Education Scotland
Foghlam Alba

Weather and Climate Change

Energy

See accompanying ‘energy’ videos in Glow video: http://tinyurl.com/z74qvt8

Transforming lives through learning

Energy

Using energy as a context for learning creates many opportunities for promoting global citizenship and developing interdisciplinary learning within Curriculum for Excellence.

Climate change is fundamentally about the importance of energy to our lifestyles in the modern world. Our energy needs have increased dramatically in line with our demand for goods and services. For instance, it is estimated that China is currently building two new power stations every week to sustain its significant economic growth. This simply reflects the process that has happened in many developed countries since the start of the Industrial Revolution 200 years ago.

This enormous need for energy has had a damaging impact on our environment and has released massive quantities of greenhouse gases into our atmosphere. Most scientists believe this is contributing to climate change. The challenge for humankind is to find new and sustainable ways to produce energy from renewable sources. Scotland aims to be a world leader in this field as it seeks to move towards a low-carbon and sustainable future.

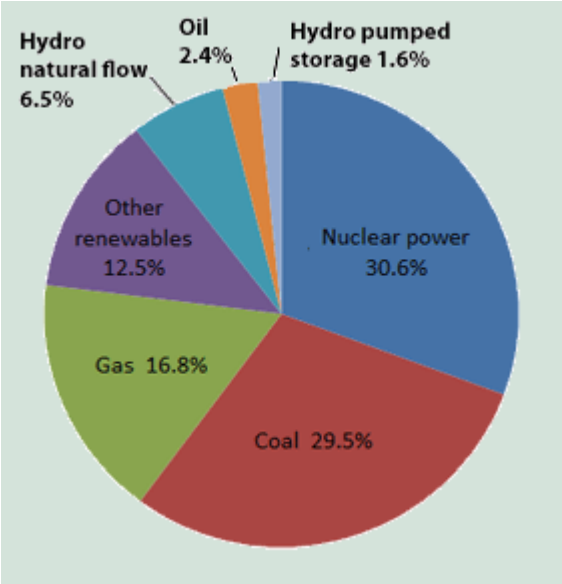
Reflective questions

- How can we help learners to develop the skills of reflection, discernment, critical thinking and deciding how to act when making moral decisions?
- How can we motivate learners to contribute to building a better world by taking responsible ethical actions to improve their lives, the lives of others and the environment?
- How can we encourage learners to become informed consumers and producers who have an appreciation of the merits and impacts of products and services?

Generation

In 2010, Scotland generated 49,910 GWh of electricity, 3% less than in 2009. This electricity was generated from the following sources:

- Nuclear power – 15,293 GWh (30.6%)
- Coal – 14,729 GWh (29.5%)
- Gas – 8,381 GWh (16.8%)
- Other renewables – 6,248 GWh (12.5%)
- Hydro natural flow – 3,267 GWh (6.5%)
- Oil – 1,212 GWh (2.4%)
- Hydro pumped storage – 779 GWh (1.6%)

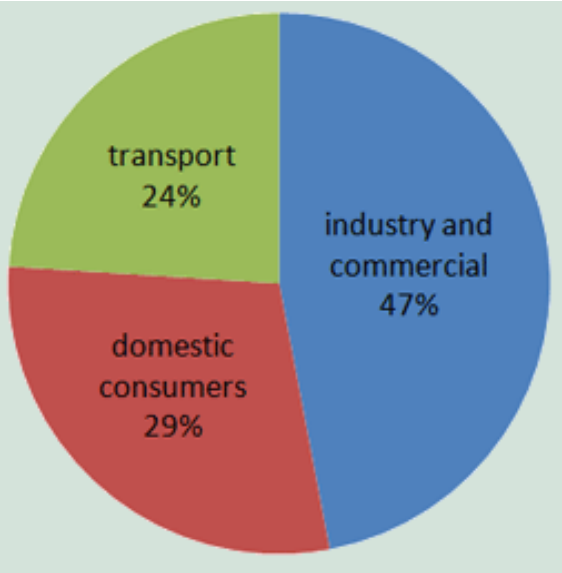


Total fossil fuels – 48.7%
Total renewables – 19%
1 GWh (Giga Watt Hour) = 1,000,000,000 Wh

Renewable energy sources like wind, solar, wave and tidal power are increasingly helping to meet a larger proportion of Scotland's energy needs.

By 2020, Scotland is committed to ensuring that 100% of our gross electricity consumption is met from renewable energy sources. Recent data shows that renewable energy production has increased by 46% to 13,735 GWh in 2011.

Source: Key Scottish Environment Statistics 2012



Consumption

- Industry and the commercial sector - 47%
- Domestic consumers - 29%
- Transport - 24%.

Reflective questions

- How can we develop in learners an understanding of the role and impact of technologies in changing and influencing societies?
- How can we build capability in learners to make reasoned choices relating to the environment, to sustainable development and to ethical, economic and cultural issues?

History of energy

The evidence shows that early humans in East Africa were using fire around 1.42 million years ago to provide light, warmth and to cook food. This marked the beginning of a process of inventiveness, discovery and ingenuity that has helped humankind harness power and energy from the Earth's resources to improve the quality of life.

The invention of the steam engine in the 1700s proved to be a tipping point in our consumption of resources sparking an enormous period of industrialisation and upheaval within societies around the world. The invention of the internal combustion engine in the 1800s later gave us a transport revolution including planes, motorcycles and cars.

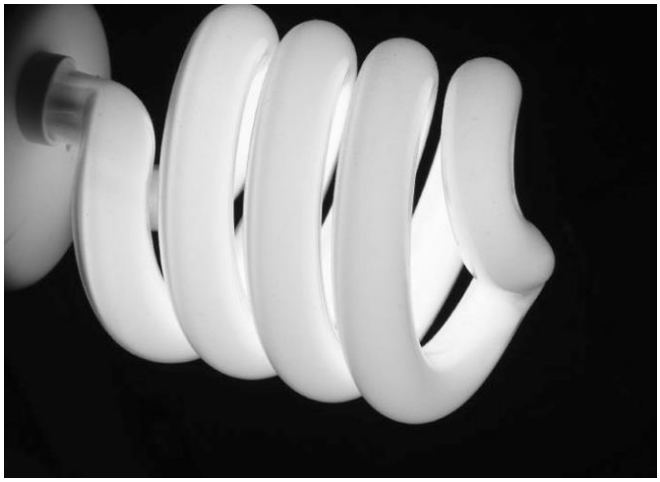
This increasing demand for energy to fuel these new innovations has continued unabated into the 21st century and left us with a legacy of greenhouse gas emissions which most scientists believe is causing our planet to warm dramatically.

If we are to tackle climate change then a further step change is required in our use of energy – this time to use modern and sustainable technologies to harness the power of the sun, wind, wave, tidal and other renewable sources. Scotland has ambitions to be a world leader in renewable technologies and within the coming decades it aims to develop a successful low-carbon economy.

Reflective questions

- How can we broaden learner's understanding of the world through learning about human activities and achievements in the past and present?
- How can we enable learners to locate, explore and link periods, people and events in time and place?

Energy in our homes



In modern times, energy in our homes is available at the flick of a switch. It is so easy and accessible that we can easily take it for granted. However, the way we have used energy in our homes has changed considerably over the last 200 years.

- Around 1793 a Scot named William Murdoch was the first man in the world to have his home lit by gas lighting. Everyone else used oil lamps or candles to light their homes. Gas lighting was popular in homes until electricity and electric light became widely available.
- Many people in Scotland traditionally used peat as fuel on their fires to heat their homes. Peat is still used today in some rural areas of Scotland.
- Forty years ago, many people in Scotland heated their homes with coal fires. The coal fire would also heat up a tank of water for your bath and for washing clothes.
- Today, most people use gas or electricity to heat their homes and make hot water.

In the 21st century more and more people across Scotland are thinking about where there electricity comes from. Instead of just buying electricity from power companies some people are generating their own electricity using solar power, wind or water. Generating small amounts of energy in this way is called ‘micro-generation’.

Reflective questions

- How can we help learners understand the role and impact of technologies in changing and influencing societies?
- How can we enable learners to gain the skills and confidence to embrace and use technologies now and in the future, at home, at work and in the wider community?

Energy for transport

The energy we have used for transporting goods and people has changed throughout the centuries.

- 200 years ago horses provided much of the transport and were used to carry individuals, pull carts, trams or canal barges.
- Trains became a popular form of transport in the 1800s and initially were powered by coal and steam. In the 1930s, steam trains were superseded by diesel and electric locomotives
- Prior to the 1860s, wind-powered sailing ships transported goods around the world. After this period, coal and steam-powered ships came to dominate until the 1900s when marine diesel and gas oil took over as the main fuels. Some military ships and submarines are powered by nuclear fuel
- The Wright brothers famously took off in 1903 and since then air travel has grown exponentially. Aviation fuel is petroleum-based while jet engines often use a blend of naphthalene and kerosene
- Today, many trains are powered by electricity. In France, the high-speed trains are powered by electricity and can reach speed of up to 320 kilometres per hour (or 199 mph)
- Space flight began in 1961 and shuttle journeys to the international space station are now common. The space shuttle uses a complex solid fuel for propulsion.

Motor vehicles

The first cars to be invented used petrol to power their engines. Today, over a hundred years later, most cars still use petrol or diesel as fuel, although in some countries LPG (Liquid Petroleum Gas) and bio-fuels are also common. However, new fuels are being developed to cut the use of fossil fuels and reduce emissions. Hybrid cars which use a combination of petrol and electricity are becoming increasingly popular and hydrogen gas is also being touted as the fuel of the future – when hydrogen combusts it produces no pollution, only pure water.

Reflective questions

- How can we help learners understand the role and impact of technologies in changing and influencing societies?
- How can we encourage learners to broaden their understanding of the applications and concepts behind technological thinking, including the nature of engineering and the links between the technologies and the sciences?

Fossil fuels

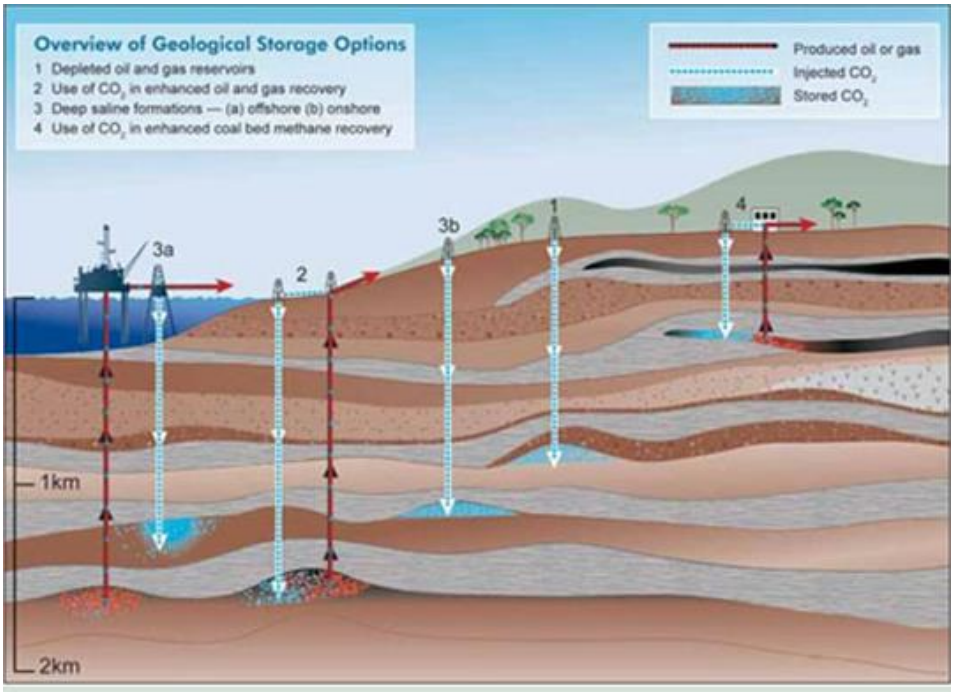
Many power stations across the world burn fossil fuels (including coal, oil and gas) to generate energy.

Coal is the remains of ancient plants and trees that grew over 200 millions of years ago. Oil and gas is made up of the remains of microscopic plankton. Over millions of years these remains become the carbon-rich coal, oil and gas we can use as fuel.

When fossil fuels are burned they release carbon dioxide into the atmosphere which contributes to global warming. Using fossil fuels to generate energy also releases pollutants into the atmosphere - such as sulphur dioxide.

Fossil fuels provide the main source of energy for our modern global economy. However, stocks of fossil fuels are limited and alternatives need to be found. Fossil fuel exploration has become increasingly controversial with widespread public anger at the massive oil spill in the Gulf of Mexico in 2010. Oil companies are increasingly looking to pristine polar regions and tar sands to provide oil in the coming decades but exploration in these areas could cause significant environmental damage.
Find out more about tar sands:
http://ostseis.anl.gov/guide/tarsands/index.cfm

`In Scotland, power stations that use fossil fuels include: Cockenzie (East Lothian), Longannet (Fife), Stornoway and Lerwick A and B (Shetland). Carbon capture and storage technologies are currently being developed to reduce the emissions of greenhouse gases from coal-fired power stations and other large emitters of carbon dioxide gas. This technology is in its infancy and it will be some years before it becomes available on a commercial scale.



Carbon capture and storage

The burning of fossil fuels over the last 200 years has caused concentrations of carbon dioxide in our atmosphere to rise and has contributed to global warming.

Carbon capture and storage provides a way for us to capture carbon dioxide from sources such as coal-fired power stations and trap it deep underground in geological formations or in other materials (such as mineral carbonates) to prevent the release of these gases into the atmosphere.

Carbon capture and storage technologies are currently being trialed in a number of locations around the world. Plans for a large scale pilot scheme at Longannet Power Station in Fife fell through in 2011 due to the cost of the long pipeline that was required.
Find out more about Longannet Power Station:
http://www.bbc.co.uk/news/uk-scotland-north-east-orkney-shetland-15371258

Carbon capture and storage technologies can reduce carbon dioxide emissions from power stations by up to 80–90%. If the technology is proven to work, and be cost effective, it could save millions of tonnes of carbon dioxide from being emitted and buy time while clean, renewable technologies come on line.

Some concerns have been expressed that carbon capture and storage technology will simply prolong our dependence on fossil fuels. Other concerns have been expressed that carbon dioxide which has been stored

underground may leak back into the atmosphere.

See the carbon capture and storage teaching resource produced by CSIRO/GCSSI or download diagrams and fact sheets from the Global Carbon Capture and Storage Institute.

Find out more about CSIRO/GCSSI
http://www.globalccsinstitute.com/publications/introduction-carbon-capture-and-storage

Image credit

IPCC, Carbon Dioxide Capture and Storage: Technical Summary (2005) 5. Geological storage, p. 29

Nuclear power

Nuclear power stations work in much the same way as fossil fuel power stations except that the fuel used to generate the heat is Uranium. Uranium gives of massive quantities of heat during a process called nuclear fission. This occurs when neutrons bombard the nucleus of Uranium atoms causing the atom to split roughly in half.

The heat from the nuclear reactor is then used to heat water or carbon dioxide which in turn produces steam to drive turbines, generating electricity in the process.

The first large-scale nuclear power station opened in 1956 and nuclear power now produces around 11% of the world's energy needs. In France alone, 78.8% of all the energy used is generated by nuclear power.

Nuclear debate

Nuclear power has proved to be controversial because of the problems associated with the long-term storage of radioactive waste and the expense of decommissioning old nuclear power stations. Nuclear power can be very expensive to produce but some are arguing for new stations to be built to help meet climate targets. This is because the process of nuclear fission doesn't produce greenhouse gases.
Nuclear power stations in Scotland are Hunterston A and B (Ayrshire) and Torness (East Lothian). In 2008, 30.2% of the energy used in Scotland was generated by nuclear power.

Renewable energy

Renewable energy is energy generated from natural resources which are replenished such as wind, wave, solar, biomass and tidal power. Governments and companies around the world are investing heavily in developing technologies to harness the power of clean renewable energy sources because of their potential to produce large quantities of energy without generating greenhouse gases which can contribute to climate change.

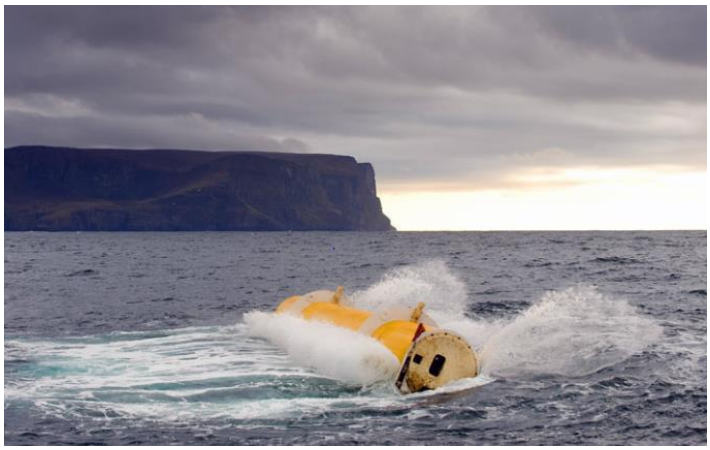
Scotland has some of the best potential for wind, wave and tidal potential in the world, with an estimated 25% of Europe's offshore wind and wave potential and 10% of tidal. It is estimated a total of 60 GW of renewable energy resources exists – this is equivalent to three-quarters of the total energy that can be generated by existing power stations in the UK.

Scottish innovators and companies are at the forefront of many renewable energy technologies and the European Marine Energy Centre in Orkney is conducting world-leading research into marine renewables. This boosts our economy and helps to create many jobs. In addition to the many onshore windfarms that currently exist across Scotland, feasibility studies are currently underway to investigate the potential of building the largest offshore windfarm in the world off the coast of Scotland. The Argyll Array if commissioned, will be located close to the Island of Tiree and could produce enough energy to power 1 million homes.

These developments will help Scotland achieve its target of ensuring that 20% of all energy use in Scotland comes from renewables. This includes specific targets for renewables to meet 50% of electricity needs and 11% of heat demand by 2020 and a target of 10% for renewable transport.

Wave and tidal power

The world's oceans offer an incredible amount of clean renewable energy and the technology to harness energy commercially from wave and tides is still relatively new.



Different devices

Wave and tidal power can be harnessed in many different ways.

Tidal barrages operate by blocking a river estuary and using the ebb and flow of the tides to turn turbines which in turn generate electricity. Research is also being conducted into generating electricity from massive tidal turbines (resembling underwater windmills) fixed to the sea bed.

Similarly, a whole host of devices are being invented to harness the power of the waves. The potential of tidal power is more limited but predictable while wave power offers a greater resource but is more erratic and dependent on wind and weather systems.

Scotland - a world-leader

Scotland's geographical location means we are ideally placed to take advantage of wave and tidal power and become a world-leader in marine renewable technology.

The world's first commercial wave power generator, the Limpet, is based on the coast of Islay and uses waves to drive air through turbines generating energy. The European Marine Energy Centre (EMEC) in Stromness, Orkney is a unique offshore test centre for marine renewable devices and has successfully trialled a variety of devices including the Pelamis sea-snake and the Oyster.

It is estimated that within the coming years marine renewable technologies could power 750,000 homes in Scotland.

The importance of this technology to Scotland's economy and future is underlined by the Saltire Prize which has been established by the Scottish Government. This international innovation prize is believed to be the largest of its kind in history and will award £10 million to the team which successfully demonstrates the first commercially viable wave or tidal device in Scottish waters.

Hydro-electric

Hydro-electric power currently provides about 20% of the world's power and accounts for 11.6% of the electricity generated in Scotland. Hydro-electric stations need a plentiful supply of water which is trapped above the power station in a loch, reservoir or river. When required, this water is released and falls through turbines generating electricity in the process. Suitable sites for hydro-electric power stations can be difficult to find and dams can be expensive to build. However, once built the energy is virtually free and produces no waste or pollution. Hydro-electric power stations are also more reliable than other renewable energy sources such as wind and wave power and hydro-electric power stations can increase to full power very quickly unlike other power stations.

Cruachan Power Station

Cruachan Power Station on the banks of Loch Awe in Argyll and Bute is the world's first high head reversible pumped-storage hydro-electric power station. Only a percentage of the energy generated by this particular type of hydro-power can be considered to be renewable. This is because the station is used to produce electricity to meet peak demand but then consumes massive amounts of power to pump the water back up into the reservoir. Cruachan can go from zero to maximum output in about 28 seconds – producing enough electricity to power a city the size of Aberdeen.

Hydro-electric power plants in Scotland include: Cruachan (Argyll and Bute), Pitlochry hydro-electric dam (Perth and Kinross), Earlstoun (Scottish Borders), Loch Dubh (Highland) and Tummel Bridge (Perth and Kinross).

Solar

Every minute, enough energy arrives at the Earth from the sun to meet our power needs for a whole year and a number of technologies exist to generate electricity and energy from solar power.

PV panels

Photovoltaic (PV) panels offer one way of harnessing the energy from the sun. These are made from semiconductor material which directly converts sunlight into electricity through a process called the photoelectric effect. This effect was discovered by Albert Einstein – earning him a Nobel Prize in 1921. Spain's solar power plants generate 3 gigawatts of power representing 2.8% of Spain's energy needs. Developments in PV technologies mean that the use of PVs in Scotland is becoming more viable and PV panels can now be found on the roofs of many Scottish schools. The island community on Eigg generate a proportion of their energy needs through their large PV array.

Solar thermal

Solar water heaters use the power of the sun to heat water thereby reducing the amount of gas or electricity required to provide heated water. Solar water heaters often consist of a series of black pipes situated within a glass panel fitted to roofs of buildings. Water is pumped into the bottom of these pipes which are painted black to absorb more heat. The heated water then exits the top of the panel and is stored in insulated water cylinders for use when required.

Wind turbines

Scotland has an abundant supply of wind, estimated to be 40% of total European wind potential, and wind turbines are now a regular feature of the Scottish landscape. Turbines require strong and reliable winds to function properly and have to be situated carefully - often in coastal areas, open moors or on rounded hilltops.

Scotland has invested heavily in wind renewables and Whitelee Windfarm near Eaglesham is the largest wind farm in Europe. It has 140 wind turbines which generate enough energy to power 180,000 homes. Feasibility studies are already being conducted with regards to the building of the Argyll Array off the coast of Tiree. If the project goes ahead then it is likely to be the biggest offshore windfarm in the world - potentially supplying power to more than a million homes.

Wind power can be easily harnessed by turbines large and small and an increasing number of island communities, home-owners and schools have installed their own turbines to micro-generate their own electricity.

Wind power locations in Scotland include: Whitelee Windfarm (East

Renfrewshire), Windy Standard (Dumfries and Galloway), and the Dancing Ladies in Gigha (Argyll and Bute).

Geothermal

Geothermal power harnesses energy that comes from the centre of the Earth where temperatures are approximately 6000°C. Even a few kilometres from the Earth's surface the temperature in the rocks can be as high as 250°C.This heat can be used to make steam to drive turbines to generate electricity. In areas with a natural ground water supply, steam is generated naturally within the hot rocks. In this case, a hole can be drilled drown to tap into this natural supply. Other geothermal power plants have to pump water into the hot rocks to generate steam.

Geothermal power stations

Large-scale geothermal energy plants tend to be found in countries with volcanic activity. For instance, geothermal energy heats 90% of all the homes and buildings in Iceland and provides 10% of the energy needs in Aotearoa/New Zealand. However, other countries are waking up to the potential of geothermal to provide a near limitless supply of renewable energy – a successful geothermal scheme has been operating in Southampton City since 1980, showing that even in the UK it is possible to use this energy source effectively.

Scotland

Some scientists believe that Scotland has significant potential for geothermal energy despite almost no current volcanic activity however most of the power we currently get from ground heat comes from the use of ground source heat pumps. These use pipes buried in gardens to extract heat from the ground. This heat is often used to heat water, radiators or underfloor heating.

Find out about ground source heat pumps:
http://www.energysavingtrust.org.uk/renewable-energy/heat/ground-source-heat-pumps

Biomass

Biomass energy is derived from living things including wood, woodchips, sugar cane, rapeseed, palm oil and corn. Biomass power plants generate electricity much in the same way as conventional power stations. The biomass fuel (wood, sugar cane pulp etc) is burned to heat water which generates steam. This steam is used to turn turbines which generate electricity.

Low carbon

Burning biofuels does generate carbon dioxide which is a greenhouse gas. However, this process simply releases carbon dioxide which has already been absorbed from the atmosphere by the biofuel when it was growing. It's not right to say that burning biofuels is carbon-neutral since energy is used in growing, fertilising and transporting the crops but biofuels can reduce emissions by 50-60% compared to fossil fuels.

Scotland

An increasing number of schools around Scotland use biomass boilers, powered by woodchips, to provide heating and Steven's Croft biomass power plant near Lockerbie generates power by burning off-cuts of waste wood and sawdust from local sawmills. Some community minibuses in Scotland are also powered by recycled chip pan fat!

Biofuel controversy

In the quest to reduce carbon emissions and boost their economies many countries invested heavily in growing biofuels, such as sugar cane, as a replacement for petrol. However, large swathes of land in the developing world were required to grow this biofuel, affecting food production and damaging biodiversity. The decreasing availability of food has also pushed the price of food up beyond the means of many, resulting in hunger in many of the poorest communities. Oxfam estimates that the increase in the production of biofuels around the world has dragged over 30 million people into poverty.

Scientists are new investigating the potential of harvesting algae and seaweed to provide a sustainable supply of biofuels.

Saving energy

Scotland's demands for energy continue to grow but the Climate Change (Scotland) Act, passed in 2009, sets out clear targets for greenhouse gas emissions to be reduced by 42% by 2020 and by 80% by 2050. This includes a commitment to cut emissions by at least 3% each year from 2020 onwards.

Being more energy efficient and reducing the energy we use is perhaps the quickest and most effective way to cut greenhouse gas emissions and meet these targets and the Scottish Government is developing national strategies to improve energy efficiencies across all sectors.

Local authorities now have legal commitments to cut their carbon, and schools buildings which are responsible for up to 50% of emissions from local authorities, have an important role to play in meeting this challenge.

Reduce, reuse, recycle.

It's important to remember that producing, transporting, packaging and disposing of consumer goods requires substantial amounts of energy and if we are to tackle climate change then we need to rethink our lifestyles and consumer habits by:

Reducing the energy we use, items we consume and waste we produce. This will also help support Scotland's zero waste action plan

Reusing the things we buy and trying to recapture the make and mend culture of 50 years ago

Recycling everything possible including: paper, plastic, cans, cardboard, glass, batteries, mobile phones, toner cartridges etc. Online auctions, charity shops and online freecycle services can help find a new home for possessions no longer required.
Find out more about online freecycle services:
https://www.ilovefreegle.org//

Reflective questions

- How can we encourage learners to think critically and creatively and make a positive difference to the world by putting their beliefs and values into action?
- How can we help learners understand the interdependence between people, the environment, and the impacts of actions, both local and global?
- How can we motivate children and young people to become informed consumers and producers who have an appreciation of the merits and impacts of products and services?