}{\text{Total energy output}} \times 100$$

What is the percentage efficiency of this particular power station?

10 Apart from the cost of the coal, what other costs do you think are involved in running a power station?

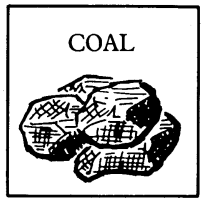
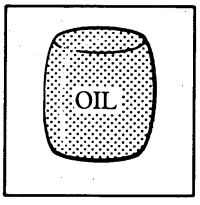
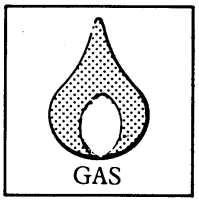
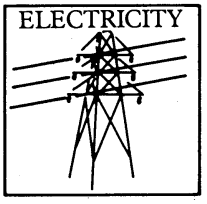
Part 4 Who are the big energy users?

There are many different types of energy users. But we can group them into five major classes:

Power stations
Industry
Road transport
Domestic (households)
Other uses.

Table 6 shows the way the different energy sources are divided between four of these uses. The figures are in billions of megajoules per year. The table does *not* show the amounts used in power stations. Use Table 6 to answer questions 11 to 17.

Table 6 Final users of different energy sources. (The figures are in billions of megajoules per year (1 billion megajoules = 10^{15} J). They apply to the year 1983.)

				
Industry	190	870	600	260
Road transport	—	1160	—	—
Domestic	210	90	940	300
Other	390	1382	240	220
Total	790	3502	1780	780

Questions

11 Road transport has only one important energy source. What is it? Why is this source particularly useful for road transport?

12 What is the biggest single energy source for domestic use? Why is it particularly suitable for this?

13 Electricity is a very convenient energy source for domestic heating. Why, then, is it not used more?

14 The total *amount of coal used per year is 2940 billion megajoules. Compare this with the total in the table. Explain what the missing coal is used for.*

15 One important energy source, used only for generating electricity, is missing from Table 6. What is it?

16 Industry uses a lot of oil. Most of it is used as an energy source, but not all of it. What non-energy *uses are there for oil products?*

17 Look at the 'Total' row. This compares the total contributions of Britain's different energy sources. In what ways might the figures be different in twenty years time?