



Energy Tutorial: Energy and Sustainability

Non-renewable and renewable resources

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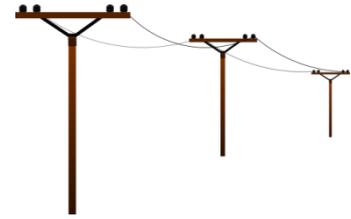


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INTRODUCTION

We use energy for everything we do, whether it is heating our homes, cooking a meal, charging our phones or taking a shower. Since the Industrial Revolution, which began in around 1760, the majority of this energy has come from a dense, energy rich resource known collectively as fossil fuels.



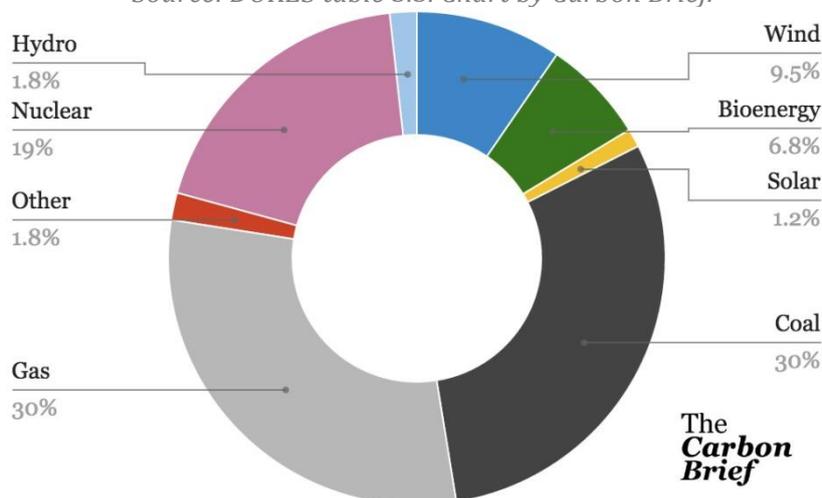
Fossil fuels are energy sources which form over billions of years from the remains of living organisms. Because fossil fuels take such a long time to form and are being used up at a much faster rate than they can be replaced, they are a non-renewable resource: a resource which once consumed cannot be replaced. This means they will one day run out. Burning fossil fuels also produces greenhouse gases and are the main cause of man-made climate change. Relying on them for energy generation is therefore unsustainable.

Because of this, we need to find more renewable, sustainable ways of generating energy. Renewable energy resources are sources of power that quickly replenish themselves and can be used again and again. Not only will renewable energy sources not run out, but they also generate clean energy which does not release greenhouse gas emissions in the process. Renewable energy sources include wind, solar, tidal, wave, and hydroelectric power.

In the UK, we have a target for 15% of our energy to come from renewable energy sources by 2020. According to government statistics, only 7% of UK energy consumed in 2014 to provide heat, electricity and transport came from renewable sources, so we still have a long way to go. Renewable energy sources are currently mainly used to generate electricity – electricity generated from renewable sources reached 19% in 2014. Figure 1 below shows the UK energy mix for electricity generation and the contribution made by different non-renewable and renewable energy sources.

Figure 1: UK energy mix (electricity generation)

Source: DUKES table 5.5. Chart by Carbon Brief.



NON-RENEWABLE ENERGY RESOURCES

Fossil fuels are energy sources which form over billions of years from the remains of living organisms. Remains of living organisms become fossil fuels when they are compacted in the Earth's crust over billions of years, which is the reason why fossil fuels are so energy dense. There is a finite amount of fossil fuels left in the Earth's sub-surface and these reserves will eventually run out.



There are three types of fossil fuels:

1. **Coal** is a solid fuel which is mined from seams sandwiched between layers of rock in the Earth. Coal is the most abundant fossil fuel and supplies are expected to last longer than for other fossil fuels.
2. **Oil** is a carbon-based liquid formed from fossilised animals. Reservoirs of oil are found sandwiched between seams of rock in the Earth. Pipes are sunk down to the reservoirs to pump the oil out.
3. **Natural gas** comes in the form of methane and some other gases which are trapped between seams of rock under the Earth's surface. Pipes are sunk into the ground to release the gas. Natural gas is the most efficient, cheap and clean fossil fuel to convert to energy.

Figure 2 below outlines the advantages and disadvantages of fossil fuels as an energy source.

Figure 2: Advantages and disadvantages of fossil fuels

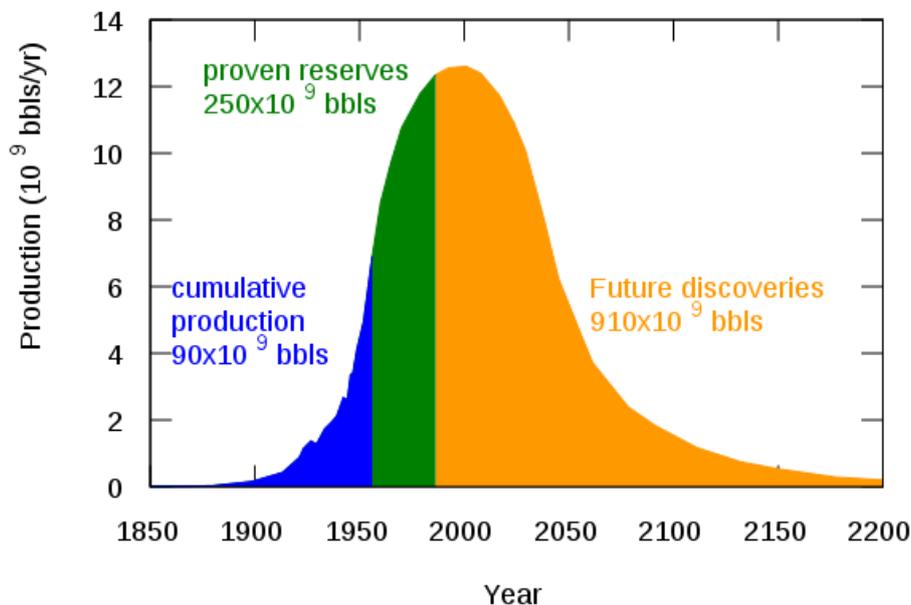
Advantages	Disadvantages
<ul style="list-style-type: none"> ▪ Ready-made fuels. ▪ They give a large amount of energy from a small amount of fuel. ▪ Relatively cheap to extract and convert to energy. ▪ Readily available and reliable. If you need more energy, you just burn more fuel – their availability is not affected by climatic condition. 	<ul style="list-style-type: none"> ▪ They are non-renewable. Once you burn them, they are gone. ▪ Burning a fossil fuel emits carbon dioxide, which contributes to climate change. ▪ Burning a fossil fuel can produce sulphur dioxide and smoke, which cause pollution and acid rain.

Peak oil

Peak oil is the idea that oil production may be at or near its limit. It is based on the work of M King Hubbert, a geophysicist who worked for the oil industry in the USA during the 1950s. Hubbert proposed that the amount of oil being discovered was reducing, and made a prediction that oil production for the US would slow, “peak” and then drop off, following a bell shaped curve graph as shown in Figure 3 below. He predicted that world oil supplies would peak in the early 2000s.

Figure 3: The Hubbert Curve

Source: Wikipedia (Author: Hankwang)



The Hubbert Curve has been used specifically for oil, but all production of fossil fuels follows a similar curve, leading to peak coal and peak natural gas. The same principle also applies to all other mined minerals, such as uranium, copper, etc. Views on when fossil fuel production will peak (reach its maximum possible production, after which production will drop off) vary, but the estimated length of time left for coal, oil and natural gas production is set out in Figure 4 below.

Figure 4: Estimated length of time left for fossil fuels

Fossil fuel	Estimated time left
Oil	40 years
Natural gas	60 years
Coal	250 years

The peak isn't the time when the resources actually run out, but the point at which the rate we can find new reserves, extract the resources and produce energy from them slows down. Fossil fuel reserves which are easiest and cheapest to extract will be used up first, leaving only the more difficult and costly resources to exploit. As fossil fuels become harder to obtain, the energy required to mine them becomes greater, making them more expensive to extract. This will make energy produced from fossil fuels more expensive for us to buy.

World demand for fossil fuels is increasing at the same time as we are approaching peak production. When the demand for energy from fossil fuels is greater than the supply, this will also make prices go up. There will come a point when energy from fossil fuels becomes too expensive for most people to use and other energy sources, such as renewables, will become a cheaper alternative. How near we are to this point is unclear.

RENEWABLE ENERGY RESOURCES

Renewable energy resources are sources of power that quickly replenish themselves and can be used again and again. Not only will renewable energy sources not run out, but they also generate clean energy which does not release greenhouse gas emissions in the process.



Renewables can be used to generate electricity, heat or sometimes both. As explained earlier, the most common use of renewable energy sources is to produce electricity.

Figure 5 below outlines the advantages and disadvantages of renewable energy sources.

Figure 5: Advantages and disadvantages of renewable energy sources

Advantages	Disadvantages
<ul style="list-style-type: none"> ▪ Won't run out and can be used again and again. ▪ Produce clean energy that does not pollute the environment or contribute to climate change. ▪ Renewable energy facilities generally require less maintenance than traditional fossil fuel generators. ▪ Renewable energy is derived from natural and available resources. This reduces the 	<ul style="list-style-type: none"> ▪ Currently difficult to generate quantities of energy as large as those produced by traditional fossil fuel generators. This may mean we need to reduce the amount of energy we use or to develop more energy facilities. It also indicates that the best solution to our energy problems may be to have a mix of different energy sources. ▪ Often rely on the weather to provide power. Hydro generators need rain to fill dams to supply flowing water. Wind turbines need wind to turn the blades, and

<p>costs of production, as the resources used to produce the energy often don't need to be purchased or can be obtained more cheaply and easily than fossil fuels.</p>	<p>solar panels need clear skies and sunshine to collect heat and make electricity. When these resources are unavailable, so is the capacity to make energy from them. This can be unpredictable and inconsistent.</p> <ul style="list-style-type: none"> ▪ Currently renewable energy technologies are a lot more expensive than traditional fossil fuel generators. This is because they are new technologies and therefore involve large capital costs. However, as the technologies become better established, the costs involved should fall.
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Figure 6 below outlines most of the major renewable energy sources available and a description of the technologies that implement them.

Figure 6: Renewable energy sources and technologies

Renewable Energy Source	Technology	Description
Solar	Solar photovoltaic (PV)	Solar panels convert the radiation energy from the sun into electricity through silicone cells
Solar	Solar thermal	Heat from the sun is used to heat water for domestic use in houses
Solar	Concentrated Solar Power (CSP)	Large scale solar farms focus the sun's energy to produce high temperatures that run a steam engine to produce electricity
Wind	Wind turbine	Wind power is converted to rotational energy by aerodynamic blades which turn an alternator to produce electricity
Biomass	Biomass space heating	Wood is burned efficiently to heat buildings
Biomass	Biofuels for transport	Energy crops are grown and processed to produce fuel to run vehicles

Biomass	Biomass electrical power production	Wood is burned to produce steam to run a generator to produce electricity in a similar way that large scale coal-fired power plants operate
Biomass	Anaerobic digestion	Organic matter decomposes under water to produce methane which is burned to produce electricity
Tidal	Tidal power plants	As the tide comes in the water is held and released through a turbine to produce electricity
Waves	Wave power	The motion of the waves are used to turn generators to produce electricity
Rivers/Streams	Hydro power	The flow of water down a hill is sent through a penstock to an impellor which turns a generator to produce electricity
Heat from Earth's core	Geothermal power	In place where the Earth's crust is thin, heat from the Earth's core is used to produce steam which turns a generator to produce electricity
Burning Waste	Landfill gas	Decomposing waste produces methane which is burned to produce electricity

FURTHER RESOURCES AND INFORMATION

- Check out “Renewable Energy Systems” back on the Energy Tutorial webpage to find about different renewable energy systems in detail.
- This factsheet was prepared using material from The University of Nottingham’s U-Now module on Sustainability and Engineering¹. You can check out the module here: http://equella.nottingham.ac.uk/uon/file/1c4d7433-74db-9779-b605-7681374bc79a/1/Eng_sustainability.zip/Engineering%20Sustailability/index.html

¹ The Sustainability and Engineering module was created by The University of Nottingham faculty member Aran Eales, 2012. Copyright c 2012 The University of Nottingham. Licence: Creative Commons BY-NC-SA.