11 TRAINING MODULE 11 Energy and Climate Change

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Contents

Our future

The way that human activity is impacting the planet is a massive global issue and to many, the environmental challenges we face threaten not only our lifestyle, but the very survival of the human species (the late Stephen Hawking suggested that we move to another planet as soon as possible).

The concept of **sustainability** is now well understood and recent direct action campaigns by Extinction Rebellion and the work of David Attenborough on the life of our oceans has helped increase awareness and take the issue right up the political agenda. How we are living at the moment is completely unsustainable - because by using and abusing so much of world's natural resources and causing the planet to get hotter, we risk the ability of future generations to survive at all. In fact, to sustain the current level of global consumption that we in the developed world take for granted, we need not one, but FOUR planet earths.

Although we have lots of problems that need to be sorted pretty urgently, climate change is potentially our greatest threat and in **Section 1** we take a brief look at what is happening to the climate. Then, as climate change is largely an energy issue, in **Section 2** we touch on the carbon-based resources with which we produce energy. **Section 3** looks at sustainable energy and in **Section 4** there are some questions for you to answer.

The learning outcomes of module 11

After successfully completing this module, you will be able to understand:

- The causes of climate change
- The main impacts of climate change
- How we generate energy and its impact on climate change
- How we can mitigate climate change by using sustainable energy

Section 1—Climate change

Year	Population
1700	610m
1800	1,000m
1900	1,600m
2000	6,145m
2010	6,958m
2019	7,715m

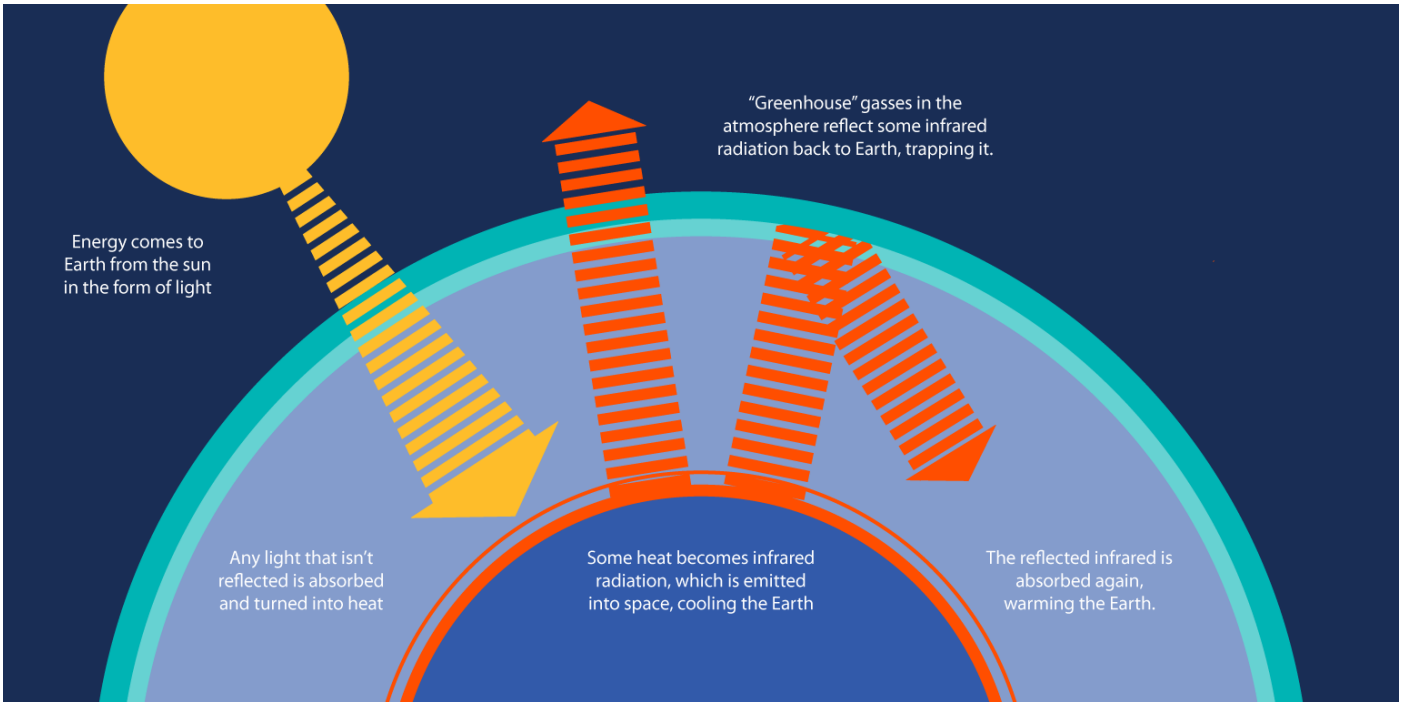
▲ Human population growth since 1700

Over the last few hundred million years the climate on Earth has fluctuated widely. As well as warmer periods that supported the dinosaurs, we have had various 'Ice Ages' (the last proper one ending about 12,000 years ago) when huge parts of the planet were covered in glaciers. But it is what has been happening over the last couple of hundred years that has led us to worry that *humankind's* activity is causing the planet's climate to heat up—with potentially devastating consequences.

So what has been happening? Well, especially since the Industrial Revolution that started in the 18th century, we have experienced a dramatic and pretty much continuous increase in global population growth, longevity and overall standard of living. The result is that the amount of energy we need to produce our food, heat our homes and to provide the products and services we want has increased exponentially.

The vast majority of our energy has (and still does) come from burning carbon (wood and fossil fuels) that, when burnt, produces carbon dioxide (CO_2). This CO_2 is one of the many gasses that makes up the atmosphere; it currently contributes about 0.04% or 400 parts per million (ppm). As the heat from the sun passes through the atmosphere, the CO_2 has the ability to 'trap' it and prevent it escaping back out into space. That's why it is called the 'greenhouse effect'; heat enters to warm the earth and is kept in by the CO_2, and so like in a greenhouse, we get hotter.

So the more CO_2 in the atmosphere, the hotter the world will become.



▲ An introduction to the greenhouse effect

CO_2 is by far the most prevalent, but not the only, gas that traps the sun's heat. Other gasses, such as methane and nitrogen dioxide, are more malign, trapping proportionately more heat than CO_2. When looking at emissions however, we generally use one measure to cover all gasses; this measure is: million tonnes of carbon dioxide equivalent (or $mtCO_2e$).

Quantities of CO_2 are emitted naturally - by volcanoes, through the natural decay of any organic matter, evaporation from the ocean and by animal exhalation; things we can't do much about. But by studying the ice deep in glaciers, scientists have estimated that in the 18th century, the atmosphere contained less than 300ppm of CO_2. Quite reasonably, they put the big increase down to human activity.

► Which UK activities produce the most CO_2? (mtco2e 2017 figures)

Source	2017 (MtCO2e)	Percentage
Transport	125.9	27.4%
Energy Supply	112.6	24.5%
Business	80.1	17.4%
Residential	66.9	14.5%
Agriculture	45.6	9.9%
Other	29.1	6.3%
Total:	**460.2**	**100.0%**

So what are the consequences of climate change? They are many and widespread and although not all of them are agreed upon by all scientists, we are living with their effects already. They include:

Changing weather patterns

It is not possible to attribute a specific weather event to climate change but more and stronger hurricanes and devastating storms (leading to floods) have occurred in many parts of the world - including in the UK. The temperature of the ocean surface water is a key factor in determining storm/hurricane intensity—and climate change is causing it to rise.

Declining or rising rainfall is occurring in many areas. In some parts of Africa and the Middle East, poor rainfall has turned to complete drought, leading to migration. Conflicts might be ignited by the need to compete for water or soil, as the area of arable land will shrink. Climate change is having serious impacts on the world's fresh water systems such as rivers and lakes through more flooding and droughts, even in the UK.

It is likely that the yield of certain food crops will fall and a huge range of other plants could cease to grow in the higher temperatures. Large areas of forest could be affected, as the tree line retreats north as temperatures rise. In tropical forests such as the Amazon, where there's abundant biodiversity, even modest levels of climate change can cause high levels of extinction. In fact, huge numbers of plants and animals could become extinct all over the world. The food supply could be drastically reduced.

At its worst, according to many climate scientists, if temperatures rise more than an average of 1.5°C across the planet, then the damage might be irreversible, leading to worldwide famines, mass global migrations of people and to serious conflict.

Sea level rise

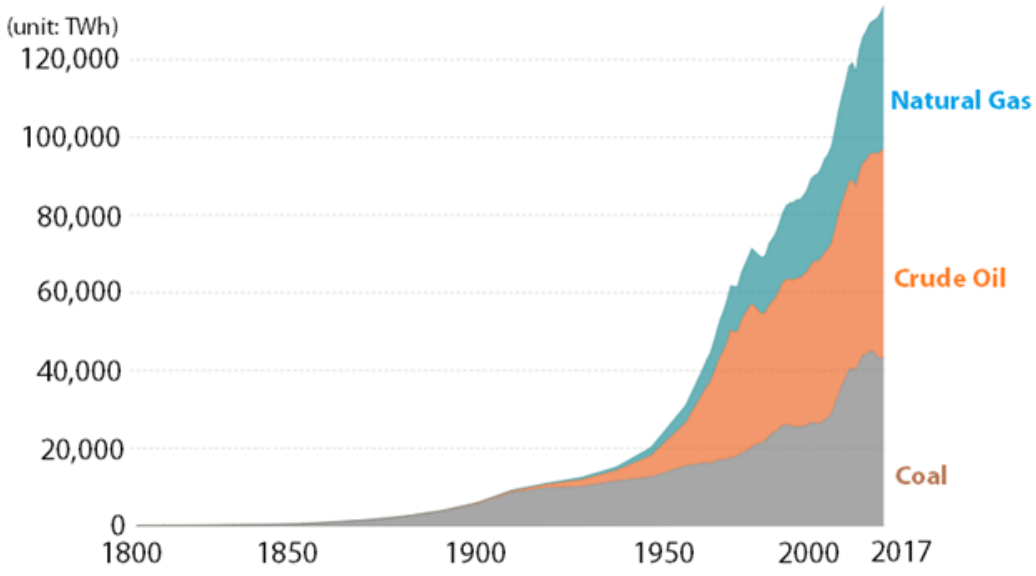
This is caused by the melting of the icecaps and because water expands as it heats up. Scientists think that up to 10% of the global population is directly at risk (700+ million people) and that the map of the world will be radically altered as sea levels could rise by around 1 metre by the end of this century. In addition, warmer oceans could result in large numbers of marine species being wiped out including coral reefs which could not easily survive if ocean temperatures rise above that 1.5°C. It is inevitable that huge sums will have to be spent on sea defenses, and cities, even whole regions, abandoned to the sea.

As the ice caps continue to melt, ocean CO^2 levels will rise as the gas that is trapped inside the ice escapes. Ocean acidity levels will increase, further impacting sensitive marine life. Ice also helps reflect heat, so melting might be speeded up.

Section 2—Carbon-based energy resources

The climate change culprits! Fossil fuels are so called because they formed millions of years ago, as animals and plants died and decayed, got compressed and became carbonised. Fossil fuels are oil (as petrol, diesel and kerosene), natural gas and coal. When burnt, these substances release the stored up carbon as heat energy and CO2.

Because they take so long to form, fossil fuels are non-renewable; once they are gone, they can't be replaced. Estimates of how long current reserves will last vary, but at current consumption, the prediction is that we will run out of oil and gas in about 50 years and coal in a bit more than 100 years.



◄ Since the industrial revolution, global consumption of all fossil fuels has skyrocketed

More and more of our energy in the UK is provided by non-fossil fuel sources, but globally unfortunately, the use of fossil fuels is still on the rise.

To avoid the worst effects of climate change, we need to find global-wide alternatives to fossil fuels without delay. Over the last few years, there has been a huge growth in the contribution made by renewable energy sources, but the world is still heavily reliant on fossil fuels! Every tonne of fossil fuels consumed, and the CO2 it emits increases the risk of climate change.

Energy	Percentage
Natural Gas	39.1%
Nuclear	24.4%
Wind	13.8%
Bioenergy	10.2%
Solar	4.2%
Oil	3.6%
Coal	2.9%
Hydropower	1.8%

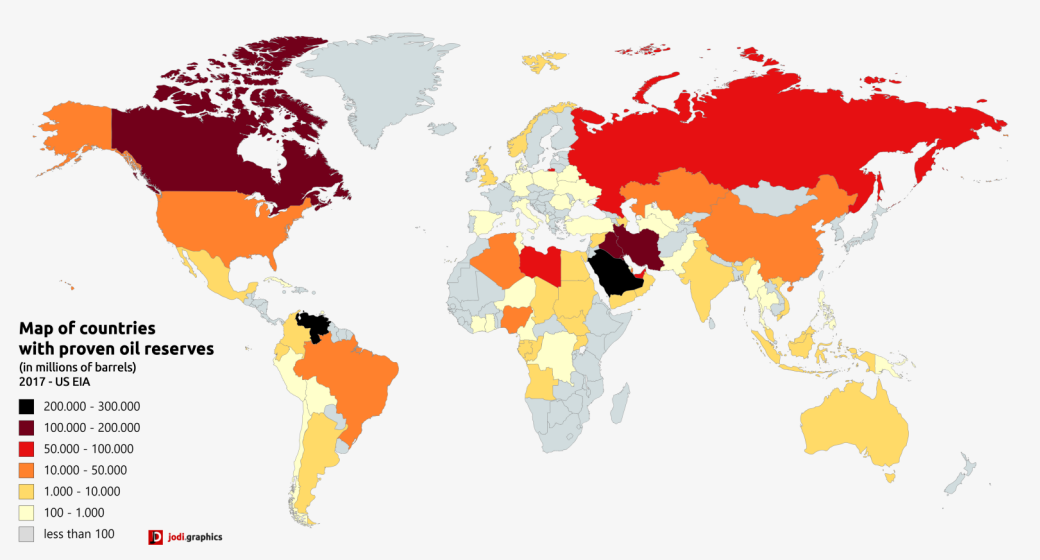
▲ Current energy use in UK (2017)

Fuel	CO2 Emissions (kg)
Natural Gas	3.14 per kg
Diesel Fuel	2.68 per litre
Coal	2.42 per kg
Petrol	2.31 per litre
LPG	1.51 per litre

▲ CO_2 emission from fossil fuels

Oil

The first recorded mention of mineral oil goes back to 600BCE, when it was used in China for lamps. It was discovered in America in 1859, in Pennsylvania. It is our biggest source of energy, accounting for 40% of all global energy used. In terms of energy output, oil is about twice as efficient as coal and three times that of wood. Of course, it is yet to be replaced as fuel for transport—especially trucks, ships and planes. Around 93 million barrels (a barrel is 42 gallons or c.159 litres) of crude oil are consumed every day. It is largely refined into petrol, diesel and kerosene (airline fuel - also known as paraffin). But oil is used for far more than just liquid energy; about 2% of oil consumption is for the manufacture of plastics and oil ends up in a huge range of other things including glues, asphalt, detergents, inks, dyes and lubricants—along with lipstick, deodorant and chewing gum.



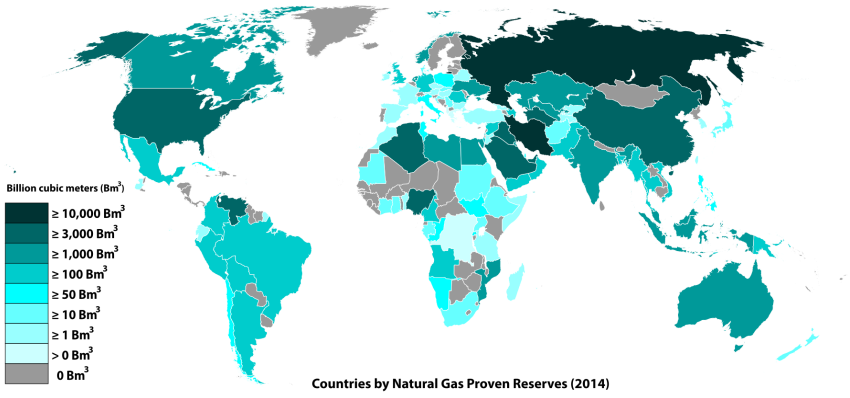
◄ Who has all the oil? Map of proven oil reserves - according to U.S. EIA (2017). Darker colours mean more oil reserves

Natural gas

Like oil, natural gas was probably first used in China around 500BCE. Discovered in the USA in 1626, it was first used commercially for lighting in the early 18th century.

Most of the world's natural gas is in the Middle East and Russia. Although it contains other gasses, such as propane (used for camping stoves and BBQs) and butane (used for cigarette lighters), it is methane that is piped into homes for cooking and heating. Unlike oil, there is no warning when a gas well is running out.

Like oil, it is non-renewable but because it releases proportionately less CO2 than oil, it is increasingly used in electricity generation and around a third of the electricity we use in Britain is generated by burning natural gas. Like oil, natural gas is also used in a variety of ways; for example, 25% ends up in the production of fabrics, fertilizer, anti-freeze and other items.



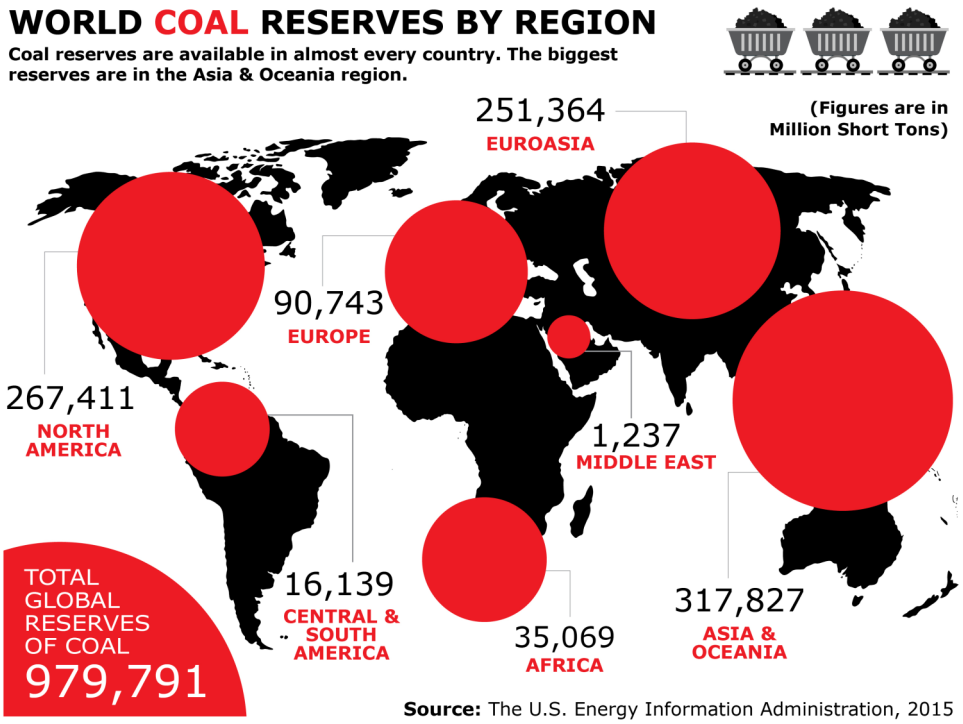
► Map of proven natural gas reserves (2014), based on data from The World Factbook. Darker colours mean more natural gas reserves

Coal

Coal deposits are very widespread and it has been mined for thousands of years (including by the Romans and the Aztecs). In the 18th century it became the fuel that drove the industrial revolution and changed the world. Coal is extracted by underground or 'open cast' mining. Unfortunately, when coal is burnt it produces more CO2 and other pollutants than any other fossil fuel.

World coal consumption is about 8 billion tons annually, of which 75% is used for the production of electricity, with most of the remainder being used for steel-making and in the paper and chemical industries. China is responsible for over 50% of the world's coal consumption, whereas Europe uses around 8%.

► World coal reserves by region in 2015. The larger the red circle, the larger the reserves.



Source: The U.S. Energy Information Administration, 2015

Like oil and natural gas, coal reserves are non-renewable, but are far more abundant and at the current production rate, world coal reserves will last around 100 years—a lot longer than oil or gas. Because it is plentiful, there is a drive to produce 'clean coal' - with the CO2 produced prevented from entering the atmosphere with carbon-capture technology.

Carbon-based fuels are putting the planet at risk but having sufficient supplies of energy is crucial to economic growth and lifting people in the developing world out of poverty, so there is a real tension between trying to reduce our impact on the planet whilst allowing poorer nations to improve their standard of living.

Section 3—Sustainable energy resources

The most important way for us to mitigate climate change is to radically change energy consumption, away from fossil to renewable fuels. Unlike fossil fuels or nuclear power, renewable energy does not run out; it is produced using resources that are in never-ending supply, such as the wind and sun. Thankfully they are already contributing to meeting our energy needs. But there is a very long way to go.

Below we outline the main renewable energy sources. Nuclear power is considered clean because no CO2 is emitted when it is used to generate power, but we have not classed it as a sustainable energy source.

Solar power

Solar power turns sunlight into electricity. Over the last few years, solar panel technology and production methods have improved and the price of panels has rapidly fallen.

In the UK, Government incentives have helped solar energy generation to grow rapidly; there are around 1 million homes with rooftop solar panels. Even though the incentives have ended, this is expected to mushroom to 4 million by 2022.

▲ The world's largest concentrated solar farm, Noor 1, in the Sahara desert, Morocco

In addition, there is rapid growth in the number of solar parks in the UK; the large-scale arrays of panels that now dot the countryside. The largest is a 250 acre site in North Wales, generating enough power for 11,000 homes and saving around 200,000 tonnes of CO2 each year. The world's largest solar farm is a 580-megawatt capacity in Morrocco in the Sahara Desert and it is expected to provide electricity for over 1 million people once completed in 2020.

Of course, the down side of solar energy is that it is only generated when it is sunny. This makes it difficult to match energy demand with supply, as lots is needed in the evenings, at night and during the winter, when the sun shines a lot less. So the key to unlocking the full potential of solar power is the development of energy storage technology—big batteries.

Wind power

Wind power has been used for many centuries. Windmills were a very common sight throughout the landscape right up to the late 19th century. Even though, like sunshine, wind is intermittent, it is now the fastest growing form of sustainable energy production—with Denmark producing more than 43.4% of its electricity with it. The UK has the breeziest coastline in Europe, has great wind-generation potential and increasingly, our wind farms are built offshore. By 2020, 10% of UK electricity will be produced by offshore windfarms, powering around 4.5 million homes. They are not free of controversy and local opposition to new wind farms, on grounds of aesthetics, noise or their danger to birds, has affected the speed of development.

◄ Wind turbines; elegant and effective

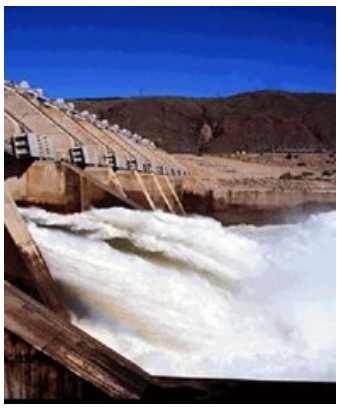
Hydropower

Using fast flowing or falling water to harness energy has been around for a long time. In fact, water wheels were first mentioned in a Greek poem back in 400 BC. Amongst other things, they have been used to power flour mills, saw mills, dock cranes and the textile industry.

In modern times, hydropower has been almost exclusively associated with dams. The building of dams can be highly controversial. When they are built, huge areas of land are flooded and people displaced. The Three Gorges dam in

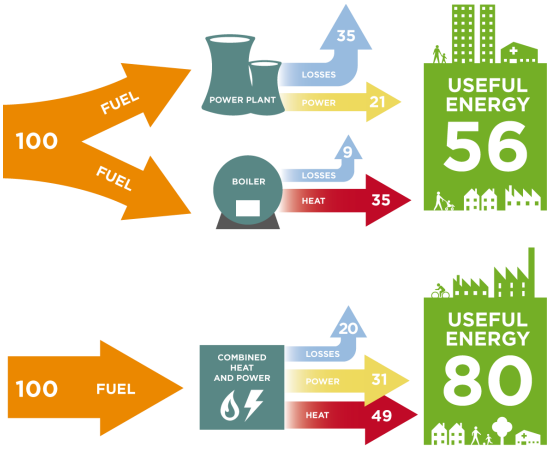
China—the world's largest hydropower project, generates 22,500 mw of electricity (similar to 4 nuclear power stations) but 1.2 million people were forced to move and 13 cities, 140 towns and 1350 villages had to be abandoned and are now submerged.

However, tidal power—using the movement of the sea as it ebbs and flows between high and low tide, to operate turbines - has great potential and schemes in the Swansea and Cardiff Bay area have recently been considered.



► Hydropower can be environmentally destructive.

Biomass power



Biomass is another increasingly popular form of sustainable energy production and several large biomass-fuelled power stations have been built in the UK (see Module 8). Fuel includes food wastes, as well as waste wood, tree thinnings and other crops.

Making electricity with biomass does produce CO2, but because the plant matter being burnt absorbed CO2 when it was growing, the process is considered 'carbon neutral'. Using waste to produce energy can help reduce fossil fuel use, CO2 emissions and reduce pollution and waste management problems, all in one go.

◄ Combined Heat and Power (CHP) plants are the most efficient way to extract energy from biomass

Geo-thermal power

This is energy generated by heat stored beneath the Earth's surface, especially in volcanic areas where heat is nearer the top. Bore holes are drilled (often several km deep) and cold water pumped down.

The temperature of the earth increases on average 1 degree centigrade for each 30 to 50 metres drilled, so the water heats up and returns to the surface to drive turbines that produce electricity. The world's first geo-thermal electricity generating power station was built in Italy, but there are now similar ones operating in New Zealand, Iceland, The Philippines, Mexico, Indonesia and in the USA.

One of the advantages of geothermal power is that—unlike solar and wind—it is unaffected by changing weather conditions. However, the locations of these power plants depend on the right geological conditions.

Volcanically active Iceland gets 87% of its heating & hot water from geothermal energy, and 25% of its electricity production.

There has been some growth in the amount of dwellings in the UK using geothermal energy, but it is an expensive technology with long payback times and requires more space than most homes have.

Section 4—Trainee exercises and questions

There are some questions for you to answer on the following pages.

Remember: don't hesitate to ask for help from your Trainer.

Module 11: Exercise 1

1. What has contributed to the rise in energy demand since the Industrial Revolution?	
2. The vast majority of our energy has traditionally been produced by burning what?	
3. What are the three fossil fuels?	
4. What is CO2?	
5. What % of the atmosphere is CO2?	
6. Name 4 non-human-induced sources of CO2:	1.
	2.
	3.
	4.
7. What is the main human-induced source of CO2?	
8. What are the 2 overall effects of global warming?	1.
	2.
9. Give 2 examples of changing weather patterns:	1.
	2.
10. Give 3 consequences of changing weather patterns:	1.
	2.
	3.

11. How many people could be directly at risk from sea level rise?	
12. How far could sea levels rise this century?	
13. Give 2 causes of sea level rise:	1. 2.
14. Give 2 consequences of the oceans warming and rising:	1. 2.
15. Oil accounts for what % of current global energy usage?	
16. How much CO2 is emitted from burning 1 litre of petrol?	
17. Give 3 end-products made from oil:	1. 2. 3.
18. Which constituent of natural gas is used for domestic cooking, heating and power generation?	
19. Give 2 end-products made with natural gas:	1. 2.
20. Why is energy generated from biomass considered carbon neutral?	

Office use only		**Number of correct answers required to pass Module 11: 16**			
Passed:		**Retake:**		**Date:**	
		Trainer's signature:			