Friends of the Earth

Renewable energy

Your questions answered

Climate crisis:
Time for an energy revolution

Climate change is the most urgent environmental threat facing people and the planet. The greenhouse gases responsible for it come from human activity. The most important of these gases is carbon dioxide (CO_2) which is pushing up average temperatures at the Earth's surface, leading to more severe weather events – floods, droughts and storms, as well as rising sea levels and disruption to entire eco-systems. The impact on people across the world could be catastrophic if we don't act soon.

To avoid dangerous changes to our climate we must curb rising global emissions of CO_2 within the next decade. As well as doing everything we can to save energy and use it more efficiently, we need to switch to forms of energy that do not produce CO_2 – and there are plenty of them.

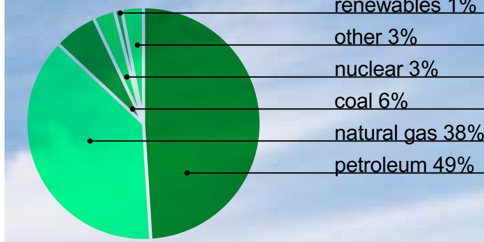
Renewable energy comes from sources that don't run out – like the sun, wind, tides, waves or plants. These natural sources can be harnessed to create electricity without adding carbon dioxide to the air.

The UK has signed a Europe-wide agreement to get 20 per cent of all energy (not just electricity but heat and transport fuel too) from renewables by 2020. The UK's share of this target is 15 per cent. We have a long way to go to reach this benchmark – in 2006 less than 2 per cent of all UK energy came from renewables.

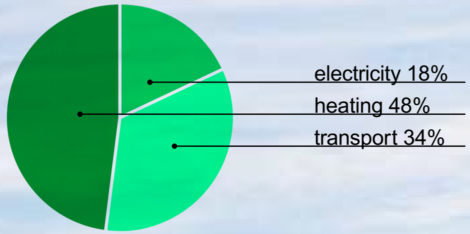
This booklet, adapted from a chapter of Friends of the Earth's *How can I Stop Climate Change?* (Collins, 2008) looks at the vital role these cleaner energy technologies will play in turning Britain into a thriving, progressive low-carbon economy. We focus on where renewables have the best potential – to clean up the way we produce electricity and heat.

Contents

Final energy supply, UK / 2006



Final energy use, UK / 2006



Source: BERR

We consume energy in Britain for three main uses: heating, electricity and transport fuel. Most – over 90 per cent – of this energy still comes from gas, oil and coal, known as fossil fuels. All fossil fuels emit large amounts of carbon dioxide when burned, although there are differences in efficiency: burning coal in a power station, for example, produces more carbon dioxide per unit of useable energy than burning petrol in a car.

Amelia Collins

There is no single silver bullet, but many

Top five green energy technologies

1 Offshore wind
2 Onshore wind
3 Solar (including concentrated solar power)
4 Sustainable biomass with combined heat and power
5 Ground source heat

Did you know?
Every gigawatt of dirty power replaced with clean green energy saves up to 1.5 million tonnes of carbon annually.

Electricity represents less than a fifth of all the energy we use. But making it produces more than a third of the UK's total carbon dioxide emissions. That's why we need to start by looking at alternative ways of generating electricity.

How much renewable energy could Britain produce?

With some of the windiest weather in Europe and almost 8,000 miles of coastline, the UK is a power house waiting to be switched on. No single source of renewable energy will provide for all our needs: visions of the whole of Britain covered in wind turbines, or the coast surrounded by wave machines are fantasy – or scaremongering. But a big, diverse family of renewable technologies could help shrink the UK's carbon footprint drastically.

How much would it cost?

Because many renewables technologies are relatively new their costs can be high – although technology tends to become cheaper as it matures. Costs can also be affected by factors such as location: windy hilltops are better sites for wind farms than are sheltered valleys; some stretches of coast offer greater wave potential than others. Ironically, one thing that has been left out of conventional economic assessments of energy is the costs of pollution and future climate change impacts. Take those into account and renewables start making economic sense, too.

The Government could make cost a less significant barrier to renewables. It could, for example, remove some of the hurdles in developing wind farms, especially offshore, provide more subsidy for renewables and make it more expensive to pollute. Given the urgent need to tackle climate change, the Government should be doing everything in its power to make the shift to clean energy very rapidly.

In future we need to get our energy from a mix of different sources. Renewables – especially large scale wind, marine and solar installations – have lots of potential, and with the right support could curb our greenhouse gas emissions massively. Sources such as solar hot water, solar electric and heat from the ground offer savings to households; and biomass – such as wood – is useful where there is a ready supply of sustainable fuel. All of these could be developed to help us make the transition away from fossil fuels.

To make the transition as cleanly as possible we also need to improve the way we use fossil fuels – through combined heat and power (CHP), more efficient use of fossil fuels, and by capturing carbon rather than simply pumping it into the atmosphere. Renewable sources will offer benefits including more jobs and better air quality – as well as being kinder to the climate. If the Government gets serious about renewables and energy efficiency, Britain doesn't need to build new dirty power stations to keep the lights on.

Given the available alternatives, what could the UK's energy mix look like in a low-carbon future?

To meet our European targets 40 per cent or more of our electricity will need to come from renewable resources. Meeting the Government's aspiration of 33 GW of offshore wind would provide 25 per cent of electricity demand. One study suggests that by 2050, small-scale renewable energy at a domestic level could provide 30-40 per cent of the UK's total electricity needs.

There are many energy options, from local power to imported solar, smart grid electrics or travelling less. No one solution will cut our emissions enough – it is the package of solutions that must be embraced if we are to cut them at all. The choice is ours.

Section 01: Electricity

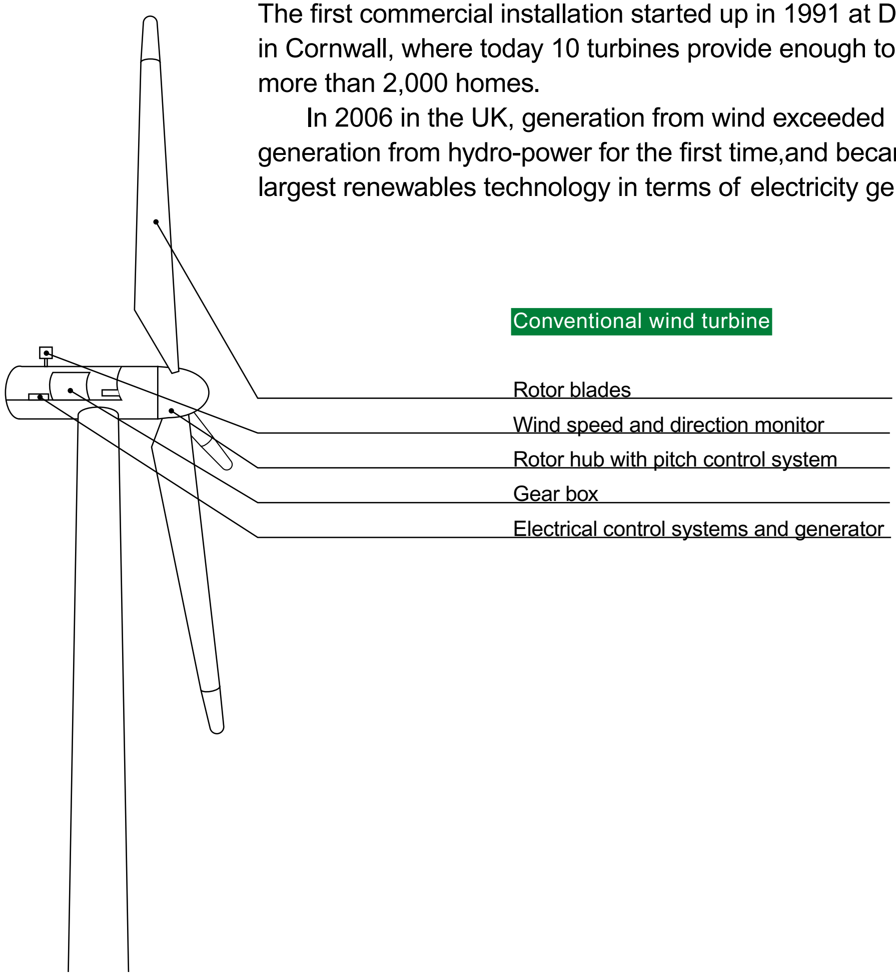
Power from wind

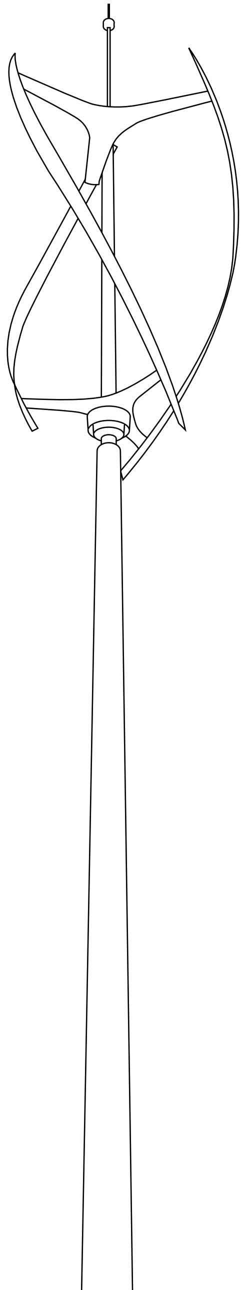
Wind turbines work on land (onshore) or in the sea (offshore). Although under-exploited, wind energy is well understood and already working hard for the UK. It is one of the most technically and economically developed forms of renewable electricity generation.

Britain's first wind farm, on Orkney, dates back to 1978. The first commercial installation started up in 1991 at Delabole in Cornwall, where today 10 turbines provide enough to power more than 2,000 homes.

In 2006 in the UK, generation from wind exceeded generation from hydro-power for the first time,and became the largest renewables technology in terms of electricity generated.

Conventional wind turbine





Vertical axis wind turbine

Five myths about wind turbines

1 **"Windpower is unreliable and needs backup from other sources"** Wind can be accurately predicted, giving a clear guide to how much power is likely to be available. The National Grid says wind power does not pose a major problem in balancing the UK's electricity supply.

2 **"Wind turbines are dangerous for birds"** The RSPB says wind farms do not pose a big hazard for birds unless poorly sited. The RSPB warns that climate change poses the most serious threat to birds and wildlife and it supports the development of wind energy.

3 **"Wind turbines are a blot on the landscape"** Public opinion surveys generally show around 80 per cent support for wind energy. Given the choice between a wind farm, a coal-fired power station or a nuclear plant near your home, which would you chose?

4 **"Wind farms bring down house prices"** Studies show that wind farms do not have a long-term effect on local house prices; prices may fall during the planning stage when there is uncertainty about the development. Improvements have overcome initial problems with noise, provided the turbines are appropriately located.

5 **"It takes more energy to build a wind farm than it will ever generate"** According to npower, the average wind farm will pay back the energy used in its manufacture within three to five months of operation. Given an expected lifespan of 20 years, that's 19 years and seven months of carbon-free energy.

Electricity: from onshore wind

What potential does onshore wind have?

By the end of 2007 there were 169 onshore wind farms in the UK providing enough electricity for more than 1.4 million homes. Projects under construction or with planning permission would bring generating capacity to nearly 5 per cent of the UK's electricity.

So what's stopping this well-understood technology coming into its own? One obstacle is the way local council planning committees apply national guidance. Wind farm applications are supposed to be processed within 16 weeks, but in reality take an average of three years, and many are getting turned down. The Government has amended planning guidance to prioritise tackling climate change, but many local councillors are ignoring the guidance. Numerous onshore wind projects have got stuck in the planning system.

Another obstacle is getting a connection to the National Grid. In 2006 projects totalling some 13.5 GW of potential on- and offshore wind power were queuing up to be connected.

Did you know?
A 1 MW turbine can provide electricity for about 600 houses; so a 5 MW wind farm can provide enough electricity for around 3,000 homes, depending on the site.

Onshore wind at a glance

Fuel	Wind
Typical capacity	2–3 MW per turbine
Land requirements	Small
Lifespan	20 years per turbine
Decommissioning	No lasting impacts
Advantages	Zero net emissions after 3-5 months, inexhaustible resource, tends to be most productive in winter when demand is high.
Disadvantages	Controversial visual effects, potential noise, interference with telecommunications, small threat to birds, variable output.

Electricity: from offshore wind

Paul Glendell / Friends of the Earth

What potential does offshore wind have?

With shallow waters and strong winds, the UK has potentially the largest offshore wind resource in the world. Some estimates put this at a third of the total offshore potential for Europe – enough electricity to power the UK several times over. Meeting the Government's ambition to install 33 GW of offshore wind would generate 25 per cent of UK electricity demand.

Yet the UK has been slow to get off the mark. Denmark's Horns Rev wind farm has been for some time the world's largest with 80 turbines. The UK had eight working offshore wind farms by the end of 2007. A big new wind farm, the London Array, is due to start up in 2012 with around 300 turbines and a total capacity of 1 GW (enough for 750,000 homes). Seven larger sites that already have permission, plus applications for more, could bring capacity up to around 5 per cent of the UK's electricity supply.

Offshore wind at a glance

Fuel	Wind
Typical capacity	3 MW per turbine; 5 MW turbines are being introduced
Land requirements	Offshore
Lifespan	20 years
Decommissioning	No lasting impacts
Advantages	Zero emissions after less than a year. Visual effects less controversial than onshore wind, larger turbines can be used and winds are stronger. Can have positive effect on marine environment. Practical potential to supply quarter of UK electricity by 2020.
Disadvantages	Possible effects on sea birds and the marine environment. Variable output. Needs new grid.

Electricity: from the sun

Electricity can be generated from the sun's rays in two ways, solar photovoltaic (PV) (or solar electric) power and concentrated solar power (CSP).

Solar electric

Solar photovoltaic (PV) cells are designed mainly for small-scale or micro-generation. They are made from semiconducting materials, such as silicon, that produce electricity when exposed to daylight. Excess electricity can be fed into the grid. Although the technology has a high initial cost, if integrated during building or refurbishment it can replace conventional tiles or cladding. Once installed it generally requires little or no maintenance. New cells are being tested that are more efficient, have a better environmental footprint, and can work indoors and in dim conditions.

Did you know?
Solar electric does not need to be in direct sunlight to work. It will produce electricity even on cloudy days (but not at night). Power varies according to the position, the amount of sunlight, and the type of cell used.

Did you know?
Installer Solarcentury says 10 square metres of panels will provide nearly a third of the electricity needed by a three-bedroom home.

Solar electric at a glance

Fuel	Sun
Typical output	Average domestic installation rated output of 1–3 KW
Land requirements	Can be fitted on existing roofs and buildings
Lifespan	30+ years
Advantages	Inexhaustible; lots of roof space available; off grid potential. The technology is improving all the time; huge potential for efficiency improvement.
Disadvantages	Cost; energy intensive in the manufacturing stage.

Did you know?
In Germany the Government has boosted renewable energy via a feed-in tariff which helps guarantee a premium rate for renewables. In 2007 Germany had nearly 4 GW of solar PV – the equivalent of 1.6 million domestic solar roofs. One town, Freiburg, had more solar panels than the whole of the UK.

Manchester Co-op CIS solar tower:
Although the UK has less sunshine than most of its European neighbours, solar power can still make a valuable contribution. Commercial buildings are beginning to take advantage of the technology. The PV façade on the CIS Solar Tower in Manchester cost £5.5 million, but every year it saves more than 100 tonnes of carbon dioxide.

www.solarcentury.co.uk

Electricity: from the sun

Concentrated solar power (CSP)

Concentrated solar power uses mirrors to focus the sun's heat on to a steam generator to produce electricity.

Europe's first commercial CSP generator, the Solair in southern Spain uses 600 mirrors that track the sun as it moves, and focus it onto a 115 metre-high tower. The plant produces enough energy to power 6,000 homes – and as more fields of mirrors are added, could power the nearby city of Seville.

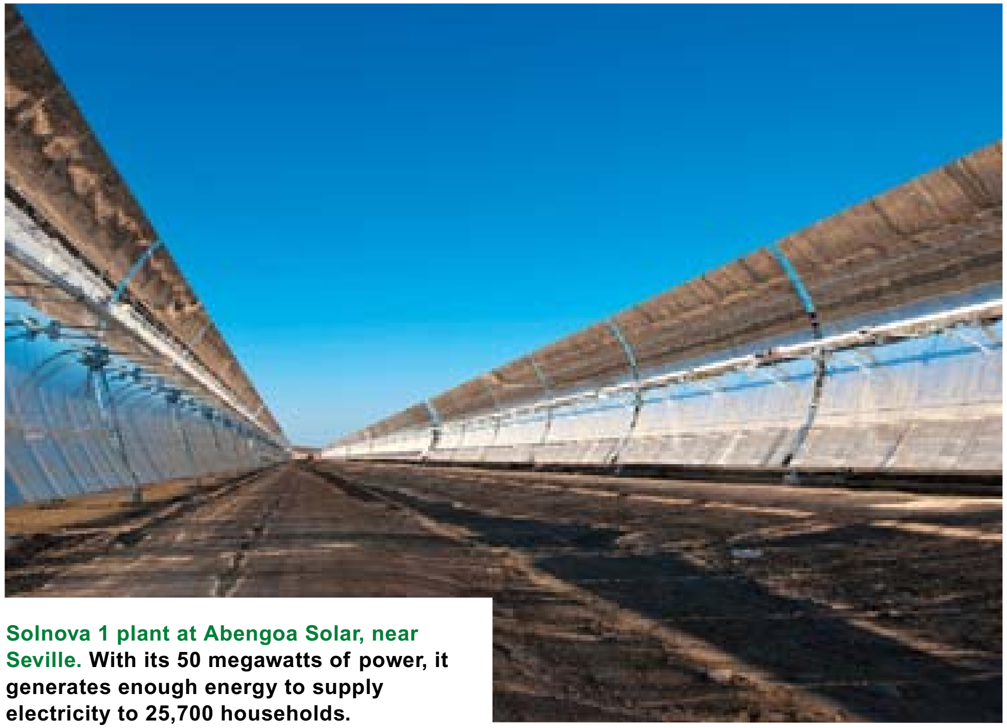
What potential does CSP have?

Concentrated solar power could make a big contribution where there is a lot of sunshine. The world's desert areas such as the Sahara, southern Spain and California are ideal locations. CSP is flexible – it has potential to generate electricity for the grid or to work at a local level powering a factory or village. Engineers are developing technologies to store the energy for use at night or on cloudy days. An additional advantage is that the sea water used for the steam process can be desalinated to provide plentiful supplies of potable water.

Some studies suggest CSP sites in Southern Europe and North Africa could generate enough electricity to replace all of Europe's nuclear power and vastly reduce electricity consumption of fossil fuels. Covering just 1 per cent of the world's deserts with CSP could produce enough electricity to meet global demand. The key challenge is that investment would be needed in high-voltage cables linking the deserts to the areas using the power. Even so, it's thought that the UK could be importing small quantities of CSP by 2020. Algeria is aiming to export 6 GW of CSP to Europe by that date.

CSP at a glance

Fuel	Sun
Typical Output	Up to 200 MW / scheme
Land requirements	Vast desert areas available
Advantages	Enormous potential; carbon-free, safe; probably low ecological impact; potential major resource in sunbelt regions; large storage capability; shade for agriculture and habitation.
Disadvantages	Not suitable for UK weather but could be connected via European grid.



Solnova 1 plant at Abengoa Solar, near Seville. With its 50 megawatts of power, it generates enough energy to supply electricity to 25,700 households.

Siemens AG/Volker Steger

Electricity:
from the sea

The British Isles have some of the most energetic waves and tides in the world. In fact it's been estimated that marine power could provide 15-20 per cent of UK electricity in the long term. Most of this would be from wave energy with a small amount from tidal streams. One study estimated marine resources could generate up to 3 per cent of the UK's electricity supply by 2020.

What potential does wave power have?

No wave power technology has yet been put through its paces on a commercial scale. The best sites for wave technology are off the west coast of Scotland, where there is as yet little carrying capacity in the grid. Wave power is expected to get cheaper as the technologies advance.

Wave power at a glance

Fuel	Waves
Potential capacity	3–7 MW (for an installation of four units)
Land requirements	1 square km could provide 80 GWh per year
Lifespan	Approx 25 years (Pelamis)
Advantages	Zero carbon emissions after 20 months. Low visual and few environmental effects.
Disadvantages	Cost; still at the pilot stage; access to the grid problematic in areas with the most potential; possible impacts on shipping, fishing and marine life.

Snakes and dragons

The Dragon:

The first and largest UK offshore wave energy installation, the Wave Dragon was commissioned in 2007 off Milford Haven. A moored device with the capacity to power 2,000-4,000 homes, the Dragon channels waves into a reservoir above sea level, then releases the water through turbines. The company behind the Wave Dragon plans a 70 MW plant in the Celtic Sea by 2010.

The Snake:

The Pelamis or Sea Snake is made up of linked floating cylinders. As these move with the waves, oil is pumped under pressure into motors which drive generators. In a pilot project four cylinders, about the length of five train carriages, are linked together, with the potential for several chains to line up in parallel to form a wave farm. The first commercial plant is off Portugal. Scottish Power was due to start testing the Pelamis off Orkney in 2008 with a single strand of four cylinders, expected to generate enough for 3,000 homes.

Pelamis Wave Power

Artist's impression courtesy of Pelamis Wave Power

Electricity: from the sea

Tidal power

The power of the tides can be captured in tidal estuaries. Any stretch of water where the difference between low and high tide is more than 8 metres – such as the Irish Sea, the outer Bristol Channel, the Wash, the eastern end of the English Channel and the Channel Islands – is considered to have the potential to develop a tidal energy plant.

What potential does tidal power have?

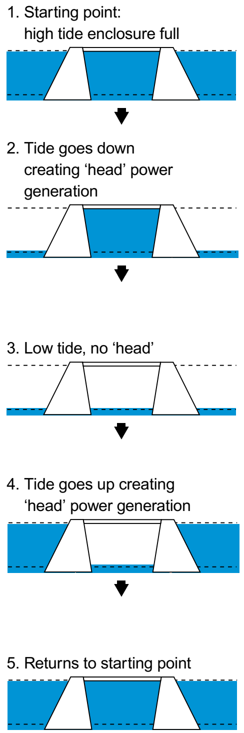
Tidal power offers predictable energy but its contribution will be in part limited by the number of suitable locations around Britain's coasts. The best potential is in the Pentland Firth in North East Scotland but the remote location is a problem, because of its distance from the National Grid. Estimates of the contribution tidal power will make in the future vary enormously.

Artist's impression of Seagen turbine courtesy of Marine Current Turbines Limited

Underwater windmills

The power of the tides is being tested in Strangford Lough in Northern Ireland. A SeaGen turbine was installed in July 2008, generating enough power for around 1,100 homes. The twin-rotor turbines, sitting below sea level, are turned by the in-coming and out-going tides. If the pilot succeeds, Marine Current Turbines, the company behind SeaGen, hopes to start work on a bigger project off North Wales in 2009.

Tidal lagoons



Tidal barrage

Are tidal barrages a good choice?

A tidal barrage dams an estuary with turbines built into a dam wall powered by the incoming or outgoing tides – or both. Friends of the Earth does not think that these large infrastructures in tidal estuaries are the right solution (the Severn barrage would impound 185 sq miles devastating unique eco-systems).

...and tidal lagoons?

Like barrages, lagoons are artificial enclosures in areas where there's a big difference between high and low tide. As the sea rises and falls water enters or leaves the lagoon, passing through turbines in its walls. Lagoons can be used to store and release water, creating a potential reserve electricity supply. Tidal lagoons can be large or small and are able to generate power on both incoming and outgoing tides. They can be located offshore thus avoiding wildlife-rich coastal mudflats. Lagoons are a more flexible generating technology – they can be controlled better to meet demand.

Tidal lagoons at a glance

Fuel	Tides
Land requirements	Infrastructure located in shallow coastal waters, can be tens of square miles
Lifespan	120+ years
Advantages	Does not impound sensitive inter-tidal areas; does not impede shipping; relatively low visual effect; creates new marine habitat; potential to store and supply energy on demand.
Disadvantages	Not tested commercially; may cause silting; some disruption to traffic in the estuary.

Electricity: from rivers

THNM Ltd

The Torrs hydro electric project in New Mills, Derbyshire seen here during installation, uses an Archimedean screw. See www.torrs-hydro-new-mills.blogspot.com

Hydro-electric power

Hydro-electric power is derived from lakes, reservoirs and rivers. It has been used for centuries – from ancient corn mills to the cotton mills of the Industrial Revolution. More efficient turbines replaced water wheels in the 19th century and a few still work today. Small-scale hydro (anything producing 1-20 MW) can use flowing water to drive a turbine. The electricity can be used locally or fed into the grid. To have enough power to generate electricity the river needs to have a drop height of at least 2 metres and a reasonable volume of water. This drop height can be created by a weir, where turbines can also be housed.

What potential does small-scale hydro-electric power have?

In 2007 the UK had slightly more installed capacity for small-scale hydro than for offshore wind. The greatest potential tends to be in mountainous areas like the Scottish Highlands where there are large waterfalls. But lower-lying rivers can be used if there is a strong enough flow. Experts estimate that turbines at the 44 weirs along the River Thames could generate enough for up to 1,200 homes. Small-scale hydro, which converts 50-90 per cent of the available energy into power, could meet 3 per cent of UK demand.

Small-scale hydro at a glance

Fuel	Flowing water
Typical capacity	1-20 MW
Lifespan	50+ years
Advantages	Local; very low carbon; reliable; low-tech; off-grid potential.
Disadvantages	Reduced potential during droughts; some effect on ecology of water course; initial cost.

Electricity: from biomass

Power from biomass

We can turn trees, plants and other organic materials such as food scraps into energy for heat and electricity. This is sometimes referred to as biomass, bioenergy, or biofuel. Bioenergy can be a carbon-neutral energy source since the plants absorb carbon dioxide as they grow. Wood fuel from managed woodlands, and waste products like wood offcuts and woodchips, will have a valuable role and should be burnt in purpose-built wood burners, preferably using CHP. It is important to note that incineration is not a climate solution – incinerators are very inefficient, and there are much greater climate savings to be gained through maximising recycling. Food and agricultural wastes can be treated in a process known as anaerobic digestion, to produce methane which can be fed into our gas supply, or burnt to generate heat and electricity.

There are concerns over the production of some bioenergy crops. Because of the large quantities of energy and fertiliser that it takes to grow, process and transport, their emissions can compare badly with fossil fuels. High demand for biomass could lead to farming of energy crops on industrial scale monoculture plantations and the displacement of food crops, with knock-on effects on worldwide food prices. Friends of the Earth believes bioenergy has a role to play in bringing down greenhouse gas emissions only if it is done in a way that protects wildlife and people's livelihoods, and guarantees emissions cuts.

Biomass at a glance

Fuel source	Energy crops, wood and food waste, slurry
Land needed	Farmland to grow crops, and woodland
Advantages	Renewable, productive use for waste, can be locally sourced; theoretically carbon-neutral energy source.
Disadvantages	Large areas of land to grow significant amounts; social and environmental impacts of big plantations; competes with food; potentially emits more greenhouse gases than fossil fuels.

Electricity: Cleaning up old electricity plants

The more renewable power we develop, the more we reduce our carbon footprint – especially if the most polluting fuels like coal are replaced. The UK could in the future get all its electricity from clean renewable sources; but in the short term they won't meet all of our needs. And we need cuts urgently. So what's the future for non-renewable sources?

Combined heat and power (CHP)

Today we get electricity mostly from power stations and heat and hot water mostly from boilers. Most of the waste in our electricity system happens before it reaches us – our power stations lose two-thirds of the energy they generate as heat. In fact they waste enough heat to keep every house in the UK nice and warm and to provide their hot water too. Producing heat and electricity from the same fuel in the same plant can increase efficiency massively, so shrinking our overall carbon footprint. This is combined heat and power (CHP) – also known as co-generation.

Most CHP plants can burn all sorts of fuels, so they're crucial for our transition away from fossil fuels towards cleaner alternatives. Odense in Denmark, for example, has a city-wide heating system including a coal-fired power station running at a claimed 90 per cent efficiency (more than double the efficiency of a non-CHP coal power station).

CHP at a glance

Fuel source	Coal, gas, oil, biomass, nuclear
Land requirements	Minimal (unless using biomass)
Advantages	Very efficient use of fuel; pipeline network would be long lasting.
Disadvantages	Needs costly hot water pipeline network; limited biomass available - most generation from gas; large CHP more expensive than simple coal and gas generation; usually requires digging up roads or pavements.

What potential does CHP have?

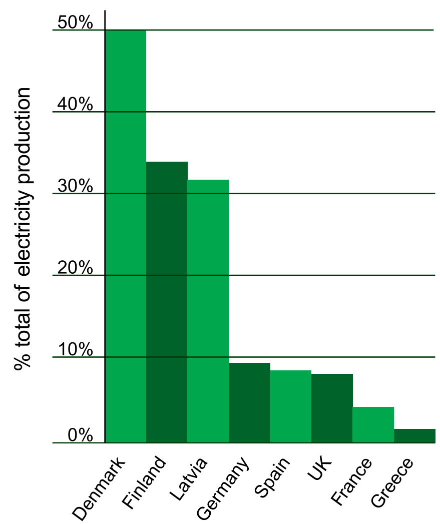
The UK currently lags behind its European neighbours. CHP can improve the efficiency of new large-scale gas-fired power stations by 30 per cent – and such plants are obliged to show that they have explored the option. Friends of the Earth believes this guidance should be strengthened.

And to work with the variations in output from renewables, CHP stations could link to city-wide heating and hot water grids, so that surplus renewable electricity could be used to heat water which can be stored for use later.

CHP plants provide both heat and power, only take a few years to build, and a relatively small number of the largest units can provide the same electricity as proposed new nuclear power plants. Because CHP can run efficiently on all sorts of fuels, it's crucial for our transition away from fossil fuels towards clean fuels like biomass.

CHP use in selected European countries

Source: European Environment Agency



CHP Focus
Supporting development of CHP in the UK
Tel: 0845 365 5153
chp.defra.gov.uk/cms/

Electricity: Combined cycle gas turbines (CCGT)

Combined cycle gas turbines (CCGT) are already used in some gas-fired power stations in the UK. They are more efficient, and therefore produce less carbon dioxide emissions, than conventional turbines as they make use of the waste heat produced by a standard gas turbine to make steam which drives a generator. The result is that around half the available energy is converted into electricity.

What potential does CCGT have?

Almost all gas-fired power stations built since the early 1990s have used CCGT technology. Combining this technology with CHP – and building power plants close to towns so that the heat can be used locally – could make gas-fired power stations even more efficient.

Electricity: New or "clean" coal

"Clean coal" is a term for ways to increase the efficiency and so reduce the emissions of energy generation from coal. Globally, there are vast resources of coal, but without clean technologies, using it to make electricity comes at a very high price to the climate. Approaches such as gasifying coal prior to burning can be more efficient and aid carbon capture and storage (see below), but have not yet been tested on a commercial scale.

What potential does "clean" coal have?

Friends of the Earth says any new gas- and coal-fired power stations must use the most efficient technologies, including the ability to use excess heat for local heating schemes. No new coal-fired power stations should be built without the technology to capture and store carbon emissions.

Electricity: Carbon capture and storage (CCS)

Carbon dioxide from power stations can be captured and the gas can be stored by pumping it underground. Empty or near-empty oil and gas fields in the North Sea have been proposed as one storage option, alongside saline aquifers (pockets of salty water underground) and abandoned coal mines. Proposals to store carbon dioxide on the ocean floor are thought to be far more risky.

What potential does CCS have?

The technology is already in use in the oil and gas industry. However, the process of capturing carbon uses a lot of energy. Once captured, the carbon dioxide has to be transported, again adding to the cost.

CCS is not yet proven on large fossil fuel plants. It is a useful tool which may buy us more time but should not be considered an alternative to developing clean renewable energy, and must not divert funding from sustainable energy options.

CCS at a glance

Fuel	Coal, gas or biomass
Land requirements	Sub-sea or other geological formations or disused oil and gas wells
Lifespan	Variable depending on location
Advantages	Potential to quickly reduce emissions from existing plants.
Disadvantages	Untested on commercial scale; potentially expensive; risk of carbon dioxide leaks.

Electricity: Nuclear power

Conventional nuclear technology uses fission – splitting atoms of heavy metals, such as uranium, to generate heat. This is used to produce steam to drive turbines, generating electricity. One drawback of nuclear energy is the waste product. Uranium fuel rods remain radioactive for thousands of years after they've stopped producing power. No safe way of disposing of nuclear waste has yet been found. Given the serious consequences of accidents involving nuclear material, the safety record of the industry is a key consideration. The most infamous accident was the explosion at Chernobyl in the former Soviet Union in 1986 that led to radioactive contamination across Europe. Scientists say it is still not possible to calculate the full extent of the damage but thousands of people are thought to have died as a result of contamination and 20 years later an exclusion zone almost as big as Greater London surrounds the plant. Safety concerns are also aroused by the fact that nuclear fuel can be used for weapons. Britain's reactors have relied in the past on uranium from Australia. There have been reports of uranium going missing in transit, and it is impossible to guarantee that it won't end up in the hands of terrorists.

Did you know?
While there are big questions over the safety and security of nuclear power, its real contribution to the overall energy mix tends to get exaggerated: in fact it accounts for just 3 per cent of final energy consumption.

Other key disadvantages of nuclear power are that its output is inflexible, the first new plant would not be ready until after 2020, and it is hugely expensive, diverting finance away from truly sustainable options.

Nuclear power at a glance

Fuel source	Uranium – limited supplies
Land requirements	Small
Lifespan	40 years
Advantages	Lower emissions than fossil fuels; potentially large quantities of baseload electricity from a small number of plants.
Disadvantages	Many risks: radioactive waste; radioactive emissions; accident risk; terrorism threat; nuclear proliferation. Direct competition for baseload with combined heat and power; industry won't go ahead without huge public subsidy.

What potential does nuclear power have?

Nuclear power today supplies 15 per cent of the UK's primary electricity supply – though only around 3 per cent of our overall final energy consumption. Britain's reactors are reaching the end of their lifespan. Seven power stations are scheduled to close by 2023, leaving just one in operation – at Sizewell B on the east coast.

The decision over whether to build new reactors has been controversial but concerns over security of supply and the need to cut carbon dioxide emissions have been used to justify a re-consideration of nuclear power.

Several companies are keen to build a new generation of plants, but won't do so unless the Government takes on the financial liabilities.

Did you know?
Once billed as likely to become "too cheap to meter", costs of nuclear power have stayed high. New plants have tended to cost far more than their original budget. Costs at Torness in Scotland, completed in 1988, soared from £742 million to £2.5 billion.

Did you know?
Sellafield's Thermal Oxide Reprocessing Plant was expected to cost £300 million but finished five years behind schedule with a final bill of £2.8 billion. In 2003 UK taxpayers bailed out the nuclear power company British Energy to the tune of £5 billion.

Flickr

Electricity grid: How do we keep the lights on?

Many renewable electricity sources produce a variable supply. So if we increase the amount of power we're drawing from the wind, sun and seas, will this add instability to our supply?

The job of the UK's National Grid is to ensure electricity supply meets demand at all times. Big power stations link to a high-voltage network of cables which transmits electricity across most of the country. This connects to local networks that deliver a low-voltage supply to homes and businesses. So how can the grid help us shift to a low-carbon future?

Did you know?
An intelligent grid could link local and central energy systems to balance supply with demand. When demand is high, more systems could be brought into the grid – and when demand is low, supply reduced.

The simple answer is that it already deals with changeable supply. No power stations are able to operate continuously. Many so-called reliable sources such as nuclear plants must be shut down for essential safety maintenance and can suffer from unexpected breakdowns – the National Grid can cope with stoppages at the UK's biggest power station, Sizewell B, by drawing on standby power and reducing demand. In comparison, the variation in output from individual wind farms around the country is small, so changes in the weather wouldn't compromise overall supply.

Balancing act

Today's National Grid can work well with up to 20 per cent of the electricity supply coming from variable energy sources such as wind. The electricity system of the future will need to be more responsive, for example by dynamically matching demand to supply: millions of smart fridges and freezers could automatically switch off for short periods if they detect decreased supply in the grid. Conversely, when renewable electricity is in oversupply, we will need to store the energy – by using batteries, generating hydrogen, converting it to heat, or recharging electric vehicles. The remaining fossil fuel generation will also need to operate more flexibly.

Local, central and super grids

Britain's energy system is centralised: but many low-carbon energy alternatives don't need to be hooked into the grid – they can provide power to just one local building or a neighbourhood. Decentralised systems can get more out of the fuel we use because less energy is lost in transmission – and that means lower greenhouse gas emissions. Although maintenance costs may be higher for a decentralised grid, power losses are lower, especially at times of peak demand. And greater efficiency saves money.

Proposals have been put forward to link Europe and North Africa with a super grid. Electricity generated across Europe and beyond – from offshore wind in the Irish Sea to concentrated solar power in southern Europe and North Africa – would feed into the grid, providing a common resource across the continent.

By using the full range of renewable sources over a wide area, as well as balancing demand with supply and storing energy, we could shift to a low-carbon economy without risking the lights going out.

Dynamic Demand
Demand control technologies on the grid
www.dynamic demand.org.uk/

Section 02: Heating

More than a third of the carbon dioxide we produce results from generating heat for our homes, offices and factories – primarily using gas. So what are the alternatives? Combined heat and power technology (CHP), where the heat otherwise wasted in the electricity generating process is captured, can reduce the need for heating fuel.

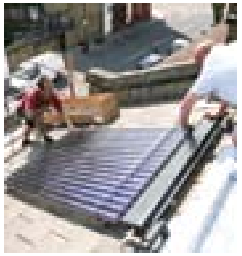
Renewable sources of heat

Did you know?
Under a by-law introduced in 2000, all new buildings and any undergoing substantial renovation in Barcelona must now be fitted with enough solar panels to provide 60 per cent of their hot water. There are now more than 40,000 square metres of solar panels in the city, saving more than 5,000 tonnes of carbon per year. Other cities across Spain are introducing similar by-laws.

On a smaller scale wood-fired stoves can use local waste wood for heat and hot water in homes. Biomass (eg wood pellets) can replace conventional heating oils in homes that are not on the gas grid and combined heat and power boilers can heat commercial and public buildings such as libraries and swimming pools. Using a renewable energy source such as wood pellets in CHP boilers is even better.

If we're to reduce the UK's reliance on imported fuels (especially coal and gas) we need a system for delivering and storing energy that can cope with variations in output. One way to do this is to build city-wide heat-grids that pipe hot water to homes, offices and industry from combined heat and power stations. CHP can also be used to cool buildings in summer – known as tri-generation. The CHP stations would balance output to meet variations in demand for electricity and heat. About half UK energy needs are for heat so excess renewable electricity not needed for the grid can be used to heat water which can be stored for when the heat is needed.

Heating: hot water from the sun


Amelia Collins / Friends of the Earth

As well as making electricity, the sun's heat can be used to heat water in homes and commercial buildings. Solar hot water systems – sometimes referred to as solar thermal – are usually fitted on a roof with liquid-filled panels or tubes collecting heat in sunlight. These connect to a hot-water storage tank.

A range of technologies is available to collect the sun's heat, and typically up to 40 per cent of the heat is transferred to the hot water system. In the UK a solar thermal system can provide hot water for all of a household's needs during the summer months, and can usefully pre-heat water in winter, saving a lot of fuel. A typical domestic system can cost between £2,500 and £8,000 and save half a tonne of carbon dioxide a year for the average household.

What potential does solar hot water have?

The technique is increasingly being used in homes – around 10,000 solar hot water systems are now installed every year. It can also be used for commercial buildings and factories, providing hot water for swimming pools and industry. In fact, any commercial or public building that uses a lot of hot water can benefit from solar hot water.

Solar hot water at a glance

Fuel	Sun
Land requirements	Can fit on existing roof space
Lifespan	25 years
Advantages	Easily retrofitted to existing housing stock; can generate 50-80 per cent of heated water for an average house; easily incorporated into new-build.
Disadvantages	Requires a hot water cylinder, re-plumbing and a bigger tank in older stock.

Heating:
ground source heat

The ground absorbs and retains heat from the sun. Liquid pumped through tubes buried underground can harness this energy and return it to a heat pump. This acts a bit like a refrigerator extracting and condensing the heat, which is used to warm water to around 40-50°C – good enough for central heating and hot water. Ground source heat pumps are best suited to under-floor heating in well-insulated homes.

With a green source of electricity for the pump, ground source heat can be a completely carbon-neutral source of heat. However, in very cold conditions, ground source heat pumps provide insufficient heat, so systems should have a dedicated boiler as back-up.

What potential does ground source heat have?

Ground source heat pumps are typically used for individual homes or commercial or public buildings. Space is needed outside to lay the pipes underground, which makes it inappropriate for a town house with a small garden. A well -insulated country house that is off-grid and depends on oil heating would really benefit. A typical domestic system would cost £6 - £10,000.

There is lots of potential for ground source heat pumps, particularly in new-build properties, where installation is cheaper. The Government estimates that around 1,550 large industrial sites in the UK could use heat pumps. On average each could generate 800 kW of thermal power.

Ground source heat at a glance

Fuel source	Electricity (to run a pump)
Land requirements	Outside space needed
Advantages	Useful for space heating.
Disadvantages	Requires energy to drive the pumps.

Easy ways to help change the world

Friends of the Earth

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Friends of the Earth

Friends of the Earth – the most influential environmental organisation in the UK – inspires solutions to environmental problems which make life better for you, your family, friends and your community. It doesn't stop there. With the support of hundreds of thousands of people we're helping to bring about changes that benefit the whole planet.

This booklet is based on a chapter from Friends of the Earth's *How Can I Stop Climate Change?* (Collins, 2008). Buy your copies from www.foe.co.uk/shop

www.foe.co.uk

Renewables directory

Energy Saving Trust
Free impartial advice that can help you save money and fight climate change
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www.est.org.uk

EST Scotland
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EST Wales
Tel: 029 2046 8340

EST Northern Ireland
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Local Energy Advice Centres
For local advice about energy efficiency in your home
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Centre for Alternative Technology
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www.cat.org.uk

British Wind Energy Association
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www.bwea.com

Renewable Energy Association
Represents renewable energy producers
www.r-e-a.net/

Low Carbon Buildings
Provides advice on microgeneration and grants
Tel: 0800 915 0990
www.lowcarbonbuildings.org.uk

TREC-UK
Promotes the idea of using CSP to provide energy across Europe
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