

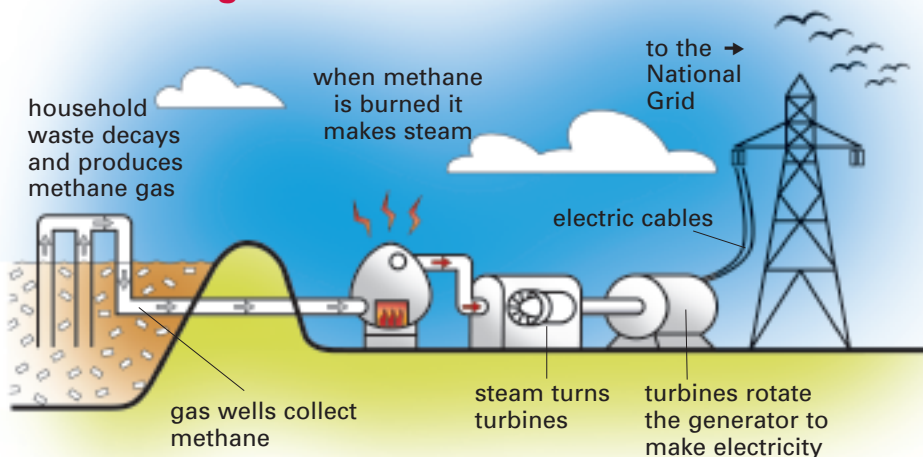
Biomass energy

What is biomass energy?

Biomass is plant and animal matter, such as wood, straw, sewage and waste food. We can burn these natural materials to produce heat and electricity, or use them to produce transport fuels such as biodiesel and bioethanol. This is called biomass energy.

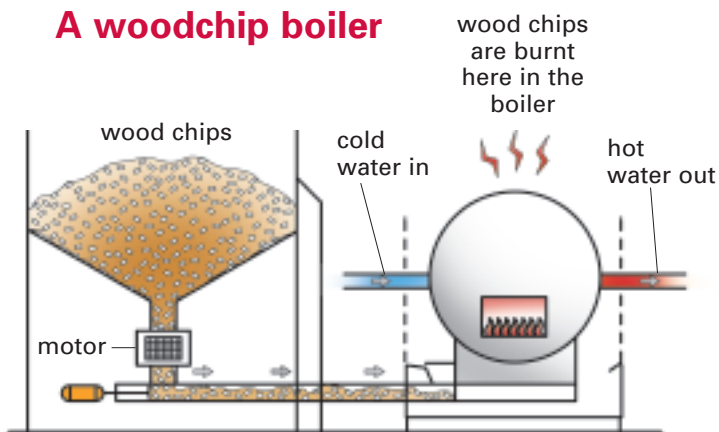
How biomass energy works

Landfill gas



- Some waste is recycled, but most of it is dumped in landfill sites.
- As the plant and animal material in the waste decays, it gives off methane gas.
- The gas is collected and used as a fuel to heat water and make steam. This turns a generator, which makes electricity.

A woodchip boiler



- Trees grown specifically for fuel are felled, cut into wood chips and dried. New trees are planted.
- The wood chips are burned in a boiler to heat water, which can be used to heat buildings or make electricity.
- Household waste, animal and factory waste, and straw can also be used as fuel.



Advantages of biomass energy

- It does not use up limited resources such as coal. Biomass cannot run out!
- It stops landfill gas from going into the air, where it could damage the atmosphere.
- It does not rely on the weather, so it can provide energy all the time.



Possible disadvantages

- Waste materials have to be collected, which can be costly.
- Burning fuels (e.g. wood chips and rubbish) does cause some air pollution.

Biomass energy in the UK

Biomass energy is one of the most widely used forms of renewable energy in the UK. Biomass produces more electricity than any other renewable.



Courtesy of NRE Slide Library / DTI

The world's largest straw-burning power station is at Ely in Cambridgeshire. Thousands of tonnes of straw from local farms are burned to generate electricity. The power produced each year is enough for 80,000 homes.



Courtesy of Weobley Primary School

Weobley Primary School in Hertfordshire is heated using wood chips. The wood is grown nearby and cut carefully from trees, so that they continue to grow. The school boiler uses about two tonnes of wood chips a week.

Biomass energy facts and figures

The number of biomass power plants in the UK	334
Areas of the UK that produce biomass energy	All parts of the country
Amount of UK's total electricity supplied by biomass energy	Around 1.6%
Can biomass energy be made from sewage?	Yes
Where is the UK's largest sewage treatment works?	Minworth, West Midlands
How does it produce energy?	As the sewage is broken down by bacteria, it gives off heat and methane gas.
How is this heat and gas used?	The heat is used to help work the treatment machinery and generate electricity.

Energy from rubbish?



Courtesy of NRE Slide Library / DTI

The UK produces 28 million tonnes of household waste every year. Only 11% of the UK's waste is used to make electricity at the moment.

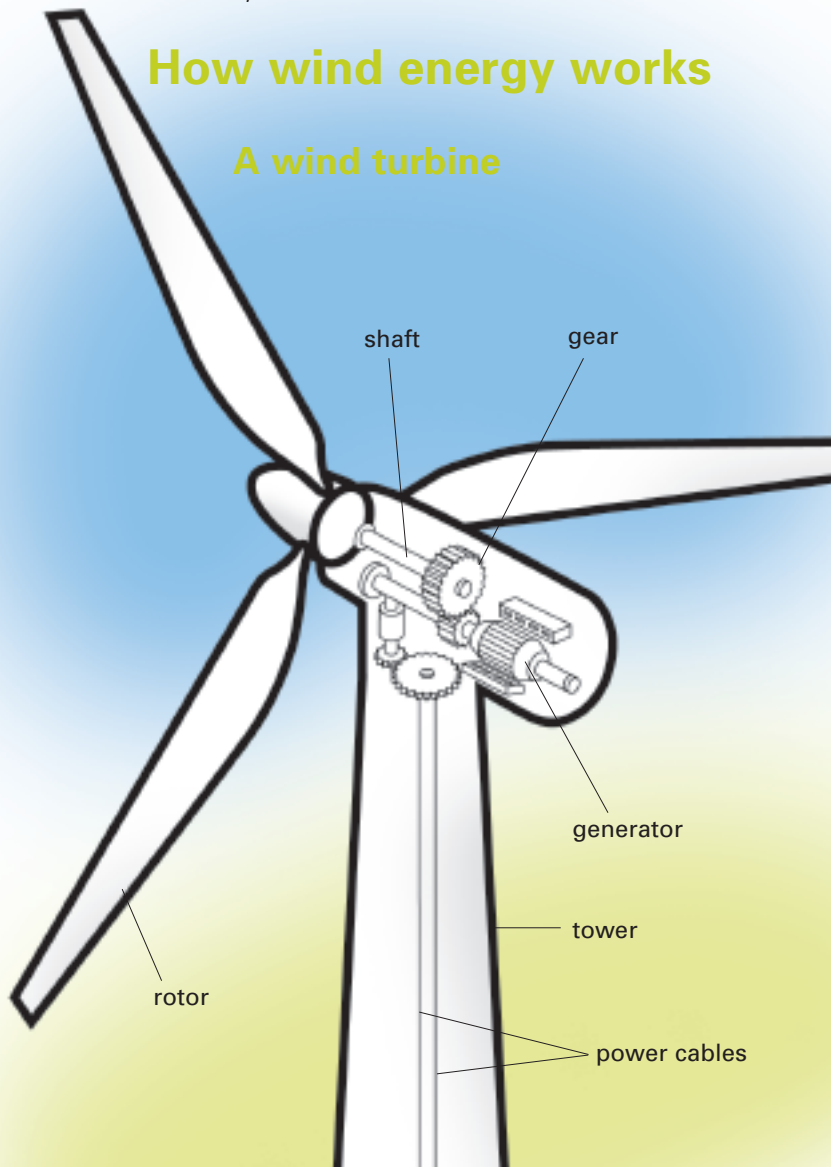
Wind energy

What is wind energy?

Humans have used wind energy to power machinery in windmills for hundreds of years. Today, electricity companies are building wind farms which use giant machines called wind turbines to make electricity for homes, schools and factories.

How wind energy works

A wind turbine



- The force of the wind turns a **rotor**, which is like a huge propeller with two or three blades. The blades are angled so they turn when the wind pushes against them.
- The rotor spins a **shaft** that is connected to **gears**.
- The gears turn a **generator**: this is a machine that contains coils of wire and powerful magnets. When the wire coils are spun quickly inside the magnets, they produce electricity.
- Tall towers are used so that the rotor faces the strongest and steadiest possible winds.



Advantages of wind energy

- It is a renewable form of energy, which means it will never run out.
- Wind energy is clean. It causes no pollution.
- The land on which turbines are built can still be used for farming.
- It costs no more than coal energy and is cheaper than nuclear energy.



Possible disadvantages

- Some people are concerned about noise, although wind turbines are quieter than many people think.
- Wind turbines do not work in very weak or very strong winds.
- Some people think that wind farms spoil the look of the landscape, although others disagree – this is a matter of opinion.

The growth of wind energy

Wind energy already supplies electricity for nearly one million households in the UK, and this figure is growing as more wind farms are constructed. There are two types of wind farm in the UK: onshore and offshore.



Courtesy of npower renewables

An onshore wind farm at Novar, Scotland

Onshore wind farms are built on land. A large farm can provide electricity for 25,000 homes. This site was chosen because it has strong winds, and is far away from houses and other buildings.



Courtesy of E.ON UK

An offshore wind farm at Blyth, England.

The first offshore wind farm in the UK was built in 2000. They are more expensive than onshore wind farms, but can use very large turbines, which give more power. The wind at sea also blows more steadily than on land.

Wind energy facts and figures

The number of wind farms in the UK	93
The areas of the UK with the most wind farms	Wales, Scotland, Cornwall
The UK's largest wind farm	Carno in Wales (56 turbines)
Number of households that a large wind turbine can power	3000
Amount of UK's total electricity supplied by wind energy	About 1 %
How tall are wind turbines?	25–100 metres
How long are the rotor blades?	Up to 65 metres
What are the rotor blades made from?	Very strong plastics
What is the best wind speed for wind turbines?	15 metres per second (33mph)



Courtesy of Cassop Primary School

Cassop Primary School

Cassop Primary School in County Durham was one of the first schools in Britain to install a wind turbine.

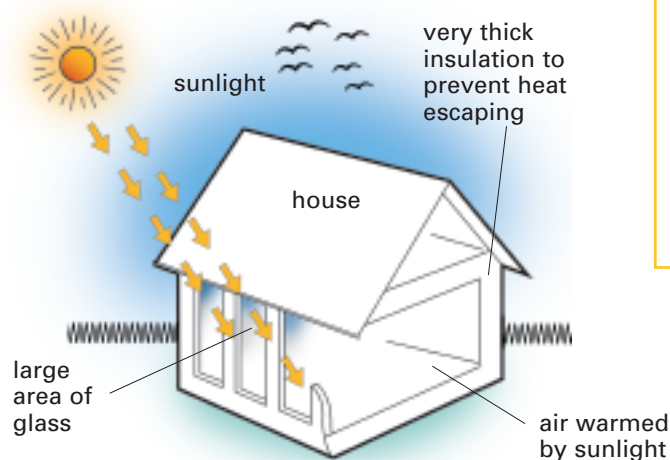
Solar energy

What is solar energy?

Solar energy means energy from the sun. Although the sun is 150 million kilometres away from the Earth, it is amazingly powerful. We can capture some of the sun's energy and use it to heat buildings, provide light and generate electricity.

How solar power works

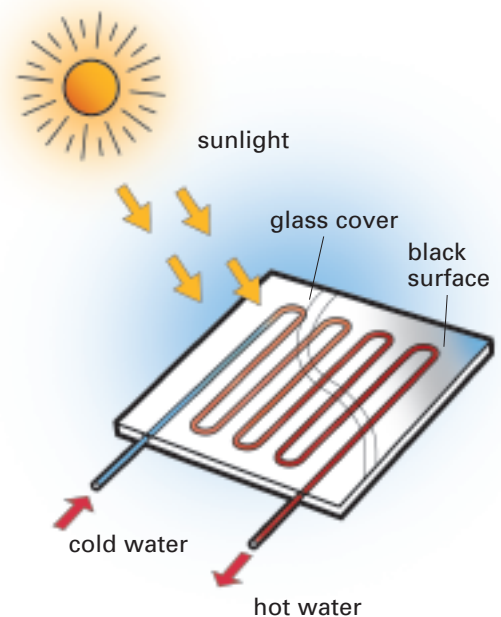
Passive solar design



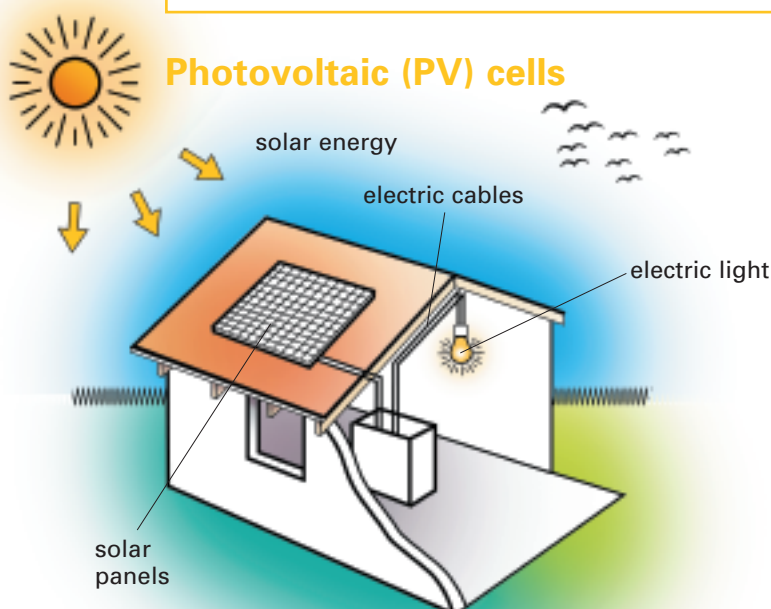
- Buildings can be designed to make the most of the sun's energy, e.g. large areas of glass allow more sunlight to come in, so less heating and lighting are needed.
- Houses built in this way have thick insulation to hold in the sun's heat.

Active solar heating

- The sun's energy heats up hot water for washing and heating.
- Water is pumped up through pipes into solar panels (or collectors) on the roof.
- The hot or warm water, which has been heated by the sun, is stored in a tank and can be used in the building.



Photovoltaic (PV) cells



- PV (photovoltaic) cells change light straight into electricity.
- Small PV cells are used to power calculators. Large panels of PV cells can be fixed to houses to power lights, computers, TVs, etc.
- PV panels are usually put on the roof of a building to capture sunlight.



Advantages of solar energy

- It is renewable energy. The sun gives out 'free' power all the time.
- It is silent, causes no pollution and does not harm wildlife.
- It provides energy where it is used, so there is no need for large cables.
- It is useful in remote places, and works on a small or large scale.



Possible disadvantages

- Solar power does not work at night.
- At the moment, PV cells are expensive (but getting cheaper).

Solar energy in the UK

Solar energy does not produce a lot of the UK's electricity at the present time. One reason for this is that the country's climate is not very sunny. PV cells work best when they are in direct sunlight. However, passive solar design can help to reduce energy bills by 20%, and active solar heating works even on cloudy days.

Solar energy facts and figures

The number of small active solar power systems in the UK	Over 100,000
Area of the UK with the most sunshine for solar energy	South of England
Amount of UK's total electricity supplied by solar energy	Less than 0.1%
How much of the electricity needed by an average household can a PV system make?	About one third
The UK's largest PV system	The Solar Office, Sunderland
What area do the PV panels of The Solar Office cover?	532 square metres
How long do PV panels last?	Up to 20 years
What are PV panels made from?	Thin layers of silicon (found in sand) underneath a sheet of glass



Courtesy of Tesco Stores Ltd

This Tesco petrol station in Hucknall near Nottingham has 96 PV panels on its roof. By using solar energy to produce electricity in this way, the station uses less energy made by burning fuels, and so reduces pollution in the air.

Geothermal energy

What is geothermal energy?

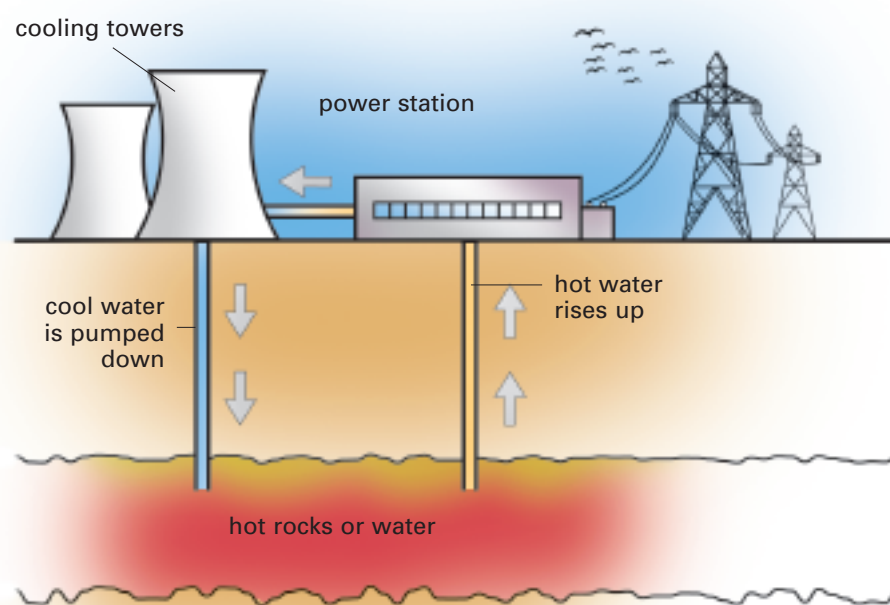
Coal miners know that the deeper you dig, the hotter it gets. This is because of the heat at the Earth's core. We call the Earth's natural heat geothermal energy ('geo' means earth and 'thermal' means heat). Water heated by geothermal energy can be used to heat buildings or generate electricity.

How geothermal energy works

There are two main ways of using geothermal energy.

- In some areas of the Earth, naturally heated underground water rises to the surface as **steam** or **hot springs**. If the hot water doesn't rise to the surface on its own, we can drill **boreholes** to get to it.
- Another way of using the Earth's natural heat is to pump cold water deep underground, where it is heated by hot dry rocks and then returned to the surface. This process is explained below.

Geothermal power plant



- Engineers drill two shafts down into the Earth to reach hot rocks or a hot underground lake.
- Cold water is pumped down underground, where it is heated by the rocks or lake.
- The very hot water rises or is pumped up to the power station at the surface.
- The steam turns a generator to make electricity.



Advantages of geothermal energy

- Geothermal power plants produce renewable energy. No fuel is used.
- There is very little pollution.
- Geothermal energy is quiet, and much of the technology needed is hidden underground.



Possible disadvantages

- Only a few parts of the UK have underground heat close enough to the surface for a geothermal power plant.

Geothermal energy in the UK

The UK doesn't have any geothermal power stations that produce electricity, but lower temperature reservoirs are used for direct heating.

Southampton Civic Centre is partly heated by a geothermal system. Hot water from a well 1800 metres deep is piped around the city and provides direct heating for a number of buildings within 2km of the borehole.

Hot springs and geysers

Here are two examples of naturally heated underground water that has made its way to the surface. They are tourist attractions at Yellowstone National Park in the USA.



Courtesy of
Southampton City Council

Southampton Civic Centre



**Mammoth Hot Springs,
USA**

Courtesy of www.pdphoto.org



Photo courtesy of
www.pdphoto.org

The Old Faithful geyser
erupts high pressure steam
from far below the Earth's
surface every 45 minutes.

Geothermal energy facts and figures

Areas of the UK best suited to geothermal energy projects	The Scottish Highlands and Welsh mountain areas
Amount of UK's total electricity supplied by geothermal energy	Less than 0.1%
Where is the UK's only geothermal power plant?	Southampton
How deep is the well it uses?	1.8km
How hot is the water from the well?	76°C
How long are the pipes carrying the water around the city?	11km

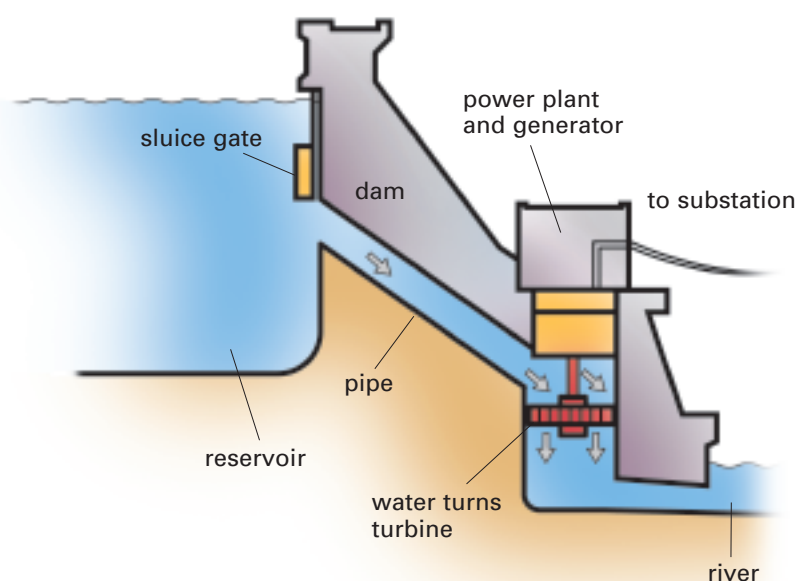
Hydroelectric energy

What is hydroelectric energy?

Hydro-energy means energy from moving water ('hydro' is from the Greek word for water). It is one of the oldest forms of power. Watermills have been used to grind corn for hundreds of years. Today, electricity can be generated by building dams, which force water to turn machinery. This is called hydroelectric energy.

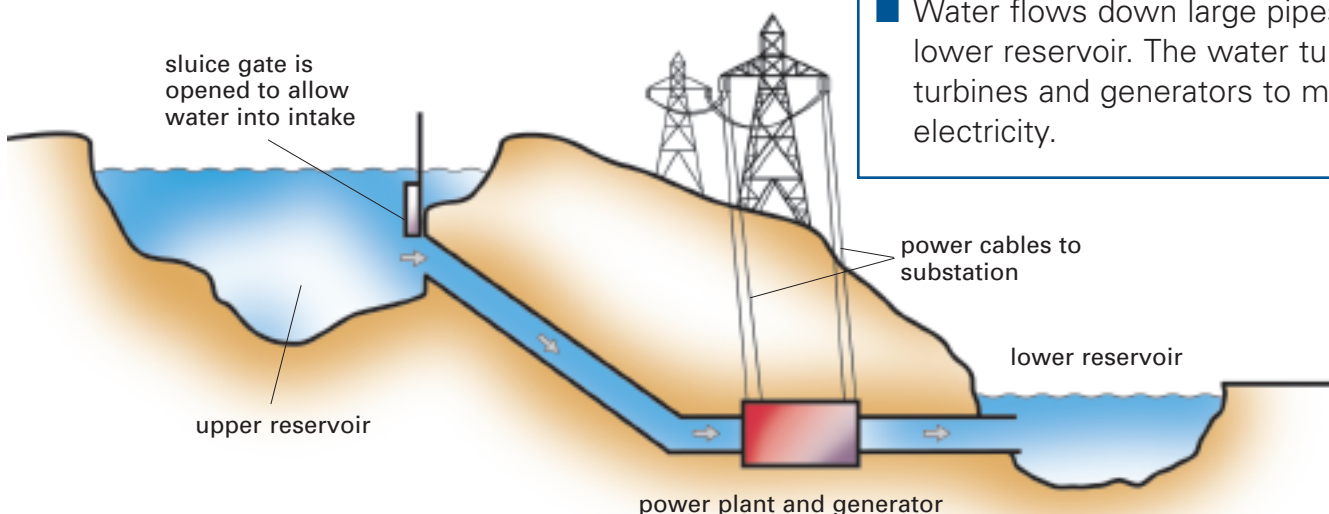
How hydroelectric energy works

A hydroelectric dam



- A river flowing through a valley is blocked by building a large concrete dam. The valley is flooded by the river, creating a reservoir, like a lake.
- Large pipes inside the dam allow water to flow through under pressure.
- The water turns turbines inside the pipes, which are connected to generators. The generators produce electricity as they spin.
- The water from the pipes flows away down the river.

Pumped storage



- Pumped storage does not use a dam, but needs two reservoirs.
- The top reservoir must be much higher than the lower one, so these schemes are built in mountain areas.
- Water flows down large pipes to the lower reservoir. The water turns turbines and generators to make electricity.



Advantages of hydroelectric energy

- It is renewable, because rain keeps falling.
- It causes no pollution.
- It is more reliable than wind or solar energy, and can be switched on when needed.



Possible disadvantages

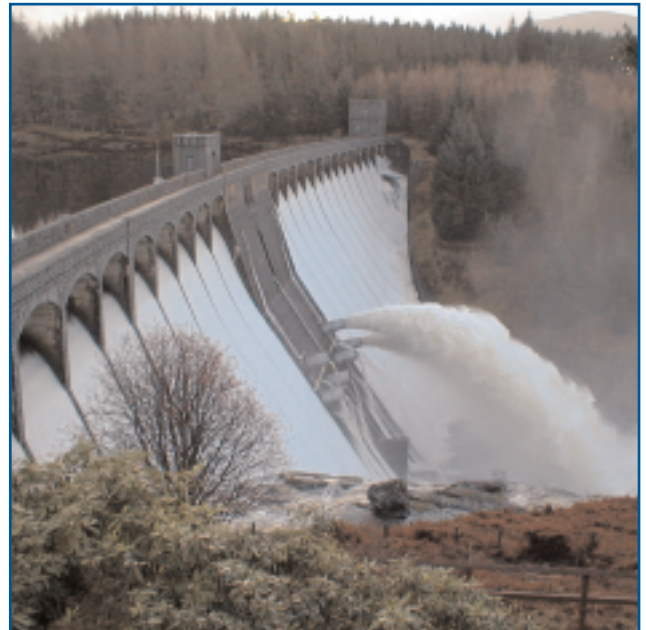
- Hydroelectric schemes are very expensive to build.
- There are few suitable sites, and land for homes may be lost when they are built.
- Wildlife habitats are lost when land is flooded to make reservoirs. River life can also be affected by dams.

Hydroelectric energy in the UK

Large hydroelectric projects have to be built in hill or mountain areas, and there are very few suitable sites left for building new dams and reservoirs. Smaller hydroelectric projects are being built on some rivers.

Hydroelectric energy facts and figures

The number of hydroelectric power plants in the UK	200
Areas of the UK that produce the most hydroelectric energy	The Scottish Highlands and Welsh mountain areas
Amount of UK's total electricity supplied by hydroelectric energy	Around 0.8%
Where is there a large hydroelectric scheme?	Elan Valley, mid Wales
How many reservoirs are there at Elan?	Five, with four dams
How much water do the reservoirs hold?	199 million tonnes
How much electricity is generated by the Elan scheme?	Enough to supply about 11,000 homes
How much electricity does a small-scale hydroelectric project produce?	A scheme at Garbhaig in Scotland can supply enough power for 750 homes



Courtesy of Roy Dyckhoff

Dams have to be extremely strong to hold the water pressing against them. This picture shows water being released under pressure, after it has turned the turbines inside the dam to generate electricity.

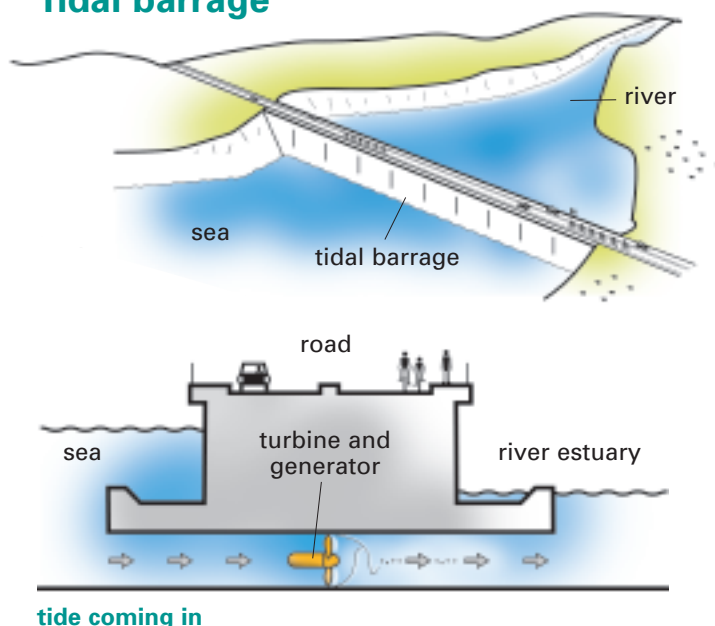
Tidal energy

What is tidal energy?

Every day the tide at the seaside goes in and out – twice. This rising and falling of the sea is caused by the pull of the moon. We can use this powerful flow of water to generate electricity.

How tidal energy works

Tidal barrage



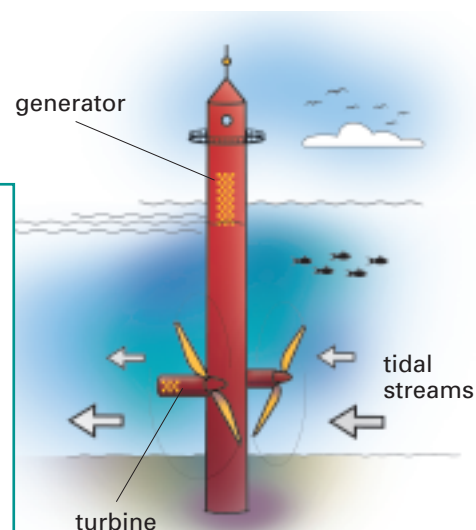
A **tidal barrage** is a giant dam that is built across a river estuary or a bay on the coast.

- As the tide comes in, the barrage holds back the sea, making a difference in the levels of water on each side.
- Gates are then opened, allowing the water to rush through and turn a turbine, to generate electricity.
- As the tide goes out, water flows the other way to turn the turbine.

Marine turbine

Tidal streams are fast sea currents that flow as tides move in and out. **Marine turbines** work like wind turbines, but are turned by sea currents.

- These turbines turn quite slowly but the sea is much more powerful than the wind.
- As the turbine turns, machinery inside it generates electricity, which is fed to shore by a cable.



Advantages of tidal energy

- Tides are more reliable than wind, waves or solar power.
- Tidal energy is renewable energy. It uses no fuel that can run out.
- Marine turbines do not affect sea life because they turn slowly.



Possible disadvantages

- There are very few good sites for tidal barrages.
- Barrages make it difficult for ships to pass through estuaries.
- Tidal barrages affect sea life, such as fish that migrate up rivers from the sea.

Tidal energy in the UK

At the moment, there are no tidal energy projects that generate electricity in the UK. In fact, there are only 40 sites across the world that are suitable for large tidal barrages. Some of these sites are in the UK, including the River Severn estuary.



Courtesy of EDF Médiathèque / G Halary

Tidal barrage at La Rance, France

These special dams have to be built across a bay or estuary where the tide rises and falls by at least 5 metres. If tidal barrages like this were built in the UK, they could generate 15% of the country's electricity.



Courtesy of Marine Current Turbines Ltd

The Seaflow project, Devon

This is the UK's first marine turbine project, and is now being tested. The rotor will be lowered into the sea so that it is turned by strong tidal streams to produce electricity. Other turbines will be added later. There are about 30 sites in the UK suitable for these machines.

Tidal energy facts and figures

The number of tidal barrages in the UK	0
The number of UK tidal stream projects being tested	2
Which parts of the UK are most suitable for tidal energy?	The West coast
Amount of UK's total electricity supplied by tidal energy	Currently 0%
How long is the tidal barrage at La Rance in France?	330 metres
How many turbines does it have?	24
How far does the sea rise and fall between tides in La Rance?	8 metres
How much electricity does the barrage at La Rance produce?	Enough for 330,000 people
For how long does it generate electricity?	About 12 hours a day

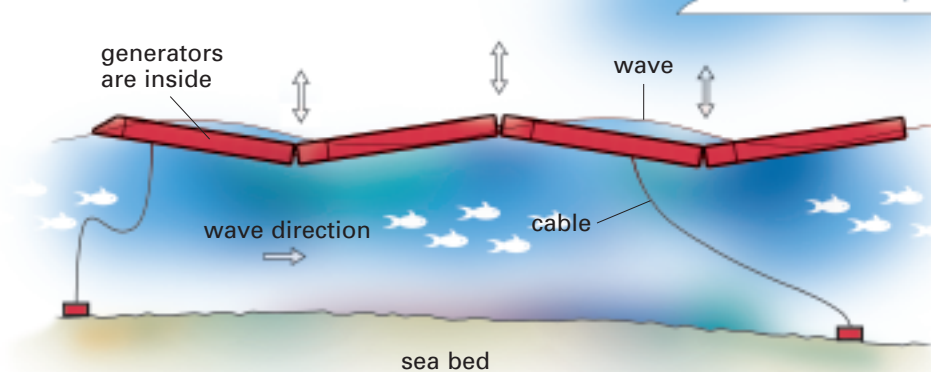
Wave energy

What is wave energy?

Waves are movements of water caused by the wind blowing across the sea. Every wave contains energy. We can use wave energy to make electricity. Waves are a source of 'renewable' energy. They will never run out, unlike fossil fuels such as coal and gas.

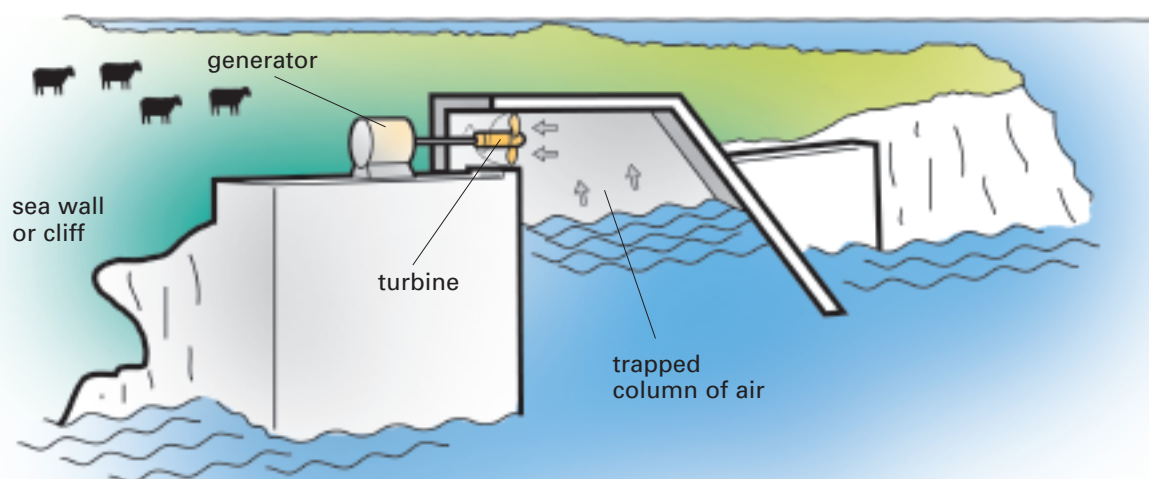
How wave machines work

The Pelamis wave machine



- The **Pelamis** is made of four giant metal tubes with movable joints.
- The action of the waves causes the tubes to move up and down.
- As the joints move, oil is forced through generators, which produce electricity as they spin.

The Limpet



- The **Limpet** is built into the shore, and has strong concrete walls.
- Incoming waves push against a column of air, which is trapped inside the machine. The air is forced upwards where it pushes a turbine (a set of spinning blades), making it turn very fast.
- As the wave retreats, air is sucked back through the turbine, causing it to spin again.
- The turbine works a generator, which makes electricity as it turns.



Advantages of wave energy

- It is a renewable form of energy, caused by wind. It can't run out.
- The machines do not spoil the landscape and do not cause pollution.
- The UK has lots of coastline and big waves from the Atlantic Ocean.



Possible disadvantages

- Storms at sea can easily damage even strong machines.
- Warning systems have to be made so ships can keep clear.
- Rust, seaweed, and barnacles can cause problems with the machinery.

Wave energy in the UK

Wave energy has not developed as quickly as wind energy, and the technology is still quite 'young'. However, since the UK is surrounded by sea, wave energy could supply a lot of the country's electricity in the future. Wave machines can be built both onshore, like Limpet, and out at sea, like the Pelamis wave machine. Scientists and engineers are trying out new ideas to make this technology better all the time.



Courtesy of Ocean Power Delivery

The Pelamis wave machine first began generating electricity from its position near Orkney in Scotland in 2004. Its location was chosen carefully for ideal waves, the best depth of sea, and to avoid passing ships.



Courtesy of Wavegen

The Limpet (Land Installed Marine Powered Energy Transformer) is on the Scottish island of Islay. It can supply electricity to about 350 homes.

Wave energy facts and figures

The number of large wave energy projects in the UK	2
The areas of the UK with the best waves for wave energy	Scotland and Cornwall
The UK's largest wave power generator	Pelamis wave machine, Orkney, Scotland
Number of households that a single large wave generator can power	500
Amount of UK's total electricity supplied by wave energy	Less than 0.1 %
How long is the Pelamis?	120 metres
How wide is it?	3.5 metres
What are the cylinders made from?	Steel
How deep is the water the Pelamis is in?	50-60 metres

Hydrogen fuel cells

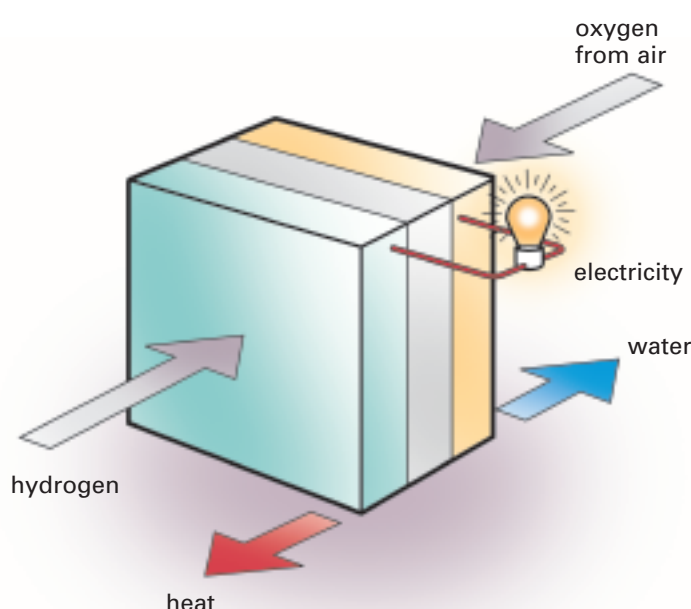
What is a hydrogen fuel cell?

A hydrogen fuel cell uses hydrogen gas to make electricity. Unlike an engine, it does not burn fuel, and so it causes no pollution. It produces only water and heat as it works.

How a hydrogen fuel cell works

Hydrogen fuel cells keep producing power as long as they have a supply of hydrogen.

Hydrogen fuel cell



- Hydrogen gas (stored in a bottle or tank) and oxygen from air are fed into the fuel cell.
- The materials in the fuel cell are arranged in layers so that a chemical process takes place.
- In this chemical process, hydrogen is used to make electricity, which can be used to power lights, motors, etc.
- Water and heat are also given off.
- There are no moving parts, so the fuel cell is very quiet.
- Hydrogen fuel cells can be very small, e.g. to power a mobile phone, or very large, e.g. to work a power station.



Advantages of hydrogen fuel cells

- Fuel cells provide quiet, clean power.
- Hydrogen can store energy to be used when it is needed – something that can't easily be done with wind or solar power.
- Fuel cells can power very small equipment or supply electricity for very large projects.
- Only water and heat are given off, but no poisonous gases.



Possible disadvantages

- Hydrogen fuel cells are still expensive to make, although they will become cheaper in the future.
- Fuel cells need a supply of hydrogen. Today, most hydrogen is made from fossil fuels such as coal, which pollute the air. However, it can be made using renewable energy, such as wind power, or from nuclear electricity.
- It is difficult to store enough hydrogen on board a vehicle to allow it to travel long distances.

Hydrogen fuel cells in the UK

Scientists are still looking into ways to make cheaper hydrogen fuel cells that work better. Currently, fuel cells are only being used in tests to find out how they can supply energy to different kinds of projects, such as transport, homes, road signs and factories.

Hydrogen fuel cell facts and figures

The number of large-scale hydrogen fuel cell projects being tested in the UK	1 (The Tees Valley Hydrogen Project)
Which parts of the UK are most suitable for hydrogen fuel cells?	All parts
Amount of UK's total electricity supplied by hydrogen fuel cells	Currently 0%
How many European cities have fuel cell buses?	9
How many fuel cell buses are being tested in London?	3
How far can they travel before they need more hydrogen?	200km
Do the fuel cell buses help to give cities cleaner air?	Yes
Are there any drawbacks to using fuel cell buses at the moment?	Fuel cell buses are heavier than buses with engines, and more expensive to run.



Courtesy of Matthew Woolf

Fuel cell buses in London

London is one of several European cities testing how well electric buses powered by fuel cells work. The buses are quiet, and produce almost no pollution. They are refuelled with bottles of compressed hydrogen, which are stored on the roof of the bus.



Courtesy of Woking Borough Council

Woking Park leisure centre

This is the first leisure centre in the UK to use hydrogen fuel cells for its energy needs. The fuel cells heat the swimming pool, provide clean water, and supply all the centre's electricity. The system even makes chilled water for the building's air conditioning.