Energy information pack

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EDF ENERGY EDUCATION inspiring the next generation

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Where does our energy come from and how do we use it?

We need energy to provide us with heat and electricity and to power our vehicles. Our modern economy, infrastructure and way of life depend on it. Most of the energy we get currently comes from burning fossil fuels (coal and gas), but renewables are increasing their share of the worldwide energy mix and currently represent 25% of generation[1].

Our energy comes from transforming one form of energy into another that is more useful to us. For example, car engines convert the chemical energy in petrol into heat energy, and then to kinetic energy that moves the car forward.

This transformation produces waste. The waste produced from transforming fossil fuels into useful energy includes the gas carbon dioxide (CO_2).

Energy use increases with the state of a country's economic development. As poorer countries become more developed, their need for energy increases. In countries with very large populations, such as India and China, the enormous increase in energy production has severe implications for climate change, particularly if the new energy requirement is met mainly by fossil fuels.

1 World Energy Outlook, IEA, 2018 https://www.iea.org/newsroom/news/2018/november/world-energy-outlook-2018-examines-future-patterns-of-global-energy-system-at-a-t.html

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Production and consumption

Consumption of energy is lower than production. This is because there are a number of ways in which energy produced can be lost. Some energy can be lost when transferring one type of energy into another (for example, turning the energy stored in coal into electricity). Some is also lost when energy is distributed (for example, due to resistance in the power lines).

The following table summarises the main ways in which energy is consumed in the UK, including energy lost during production and distribution.

UK Inland Energy Consumption, 2017

	Million tonnes of oil equivalent
Total inland primary energy consumption*	**192.1**
Losses	
Conversion losses (losses that occur from transferring one energy type into another)	35.8
Distribution losses and energy industry use (losses that occur when energy is distributed across the network from its source to distribution points)	15.0
Total final energy consumption	**141.2**
Final consumption of which, comes from:	
Industry	24.1
Domestic sector	40.1
Transport	56.5
Services (includes agriculture)	20.5
Temperature-corrected total inland consumption	**195.2**

* Excludes non-energy use

Source: UK Energy in Brief 2018, Department for Business, Energy and Industrial Strategy

What is the energy mix?

The energy mix is the combination of sources used to provide sufficient energy to meet demand, at any given time and place.

Energy sources include coal, oil, gas, water (hydro), uranium (nuclear), wind, sunlight and others. The electricity generated from these sources is distributed around the UK using a national network called the National Grid and regional distribution systems.

Fulfilling energy demand requires a careful balancing of supply. Electricity cannot be stored effectively on the National Grid, and demand can soar at peak times and plummet in the middle of the night. This means the range of energy sources making up the energy mix must contain a combination of reliable fuels that are on constantly, as well as those that can be switched on, or dispatched, when needed to meet spikes in electricity demand.

Why is the energy mix important?

One of the most important issues facing any country is the challenge of securing access to energy resources that are sufficient to run its economy, feed and house its people, and protect its borders.

But also, ensuring that the energy mix contains sustainable sources is vital, if we are to minimise the effects of climate change. With a finite supply of fossil fuels and a growing role for nuclear and renewable energy – combined with increasing international concern about global warming – governments, policy makers, companies and citizens are all considering what the best mix of energy resources is, and which factors should play a role in determining that mix.

What are the challenges in balancing the energy mix?

The energy mix challenge is a complex one, partly due to energy supply being closely connected to national and international security. It also affects many of the most damaging and dangerous environmental problems – from air quality to climate change – as well as the capacity to meet basic human needs and drive economic growth.

An energy mix solution must satisfy economic, environmental, socio-political and cultural criteria, while the goal of sustainable energy entails developing a supply that will meet demand indefinitely.

This challenge includes not only improving the standard of living in developing countries, but also converting currently unsustainable practices (e.g. use of finite resources for energy production) into sustainable ones, and supporting the standard of living in industrialised ones.

The multiplicity and importance of these issues would make the energy mix a perplexing issue even in a world where energy demand was constant and stable. But that is not the world we live in. Continuing population growth and rapidly rising wealth in many parts of the world are driving an increasing rate of energy use that has serious implications for future generations.

Factors influencing the energy mix

The three main factors that influence a country's energy mix are:

- **Energy security:** ensuring that we have a secure and stable supply of energy
- **Energy affordability:** ensuring that energy is affordable for everyone in society
- **Energy sustainability:** ensuring that the energy mix contains sustainable energy sources

Energy security

The term 'energy security' is used to reflect a number of different issues which have an impact on both energy supply and cost:

- The security of transferring fuels and/or energy between the source and the consumer (i.e. ensuring energy gets to people)
- The finite nature of fossil fuels: one day they will run out

- The effect that geo-political events have on energy generation and supply
- As we are absolutely dependent on energy, governments must ensure that there are reliable supplies of energy at affordable prices. This is an important issue in the UK, as North Sea oil and gas are in decline, which means we might need to import (buy in) oil or gas from other countries.

In contrast to coal and gas, oil reserves are found in relatively few countries. Some of these countries can be politically turbulent, and there is always a risk of oil- and gas-rich countries using energy supply and pricing as a political weapon. This compromises energy security in other countries.

It is also important that we are not dependent on any one country, technology or supplier for our energy. Reducing the need to import fuel, by reducing demand or increasing the supply of our own renewable resources, will increase the security of our supply.

Energy affordability

Energy affordability is usually determined by a combination of factors, including household income, fuel costs and the energy efficiency of homes.

Fuel poverty is often defined as when a household needs to spend more than about 10% of its income on fuel to maintain a reasonable standard of warmth. Fuel poverty is usually caused by low household income, increased fuel costs and poor energy efficiency in a home.

The highest risk individuals are the elderly, single parents, disabled people, and families where adult members are either on a low income or unemployed. In the UK, the government has rolled out an energy efficiency scheme to help low income households make their homes more energy-efficient (e.g. by installing insulation or more efficient heating systems)[2]. Energy companies also offer assistance to customers who have difficulty paying; for instance, by offering pre-paid services.

The price of energy is directly linked to the cost of production – different sources in the mix have varying energy production costs – so the energy mix has an important role to play in maintaining energy affordability.

Energy sustainability

Energy is sustainable when it is produced in a way that meets the needs of the present, without compromising the ability of future generations to meet their needs.

Increasing energy consumption around the world has led to concerns about where this energy comes from. A number of types of energy can be thought of as sustainable – for example, solar, wind or nuclear power. Many governments promote the use of sustainable energy and the development of new types of technology which can generate sustainable energy.

2 Department for Business, Energy and Industrial Strategy, https://www.gov.uk/government/news/government-delivers-on-manifesto-pledge-with-6-billion-package-to-help-end-fuel-poverty-and-drive-innovation-in-energy-efficiency

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Several factors determine whether electricity generation or usage is sustainable:

- **Whether a method of generating energy can continue indefinitely.** Many forms of renewable energy qualify as sustainable because they meet this criteria. People can generate energy from the wind, water, and the sun without running out of resources, making these methods sustainable for use by future generations. By contrast, fossil fuels are not treated as sustainable because the Earth's supplies of oil, coal and gas will eventually run out.

- **Energy efficiency** is something we try to improve in things and places that use energy, such as homes, cars, and businesses. Increased efficiency in the way energy is used makes sustainable energy go further.

- **Environmental impact**. The impact that a method of energy generation has on the environment is important. For instance, some of the methods used to produce solar panels, wind turbines and other technology to convert renewable sources into energy are polluting, leading to concerns that such technology merely 'hides' the pollution, making it unsustainable.

- **Energy independence** is another factor important in energy sustainability. Some critics argue that energy is not sustainable if a nation is forced to rely on another nation to meet its energy needs, even if the energy is renewable, non-polluting, and energy efficient.

What's the global energy mix?

There's no such thing as a 'standard' energy mix; the factors mentioned above – security, affordability and sustainability – along with a country's geography (any natural energy resources it has, for instance), politics, society and its people affect the choice of power sources that it relies on for electricity... It's why even neighbouring countries can get their electricity from very different energy sources!

To find out more about the energy mix around the world, download our **Global Energy Mix poster**

What does the UK's current energy mix look like?

When looking at energy consumption, it helps to split it into three main categories:

1) Electricity

2) Fuels for transport

3) Heat

1) Electricity

When discussing the composition of the UK's energy mix, we will be primarily concentrating on electricity production and consumption.

Electricity supply

England and Wales has an electricity transmission network called the National Grid. This includes approximately 4,500 miles of overhead lines and about 340 substations.

Because electricity cannot be stored in large quantities, it is the job of the National Grid administrators to ensure that there is always enough supply to meet demand. They do this by careful forecasting and planning, taking into account weather forecasts and historical data, even what's coming up on TV! Although on-demand TV services (like Netflix and iPlayer) have reduced the intensity of the surges in electricity demand that happen as the nation rises up simultaneously from the sofa to switch on the kettle (called a 'TV pick-up'), these still occur for big events, like the football World Cup[3].

Did you know....

The biggest ever 'TV pick-up' recorded to date was after England's World Cup semi-final against West Germany in 1990, when demand soared by 2,800 megawatts – equivalent to more than a million kettles being switched on![4]

3 https://www.telegraph.co.uk/news/2016/10/03/no-more-electricity-surges-as-the-nation-switches-on-the-kettle/

4 National Grid website – Forecasting Demand, Page 1 (http://www.nationalgrid.com/NR/rdonlyres/1C4B1304-ED58-4631-8A84-3859FB8B4B38/17136/demand.pdf)

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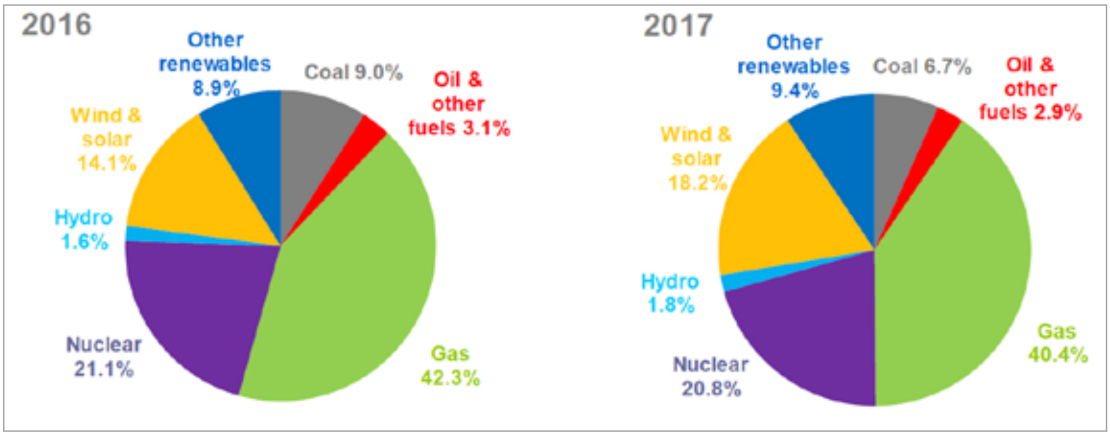
A breakdown of the UK's energy mix

In the UK we have a diverse mix of energy supplying our electrical needs. The main sources are currently gas (40%), renewables (29%) and nuclear (20%). The following table and graphs summarise the UK energy mix by energy source and the quantity of electricity supplied in terawatt hours.

UK electricity: amount generated by fuel type, 2016 and 2017



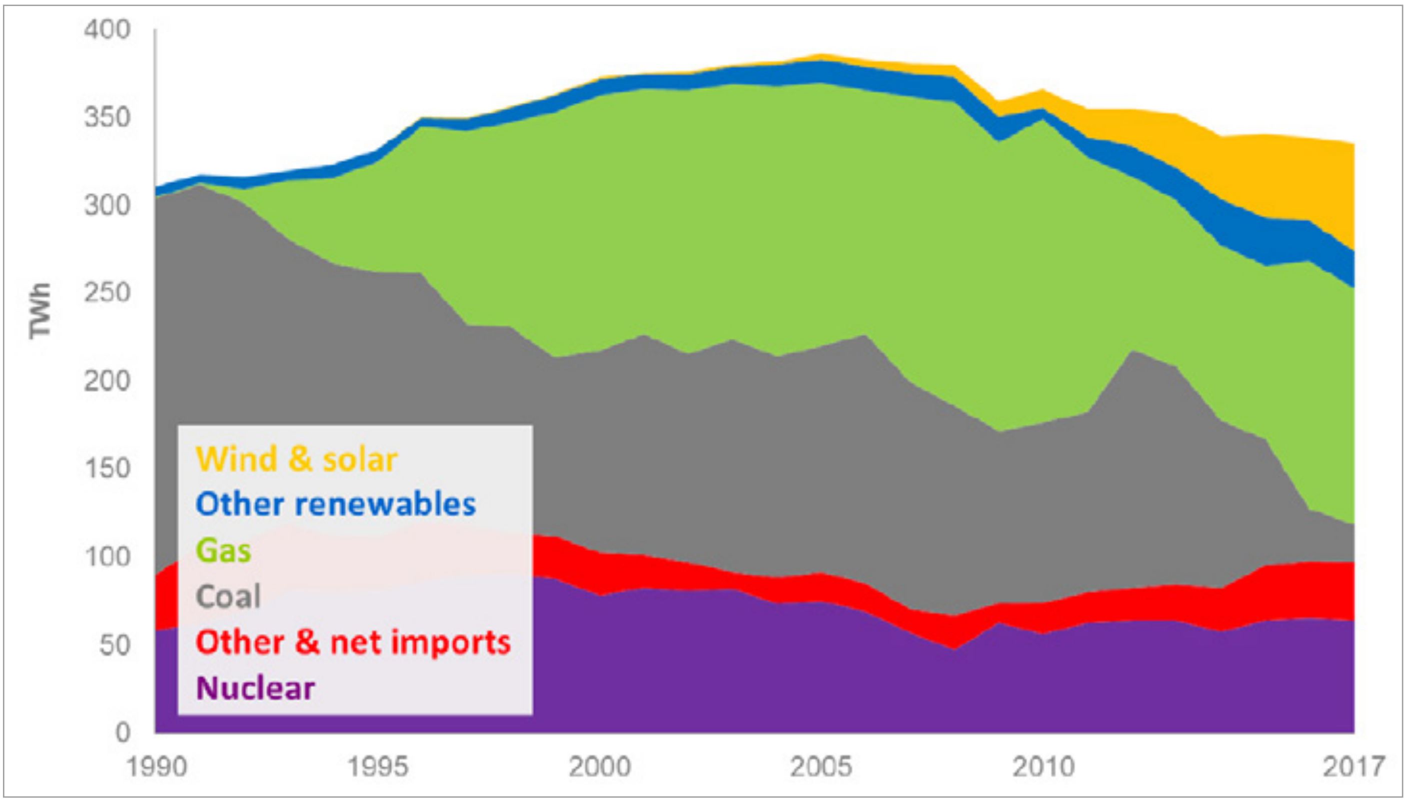
Source: UK Energy in Brief 2018, Department for Business, Energy and Industrial Strategy

UK electricity: amount generated by fuel type 1990 to 2017 (TWh)

Fuel Type	1990	2000	2010	2016	2017
Coal	229.8	120.0	107.6	30.7	22.5
Oil and other fuels*	20.7	13.6	10.5	10.4	9.7
Gas	0.4	148.1	175.7	143.4	136.7
Nuclear	63.2	85.1	62.1	71.7	70.3
Hydro	5.6	5.1	3.6	5.4	5.9
Wind & Solar	–	0.9	10.3	47.7	61.5
Other Renewables	–	4.3	12.3	30.1	31.9
Total electricity generated	**319.7**	**377.1**	**382.1**	**339.3**	**338.6**

*Includes generation from pumped storage
Source: UK Energy in Brief 2018, Department for Business, Energy and Industrial Strategy

UK electricity: amount supplied by fuel type, 1990 to 2017



Source: UK Energy in Brief 2018, Department for Business, Energy and Industrial Strategy

Find out how challenging it is to balance the energy mix by playing our **Power the UK game**

2) Transport

95% of energy for transport comes from fossil fuels[5]. Road transport accounted for 73% of total transport energy consumption in 2017 in the UK, air transport was 23%, rail was 2% and water transport was 2%[6].

More than two-thirds of the oil used in the UK is for transport[7]. There has been an increase in the use of biofuels over recent years. However, these have their own environmental and social impacts which must be considered before they become widely used. What the crop is; where and how it is grown; how it is processed; and where it is used all have to be assessed.

Some biofuels, such as corn ethanol, can still cause significant levels of greenhouse gas emissions. If food crops are used as fuel, this can also push the price up, which can have damaging social consequences if people rely on those crops as a source of affordable food. In contrast, other sources, like sugarcane ethanol used in Brazil, produce fewer greenhouse gas emissions, and can provide jobs and a measure of energy security.

There is also a growing trend for the electrification of vehicles. While electric cars might still consume electricity generated by burning fossil fuels, they don't produce any exhaust pollution and are quieter than petrol vehicles. But the move towards the electricification of vehicles will take time: the technology is still being developed, most can't travel long distances on a single charge and we need to have in place a more robust infrastructure (more charging points, for instance) and address behavioural issues (charging an electric car takes longer than a petrol car, for example) before electrification becomes the norm.

But the other significant factor that determines the continued use of oil for transport for the forseeable future is the simple fact that planes and large goods vehicles are less amenable than cars to be adapted for electrification and alternative fuels.

3) Heat

Sources such as oil, natural gas and biomass are used to produce the majority of heat energy. This energy can be transported in pipes as district heating, or produced on site. Heat energy is primarily used in households for heating buildings and hot water, and in industry for various processes which require heat.

The demand for heat production is directly related to the weather and air temperature. This means a particularly cold winter, such as that in 2009/10, can have a big impact on demand. Reducing demand by increasing the thermal efficiency of buildings (e.g. insulation, double- or triple-glazing, draught proofing) is a key measure to ensure a reduction in demand and needless waste.

5 Intergovernmental Panel on Climate Change (2007). "IPCC Fourth Assessment Report: Mitigation of Climate Change, chapter 5, page 325, Transport and its Infrastructure"

6 Energy Consumption in the UK, 2018, Department for Business, Energy and Industrial Strategy (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/729317/Energy_Consumption_in_the_UK__ECUK__2018.pdf)

7 UK Digest of Energy Statistics, Chapter 3, Petroleum (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/729403/Ch3.pdf)

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Energy demand

The global population is increasing and economies around the world are expected to grow significantly over the long term. What do these fundamental changes in population and income mean for energy demand?

Global energy demand

Between 1973 to 2005, worldwide energy demand increased by nearly 70%[8]. This change has largely been driven by developing countries, but developed nations have also experienced moderate levels of growth.

The International Energy Agency (IEA) predicts that rising incomes and an extra 1.7 billion people will increase global energy demand by more than a quarter to 2040. This increase would actually be around twice as large were it not for improvements taking place in energy efficiency!

All the growth comes from developing economies, led by India. Only 20 years ago, Europe and North America accounted for more than 40% of global energy demand, while developing economies in Asia represented around 20%. But by 2040, the IEA expects this situation will be completely reversed. Asia already accounts for half of global growth in natural gas, 60% of the rise in wind and solar PV, more than 80% of the increase in oil, and more than 100% of the growth in coal and nuclear[9].

World energy consumption by sector and share of energy use

Sector	Main types of energy used	Share of total energy use
Transport	▶ Petrol for cars, motorcycles and light trucks ▶ Diesel for cars, trucks, buses and trains ▶ Jet fuel for airplanes	21%
Industry (including the non-combusted use of fuels)	▶ Natural gas for boiler fuel and process heat ▶ Electricity for power ▶ Coal for boiler fuel	50%
Residential and commerical buildings	▶ Natural gas for space heating ▶ Electricity for lighting, appliances, refrigeration and some types of heating and cooling	29%

Source: BP (https://www.bp.com/en/global/corporate/energy-economics/energy-outlook/demand-by-sector.html) and explanation from EIA, World Energy Consumption by End Use Sector, May 2014 (http://www.eia.gov/tools/faqs/faq.cfm?id=447&t=1)

8 International Energy Agency, Key World Energy Statistics 2007, Page 28
9 International Energy Agency, World Energy Outlook 2018, https://webstore.iea.org/download/summary/190?fileName=English-WEO-2018-ES.pdf

UK energy demand

The UK's total electricity supply rose continuously from 1997 to reach a peak in 2005. It has subsequently fallen, reflecting lower demand due to energy efficiency, economic and weather factors, with 2017 supply 15% lower than that in 2005[10].

For example, there have been extensive trials of smart meters by Ofgem and energy providers, such as EDF Energy. Smart meters send back information on energy use to the supplier automatically, so energy providers no longer have to estimate how much energy has been used. They can also help households and businesses become more energy-efficient as they show how much energy is being used in near real-time and how much it costs, as well as how much has been used in the past. This means households and businesses can identify periods when too much energy has been used.

To see real UK electricity demand data, including the last 24 hours or past week, visit the National Grid website: **http://www.nationalgrid.com/uk/Electricity/Data/Realtime/**

Minimising the effects of climate change

The Greenhouse Effect

The Earth's atmosphere is a mixture of gases forming a layer around the planet. If the Earth did not have an atmosphere, its average temperature would be well below freezing. The atmosphere traps heat from the sun and the Earth, raising the temperature of our planet to a point where it is generally comfortable for life. This is a completely natural process known as the Greenhouse Effect. The main gases responsible for the Greenhouse Effect are water vapour, carbon dioxide and methane. Together they form less than 1% of the atmosphere.

Man-made climate change

Burning fossil fuels to produce energy also produces billions of tonnes of carbon dioxide (and some other gases) every year. These stay in the atmosphere for many years, trapping more of our planet's heat. It has been scientifically shown that the atmosphere and the oceans are warming up because of human activities – particularly the burning of fossil fuels.

Fossil fuel use is not the only cause of increasing greenhouse gases. However, industrial and energy-related fossil fuel emissions are responsible for about three-quarters of greenhouse gas emissions. Energy-related emissions are increasing for three main reasons:

- Our wish to have ever more convenient services and products
- The rapid economic development of large populations in India and China
- The rapid rise in the world's population, particularly in developing countries.

10 UK Energy in Brief 2018, Department for Business, Energy and Industrial Strategy

Why does this matter?

Small increases in the average temperature of the Earth's atmosphere and oceans will have huge effects on our climate. (The climate is the average weather conditions over many decades at a particular place on the Earth's surface. Weather is different to climate; weather is what you experience on a daily basis).

If temperatures rise by more than 2°C above pre-industrial levels, scientists predict severe consequences. A warmer climate means a changing climate: shifting weather patterns; more extreme weather events; reduced agricultural production; rising sea levels; droughts and floods; tropical diseases expanding their range; and displaced climate refugees on a massive scale.

However, many scientists say that we have a chance of staying below the critical 2°C average global temperature increase if we can cut our greenhouse gas emissions by about three-quarters by 2050, and reduce them still further to almost nothing by 2100[11]. This will be very difficult to achieve, but not impossible!

Reducing our demand for energy is the cheapest and easiest way to reduce our greenhouse gas emissions. It has been estimated that with widespread action we could reduce our electricity demand by a fifth by 2050[12].

Read more about our changing climate and the implications for the planet in our Climate Science information pack

Who is doing what to help?

These reductions in emissions will not happen unless we all make an effort. We can all do something to help.

Governments

A United Nations (UN) conference in Copenhagen in December 2009 resulted in the Copenhagen Accord, signed by the majority of countries. The accord includes:

- International backing for a limit of 2°C on global warming
- Agreement that all countries need to take action on climate change

11 Avoiding Dangerous Climate Change: International Symposium on the Stabilization of Greenhouse Gas Concentrations (Report of the International Scientific Steering Committee, Hadley Centre, Met Office, Exeter, UK, 2005), Page 19

12 Climate Change 2007, the Fourth Assessment Report (AR4) of the United Nations Intergovernmental Panel on Climate Change (IPCC)

- Financial help for the countries most at risk from climate change.

Industry

Many of the world's biggest companies are working hard to reduce their greenhouse gas emissions. They can do this by using more efficient equipment (using less energy to make their products, like Samsung[13]); by capturing and/or offsetting the emissions they do make (reducing the impact of the gases emitted); or by sourcing electricity from renewable sources (like Tesco, Coca-Cola in Europe, Whitbread and Lego[14]).

You and me

There are many things we can do to reduce our individual impact on the climate, including using public transport; switching off electrical equipment when we are not using it; turning the heating down; taking short showers instead of baths; insulating our homes; and recycling our rubbish.

Together, we can meet our energy needs and reduce our emissions by:

1. Reducing our demand for energy

2. Reducing the impacts of existing energy production

Take a look at our factsheet with tips and advice on how to save energy at home

UK targets

The UK has committed to tackling climate change through international climate change obligations, such as the Kyoto Protocol (December 1997) and Paris Agreement (November 2016).

In 2008, the Climate Change Act was passed to help the Government meet its international requirements. It committed the UK to two key targets:

- Reducing carbon dioxide (CO2) emissions by at least 80% of 1990 levels by 2050;

- Contributing to global emission reductions, to limit global temperature rise to as little as possible above 2°C[15]

The Climate Change Act 2008 made the UK the first country to establish a long-term legally binding framework to cut carbon emissions[16].

13 https://www.samsung.com/uk/aboutsamsung/sustainability/environment/climate-action/
14 https://business.energysavingtrust.org.uk/news-opinion/renewable-companies-big-businesses-getting-serious-about-green-energy
15 https://www.theccc.org.uk/tackling-climate-change/reducing-carbon-emissions/carbon-budgets-and-targets/
16 https://www.theccc.org.uk/tackling-climate-change/

To help it meet its targets, the Government set five-yearly carbon budgets, up to 2032:

- 1st carbon budget (2008-2012): reducing carbon emissions by 25% below 1990 levels
- 2nd carbon budget (2013 to 2017): reducing carbon emissions by 31% below 1990 levels
- 3rd carbon budget (2018 to 2022): reducing carbon emissions by 37% below 1990 levels
- 4th carbon budget (2023 to 2027): reducing carbon emissions by 51% below 1990 levels
- 5th carbon budget (2028 to 2032): reducing carbon emissions by 57% below 1990 levels[17]

The Committee on Climate Change carries out an annual assessment to determine whether the UK is on track to meet its carbon budgets. The first carbon budget was met and the UK is on track to meet the second and third carbon budgets; but not the fourth (from 2023-2027). In 2017, UK carbon emissions were 43% below 1990 levels[18].

While the UK was part of the EU[19], it was signed up to the Renewable Energy Directive. This committed the EU to fulfil at least 20% of its total energy needs with renewables by 2020, and at least 10% of its transport fuels from renewable sources by 2020. In November 2016, the EU Commission published a proposal for updating the Renewable Energy Directive, which would bring in a target of ensuring at least 27% energy needs are met by renewables by 2030[20].

Each country was required to fulfil the Renewable Energy Directive through its own national targets – in the UK this target was 15% of all energy and 10% of transport fuels from renewables by 2020[21]. In 2017, 10.2% of final energy consumption in the UK was from renewable sources[22].

At the time of writing, the full impact of Brexit on the UK's climate change or renewable energy targets isn't known. But the Government has said that even if there's no deal, there will be "no change to the UK's deep commitment to domestic and international efforts to tackle climate change"[23]. The UK's Climate Change Act is national legislation so won't be affected by leaving the EU, nor will the UK's commitment to international treaties. In October 2017, the UK Government published its Clean Growth Strategy, which outlined its plans to move to a low-carbon economy and meet its national and international commitments to tackle climate change[24]. Key proposals include:

- Helping businesses and industry become more energy efficient
- Improving the energy efficiency of homes
- Rolling out low carbon heating
- And investing in low-emission and electric transport.

17 https://www.theccc.org.uk/tackling-climate-change/reducing-carbon-emissions/carbon-budgets-and-targets/

18 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/695929/2017_Provisional_emissions_statistics_one_page_summary__1_.pdf

19 This information was updated in March 2019 when a post-Brexit deal hadn't yet been finalised

20 https://ec.europa.eu/energy/en/topics/renewable-energy/renewable-energy-directive

21 https://publications.parliament.uk/pa/cm201617/cmselect/cmenergy/173/17305.htm

22 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/728374/UK_Energy_in_Brief_2018.pdf

23 https://www.gov.uk/government/publications/meeting-climate-change-requirements-if-theres-no-brexit-deal/meeting-climate-change-requirements-if-theres-no-brexit-deal

24 https://www.gov.uk/government/publications/clean-growth-strategy/clean-growth-strategy-executive-summary

Reducing our demand for energy

Households, schools and businesses can undertake many energy efficiency measures, without significant cost, by improving building maintenance and changing behaviour. If we can reduce the amount of energy we use by improving energy efficiency, we will reduce both emissions and costs.

Heating buildings

A well-insulated building requires less energy to heat and maintain at the required temperature, saving money and reducing emissions. Insulation stops heat escaping through the roof, floors and walls. Double glazing can halve the heat loss through windows, and triple glazing is even better. Replacing old boilers with modern, highly-efficient condensing boilers also reduces greenhouse gas production.

Electricity in buildings

Many electrical appliances are more efficient than their older counterparts; new energy efficient fridges use 60% less energy than they did 20 years ago, for example, because of factors like improved insulation and temperature control. Many newer electrical items will turn themselves off when not in use. Energy-efficient lighting produces the same amount of light using less energy than conventional bulbs.

New buildings are increasingly being designed to maximise energy efficiency, with energy-saving measures incorporated into guidelines and regulations for new construction projects.

Take a look at our **factsheet** with ideas for how to save energy at school

Behaviour change

Changing the behaviour of the population is often suggested as a cheap way to reduce emissions, but it is easier said than done. There is often a gap between what people think they should do and what they actually do. Also, when people save money on energy, they may spend that money on something that cancels out the efficiency benefit, like a flight abroad.

However, simple changes to everyday behaviour can make an impact. Heating is the biggest form of energy consumption in most British buildings. For every degree you turn down the heating in your building, you can save 10% of your heating bill.

Distributing electricity

Almost all of our electricity is produced in large power stations and the National Grid is the network that transfers electricity from power stations (where it's supplied) – sometimes over hundreds of miles – to homes and businesses (where demand is).

From the power station, a step up transformer increases the potential difference from 25,000 volts to 400,000 volts to the transmission cables. That's because if the current (I) is high, lots of energy is lost through heat – you might remember from your science lssons that P (power) = IV (current x potential difference). So instead a high potential difference is used and the current kept as low as possible. This makes the National Grid an efficient way of transferring energy.

As the electricity nears its final destination, the voltage needs to be lowered to a safer level for us to use. This is 230 volts in homes. The potential difference is decreased inside a substation using a 'step down transformer' – the opposite of a step up transformer used at the beginning of its journey.

What energy options do we have?

Carbon-intensive energy sources

Conventional power stations burn coal or gas to produce electricity. Coal and gas are called fossil fuels because they were formed over millions of years ago through the decay, burial and compaction of rotting vegetation on land (coal), and marine organisms on the sea floor (gas).

Fossil fuels are non-renewable resources because they take millions of years to form, and reserves are being depleted more quickly than new ones are being formed. Once we have used them all, they will be gone for ever. All fossil fuels are made of hydrocarbons. Energy stored in hydrocarbons can be released very easily – we just have to burn them. Burning fossil fuels in this way releases large quantities of carbon dioxide (CO_2, a greenhouse gas), sulphur dioxide (which is a cause of acid rain) and nitrogen oxides (also a cause of acid rain).

One of the biggest benefits of fossil fuels is their cost. Coal and natural gas are plentiful right now, and relatively inexpensive to drill or mine for. But as fossil fuel resources decline, their price will increase. This will make other, more expensive, sources of energy more viable – and this includes many of the renewable energy options.

Coal

Coal is an abundant and flexible energy source which remains an important part of the energy mix globally, but its use in the UK has declined considerably.

Millions of years ago the world was covered in tropical forests. They absorbed huge amounts of CO_2 and converted it into more forest using energy from the sun. As these forests died, they became buried by the sediments left by flooding seas. As they sank deeper and deeper over millions of years, the increasing pressure and heat they were subject to turned the forests into coal. So coal is basically fossilised jungle!

Coal power stations use the heat from burning coal to turn water into steam, which drives a turbine to produce electricity. Coal power plants have long been used to provide baseload electricity, as the cost of generation is low and plants can be run 24/7.

It's also a flexible power source, as a sudden increase in demand can be met by burning more coal. But burning coal produces a lot of CO_2 per unit of energy compared to burning gas – THREE TIMES more – so its increased use has major implications for climate change.

Coal is found in over 100 countries, particularly Australia, China, India, Russia, South Africa and the US. In the US, India and China, large supplies are matched by a large demand. Coal use is growing rapidly in some of these countries, primarily to generate electricity. Until the first North Sea gas was brought ashore in 1967, coal was the UK's chief energy source. It was used for town gas production and electricity generation by industry, the public sector and individual households.

But over the past 60 years, coal's share of total UK energy supply has fallen; it accounted for 90% in 1948, but had fallen to 50% by 1968[25]. By 2000, solid fuels (coal and other solid fuels like tars and coke oven gas) only represented 16% of all energy consumption in the UK. In 2016, the level of coal generation fell to 9% and in April 2017 we had the first 24-hour period without coal on the system since the first coal power station opened in 1882[26].

Many of the UK's coal power stations are now due to shut down, as the Government plans to phase out old polluting coal plants by 2025 – and won't be investing in any new coal-fired power stations after this date.

Find out how we generate power from coal and gas in our fossil fuels poster

Gas

Gas power stations use the heat from burning gas to turn water into steam, which drives a turbine to produce electricity. Gas has become a popular energy source as it's a reliable, flexible and fairly low-cost way to generate lots of power. So if there's a sudden increase in demand, it can be met by burning more gas. But gas is a fossil fuel, so generating electricity this way produces carbon dioxide and contributes to climate change.

During the 1980s and early 1990s there was a huge increase in the amount of electricity generated by gas, known as the 'dash for gas'. Although gas production is now in decline, the remaining resource is sufficient to provide a secure supply for many years. In 2009, around 80% of the UK's primary demand for oil and gas was UK-produced, about two-thirds of the UK's overall primary energy need.

The UK used to be self-sufficient in gas from the North Sea. Now this is running out and we need to buy gas from other countries. These countries could use the price and availability of gas as a political weapon, threatening our energy security.

Carbon Capture and Storage (CCS) technology could present a possible solution to reduce the amount of emissions from burning gas, but has not yet been proven to work on an industrial scale. CCS is also expected to increase the cost of constructing a gas-fired power station, and reduce its efficiency.

It is likely that gas-fired power stations will remain part of the UK electricity generating mix for the foreseeable future, and in the longer term gas with CCS may play a prominent role[27].

25 DECC archives

26 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/672137/Government_Response_to_unabated_coal_consultation_and_statement_of_policy.pdf

27 EDF Energy, https://www.edfenergy.com/future-energy/energy-mix/gas

Low-carbon energy sources

Nuclear

Nuclear energy is energy that is stored in the centre of an atom. The nuclear energy is what holds the atom together. To use the energy, the atom has to be split into two smaller atoms. This process is called fission. The two smaller atoms don't need as much energy to hold them together, so the extra energy is released as heat and radiation. In nuclear power stations, the heat caused by fission is used to boil water into steam. The steam is then used to turn a turbine that drives generators to make electricity. Nuclear power stations need to be located near water, as this is pumped in to cool down the steam so it can be re-used in the process.

Nuclear is a low-carbon source of power. It uses a non-renewable fuel (uranium) to produce the nuclear reaction, but no carbon is released during the generation process. Nuclear power stations provide baseload electricity, so they can be relied on to produce power throughout the year, whether day or night. They also have a higher output than renewables – and don't take up anywhere near as much land.

Find out how nuclear power stations generate electricity in our nuclear poster

But building a nuclear power station is a big project – involving government and lots of organisations – and works best in the energy mix alongside a combination of other sources. Nuclear power plants currently cost more to build than coal or gas plants. This difference is narrowing, as new nuclear plants are being built more quickly, and last for longer, than previously. Already, due to low-cost fuel and improved efficiency, nuclear plants – once built – can be less expensive to operate than fossil fuel plants[28]. Capital costs, including decommissioning plants, are a much larger proportion of the total cost than for other technologies, while fuel costs are a relatively small fraction.

As oil and gas prices rise, nuclear power may be seen as a more favourable option. Nuclear power also looks more cost effective when a financial value is put on carbon dioxide emissions. Nuclear power stations only emit low levels of carbon dioxide when generating electricity, and even if the emissions from the mining of uranium, building of power stations and treatment of waste are taken into account, they can still have a far lower total carbon footprint than fossil fuel burning power stations[29].

Radioactive waste

Generating electricity from nuclear power produces some waste – the majority of which is low level. Low-level waste contains mostly short-lived radioactivity and can be incinerated or buried in shallow ground. A very small amount of high-level radioactive waste is produced. It comes from the substances left over after the nuclear reaction and needs to be shielded from the environment for thousands of years.

28 World Nuclear Association (http://www.world-nuclear.org/)
29 BBC, Guide to UK nuclear power

At EDF Energy, we treat radioactive waste in a number of ways, depending on its type[30]:

Low-level waste

This makes up around 90% of the volume of the UK's radioactive waste, but counts for only 1% of its radioactivity. It's mostly made up of machinery and equipment parts that have been part of the reactors. To dispose of this waste, we compact it down, seal it into containers and encase it in cement. We then store it at a low-level waste repository in Cumbria.

Intermediate-level waste

This counts for around 7% of all the UK's radioactive waste. It mostly comes from the fuel reprocessing procedure and the components used in the reactor removed whilst it's being decommissioned. Intermediate-level waste requires special shielding and handling while we encase it in cement and then seal it in stainless steel containers. The waste is then stored securely within the power stations, ready for a planned long term geological disposal facility.

High-level waste

High-level waste comes from spent fuel after it has been used in the reactor. It makes up just 3% of the volume of the UK's radioactive waste, but 95% of its radioactivity. The liquid high-level waste is turned into stable and secure glass blocks by heating it until it turns into powder, then mixing it with crushed glass which is then heated until it melts to form a solid block. It can then be sealed into steel canisters. These canisters are stored securely at Sellafield in readiness for a planned geological disposal facility.

The future of nuclear

The nuclear power industry is planning and developing a new generation of reactors. Simpler, improved designs will reduce the time and cost of construction, while maintaining the highest standards of safety. Advanced reactors will also cost even less to operate, and produce less waste.

As of March 2019, there are some 454 nuclear power plants around the world, with a further 54 under construction[31]. These power plants provide around 10% of the world's electricity or 2,506TWh of electricity[32].

The UK currently has 15 reactors generating about 21% of its electricity, but almost half of this capacity is to be retired by 2025[33]. Consequently, the government has undertaken a thorough assessment of new reactor designs and construction has commenced on the first of a new generation of plants. EDF Energy owns and operates eight of the UK's 10 existing nuclear power stations and is currently building a new one at Hinkley Point C in Somerset – the first nuclear power station to be built in the UK for more than 20 years. EDF Energy is also jointly developing other new build proposals with China General Nuclear Power Corporation: Sizewell C in Suffolk and Bradwell B in Essex[34].

Learn about day-to-day life at a nuclear power station in our film starring Busta

30 https://www.edfenergy.com/virtual-tours/nuclear-safety

31 World Nuclear Association, www.world-nuclear.org/Nuclear-Basics/Global-number-of-nuclear-reactors/

32 World Nuclear Association, www.world-nuclear.org/Nuclear-Basics/Electricity-supplied-by-nuclear-energy/

33 World Nuclear Association, www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/United-Kingdom/

34 https://www.edfenergy.com/energy/nuclear-new-build-projects

Renewable energy

Renewable energy comes from sources of power that will never run out and produce few CO_2 emissions. The renewable energy sector is growing rapidly as demand increases, leading to technological improvements that make it even more financially viable.

Many sources of renewable energy – wind, sunlight, water, waves and tides – are not highly concentrated forms of energy in the way that fossil fuels are. Instead of the tens of fossil fuel power plants in the UK currently, many thousands of renewable energy installations may have to be built. These will take up large portions of land and, in the case of wind turbines and solar panels, be very visible.

Renewable sources are often, by their nature, found in remote and beautiful places. To bring the energy to the places people live, many more power lines will have to be built. Large scale use of renewable energy will change the way a lot of the countryside looks. However, making these trade-offs is vital if we are to continue increasing low carbon energy generation.

Renewable energy is a vital component of the UK's diverse energy mix – and in 2017 it accounted for 29.3% of the UK's electricity mix[35]. In offshore wind, the UK has one of the best natural resources in Europe, and has the largest installed offshore wind capacity in the world[36].

UK renewable electricity generation has increased significantly since 2002, when the Renewables Obligation (RO) was introduced[37]. This requires all licensed electricity suppliers in England and Wales to supply a certain amount of their electricity from renewable sources, and provides financial incentives for them to do so. Scotland and Northern Ireland have their own ROs that perform the same function. This can increase the cost of supply to consumers, but is intended to help to encourage the development of renewable energy.

In 2018, the Government published its Clean Growth Strategy, which outlined its plans to use investment in low carbon and renewable technologies – like wind and electricity storage – and initiatives to support national growth. The Government estimates that the UK low carbon economy could grow by 11% a year between 2015 and 2030 – four times faster than the rest of the economy – and deliver between £60 billion and £170 billion of export sales of goods and services by 2030[38].

35 UK Energy in Brief 2018, Department for Business, Energy and Industrial Strategy

36 Clean Growth Strategy, 2018, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf

37 Energy trends, DECC

38 Clean Growth Strategy, 2018, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf

Wind

Wind has been used as an energy source for thousands of years: to propel boats, pump water, grind grain and more. The energy in wind can be used to generate electricity via wind turbines; the wind turns the blades of the turbine, which is connected to a generator. The turbines are on a tower, as the higher you go, the greater the wind speed tends to be. The bigger the turbine, the more electricity it will generate.

Wind is a low-carbon power source: turbines don't emit any carbon emissions or produce pollution, and they're also relatively inexpensive to run, with no fuel costs. The UK is also a windy country, so wind is in plentiful supply! But this renewable power source is highly variable, so no wind means no electricity.

Wind speeds are stronger out at sea and offshore wind farms have bigger turbines than their onshore equivalents, so they can generate more electricity. But it's trickier and more expensive to build a wind turbine out at sea. Onshore wind generates more electricity than offshore at the moment – simply because there are more of them. But onshore wind is limited by the availability of land space. Wind farms can't be built in areas of outstanding national beauty and if you covered the UK in wind farms, you wouldn't be popular with residents!

Find out more in our **wind power generation poster**

How much space do wind farms require?

The wind is a diffuse form of energy, in common with many renewable sources. A wind farm of 20 turbines might extend over an area of 4 square kilometres, but only a small percentage of the land area would be used to house the turbines, electrical infrastructure and access roads. The remainder can be used for other purposes, such as farming, natural habitat or industrial and commercial uses.

Larger wind turbines deliver financial economies of scale, but they don't greatly increase the total power per unit land area, because bigger windmills have to be spaced further apart.

The coast around the UK is well suited to offshore wind farms. There are advantages to this, as it opens up more available sites and has less impact on the environment. However, it is also more costly, and there are big engineering challenges in getting turbines to work reliably at sea with minimal maintenance.

Small scale turbines can power a house or building, and micro-generation from wind can be used for applications such as charging batteries on caravans or boats, lighting and electric pumps in remote locations. However, houses in urban settings are unlikely to be suitable due to wind turbulence over cities. Small scale wind generators are particularly suited to using in conjunction with photovoltaic generation (explained below), as wind is stronger in the winter months when there is less sun.

With wind power, the available output must be taken as and when it is produced. Other supplies need to be used to top up that supply when enough is not being produced. If the turbine is connected to the national grid, any excess energy produced can be bought by the electricity company.

Play our **Will wind work? game** and choose a site for wind turbines

Solar

Solar energy is energy produced by the sun. It's thought that the sun gives the Earth enough energy each day to meet the global energy demand for a whole year. If only we could capture it all! The UK isn't known for being a sunny destination, but we get enough sunlight to make solar power a viable energy source – even if it's only ever going to be a relatively small contributor to our energy mix.

Solar is a low-carbon power source: no carbon emissions are released to convert the sun's energy into electricity, and it doesn't produce pollution either. Like wind power though, it's highly variable: we don't get much power from solar during dark British winters, or at all in the night!

The UK is also restricted in how many solar farms can be installed: too many might be unpopular with residents, for example, and require significant land use. For instance, to produce 1TWh of electricity (about 0.3% of UK demand) from nuclear power, requires the space of about five football pitches. But to produce the same amount of electricity from solar requires the space of 4,400 football pitches – and for wind, it's more than 7,000[39]!

Solar power could also become expensive to manage if rolled out on a large scale. This is because solar power can't be stored very easily or cheaply over a long period (from one season to the next).

Find out more in our solar power generation poster

There are three main, recognised ways of producing energy directly from the sun. The first two, described as passive and active, both absorb the sun's heat and store it to be used, for example, to heat buildings or water. The third method converts sunlight into electricity using photovoltaic (PV) cells. This method is flexible, as the electricity can be used in many ways.

Passive solar design

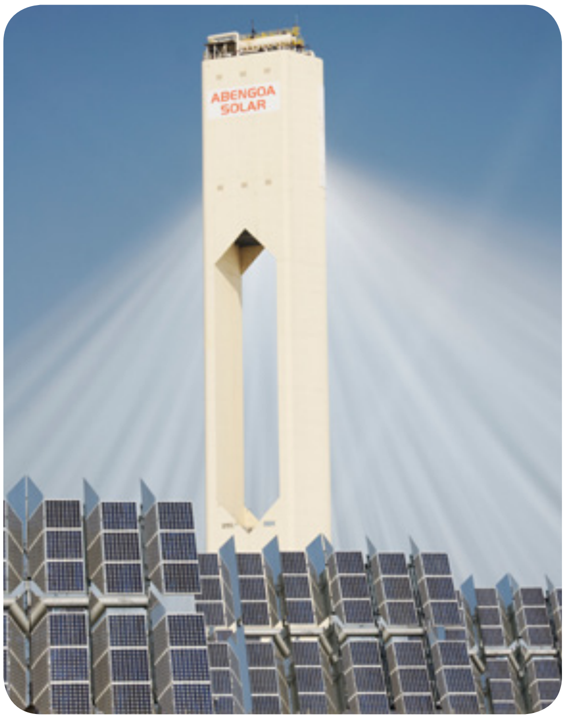
This involves designing buildings to make the most of the natural heat (and light) of the sun. The building is positioned to best capture the sun's heat, and lots of glass is used to allow sunlight in to heat rooms. Good insulation keeps heat in, while 'thermal mass', such as dense concrete, stores that heat and releases it slowly over time (much like the rock cliff faces in the Eden Project's giant greenhouses).

Solar panels for heating

The panels are black and absorb the sun's heat, which then heats water in pipes or tubes in the panels. Depending on the type of solar panel, the heat from the water, or the water itself, is then used for providing heating or hot water in a building.

39 Power the UK game

Concentrated solar thermal power



This technique produces electricity by using mirrors to focus the sun's energy onto a precise spot. This heats water to a point where it can be used to run a turbine and generate electricity.

Although still in development stages, this technology is being scaled up rapidly, and could produce significant amounts of electricity if deployed on a large scale in deserts. Unlike other renewable sources, the heat can be stored overnight to produce electricity in the dark, so production is not intermittent.

Photovoltaic (PV) cells for electricity

These directly convert the sun's energy into electricity. The PV cells contain special chemicals which produce electricity when sunlight touches them. The PV cells are arranged in panels for fixing to roofs and walls. Many small scale applications can be powered by PV cells, such as garden lighting and charging batteries in caravans or on boats.

Currently PV systems are significantly more expensive than solar hot water systems, but as technology progresses they are becoming cheaper. Solar energy is prized as an inexhaustible fuel source. The technology is also versatile. For example, solar cells can generate energy for remote places, like satellites in space and cabins deep in the mountains, as easily as they can power city buildings and futuristic cars.

Hydropower

Hydropower is one of the oldest and most reliable low-carbon power sources. The Dinorwig power station in Wales can go from zero to 1,320MW in 12 seconds! But hydropower needs both a large body of water and a big drop next to it, which limits the number of places where hydropower plants can be built.

That said, it's the main renewable source for electricity generation worldwide, supplying 71% of all renewable electricity[40].

40 World Energy Council (https://www.worldenergy.org/data/resources/resource/hydropower/)

There are a variety of ways in which the energy in moving water can be used to generate electricity:

Dams

Hydroelectric dams store water in higher ground – behind dams. When water is released, it rushes down through pipes, turning turbines and producing electricity. Because the water can be released at almost any time, hydroelectric dams can act as a store, releasing the water to provide energy for peak use periods.

Some other types of power stations remain 'on' all night, which is wasteful, but their excess energy can be used to pump the water back into the reservoir where it is stored to be used again during peak periods.

Small hydropower schemes usually do not interrupt the river flow with dams or barrages – most often they consist of a weir. Little or no water is stored, so there is only a minimal adverse effect on the local environment. These are built to meet the needs of small locations such as a single building or small community.

Waves

Ocean waves are produced by wind blowing across the sea's surface. The movement of the waves can be used to generate electricity. Wave generators convert the up and down movement of waves (kinetic energy) into electrical energy via a generator.

Tides

Vast amounts of energy are generated every day by the sun and moon's pull on the oceans, which cause enormous movements of water on a daily basis – known as tides. Harnessing this energy could generate enormous amounts of power, with very few greenhouse gas emissions.

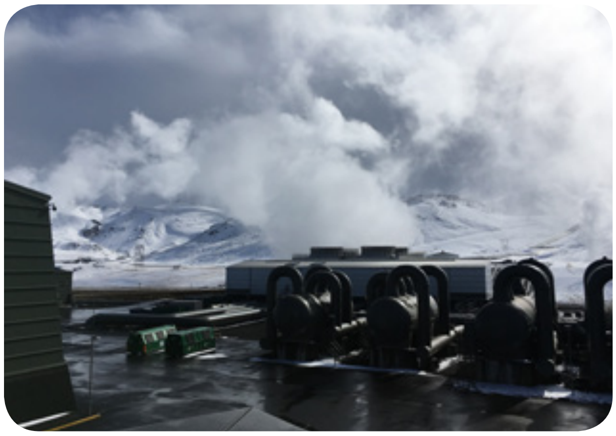
To capture tidal energy, a barrage is built across the mouth of a tidal river estuary. At low tide the barrage is closed, so that the water level on the seaward side rises with the rising tide.

At high tide the barrage is opened and water flows into the estuary through turbines, generating electricity. When the flow of water stops, the barrage is closed again until low tide. The water trapped on the estuary side is then allowed to flow back out to sea through the turbines, generating more electricity.

Tidal barrages are controversial, however, as they can have an impact on local ecology and affect the migration of fish like salmon and eels. There is also some concern about the future of tidal energy in the UK – which was previously considered to be a world leader for investing in new tidal technologies – after the Government turned down a proposal to build a barrage across the river Severn.

Energy information pack

Geothermal



There is heat deep inside the Earth caused by the natural radioactivity found in the planet's rocks. Geothermal energy uses water to bring that underground heat to the surface where we can use it. Geothermal power stations use the heated water to produce steam, which then drives turbines to produce electricity. The water can either be underground naturally, or can be pumped down from the surface to capture the heat.

The hot water described above can also be use for heating purposes. The Earth's surface absorbs the sun's heat and stores it. Even when the surface is freezing, the ground below can be many degrees warmer. Ground source heat pumps convert this shallow Earth heat and use it to warm buildings. They are becoming increasingly common. But the number of geothermal plants are limited globally, however, to those countries that have the right geographic conditions, like Iceland.

Geothermal heat can also be captured by pumping water through coiled plastic pipes buried in trenches. The water is heated underground, and a heat exchanger coil is used to transfer the heat to other water pipes in the house. Although electricity is needed to power the pump, this is significantly less than would be required to produce the same amount of heat by other means.

Biomass

Biomass power plants produce electricity from burning organic matter – like woodchips, even chicken poo! – which is why it's often referred to as a low-carbon power source.

It has been suggested that some types of biomass can be carbon neutral – crops that only release the carbon that was absorbed by the plants during their lifetime when they are burned to produce heat. But critics say that new fuel isn't being grown quickly enough to keep pace.

To be sustainable, the biomass burnt must have been recently grown and the land replenished. A biomass energy plant will have a plantation on which suitable plant material is grown. As the plant material grows, it absorbs CO_2 from the atmosphere, which is converted to woody plant tissues. When this is burned, the carbon is released back into the atmosphere as CO_2. Ideally there will be no net gain or loss of carbon.

Biomass boilers are becoming increasingly popular for heating. Like a traditional boiler, they can be connected to a building's central heating and hot water systems. They use woodchips or pellets made from industrial wastes, therefore preventing this waste going to landfill. Biomass stoves can be used to heat a room and, when fitted with a small boiler, can produce hot water and heat radiators on a domestic scale.

In 2017, bioenergy was the second biggest source of renewable electricity, after wind[41]. But the UK Government has said it plans to remove financial support for some types of biomass by 2027[42].

41 UK Energy in Brief 2018, Department for Business, Energy and Industrial Strategy

42 Power the UK game

Other sources of energy

Energy from rubbish

Household waste is a major environmental issue in the UK. Traditionally, waste is simply buried in landfill sites, at a rate of millions and millions of tonnes per year. Producing energy from waste is a step toward solving two problems: it reduces the need for landfill sites, and the greenhouse gases that would be emitted if the waste was simply allowed to rot underground.

Landfill sites give off methane gas as the rubbish rots. This can be collected and burned to produce electricity and heat. 4% of renewable electricity in the UK in 2017 was produced from landfill gas[43].

Another method is Energy-from-Waste (EfW) plants.
They work very much like coal- or gas-fired power plants, except that they use rubbish rather than fossil fuels to fire an industrial boiler. This method can recover substantial amounts of energy and lead to a reduction in the amount of waste that requires final disposal. To protect public health, there are strict guidelines on the emissions from these plants.

Interconnectors

Interconnectors are pipes that run under the sea or underground to allow the transfer of electricity and gas between countries. They provide a way for countries to import (buy in) or export (sell) electricity or gas when they haven't got enough (and, therefore, need to import extra to meet demand) or have too much (and, therefore, have spare capacity to export to other countries). For instance, we have 4GW of interconnector capacity in the UK with links to France, the Netherlands, Northern Ireland and the Republic of Ireland. Interconnectors are vulnerable to damage, however; in November 2016, storm Angus knocked out half of the UK's link to France – for three months[44]!

Find out how geography affects the location of different types of power station in our **Power around the UK poster**

43 UK Energy in Brief 2018, Department for Business, Energy and Industrial Strategy
44 https://www.ft.com/content/52e957a6-b64a-11e6-ba85-95d1533d9a62?mhq5j=e2

Dispatchable generation

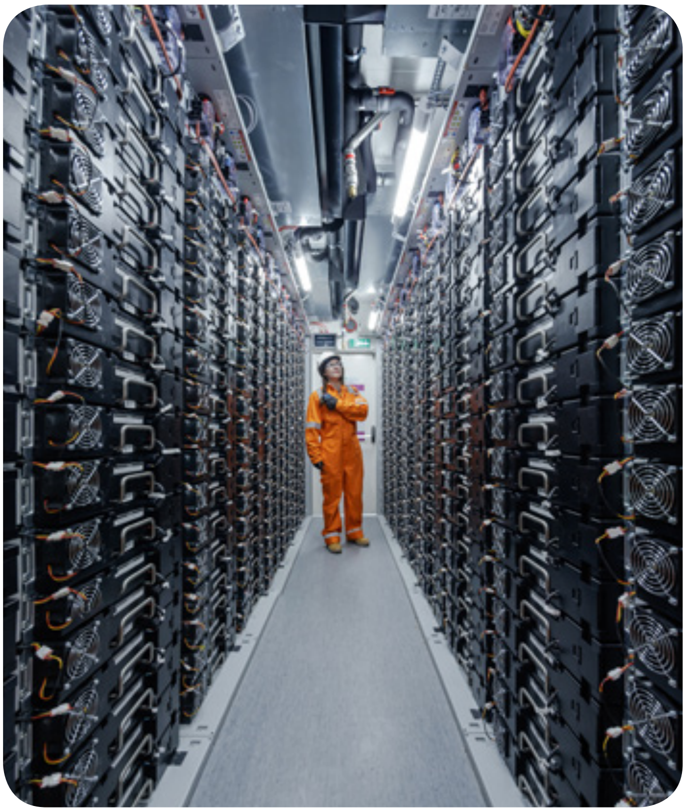
The National Grid relies on a baseload provided by energy sources that cannot easily be turned on or off, such as nuclear. Dispatchable generation refers to sources of electricity that can be dispatched at the request of power grid operators; that is, can be turned on or off upon demand. Hydropower is an example of a dispatchable source, as is battery storage.

Intermittent power sources such as wind and solar cannot be controlled by operators. They cannot be dispatched on request, and most of the time cannot be relied upon as part of the baseload.

The time at which dispatchable generation plants may be turned on or off can vary, and may last for minutes or hours. The power grid operators need to carefully balance the use of renewable energy with power generation that is constant and reliable, while having back up dispatchable generation for peaks in energy demand.

Battery storage

Battery storage plants provide a back-up source of power – like hydropower stations – to respond quickly to fluctuations in the electricity grid. With the strong growth of renewable generation and the closure of large power plants, battery storage technology supports the stability of the national grid network. As such, storage is expected to play an important role as part of a balanced energy system which will include renewables, nuclear and gas.



Appendix

Glossary of terms

Low carbon

A low carbon power source doesn't emit any carbon emissions to generate electricity. This includes nuclear, wind, solar, tidal, wave, hydro, geothermal and biofuels.

Renewables

These power sources will never run out. Sunlight and wind will never get used up, for instance.

Non-renewables

These power sources will run out one day. This includes fossil fuels – like gas, oil and coal – but also uranium (which is needed for nuclear power), although we won't be running out of this metal any time soon.

Baseload

Power stations that generate electricity reliably 24/7, all year round (except when they come offline for maintenance) deliver baseload electricity. Any non-renewable technology – such as nuclear, gas and coal – can provide baseload electricity.

Reliable / predictable

These are power sources that we can predict with a high degree of accuracy (e.g. the week before) what their output will be across the UK. Non-renewable power sources, like nuclear, gas and coal, are considered to be reliable and predictable. But weather-dependent renewables – like solar and wind – are NOT reliable or predictable, since their power output depends on the sun shining or the wind blowing.

Flexible / dispatchable

These are power sources that can be controlled easily or brought online quickly to meet a sudden change in demand. All non-weather dependent technologies are dispatchable – such as gas and coal – as the output can be controlled for any given hour of the year. Nuclear is not as flexible as gas or coal – as the nuclear reaction needs to be carefully controlled and managed – but nuclear power stations can respond to a change in demand with enough notice.

Variable / intermittent

This is the opposite of flexible and dispatchable, and means that the output of the power source changes across the year. This is the case with weather-dependent renewables, such as solar and wind, so they can't be relied on to meet a sudden change in demand.

Advantages and disadvantages of different types of energy production

Energy source	Advantages	Disadvantages
Coal	▶ One of the world's most plentiful energy sources. ▶ Inexpensive compared with other energy sources due to large reserves and easy accessibility. ▶ Versatile. Coal is not only burned directly, but it can also be transformed into liquid or gas form. Proponents claim that liquefied or gasified coal burns cleaner, meaning less air pollution. ▶ Easily combustible, and produces high energy upon combustion, suitable for the generation of electricity and various other forms of energy. ▶ Widely and easily distributed all over the world. ▶ A fossil fuel power station can be built almost anywhere fuel can be delivered to it. Most coal-fired power stations have dedicated rail links to supply the coal.	▶ Pollution. Coal-fired power plants are a major source of air pollution and burning coal may contribute to acid rain. ▶ Burning coal releases large amounts of CO_2, which contributes to global warming. Building and decommissioning also causes waste and emissions. ▶ Finite lifespan. In the UK, for instance, the Government has said all polluting old coal power stations must close by 2025. ▶ Health concerns. Air pollution from burning coal poses a health hazard, especially for individuals with respiratory diseases. ▶ Non-renewable. Like other fossil fuels, coal is a non-renewable energy source, so stocks won't last forever. ▶ High coal transportation costs, especially for countries with no coal resources, which require special harbours for coal import and storage. ▶ Storage costs are high, especially if stock for a few years is required to assure power production availability. ▶ Mining coal causes irreversible damage to the adjoining environment. ▶ Prices for all fossil fuels are rising, especially if the real cost of their carbon is included. ▶ Mining coal is a very dangerous job.

Energy information pack

Energy source	Advantages	Disadvantages
Gas	▶ Large quantities still exist today. ▶ Burns at least 30% cleaner than coal and is considered a 'safe' fossil fuel. ▶ Economical, as costs and time periods required to build a gas plant are considerably less than for coal plants. ▶ Easily transported via pipelines and fairly easily using tankers (land and sea) ▶ Can be piped into homes to provide heating and cooking and to run a variety of appliances. ▶ Where homes are not piped, it can be supplied in small tanks. ▶ Can be used as a fuel for vehicles (cars, trucks and jet engines) where it is cleaner than gasoline or diesel. ▶ Used to produce ammonia for fertilizers; hydrogen; and in the production of some plastics and paints.	▶ Although cleaner than coal and oil, it still contributes a large amount of CO_2 to greenhouse gases. ▶ Numerous environmental impacts arise from gas exploration. Dangers include explosions and oil spills. In addition, ocean habitats can be disturbed. ▶ Natural gas is a non-renewable resource. ▶ Building and decommissioning also causes waste and emissions.

Energy source	Advantages	Disadvantages
Nuclear	▶ Emits relatively low amounts of CO_2 and other greenhouse gases, so the contribution to global warming is relatively small. ▶ The fuels for nuclear power – uranium and thorium – are found in politically stable countries such as Australia and Canada. ▶ Waste produced is much lower in volume than coal plants. ▶ With available technology, there is sufficient uranium to build and operate more than four times the number of power plants currently in use and run them for 50 years. ▶ There's a huge amount of innovation taking place in the nuclear sector. ▶ To generate all our current UK electricity needs, we would only need around 45 nuclear power stations.	▶ If accidentally released, radioactive material could be harmful to people's health. ▶ Nuclear waste can remain radioactive for thousands of years. This means disposal of the waste is very expensive, as it needs to be kept safe for a very long time. ▶ If there is high demand for uranium it will become more scarce and costs will increase. ▶ Nuclear power plants can take about 10 years to plan and build. ▶ Building and decommissioning does cause waste and emissions.
Wind	▶ Wind is in infinite supply. ▶ No waste or pollution, (except in manufacture and decommissioning of the equipment). An industrial turbine will pay back the energy used in its manufacture in 3-6 months and last for around 25 years. ▶ Once a turbine is built, running costs are low.	▶ No wind = no power. ▶ Turbines are often seen as a blot on the landscape; areas with good average wind speeds are often in coastal or higher ground locations. ▶ Waste and pollution do arise from the manufacture, construction and decommissioning of the equipment.

Energy source	Advantages	Disadvantages
Solar	▶ There is an infinite supply of sunshine – it is renewable. ▶ No greenhouse emissions released when generating. ▶ Space saving (panels can go on roofs). ▶ Latest technology is lightweight and allows a number of surfaces to generate electricity (e.g. solar cladding). ▶ Energy is generated close to where it will be used, keeping transmission and distribution costs to a minimum. ▶ Can be used to supply electricity to remote areas.	▶ Doesn't work at night or as effectively during winter. ▶ Expensive, although it is getting cheaper. ▶ Sun intensity affects energy production, so it is more favourable in areas with high hours of sun per year ratios. ▶ Current technology is unsuitable for large scale energy production. ▶ Waste and pollution do arise from the manufacture, construction and decommissioning of the equipment.
Geothermal	▶ Potentially infinite supply. ▶ Unobtrusive – there are no large exposed external units. ▶ No emissions or noise nuisance when generating. ▶ No fuel handling / storage requirements. ▶ No fire / explosion hazard. ▶ Long lifetime. ▶ Significant reduction in CO_2. ▶ Reduced plant room requirements.	▶ Limited by a country's geography, so Iceland can draw on geothermal more effectively than the UK. The rock required must also be of a suitable temperature and depth. This can make it difficult to find suitable sites. ▶ Occasionally, dangerous gases and minerals can escape out of the borehole, which can be difficult to dispose of. ▶ Can be expensive to set up. ▶ Waste and pollution do arise from the manufacture, construction and decommissioning of the equipment.

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Energy source	Advantages	Disadvantages
Hydroelectric dams	▶ Once a dam is built, operating costs are low. ▶ More reliable than wind, solar or wave power. ▶ Water can be stored ready to cope with peaks in demand. ▶ Hydroelectric power stations can increase to full power very quickly, unlike some other types of power station. ▶ The water can be used for other purposes, which can be subsidised by electricity sales (e.g. irrigation, municipal and industrial water supply).	▶ Suitable sites for large-scale projects are hard to find and are often remote, which leads to higher distribution costs. ▶ Expensive to build. However, many dams are also used for flood control or irrigation, so building costs can be shared. ▶ Building a large dam will flood a very large area upstream, causing problems for existing wildlife and animals. ▶ Water quality and quantity downstream can be affected, which can impact surrounding aquatic ecosystems. ▶ Methane (also a greenhouse gas) released from rotting vegetation (from submerged forests due to dam creation) can be high in some circumstances.
Wave power	▶ Renewable. ▶ No fuel needed, so there’s no waste. ▶ If given a large enough area, wave power can produce a great deal of energy.	▶ The technology is only just starting to come out of the development phase. ▶ Depends on the waves – sometimes you get lots of energy, sometimes none. ▶ Needs a suitable site, where waves are consistently strong. ▶ Equipment must be able to withstand very rough weather and salt water. ▶ Offshore installations need a long submarine cable to transfer the electricity to land. ▶ High initial start-up costs. ▶ Building causes waste and emissions.

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Energy source	Advantages	Disadvantages
Tidal power	▶ Predictable. ▶ The electricity generation doesn't produce any CO_2 or pollutants. ▶ Running costs are low. ▶ Technology is reliable.	▶ Damming bays or inlets can affect the environment over a large area. ▶ Suitable locations can be hard to find. ▶ Expensive to install. ▶ Building causes waste and emissions.
Biomass	▶ As long as biomass crops are replaced, biomass can be a long-term sustainable energy source and, therefore, renewable. ▶ It's a cheap and readily available source of energy. ▶ Could be carbon neutral. ▶ Handles municipal solid waste with no pre-treatment required . ▶ State-of-the-art technology is in use globally, including pollution control technology.	▶ Crops must be replenished if the supply is to continue, otherwise it is not a renewable energy source. ▶ In the UK, the Government has said it will cease support for some types of biomass plant. ▶ Can compete with land used for food production, increasing food crop prices. ▶ Biomass has to be burnt in plants which need to be constructed and eventually decommissioned, which will result in some waste and emissions. ▶ High capital costs. Since fixed costs are high, the need for consistently high use is paramount. ▶ Negative public perception – "not in my back yard!" – due to emissions and a lack of understanding of the technology.

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Energy source	Advantages	Disadvantages
Energy from rubbish	▶ Handles municipal solid waste with no pre-treatment required . ▶ State-of-the-art technology is in use globally, including pollution control technology. ▶ Energy recovery, including Combined Heat and Power (CHP) plants, and opportunity for district heating programmes. ▶ Proven and commercially available technology.	▶ High capital costs. Since fixed costs are high, the need for consistently high use is paramount. ▶ Negative public perception – "not in my back yard!" – due to emissions and a lack of understanding of the technology. ▶ Residue quality and disposal, although bottom ash can be reused. ▶ Debate over measurement and long term health effects of emissions. ▶ Minimum materials recovery, except for ferrous materials. ▶ A minimum or guaranteed volume may be required by the operator to cover costs.

Related resources

Take a look at these other **energy resources** on the Pod:

- **Factsheet** with tips and advice on how to save energy at home
- **Factsheet** on smart meters
- **Infographic** that illustrates how electricity gets to the home
- **Film** in which Busta investigates how wind power works
- **Activity** about the different types of energy storage
- **Activity** about the ‘internet of energy’ and future ways in which we might use electricity
- **Activity** about the use of renewable power in developing countries
- **Activity** about the causes and implications of energy poverty
- **Film** in which Busta learns about nuclear power
- **Series of posters** about how we generate power (from nuclear, wind, solar and fossil fuels)
- **Timeline** showing the history of electricial appliances over the past 150 years
- **Map** of the UK illustrating how geography affects the location of different types of power stations
- **Infographic** showing the energy mix of different nations around the world
- **Factsheet** with six ideas for how to save energy at school
- **Power the UK game** in which players have to achieve a low-carbon energy mix before 2032
- **Will Wind Work? game** in which players have to find the best location to site a wind turbine
- **Film** showing a day in the life of a nuclear power station
- **Films** featuring Busta that explore energy issues like sustainability and the greenhouse effect
- **Assembly** about energy and different types of energy generation
- **Timeline** showing the history of electricity.

Energy information pack

Curriculum links

The Energy information pack can be used to support your teaching of the following curriculum elements:

England: Key Stage 3

Science

Working scientifically

Chemistry – Earth and the atmosphere

Physics - Energy; Matter

Geography

Human and physical geography – human geography relating to: the use of natural resources

England: Key Stage 4

AQA GCSE Combined Science: Synergy

Working scientifically; The National Grid; Atomic structure – Human impacts on the climate; Electricity: energy resources

AQA GCSE Combined Science: Trilogy

Working scientifically; Power – the National Grid; Chemistry – atomic structure – Human activities which contribute to an increase in greenhouse gases in the atmosphere; Physics - National and global energy resources

AQA GCSE Physics

Working scientifically; Power – the National Grid; Nuclear fission and fusion; Energy – National and global energy resources; Induced potential (HT only); Transformers (HT only)

AQA GCSE Chemistry

Working scientifically; Chemistry – atomic structure – Human activities which contribute to an increase in greenhouse gases in the atmosphereEdexcel GCSE (9-1) Combined Science

Working scientifically; Physics: Topic 3 – Atoms and Conservation of energy; Topic 6 – Radioactivity

Edexcel GCSE (9-1) Physics

Working scientifically; Topic 3 – Conservation of energy; Topic 6 – Radioactivity Scotland

Edexcel GCSE (9-1) Combined Science

Physics: Topic 3 – Conservation of energy

Energy information pack

Scotland

Science

Planet Earth – energy sources and sustainability (SCN 4-04a, SCN 4-04b, SCN 3-05b); Processes of the planet (SCN 3-05b)

Topical science (SCN 4-20b)

Social Studies

People, place and environment (SOC 3-08a, SOC 4-08a, SOC 4-10a)

Technologies

Technological developments in society and business (TCH 3-05a)

SQA National 4 Physics

Generation of electricity; Electrical power; Electromagnetism

SQA National 5 Physics

Electricity: Potential difference; Radiation – nuclear radiation

SQA National 4 Science

Fragile Earth — Energy

SQA National 4 Chemistry

Nature's Chemistry – Fossil fuels; Impact on the environment of burning fossil fuels; Finite energy sources and biofuels; Benefit and risks of different energy sources

SQA National 5 Chemistry

Nature's chemistry – energy from fuels

SQA National 4 Environmental Science

Earth's Resources – Responsible use and conservation of non- renewable and renewable resources; Formation and use of fossil fuels; Risks and benefits of different energy sources, including those produced from plants.

Sustainability – Sustainability of key natural resources and possible implications for human activity; The interaction between humans and the environment and the impact of human activity on an area; Society's energy needs.

SQA National 5 Environmental Science

Earth's resources – Classification of resources into physical, biological, renewable and non-renewable; Energy from water; Energy from biological resources; Energy from wind

Sustainability – Energy

Energy information pack

Wales Key Stage 3

Geography

Understanding places, environments and processes; Range

Science

Interdependence of organisms; How things work

Wales Key Stage 4

WJEC Applied Science GCSE (Double Award)

2.1 Energy, resources and the environment

WJEC Applied Science GCSE (Single Award)

2.1 Science in the modern world

WJEC Physics GCSE

2.1 Electricity, energy and waves; 2.2 Forces, space and radioactivity

Northern Ireland Key Stage 3

Environment and Society: Geography

Explore how we can exercise environmental stewardship and help promote a better quality of life for present and future generations, both locally and globally

Science and Technology: Science

Earth and Universe: The environment and human influences; Investigate specific measures to improve and protect the environment

Northern Ireland Key Stage 4

CCEA GCSE Science (Double Award)

Physics Unit P1: Energy, Radioactivity, Nuclear Fission and Fusion

CCEA GCSE Science (Single Award)

Unit 3: Physics

CCEA Physics

Unit 1: Energy