Energy information pack

Contents

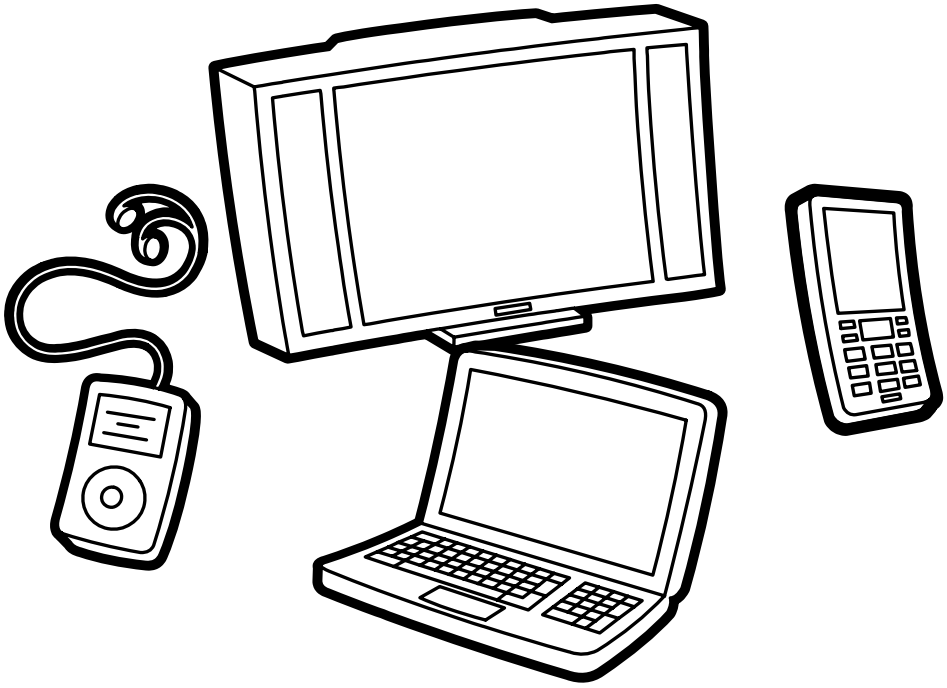
Energy information pack

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. Worldwide, 82% of energy used for heat, electricity and transport comes from burning fossil fuels[1]. In the UK 84.6% does[2].

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, 2014
2 Energy Trends, DECC, March 2015

Energy information pack

World primary energy demand by fuel

Energy source (in million tonnes of oil equivalent*)	1990	2012**
Oil	3231	4158
Gas	1668	2869
Coal	2230	3796
Nuclear	526	642
Hydro	184	313
Bioenergy (traditional and modern biomass uses)	893	1318
Other renewables	36	142

Source: World Energy Outlook, IEA, 2014

** Based on preliminary estimates

* Conversion information

Toe = tonnes of oil equivalent
1 toe = 11.63 MWh
1MWh (megawatt-hour) = 1000 kWh
1 GWh (gigawatt-hour) = 1,000,000 kWh
1TWh (terawatt-hour) = 1,000,000,000 kWh

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 2014

	Million tonnes of oil equivalent
Total inland primary energy consumption*	**193.4**
Losses	
Conversion losses	43.7
Distribution losses	14.9
Sector	
Industry	24.0
Domestic	38.2
Transport	54.2
Services (includes agriculture)	19.0
Total final energy consumption	**135.3**

* Excludes non-energy use

Source: UK Energy in Brief 2015, DECC

Energy information pack

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.

Ensuring that the energy mix contains sustainable sources is vital if we are to minimise the effects of climate change. However, this must be balanced with using sources that guarantee a secure and consistent supply of energy, as well as providing affordable energy to the most vulnerable members of society.

The energy mix debate

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.

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.

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.

So, 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 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 energy mix

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

- Security
- Affordability
- Sustainability

Here we look at the implications each factor can have on determining energy mix.

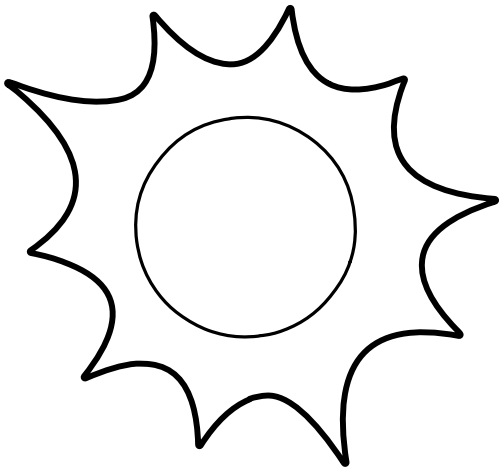
Energy security

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

Energy information pack

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, and we will become increasingly dependent on oil and gas supplied by other countries in the future[3].



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 important that we are not dependant 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. A successful energy mix will ensure a secure supply of energy.

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 developed many schemes for low income households to benefit from free insulation installation. Energy companies also offer assistance to customers who have difficulty paying, such as offering pre-paid services.

The price of energy is directly linked to the cost of production, so the energy mix has an important role to play. Different sources in the mix have greatly varying energy production costs, so the mix must be well balanced to maintain energy affordability.

3 Energy Security Strategy, DECC, page 5

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 or wind power.

Many governments promote the use of sustainable energy and the development of new types of technology which can generate sustainable energy.

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.

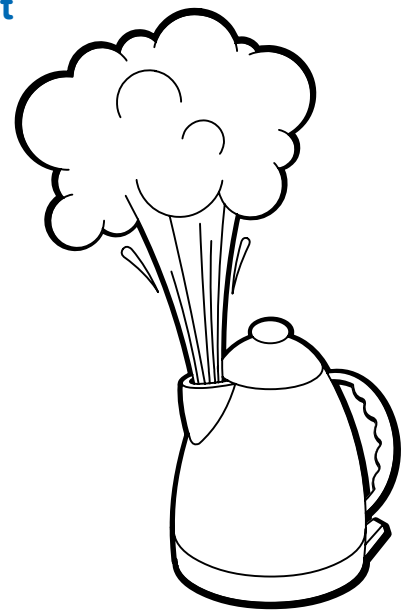
- **Energy efficiency** is something we try to improve in things and places that use energy, such as homes, cars, and businesses. Increased efficiency in the way energy is used makes sustainable energy go further.

- **Environmental impact**. The impact that a method of energy generation has on the environment is important. It is why sources like nuclear power are often not considered to be sustainable. Likewise, 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 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, as well as noting what is on TV! The most common surges in electricity demand are often linked to TV programmes such as soaps or football matches. During a break or at the end of the programme demand can surge by as much as 10%, as everyone rushes into the kitchen to switch on the kettle or open the fridge for a cold drink[4].

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![5]

4 UK Energy in Brief, DECC, 2012

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

Energy mix

In the UK we have a diverse mix of energy supplying our electrical needs. The main sources are currently coal (30%), gas (30%) and nuclear (19%). Renewables currently makes up 19.1% of the electricity supplied[6]. The following table and graph summarise the UK energy mix by energy source and the quantity of electricity supplied in terawatt hours.

Even fashion can influence energy demand. In recent years there has been an increased demand in the morning and it took a while for those at the National Grid to understand what was causing it – the fashion for straight hair! The trend for using hair straighteners has made a noticeable increase to electricity demand in the morning.

UK electricity: amount supplied by fuel type 1980 to 2014

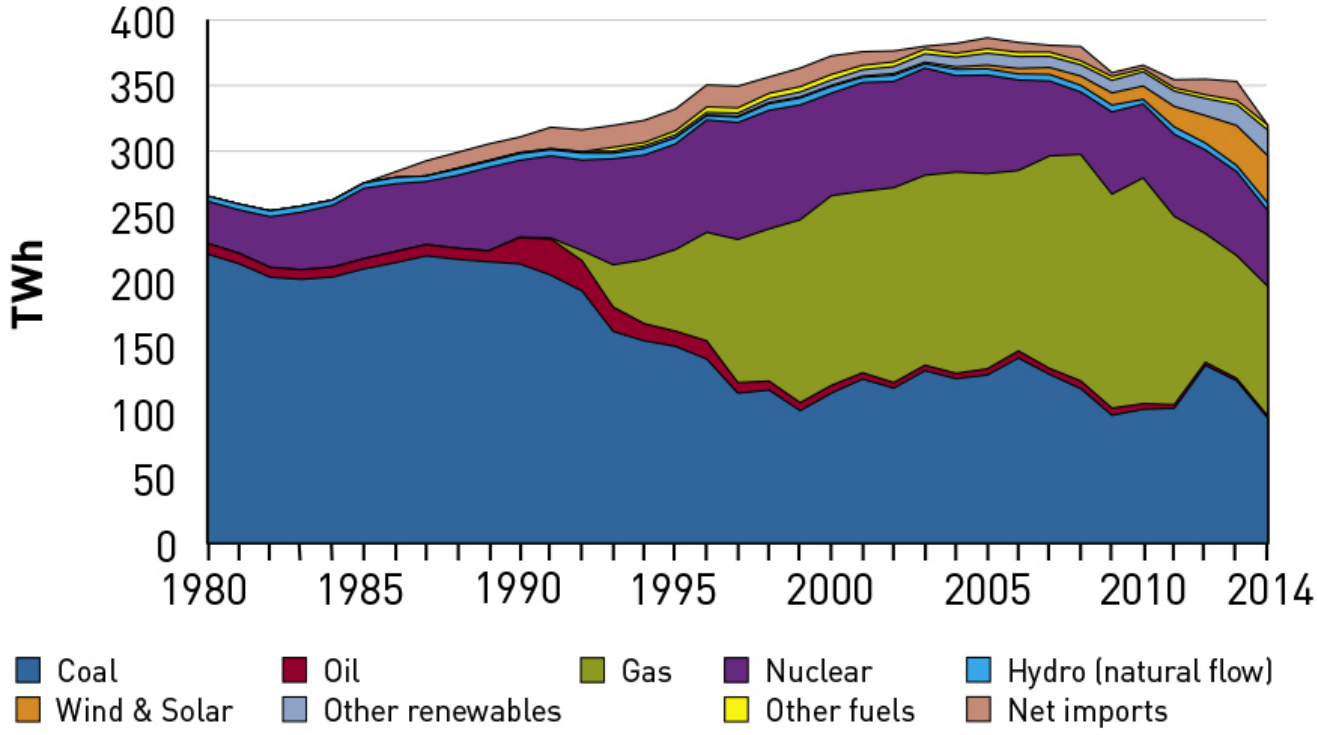
The following table and graph summarise the UK energy mix by energy source and contribution to the total electricity supply.

Fuel Type	TWh supplied 1980	TWh supplied 1990	TWh supplied 2000	TWh supplied 2010	TWh supplied 2013	TWh supplied 2014
Coal	220.8	213.4	114.7	102.3	124.1	95.5
Oil*	7.9	19.2	9.2	5.6	4.1	4.6
Gas	–	0.4	144.9	172.5	94.2	99.0
Nuclear	32.3	58.7	78.3	56.4	64.1	57.9
Hydro	3.9	5.2	5.1	3.5	4.7	5.8
Wind & Solar	–	–	0.9	10.3	30.4	36.1
Other Renewables	–	–	4.1	10.8	15.7	19.6
Net Imports	–	11.9	14.2	2.7	14.4	20.5
Total	**264.9**	**308.7**	**371.4**	**364.1**	**351.8**	**339.0**

*Includes net supply from pumped storage
Source: UK Energy in Brief, DECC, 2015

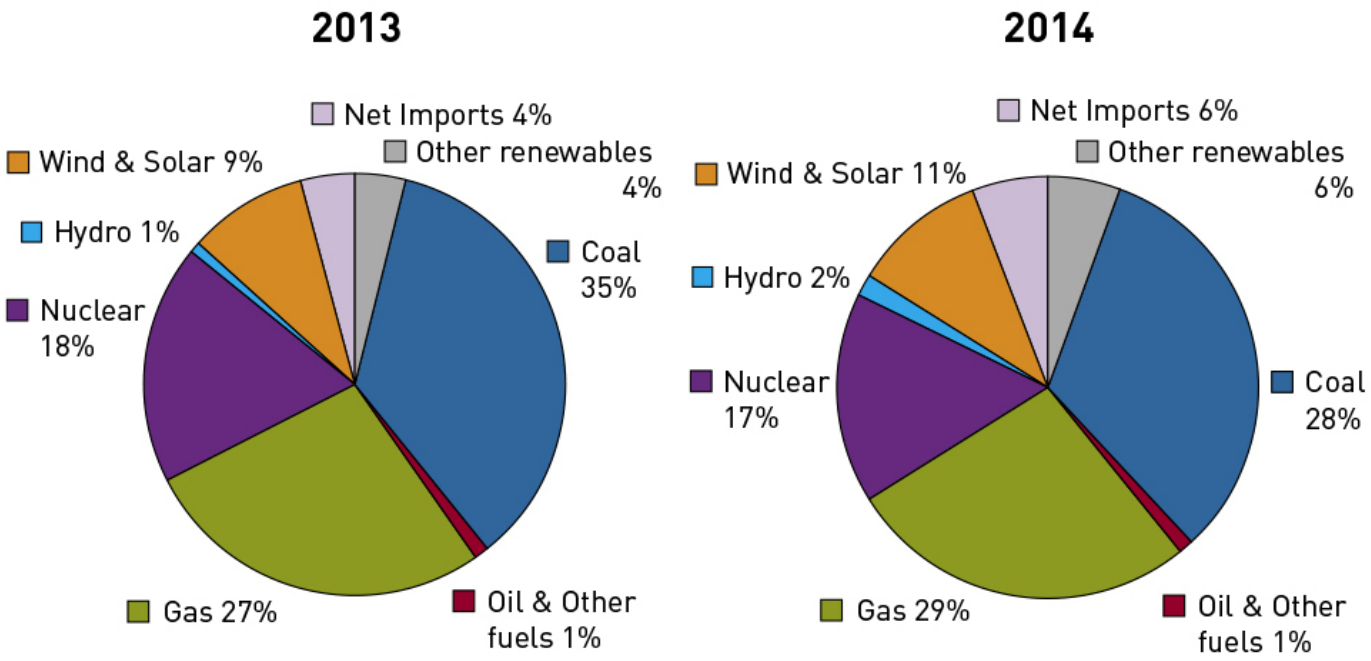
6 Digest of UK energy statistics (DUKES), 2015, Chapter 5: Electricity

UK electricity: amount supplied by fuel type, 1980 to 2014



Source: UK Energy in Brief, DECC, 2015

UK electricity: amount supplied by fuel type, 2013 and 2014



Source: UK Energy in Brief, DECC, 2015

2) Transport

95% of energy for transport comes from fossil fuels[7]. Road transport accounted for 74% of total transport energy consumption in 2014 in the UK, air transport was 23%, rail was 1.9% and water transport was 1.4%[8]. Around half of all oil is converted into fuel for transport.

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 then 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 less greenhouse gas emissions, and can provides jobs and a measure of energy security.

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

8 Energy Consumption in the UK, 2015, DECC

The real root of the problem with transport is the inefficiency of the internal combustion engine and the reluctance to move away from it. Electric vehicles may provide an alternative, however. While still consuming energy reliant on fossil fuels, they generally emit fewer greenhouse gases. Electric cars have the added benefit of not producing the exhaust pollution and noise that their petrol counterparts do. Because the technology is still being developed, electric cars currently cost more than regular cars and most can't travel long distances on a single charge. However, this situation is rapidly improving.

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 can be 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, draft proofing) is a key measure to ensure a reduction in demand and needless waste.

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%[9]. This change has largely been driven by developing countries, but developed nations have also experienced moderate levels of growth. The International Energy Agency predicts that emerging economies will account for more than 90% of net energy demand growth to 2035. Energy demand growth in Asia is led by China this decade, but will shift towards India and, to a lesser extent, Southeast Asia after 2025[10].

Factors responsible for this pattern include:

- Increased industrialisation
- Growth of electrical appliances in the home and car ownership
- In developing countries, rapid population growth, Gross Domestic Product (GDP) growth and industrial expansion have led to increased overall energy demand
- In developed countries, tougher fuel efficiency standards, slower population growth, and a shift in energy requirements from energy intensive industries to service industries have recently tempered demand.

9 International Energy Agency, Key World Energy Statistics 2007, Page 28
10 International Energy Agency, World Energy Outlook 2013 factsheet

World energy consumption by end-user and share of energy use, 2011

Sector of the economy	Main types of energy used	Share of total energy use
Transportation	▶ Petrol for cars, motorcycles and light trucks ▶ Diesel for cars, trucks, buses and trains ▶ Jet fuel for airplanes	20%
Industry & manufacturing	▶ Natural gas for boiler fuel and process heat ▶ Electricity for power ▶ Coal for boiler fuel	51%
Residential buildings	▶ Natural gas for space heating ▶ Electricity for lighting, appliances, refrigeration and some types of heating and cooling	18%
Comercial buildings	▶ Electricity for lighting ▶ Natural gas for space heating	12%

Source: EIA, World Energy Consumption by End Use Sector, May 2014 (http://www.eia.gov/tools/faqs/faq.cfm?id=447&t=1)

Today, consumers (rather than industrial users) are responsible for the majority of global energy demand. The largest consumer uses of energy include road transportation, residential heating and lighting, and the heating and cooling of commercial buildings (such as office space).

To meet global carbon emissions targets, developed nations need to greatly reduce their energy demand, while increasing production of low carbon energy. Investment in developing nations is also required to ensure low carbon technologies are used to meet increasing energy demands.

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. 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.

The exceptions to this fall in electricity supply were in 2010 and 2012, when slight increases occurred, due in part to particularly cold winters. Supply continued to fall in 2013 and 2014, however[11].

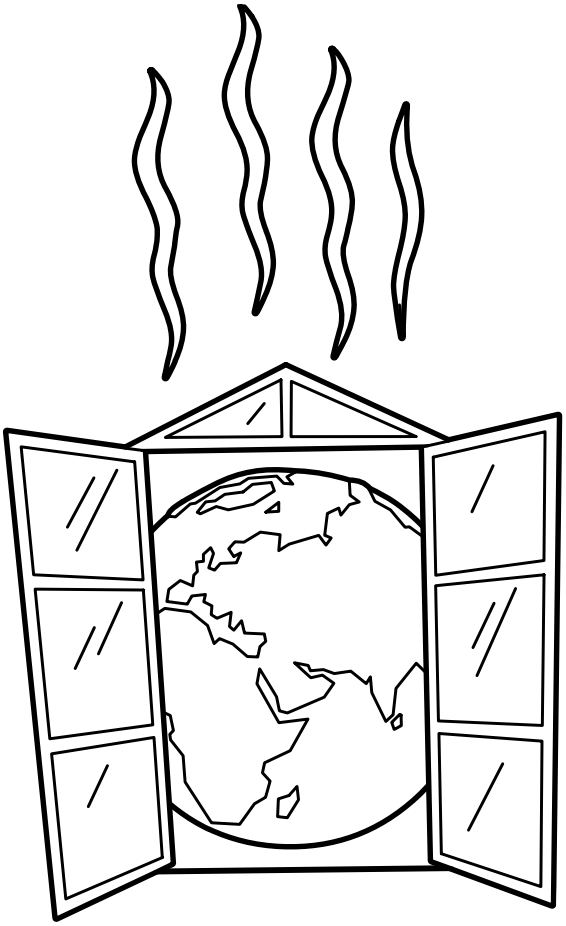
To see real UK electricity demand data, including the last 24 hours or past week, visit the National Grid website: **http://www.nationalgrid.com/uk/Electricity/Data/Realtime/**

11 UK Energy in Brief, 2015, DECC

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 (see below) 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.

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[12]. This will be very difficult to achieve, but not impossible!

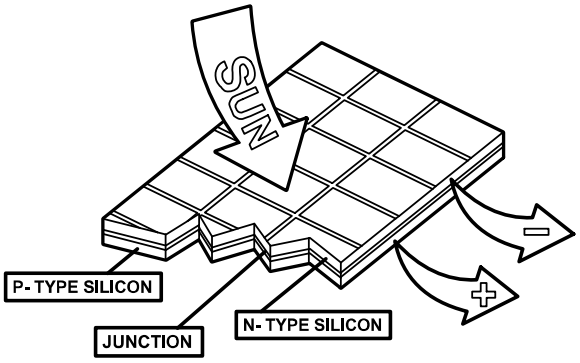
Reducing our demand for energy is the cheapest and easiest way to reduce our greenhouse gas emissions. It has been estimated that with widespread action we could reduce our electricity demand by a fifth by 2050[13].

12 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

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

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 aimed to decide what the global targets and action will be after 2012 (when the current Kyoto targets expire). The Copenhagen conference 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
- 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 (making their products using less energy), or by capturing and/or offsetting the emissions they do make, reducing the impact of the gases emitted.

You and me

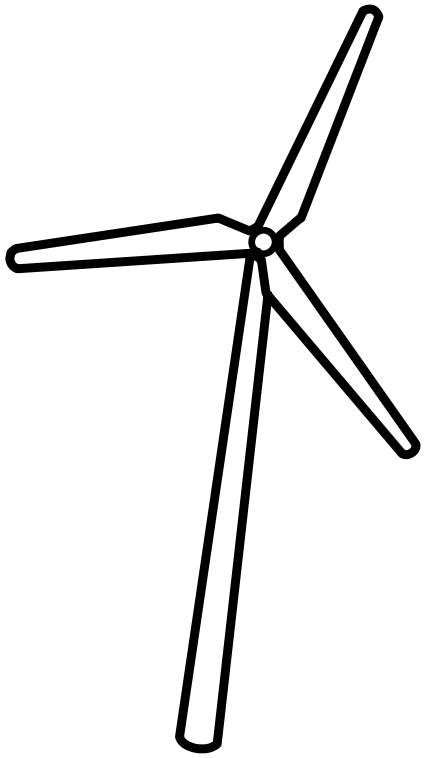
There are many things we can do to reduce our individual impact on the climate, including using public transport; switching off electrical equipment when we are not using it; turning the heating down; taking short showers instead of baths; insulating our homes; and recycling our rubbish. Together, we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

1. Reducing our demand for energy

2. Reducing the impacts of existing energy production

3. Increasing the supply of less damaging sources of energy.

This last point is vital when considering the future energy mix. Getting the balance of low-carbon sources in the energy mix right is an important component in fulfilling demand while minimising the effects of climate change.



UK targets

In December 1997 the UK signed the Kyoto Protocol, which became legally binding in February 2005. As part of this, we pledged to reduce our greenhouse gas emissions by 12.5% between 2008 and 2012, and to try to reduce emissions to 20% below 1990 levels by 2010.

The Climate Change Act 2008 pledged to cut current carbon dioxide (CO_2) emissions in the UK by 80% by 2050. In spring 2007, the UK agreed with other Member States to an EU-wide target of 20% renewable energy by 2020 – including a binding 10% target for the transport sector.

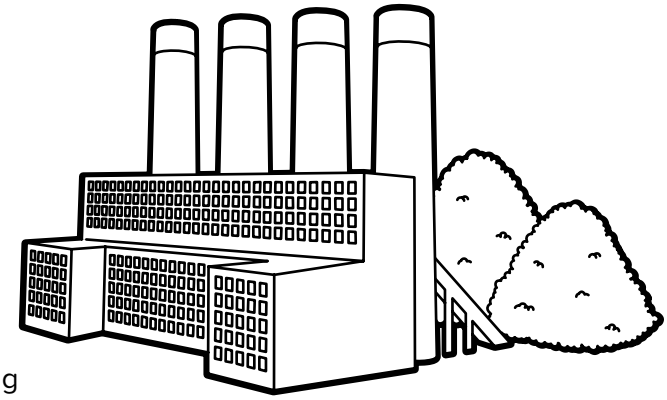
Member States have now signed up to the Renewable Energy Directive, which includes a UK share of 15% of energy from renewables by 2020. In 2013, renewable energy is estimated to have accounted for 5.2% of final energy consumption, up from 4.2% in 2012[14].

There is still a long way to go before the UK reaches 15%, however, and the UK government has put in place a number of policy measures to further increase renewables deployment, including: financial incentives (such as Feed-in Tariffs), measures to improve existing grid connection arrangements; and promoting business opportunities in the renewables sector[15].

14 Renewable Energy in 2013, DECC
15 Renewable Energy in 2013, DECC

Reducing our demand for energy

Reducing our demand for energy is the cheapest and easiest way to reduce our greenhouse gas emissions. If all countries made electricity in the most efficient fossil fuel power stations now available, fossil fuel use for electricity generation would fall by around a quarter. Scientists estimate that with widespread action we could reduce our electricity demand by a fifth by 2050.

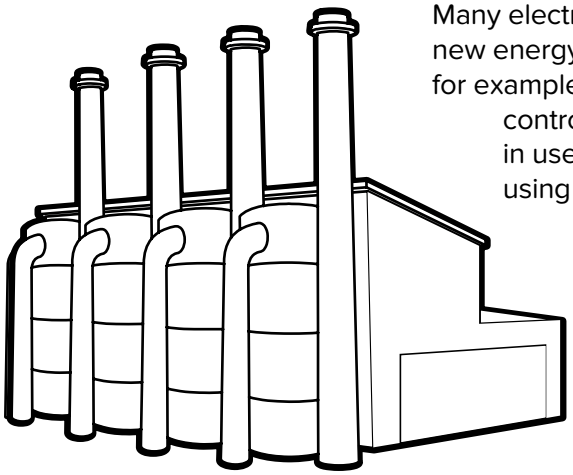


Households, schools and businesses can undertake many energy efficiency measures, without significant cost, by improving building maintenance and changing behaviour. If we can reduce the amount of energy we use by improving energy efficiency, we will reduce both emissions and costs.

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.

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 holiday flight to somewhere sunny.

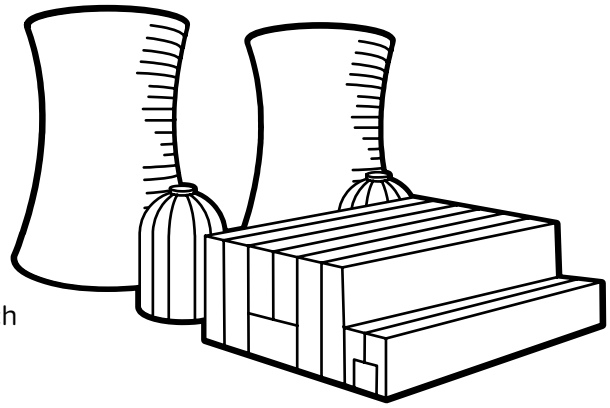
However, simple changes to everyday behaviour can make an impact. Heating is the biggest form of energy consumption in most British buildings. For every degree you turn down the heating in your building, you can save 10% of your heating bill.

Distributing electricity

Almost all of our electricity is produced in large power stations connected to the electricity grid. The grid brings the electricity from the power station (which may be hundreds of miles away) to where we need it in our homes, schools, factories, etc. Distributing electricity in this way is inefficient, as some of the power is wasted. The further it travels along the power lines, the higher the wastage. New means of generating electricity more locally are being developed, as are more efficient power lines.

What energy options do we have?

Fossil fuels



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

Fossil fuels are non-renewable resources because they take millions of years to form, and reserves are being depleted much more quickly than new ones are being formed.

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).

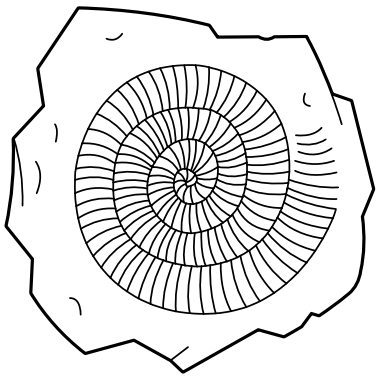
One of the biggest benefits of fossil fuels is their cost. Coal, oil and natural gas are plentiful right now, and relatively inexpensive to drill or mine for.

Coal

Coal is an abundant and flexible energy source which remains an important part of the energy mix, both globally and in the UK.

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 fossilised jungle.

Coal is found in over 100 countries, particularly Australia, China, India, Russia, South Africa and the USA. In the USA, 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. Burning coal produces a lot of CO_2 per unit of energy compared to burning natural gas or oil, so its increased use has major implications for climate change.



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. 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[16]. 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. It has fluctuated slightly in the years since, returning to 16% in 2014 following a fall in energy consumption on the previous year[17].

Many of the UK's coal power stations are to shut down in line with the EU's Large Combustion Plant Directive, which demands that highly pollutant plants close by the end of 2015 or after 20,000 operating hours post-January 2008[18]. It is expected that new coal-fired power stations will be built, but with the capacity to capture and store some of their future CO_2 emissions. This process is called carbon capture and storage (CCS - see below). However, CCS is still at a developmental stage.

Oil and gas

Oil and gas remain vital parts of the UK's energy mix; both of these fossil fuels are used for electricity generation.

Millions of years ago the sea and swampy areas of the world were rich in microscopic plants and animals. The plants captured the sun's energy and CO_2 from the atmosphere to make more plants. As the plants and animals died, they sank and became buried under layers of sediment. The heat and pressure increase as they were buried deeper below the Earth's surface converted the remains into oil and gas.

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 oil and 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.

16 DECC archives
17 Energy Consumption in the UK, 2015, DECC
18 Energy Global

As stated by DECC, the UK oil and gas industry has been the UK's largest sector of industrial development over the past four decades. It continues to support over 400,000 jobs and to contribute around £8 billion a year to the Treasury.

In 2010 the UK, Norway and the Netherlands collectively ranked 4th on a list of major oil and gas producing countries, and production remains central to UK energy supplies[19]. That said, 2015 marks the last year that oil contributes to the UK's electricity supply, following the closure in March of this year of the UK's last oil-fired power station.

How long will fossil fuels last?

It took millions and millions of years for nature to create our fossil fuels, but we are using them up in only a few human lifetimes. Once we have used them all, they will be gone for ever. It is estimated that we have used about half of the world's oil that is easily accessible[20] – that is, we have currently reached 'Peak Oil', an issue of major interest and concern at the moment.

Other sources of oil are available (such as Canada's oil shales), but are very expensive to extract and have a huge environmental impact. However, if these are fully exploited they could provide oil for centuries to come. We have enough coal left around the world to last well over a century, based on current consumption rates[21].

Fossil fuels can be used interchangeably, although this costs money and is not an efficient use of their basic properties. 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.

Natural Gas

Natural gas is the cleanest fossil fuel, producing around half the emissions of coal for the same amount of electricity generated. The UK's CO_2 emissions fell 15% between 1990 and 2003, mostly as a result of switching from coal to natural gas for electricity generation[22]. Natural gas plants are also cheaper and quicker to build. The key challenge in switching from coal to gas is price and availability.

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.

Combined heat and power plants capture and use heat at the cost of losing some efficiency in electricity generation. As less fuel is needed to produce the same amount of useful energy, the overall efficiency of the plant is increased when compared with generating heat and electricity separately. Natural gas condensing boilers for water and space heating are efficient at 90%: only 10% of the heat goes up the chimney.

19 BP Statistical Review of World Energy 2011, Figure 13: Major Oil and Gas Producing Countries, 2010

20 World Energy Outlook, 2008, IEA

21 BP Statistical Review

22 http://www.defra.gov.uk/environment/statistics/globatmos/alltables.html

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.

The use of nuclear power is controversial. But it is an important part of the modern energy mix: the world produces as much electricity from it as it previously did from all other sources combined in 1960, according to the World Nuclear Association. In the UK, 16 nuclear power stations produce 19% of our electricity.

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[23]. 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[24].

Radioactive waste

Storing radioactive waste is currently one of the biggest issues the nuclear industry is addressing. A small proportion of nuclear waste is 'high-level waste': waste so radioactive that it generates heat and can corrode normal containers.

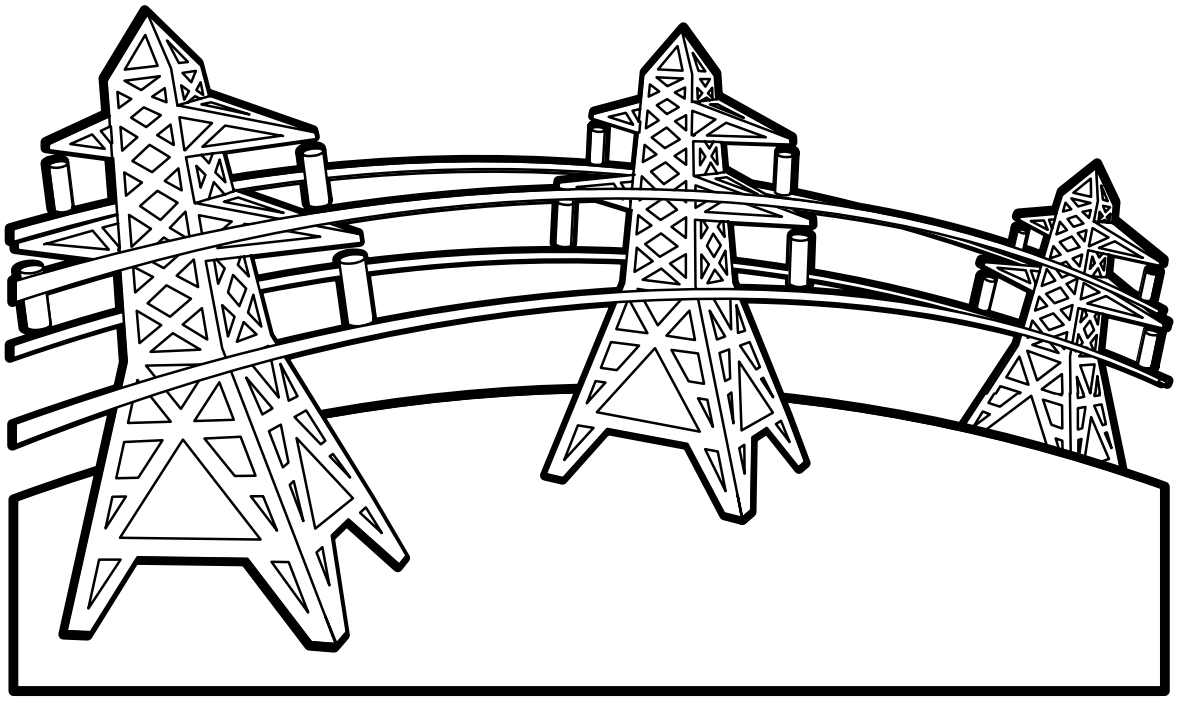
Currently, the nuclear industry lets waste cool for a number of years before mixing it with glass and storing it in huge concrete structures, where it is maintained, monitored and guarded. In the future, much of this waste may be transported deep underground. Finland and the US already have plans to build repositories deep underground in geologically stable areas. This solution is one of those under consideration in the UK[25].

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

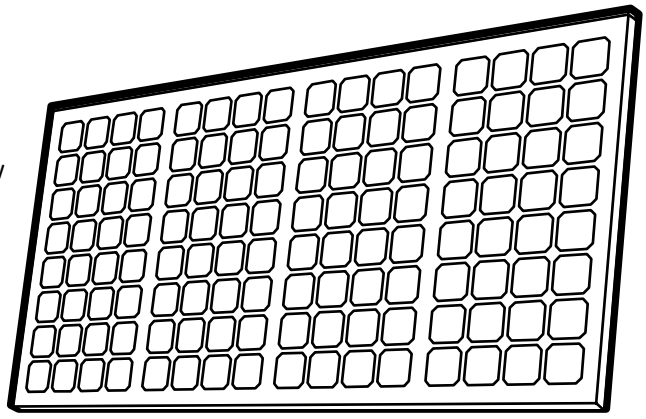
The future of nuclear

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 September 2015, there are some 437 nuclear power plants around the world, with a further 66 under construction[26]. These power plants provide around 13% of the world's electricity or 2518 TWh of electricity[27]. If this electricity had instead been generated from fossil fuels, total world carbon emissions would certainly be higher than they are today[28].



26 World Nuclear Association, www.world-nuclear.org/Nuclear-Basics/Global-number-of-nuclear-reactors/
27 World Nuclear Association, www.world-nuclear.org/Nuclear-Basics/Electricity-supplied-by-nuclear-energy/
28 World Nuclear Association, www.world-nuclear.org/Nuclear-Basics/Greenhouse-gas-emissions-avoided/



According to the World Nuclear Association, the UK currently has 16 reactors generating about 18% of its electricity. However, all except one of these reactors is due to be retired by 2023. Consequently, the government has undertaken thorough research into the development of new reactors with a view to launching the first next-generation nuclear plants by 2023. It aims to have 16GWe of new nuclear power being generated by 2030[29].

The UK's existing energy policy is designed to address the twin challenges of climate change and security of energy supply. The Nuclear white paper 2008: 'Meeting the energy challenge' set out the view that nuclear, as an affordable, dependable and safe form of energy, should be part of the UK's future low-carbon energy mix, and that energy companies should have the option of building new nuclear power stations.

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.

EDEN FACTS

Eden has a 5kW wind turbine that produces enough electricity annually to power an average home for a year. That's about 4,500kWh.

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.

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

Renewable energy is a vital component of the UK's diverse energy mix – and in 2014 it accounted for 19.1% of the UK's electricity mix, a record high[30]. In offshore wind, the UK has one of the best natural resources in Europe, and is already leading the world in offshore wind farms[31]. The UK is also one of the leaders in several areas of developing technology, like wave and tidal energy[32].

> The UK has set a target to produce 15% of its energy for electricity, heat and transport from renewable sources by 2020. This is ten times the amount produced in 2006.
>
> Meeting the Energy Challenge: a white paper on energy

The government created a 'renewable energy roadmap' in July 2011, which set out how it aims to achieve its target of ensuring that 15% of our energy comes from renewable sources by 2020. This report acknowledged that, although these were ambitious targets for the UK, they were quite possible to achieve as our country has huge wind, wave and tidal resources. It also predicted that, potentially, the renewable energy sector could employ over half a million people by 2020[33].

UK renewable electricity generation has increased significantly since 2002, when the Renewables Obligation (RO) was introduced[34]. 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.

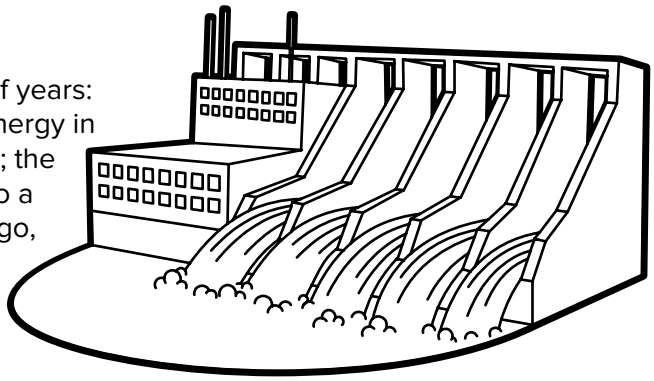
In 2011, 9.4% of the UK's electricity was produced by renewable sources. Between 2010 and 2011, electricity generation from renewable sources increased by approximately a third to 34.4 TWh[35].

Green tariffs

Many energy providers offer green energy tariffs to encourage the switch to more renewable sources of electricity, and raise funding to do this. This means that the supplier will add one unit of electricity generated from renewable sources to the grid for every unit of electricity you use.

30 UK Energy in Brief, DECC, 2015
31 DECC
32 UK Renewable Energy Roadmap, July 2011, DECC
33 UK Renewable Energy Roadmap, July 2011, DECC
34 Energy trends, DECC
35 DECC: https://restats.decc.gov.uk/cms/national-renewables-statistics/

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.

Modern wind farms can have rotor diameters in excess of 100 metres and can stand over 120 metres high.They require substantial capital investment to build and involve a lengthy planning process, as careful consideration must be given to the possible impacts on the local environment[36].

How much does it cost to make energy from the wind?

Wind energy is one of the cheapest renewable energy sources. The cost of wind energy varies according to many factors such as the average wind speeds, the size of the wind farm and the individual turbines, the technology used, the costs of building and maintenance (which vary greatly between onshore and offshore wind farms) and the land and planning costs.

How much space do windmills 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 Britain 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.

36 Wind power: environmental and safety issues, BERR

Small scale turbines can power a house or building. 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.

Micro-generation from wind can be used for applications such as charging batteries on caravans or boats, lighting and electric pumps in remote locations.

Solar

Solar energy is the 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!

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 Projects 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 heating or hot water in a building.

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 the 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.

Despite the drawbacks, it has been reported that solar energy use has increased at about 30% a year over the past 20 years[37], thanks to rapidly falling prices and improved efficiency. Japan, Germany, and the United States are major markets for solar cells.

EDEN FACTS

Solar photovoltaic panels are used on the roof of our educational building, called The Core, generating about 20,000 kWh a year. This saves over 9 tonnes of CO_2 annually.

The Core also has a passive ventilation system that uses ducts to pass air underground before it enters the building. As it is passed underground, the air is cooled in summer and heated in winter. Only a small amount of electricity is used by a fan to draw the energy through the ducts. In 2009, solar thermal heating for visitor hot water was installed too.

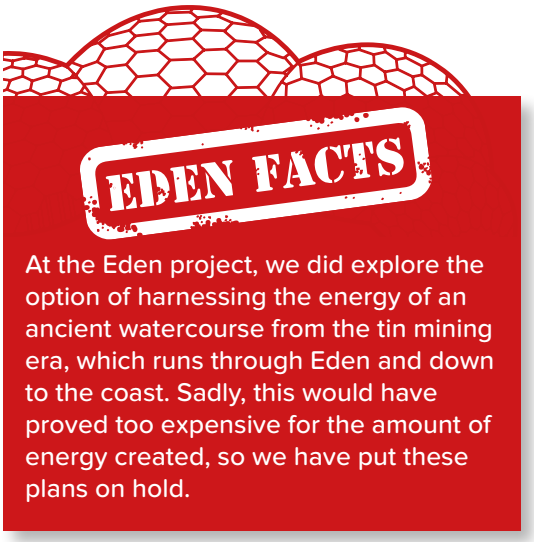
37 Solarbuzz

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, as the name suggests. 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.



Today, about 16% of global electricity generation comes from large and small production schemes on river flows and dams. The number of small scale hydropower projects is increasing, as they are highly efficient and easier to install.

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 – 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.

The proposed barrage across the river Severn could produce as much as 5% of the UK's electricity[38]. However, tidal barrages are controversial, as they can have an impact on local ecology and affect the migration of fish like salmon and eels.

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.

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.

38 Renewable Energy UK

Biomass

Biomass is made up of many types of organic matter, and can be used to produce power, heat and steam. 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.

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.

In capacity terms, plant biomass was the third biggest source of renewable energy after wind and hydro in 2011. Biomass and landfill gas both produced around 9% of the UK's electrical capacity[39].

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.

39 Digest of UK energy statistics' (DUKES), 2012, Chapter 6: Renewable 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. 9% of renewable electricity in the UK in 2011 was made from landfill gas[40].

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.

Emerging technologies

The UK is leading the development of a number of low-carbon technologies that could play an important role in the future. These include:

- marine energy technology (such as from wave and tidal power)
- offshore wind power
- organic LED materials technology
- ultra-efficient panel lighting
- control systems for smart metering of electricity
- intelligent management of the electricity grid
- battery chemistry and management

40 DECC, https://restats.decc.gov.uk/cms/national-renewables-statistics/

Reducing the impact of existing energy production

Fossil fuels will continue to be a major source of our energy for decades to come. Despite the downsides of fossil fuels already outlined, it will be a long time before alternative and greener energy sources are developed and installed to a point where they can take over. Furthermore, the cost of electricity production from fossil fuels is still cheap compared with the alternatives, an extremely important factor for consumers, especially in today's economic climate.

So, how can we still produce electricity from fossil fuels while reducing their effects on the climate?

Carbon capture and storage

Carbon capture and storage (CCS) involves separating the CO_2 from industrial or energy processes, compressing it and transporting it to long-term storage, ideally underground. This could be in oil wells after the oil has been taken out, for example. The storage site is then monitored for leakages.

This could be a major advance in the greener use of fossil fuels, but it is only at an experimental stage at the moment. It will be very expensive and complicated to develop to a point where it can be a major tool in reducing CO_2 emissions. It will also increase the cost of energy from fossil fuels. But, the major advantage of this alternative is that it is much more socially and politically acceptable; it does not necessitate the huge changes in lifestyle and legislation that abandoning fossil fuels does.

Advanced coal technologies

Coal is currently the cheapest fuel. It also very widespread, mined in over 100 countries. Unless a new technology that is cheaper than coal comes along, we will be using it for a long time. Most coal is burnt to produce steam, which is then used to spin a turbine that runs a generator to produce electricity. Efficiency varies, but is much lower than gas turbines, at a world average of 35%. However, coal can be used more effectively: a range of new technologies can produce more energy from the same amount of coal.

The challenge is to get everyone to adopt the best technology; if every coal plant in China was as efficient as the Japanese average, China would use a fifth less coal.

Distributed / decentralised energy and heat

Distributed energy systems generate electricity and heat near to the end user. Distributing (or decentralising) energy production to be closer to the end user reduces overall demand, as less energy is lost in transmission. As stated by the Energy Technologies Institute, analysis has shown that increased deployment of distributed energy could reduce UK CO_2 emissions associated with heat and power generation by up to 30%[41].

41 Energy Technologies Institute, Distributed Energy Programme

There are many different definitions of ‘decentralised’ or ‘distributed’ energy. The UK Government takes a broad view, using the term ‘distributed energy’ to refer to the range of technologies that do not rely on the National Grid or the gas grid. These technologies include combined heat and power (CHP); small scale and micro hydropower; micro and small wind turbines; photovoltaics (solar PV); biomass; and district heating as a means of transporting renewable or low carbon heat to multiple consumers.

The technology to support decentralised energy is well developed, but there are many issues to be resolved before it will become widespread – for example, fluctuation of supply, energy storage effectiveness, and the ways in which the energy can be imported from and exported to the distribution network.

Distributed energy generation technologies can be either integrated into buildings when they are built, retro-fitted to existing buildings, or installed nearby (on waste land, nearby roofs or car parks). Distributed energy gives homeowners, communities, businesses or other organisations the option of moving from being ‘passive’ energy consumers (who simply pay for electricity or gas) to energy producers or ‘microgenerators’, thus contributing to the reduction of carbon emissions.

Dispatchable generation

The National Grid relies on a base load 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.

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 base load.

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.

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. ▶ Fossil-fuelled power stations can be built almost anywhere, as long as you can get large quantities of fuel 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. ▶ Burning coal releases large amounts CO_2, which contributes to global warming. Building and decommissioning also causes waste and emissions. ▶ Burning coal may contribute to acid rain. ▶ 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 source	Advantages	Disadvantages
Oil	▶ Convenient, because you can burn it anywhere, and it is easy to handle, store and transport.	▶ Non-renewable. Like other fossil fuels, oil is a non-renewable energy source, so stocks won't last forever. ▶ Although new oil deposits are being discovered every year, consumption is increasing annually at a faster rate, so prices will continue to rise. ▶ The CO_2 released during the burning of oil contributes to global warming. ▶ It also causes strong localized effects. CO, NOx, and particulates damage local ecosystems and can damage human health. ▶ Drilling may affect ocean and terrestrial habitats. ▶ The threat of oil spills exists.

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 still a non- renewable resource. ▶ Building and decommissioning also causes waste and emissions.

Energy information pack

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. ▶ 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 ▶ Nuclear reactors can produce materials that can be used to make nuclear weapons.
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 information pack

Energy source	Advantages	Disadvantages
Solar PV	▶ There is an infinite supply of sunshine – it is renewable. ▶ No greenhouse emissions released when generating. ▶ Space saving (they 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. ▶ Expensive, although it is getting cheaper. ▶ Sun intensity effects energy production, so 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.	▶ The rock required must 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.

Energy information pack

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 animals that used to live there. ▶ 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, no waste produced. ▶ 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.

Energy information pack

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. ▶ 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. ▶ 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.

Energy information pack

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 dioxin emissions. ▶ Minimum materials recovery, except for ferrous materials. ▶ A minimum or guaranteed volume may be required by the operator to cover costs.