Energy Sources & Power Stations

There are 12 different types of energy resource.
They fit into two broad types: renewable and non-renewable.

Non-Renewable Energy Resources Will Run Out One Day

The non-renewables are the three FOSSIL FUELS and NUCLEAR:

1) Coal
2) Oil
3) Natural gas
4) Nuclear fuels (uranium and plutonium)

a) They will all 'run out' one day.
b) They all do damage to the environment.
c) But they provide most of our energy.

Renewable Energy Resources Will Never Run Out

The renewables are:

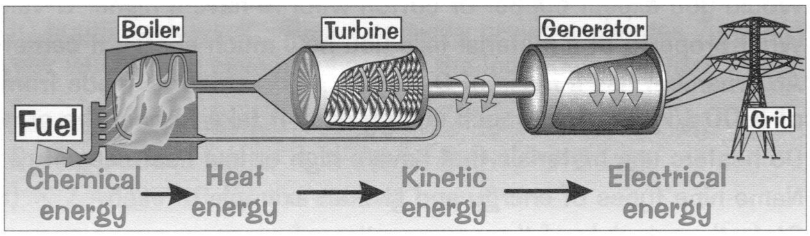
1) Wind
2) Waves
3) Tides
4) Hydroelectric
5) Solar
6) Geothermal
7) Food
8) Biofuels

a) These will never run out.
b) Most of them do damage the environment, but in less nasty ways than non-renewables.
c) The trouble is they don't provide much energy and some of them are unreliable because they depend on the weather.

Energy Sources can be Burned to Drive Turbines in Power Stations

Most of the electricity we use is generated from the four NON-RENEWABLE sources of energy (coal, oil, gas and nuclear) in big power stations, which are all pretty much the same apart from the boiler.

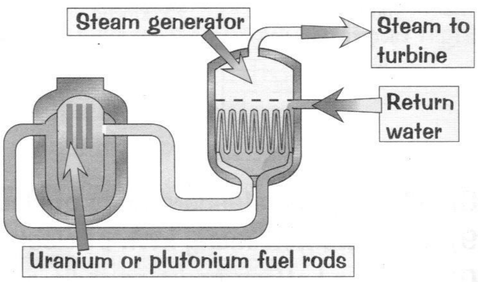
Learn the basic features of the typical power station shown here and also the nuclear reactor below.



1) The fossil fuel is burned to convert its stored chemical energy into heat (thermal) energy.
2) The heat energy is used to heat water (or air in some fossil-fuel power stations) to produce steam.
3) The steam turns a turbine, converting heat energy into kinetic energy.
4) The turbine is connected to a generator, which transfers kinetic energy into electrical energy.

Nuclear Reactors are Just Fancy Boilers

1) A nuclear power station is mostly the same as the one above, but with nuclear fission of uranium or plutonium producing the heat to make steam to drive turbines, etc. The difference is in the boiler, as shown here:
2) Nuclear power stations take the longest time of all the power stations to start up. Natural gas power stations take the shortest time of all the fossil fuel power stations.



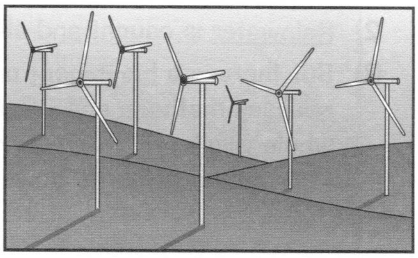
It all boils down to steam...

Steam engines were invented as long ago as the 17th century, and yet we're still using that idea to produce most of our electricity today, over 300 years later. Amazing...

Renewable Energy Sources

Renewable energy sources, like wind, waves and solar energy, will not run out. What's more, they do a lot less damage to the environment. They don't generate as much electricity as non-renewables though — if they did we'd all be using solar-powered toasters by now.

Wind Power — Lots of Little Wind Turbines

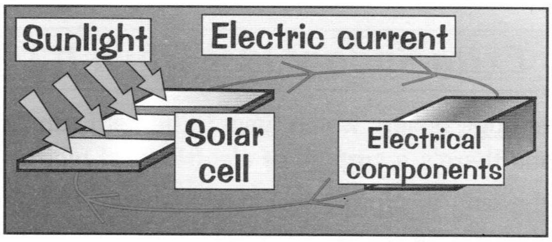


1) This involves putting lots of windmills (wind turbines) up in exposed places like on moors or round coasts.
2) Each wind turbine has its own generator inside it. The electricity is generated directly from the wind turning the blades, which turn the generator.
3) There's no pollution (except for a little bit when they're manufactured).
4) But they do spoil the view. You need about 1500 wind turbines to replace one coal-fired power station and 1500 of them cover a lot of ground — which would have a big effect on the scenery.
5) And they can be very noisy, which can be annoying for people living nearby.
6) There's also the problem of no power when the wind stops, and it's impossible to increase supply when there's extra demand.
7) The initial costs are quite high, but there are no fuel costs and minimal running costs.
8) There's no permanent damage to the landscape — if you remove the turbines, you remove the noise and the view returns to normal.

Solar Cells — Expensive but No Environmental Damage

(well, there may be a bit caused by making the cells)

1) Solar cells generate electric currents directly from sunlight. Solar cells are often the best source of energy for calculators and watches which don't use much electricity.



2) Solar power is often used in remote places where there's not much choice (e.g. the Australian outback) and to power electric road signs and satellites.
3) There's no pollution. (Although they do use quite a lot of energy to manufacture in the first place.)
4) In sunny countries solar power is a very reliable source of energy — but only in the daytime. Solar power can still be cost-effective even in cloudy countries like Britain.
5) Initial costs are high but after that the energy is free and running costs almost nil.
6) Solar cells are usually used to generate electricity on a relatively small scale, e.g. powering individual homes.
7) It's often not practical or too expensive to connect them to the National Grid — the cost of connecting them to the National Grid can be enormous compared with the value of the electricity generated.

People love the idea of wind power — just not in their back yard...

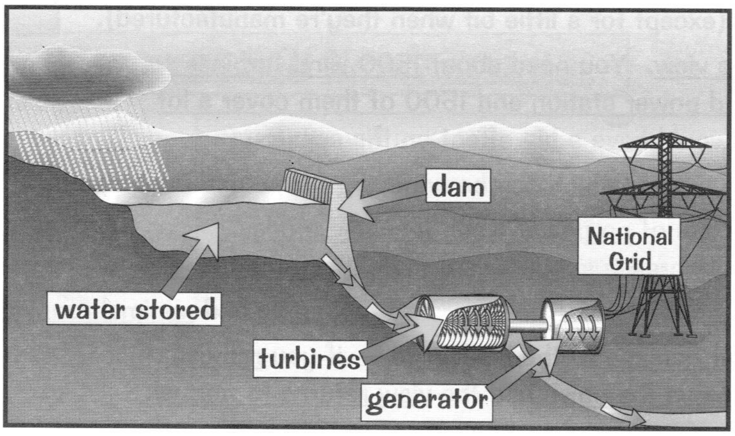
Did you know you can now get rucksacks with built-in solar cells to charge up your mobile phone, MP3 player and digital camera while you're wandering around. Pretty cool, huh.

Renewable Energy Sources

Good ol' water. Not only can we drink it — we can also use it to turn turbines in the same way as wind. Wherever water is moving — in waves, rivers and tides, we can transfer its kinetic energy into electrical energy.

Hydroelectric Power Uses Falling Water

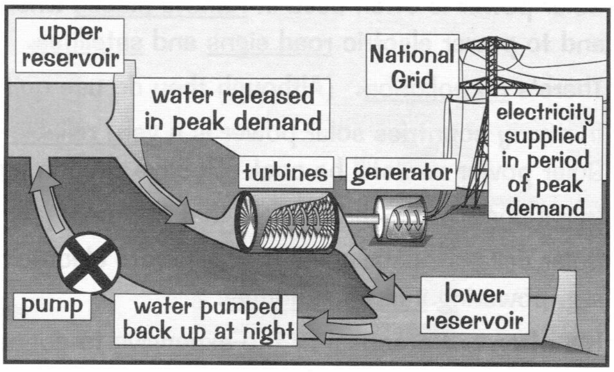
1) Hydroelectric power usually requires the flooding of a valley by building a big dam.
2) Rainwater is caught and allowed out through turbines. There is no pollution (as such).
3) But there is a big impact on the environment due to the flooding of the valley (rotting vegetation releases methane and CO_2) and possible loss of habitat for some species (sometimes the loss of whole villages). The reservoirs can also look very unsightly when they dry up.
Putting hydroelectric power stations in remote valleys tends to reduce their impact on humans.



4) A big advantage is it can provide an immediate response to an increased demand for electricity.
5) There's no problem with reliability except in times of drought — but remember this is **Great Britain** we're talking about.
6) Initial costs are high, but there's no fuel and minimal running costs.
7) It can be a useful way to generate electricity on a small scale in remote areas.

Pumped Storage Gives Extra Supply Just When It's Needed

1) Most large power stations have huge boilers which have to be kept running all night even though demand is very low. This means there's a surplus of electricity at night.
2) It's surprisingly difficult to find a way of storing this spare energy for later use.
3) Pumped storage is one of the best solutions.
4) In pumped storage, 'spare' night-time electricity is used to pump water up to a higher reservoir.
5) This can then be released quickly during periods of peak demand such as at teatime each evening, to supplement the steady delivery from the big power stations.
6) Remember, pumped storage uses the same idea as hydroelectric power, but it isn't a way of generating power — it's simply a way of storing energy which has already been generated.



The hydroelectric power you're supplying — it's electrifying...

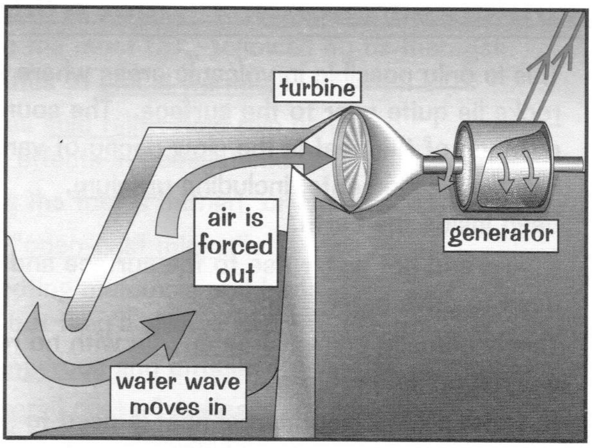
In Britain only a pretty small percentage of our electricity comes from hydroelectric power at the moment, but in some other parts of the world they rely much more heavily on it. For example, in the last few years, 99% of Norway's energy came from hydroelectric power. 99% — that's huge!

Renewable Energy Sources

Don't worry — I haven't forgotten about wave power and tidal power. It's easy to get confused between these two just because they're both to do with the seaside — but don't. They are completely different.

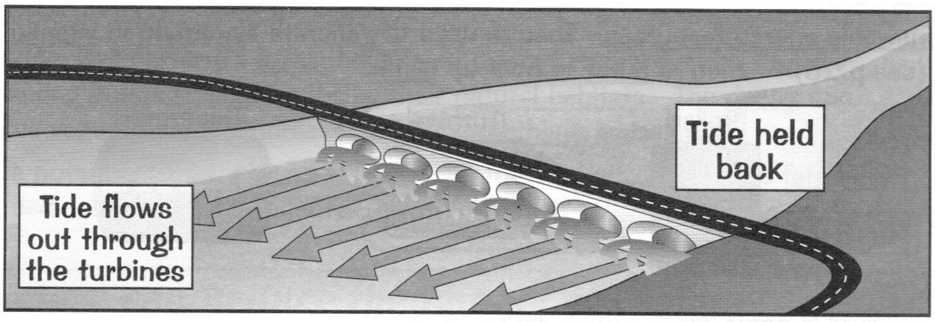
Wave Power — Lots of Little Wave-Powered Turbines

1) You need lots of small wave-powered turbines located around the coast.
2) As waves come in to the shore they provide an up and down motion which can be used to drive a generator.
3) There is no pollution. The main problems are spoiling the view and being a hazard to boats.
4) They are fairly unreliable, since waves tend to die out when the wind drops.
5) Initial costs are high, but there are no fuel costs and minimal running costs. Wave power is never likely to provide energy on a large scale, but it can be very useful on small islands.



Tidal Barrages — Using the Sun and Moon's Gravity

1) Tidal barrages are big dams built across river estuaries, with turbines in them.
2) As the tide comes in it fills up the estuary to a height of several metres — it also drives the turbines. This water can then be allowed out through the turbines at a controlled speed.
3) The source of the energy is the gravity of the Sun and the Moon.
4) There is no pollution. The main problems are preventing free access by boats, spoiling the view and altering the habitat of the wildlife, e.g. wading birds, sea creatures and beasties who live in the sand.



5) Tides are pretty reliable in the sense that they happen twice a day without fail, and always near to the predicted height. The only drawback is that the height of the tide is variable so lower (neap) tides will provide significantly less energy than the bigger 'spring' tides. They also don't work when the water level is the same either side of the barrage — this happens four times a day because of the tides. But tidal barrages are excellent for storing energy ready for periods of peak demand.
6) Initial costs are moderately high, but there are no fuel costs and minimal running costs. Even though it can only be used in some of the most suitable estuaries tidal power has the potential for generating a significant amount of energy.

Learn about Wave Power — and bid your cares goodbye...

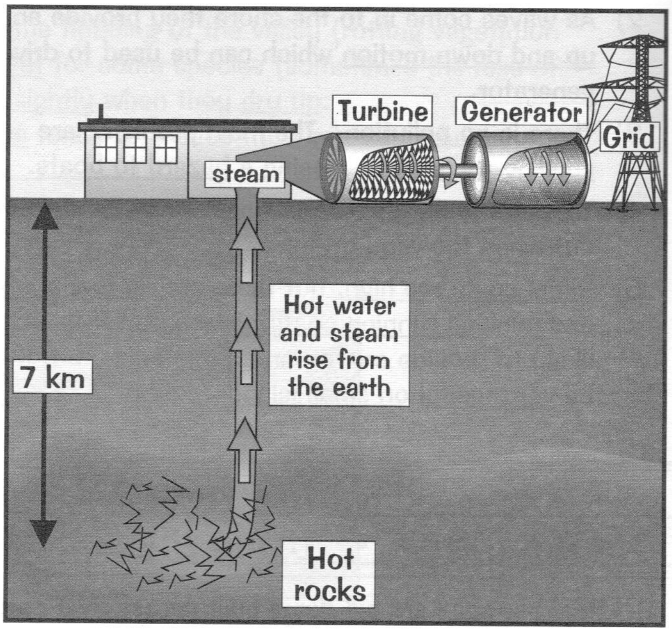
I do hope you appreciate the big big differences between tidal power and wave power. They both involve salty seawater, sure — but there the similarities end. Lots of jolly details then, just waiting to be absorbed into your cavernous intracranial void. Smile and enjoy. And learn.

Renewable Energy Sources

Well, who'd know it — there's yet more energy lurking about in piles of rubbish and deep underground. Makes you wonder sometimes why we even need to use oil. (If you are wondering about that, page 32 is all about comparing energy resources, so sit tight for now.)

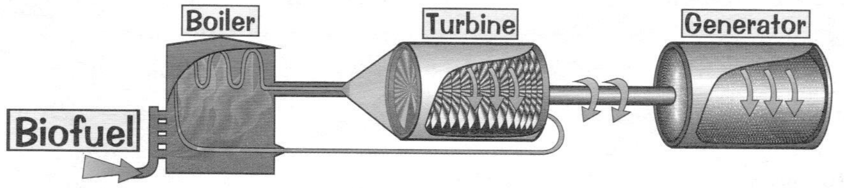
Geothermal Energy — Heat from Underground

1) This is only possible in volcanic areas where hot rocks lie quite near to the surface. The source of much of the heat is the slow decay of various radioactive elements, including uranium, deep inside the Earth.
2) Steam and hot water rise to the surface and are used to drive a generator.
3) This is actually brilliant free energy with no real environmental problems.
4) In some places, geothermal heat is used to heat buildings directly, without being converted to electrical energy.
5) The main drawback with geothermal energy is there aren't very many suitable locations for power plants.
6) Also, the cost of building a power plant is often high compared to the amount of energy we can get out of it.

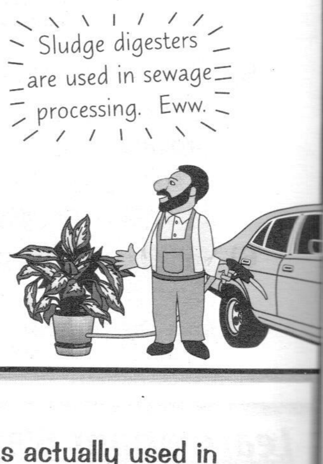


Biofuels are Made from Plants and Waste

1) Biofuels are renewable energy resources. They're used to generate electricity in exactly the same way as fossil fuels (see p.26) — they're burnt to heat up water.



2) They can be also used in some cars — just like fossil fuels.
3) Biofuels can be solids (e.g. straw, nutshells and woodchips), liquids (e.g. ethanol) or gases (e.g. methane 'biogas' from sludge digesters).
4) We can get biofuels from organisms that are still alive or from dead organic matter — like fossil fuels, but from organisms that have been living much more recently.
5) E.g. crops like sugar cane can be fermented to produce ethanol, or plant oils can be modified to produce biodiesel.



Sugar cane to ethanol — a terrible waste in my opinion...

Biofuels sound quite futuristic. But believe it or not, biofuel mixed with petrol or diesel was actually used in some cars before WW2. Biofuel never really became massively successful though because of cheap oil. One big advantage of biofuels is they don't release as much greenhouse gas compared with common transport fuels like petrol and diesel. They aren't completely innocent in the pollution game though, as you'll see on the next page.

Energy Sources and the Environment

They might fly you to Spain for your holidays and power your games consoles, but using non-renewable energy sources and biofuels to generate electricity can have damaging effects on the environment.

Non-Renewables are Also Linked to Other Environmental Problems

1) All three fossil fuels (coal, oil and gas) release CO_2 into the atmosphere when they're burned. For the same amount of energy produced, coal releases the most CO_2, followed by oil then gas. All this CO_2 adds to the greenhouse effect, and contributes to global warming.
2) Burning coal and oil releases sulfur dioxide, which causes acid rain. Acid rain can be harmful to trees and soils and can have far-reaching effects in ecosystems.
3) Acid rain can be reduced by taking the sulfur out before the fuel is burned, or cleaning up the emissions.
4) Coal mining makes a mess of the landscape, especially "open-cast mining".
5) Oil spillages cause serious environmental problems, affecting mammals and birds that live in and around the sea. We try to avoid them, but they'll always happen.
6) Nuclear power is clean but the nuclear waste is very dangerous and difficult to dispose of.
7) Nuclear fuel (i.e. uranium) is relatively cheap but the overall cost of nuclear power is high due to the cost of the power plant and final decommissioning.
8) Nuclear power always carries the risk of a major catastrophe like the Chernobyl disaster in 1986.

Biofuels Have Their Disadvantages Too

1) Biofuels (see p.30) are a relatively quick and 'natural' source of energy and are supposedly carbon neutral.
2) There is still debate into the impact of biofuels on the environment, once the full energy that goes into the production is considered.

The plants that grew to produce the waste (or to feed the animals that produced the dung) absorbed carbon dioxide from the atmosphere as they were growing. When the waste is burnt, this CO_2 is re-released into the atmosphere. So it has a neutral effect on atmospheric CO_2 levels (although this only really works if you keep growing plants at the same rate you're burning things). Biofuel production also creates methane emissions — a lot of this comes from the animals. Nice.

Huge areas of land are needed to produce biofuels on a large scale.

3) In some regions, large areas of forest have been cleared to make room to grow biofuels, resulting in lots of species losing their natural habitats. The decay and burning of this vegetation also increases CO_2 and methane emissions.
4) Biofuels have potential, but their use is limited by the amount of available farmland that can be dedicated to their production.

Carbon Capture can Reduce the Impact of Carbon Dioxide

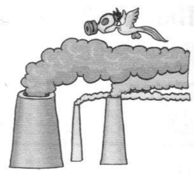
1) Carbon capture and storage (CCS) is used to reduce the amount of CO_2 building up in the atmosphere and reduce the strength of the greenhouse effect.
2) CCS works by collecting the CO_2 from power stations before it is released into the atmosphere.
3) The captured CO_2 can then be pumped into empty gas fields and oil fields like those under the North Sea. It can be safely stored without it adding to the greenhouse effect.
4) CCS is a new technology that's developing quickly. New ways of storing CO_2 are being explored, including storing CO_2 dissolved in seawater at the bottom of the ocean and capturing CO_2 with algae, which can then be used to produce oil that can be used as a biofuel.

Biofuels are great — but don't burn your biology notes just yet...

Wowsers. There certainly is a lot to bear in mind with all the different energy sources and all the good things and nasty things associated with each of them. The next page is really handy for making comparisons between different energy sources — it'll tell you everything you need to know. (Secret hint: you should definitely read it.)

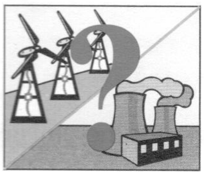
Comparison of Energy Resources

Setting Up a Power Station



Because coal and oil are running out fast, many old coal- and oil-fired power stations are being taken out of use. Often they're being replaced by gas-fired power stations because they're quick to set up, there's still quite a lot of gas left and gas doesn't pollute as badly as coal and oil.

But gas is not the only option, as you really ought to know if you've been concentrating at all over the last few pages.



When looking at the options for a new power station, there are several factors to consider: How much it costs to set up and run, how long it takes to build, how much power it can generate, etc. Then there are also the trickier factors like damage to the environment and impact on local communities. And because these are often very contentious issues, getting permission to build certain types of power station can be a long-running process, and hence increase the overall set-up time. The time and cost of decommissioning (shutting down) a power plant can also be a crucial factor.

Set-Up Costs

Renewable resources often need bigger power stations than non-renewables for the same output. And as you'd expect, the bigger the power station, the more expensive.

Nuclear reactors and hydroelectric dams also need huge amounts of engineering to make them safe, which bumps up the cost.

Reliability Issues

All the non-renewables are reliable energy providers (until they run out).

Many of the renewable sources depend on the weather, which means they're pretty unreliable here in the UK. The exceptions are tidal power and geothermal (which don't depend on weather).

Environmental Issues

If there's a fuel involved, there'll be waste pollution and you'll be using up resources.

If it relies on the weather, it's often got to be in an exposed place where it sticks out like a sore thumb.

Atmospheric Pollution
Coal, Oil, Gas,
(+ others, though less so)

Visual Pollution
Coal, Oil, Gas, Nuclear, Tidal, Waves, Wind, Hydroelectric,

Other Problems
Nuclear (dangerous waste, explosions, contamination), Hydroelectric (dams bursting)

Using Up Resources
Coal, Oil, Gas, Nuclear

Noise Pollution
Coal, Oil, Gas, Nuclear, Wind,

Disruption of Habitats
Hydroelectric, Tidal, Biofuels.

Disruption of Leisure Activities (e.g. boats)
Waves, Tidal

Set-Up/Decommissioning Time

These are both affected by the size of the power station, the complexity of the engineering and also the planning issues (e.g. discussions over whether a nuclear power station should be built on a stretch of beautiful coastline can last years). Gas is one of the quickest to set up. Nuclear power stations take by far the longest (and cost the most) to decommission.

Running/Fuel Costs

Renewables usually have the lowest running costs, because there's no actual fuel involved.

Location Issues

This is fairly common sense — a power station has to be near to the stuff it runs on.

Solar — pretty much anywhere, though the sunnier the better

Gas — pretty much anywhere there's piped gas (most of the UK)

Hydroelectric — hilly, rainy places with floodable valleys, e.g. the Lake District, Scottish Highlands

Wind — exposed, windy places like moors and coasts or out at sea

Oil — near the coast (oil transported by sea)

Waves — on the coast

Coal — near coal mines, e.g. Yorkshire, Wales

Nuclear — away from people (in case of disaster), near water (for cooling)

Tidal — big river estuaries where a dam can be built

Geothermal — fairly limited, only in places where hot rocks are near the Earth's surface

Of course — the biggest problem is we need too much electricity...

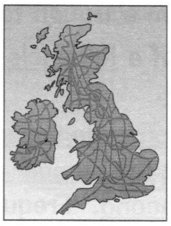
It would be lovely if we could get rid of all the nasty polluting power stations and replace them with clean, green fuel, just like that... but it's not quite that simple. Renewable energy has its own problems too, and probably isn't enough to power the whole country without having a wind farm in everyone's back yard.

Electricity and the National Grid

The National Grid is the network of pylons and cables that covers the whole of Britain, getting electricity to homes everywhere. Whoever you pay for your electricity, it's the National Grid that gets it to you.

Electricity is Distributed via the National Grid...

1) The National Grid takes electrical energy from power stations to where it's needed in homes and industry.
2) It enables power to be generated anywhere on the grid, and then be supplied anywhere else on the grid.
3) To transmit the huge amount of power needed, you need either a high voltage or a high current.

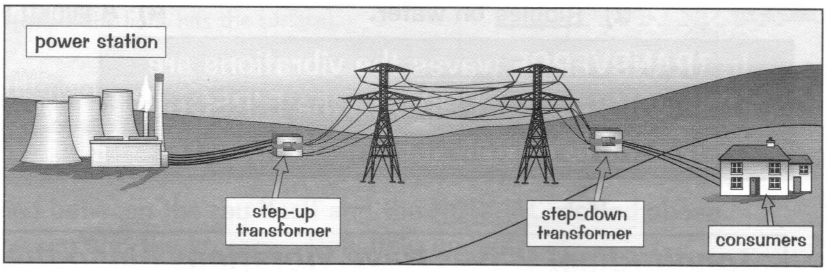


You might come across the term 'potential difference' — this is just another way of saying 'voltage'.

4) The problem with a high current is that you lose loads of energy through heat in the cables.
5) It's much cheaper to boost the voltage up really high (to 400 000 V) and keep the current very low.

...With a Little Help from Pylons and Transformers

1) To get the voltage to 400 000 V to transmit power requires transformers as well as big pylons with huge insulators — but it's still cheaper.
2) The transformers have to step the voltage up at one end, for efficient transmission, and then bring it back down to safe, usable levels at the other end.



3) The voltage is increased ('stepped up') using a step-up transformer. (Yep, does what it says on the tin.)
4) It's then reduced again ('stepped down') at the consumer end using a step-down transformer.

There are Different Ways to Transmit Electricity

1) Electrical energy can be moved around by cables buried in the ground, as well as in overhead power lines.
2) Each of these different options has its pros and cons:

	Setup cost	Maintenance	Faults	How it looks	Affected by weather	Reliability	How easy to set up	Disturbance to land
Overhead Cables	lower	lots needed	easy to access	ugly	yes	less reliable	easy	minimal
Underground Cables	higher	minimal	hard to access	hidden	no	more reliable	hard	lots

Supply and Demand

1) The National Grid needs to generate and direct all the energy that the country needs — our energy demands keep on increasing too.
2) In order to meet these demands in the future, the energy supplied to the National Grid will need to increase, or the energy demands of consumers will need to decrease.
3) In the future, supply can be increased by opening more power plants or increasing their power output (or by doing both).
4) Demand can be reduced by consumers using more energy-efficient appliances, and being more careful not to waste energy in the home (e.g. turning off the lights or running washing machines at cooler temperatures).

Transformers — NOT robots in disguise...

You don't need to know the details about exactly what transformers are and how they work — just that they increase and decrease the voltage to minimise power losses in the National Grid. Make sure you know the good, bad and occasionally ugly pros and cons of underground and over-ground electricity transmission too.