Get Energised!

Renewable Energy in Scotland

Primary Teachers' Guide

Foundation SCOTTISHPOWER

National Museums Scotland

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The purpose of this guide is to provide information on the different sectors of renewable energy in Scotland. This can be used as a starting point for activities and further discussion with pupils on how we can use renewable energy in real life.

Contents

For more information about our Get Energised sessions, visit **www.nms.ac.uk/GetEnergised**

You can also contact us on **schools@nms.ac.uk**

Introduction

Scotland's rugged landscape and weather provides massive potential for the generation of electricity through renewable energy and its use has been growing significantly in recent years.

The Scottish Government has set ambitious targets to be generating 100% of the electricity from renewable sources and 30% of all energy (electricity, heat and transport) by the year 2020, and 50% by 2030. In 2010 Scotland achieved around 24% of electricity by renewables and by 2017 this had more than doubled to 59%. This increase is due to more wind farms being built, people putting solar panels on their houses and investment in hydroelectric power (using water to generate electricity).

Renewable energy offers an excellent opportunity for cross-curricular study, as can be seen from the curriculum links listed below. In addition this is a strong area of topical science with regular news stories updating on developments in this field.

This guide contains background information on renewable energy sources, including how they work alongside the risks and benefits of each. There are suggestions for related classroom activities and suggestions for further sources of information.

Curriculum Links

The content of this guide links to first and second level outcomes linked to the following areas of the Curriculum for Excellence:

Topic	Curriculum links
Science	Planet Earth Forces, electricity and waves Topical Science
Social Studies	People, past events and societies People, place and environment
Technology	Technological developments in society

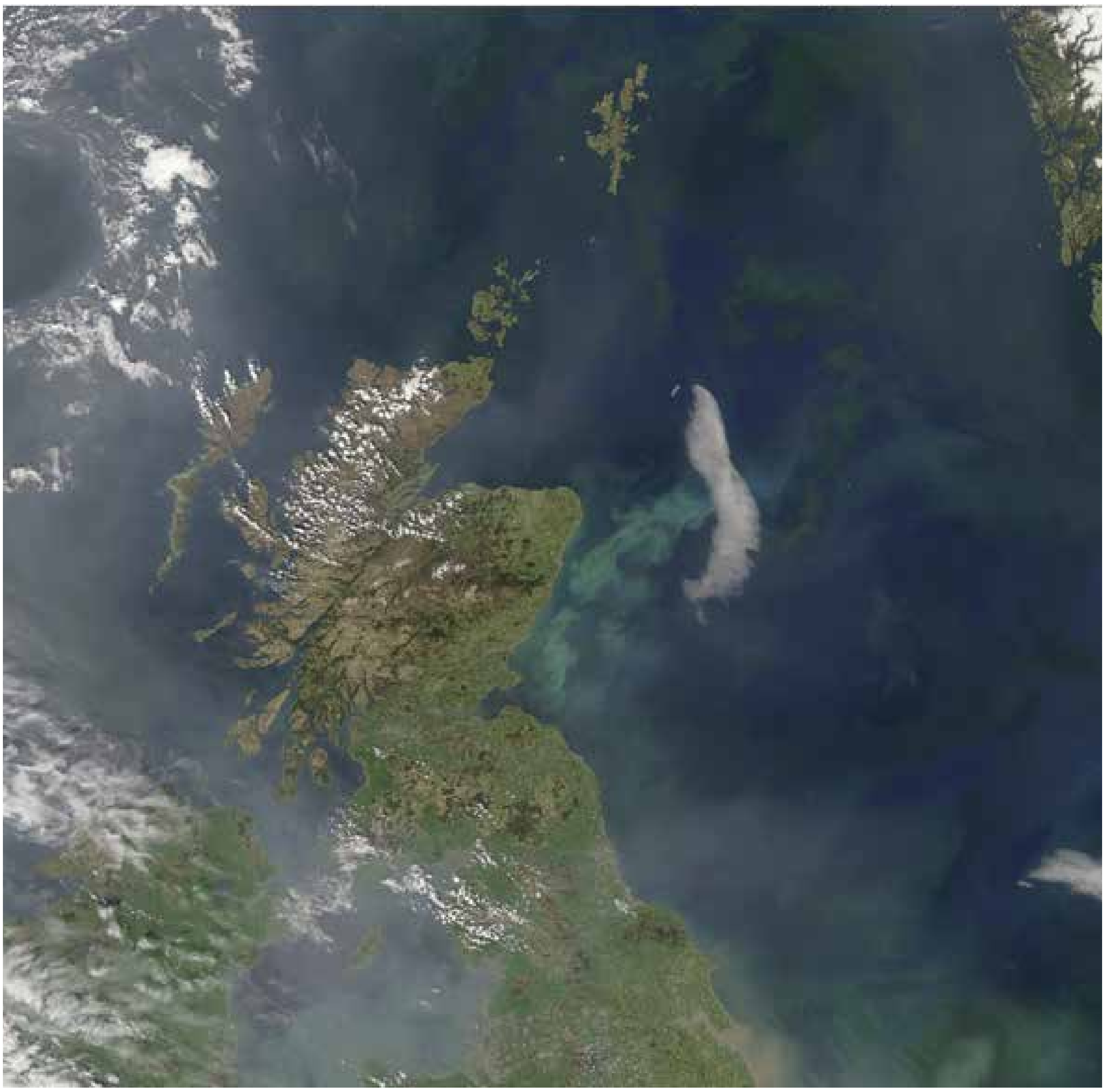
For details of the links to the Benchmarks for Science and Technologies, please see appendix A.

Scotland's Landscape

Over the course of billions of years, various geological processes have formed the landscape of Scotland. Volcanic activity, the movement and collision of landmasses, and ice and water moving across the surface acted to produce the landscape we see today. Not all processes were active across the whole of Scotland: the geography changes from North to South and East to West. Scotland can be split into three main areas for comparison: the Southern Uplands, the Midland Valley and the Highlands.

- The Southern Uplands is a gentle, rolling landscape formed by ice, wind and water moving over the surface. This area contains the Borders and up towards central Scotland.
- The Midland valley takes in central Scotland between the Southern Uplands and the Highlands. Even though it is suggested by the name, it isn't just one valley and there are many different features. The most distinct features were created by volcanic activity and examples of this can be seen at the sites of the castles in Edinburgh and Stirling.
- The Highlands begin north of Stirling and the area is very different to the rest of Scotland. Here we find a combination of high mountains, valleys and lochs. The type of rocks vary from East to West but in general, the features are a result of the movement of ice.

Scotland from space



NASA image by Norman Kuring, Ocean Color Team, Goddard Space Flight Center

The National Grid

The National Grid is the network of cables that carries electricity around the UK from where it is generated to the homes and businesses where it is used. Electricity can be generated in a range of different places such as nuclear power stations, wind farms or hydroelectric stations. Due to the increase in electricity coming from renewable sources, more and more connections are being made to the grid. The large metal pylons you see in fields carry cables the length and breadth of the country and there's many more power cables underground.

Metal pylons carrying cables

History

The United Kingdom's first pylon was erected in Scotland in 1928 and was located in Bonnyfield, near Falkirk. The National Grid was established as seven regional grids with the Scottish control based in Glasgow. The first section opened in Scotland in 1930 and connected to Portobello Power station. During the Second World War, a major expansion of the network took place as factories and army bases were sited outside of cities. As demand increased, the network was upgraded in the 1950s-60s to look more like what we see today.

Workers in a station

The network is maintained by a team of engineers who monitor the equipment and cables. A central control room monitors demand for electricity. They ensure that enough electricity is available for use throughout the day. There are peak times when we use more electricity, for example late afternoon in winter when we all have our lights and heating on. At other times there are spikes in demand, this could happen during the commercial break of a popular TV show when everyone gets up to put the kettle on. Ensuring that supply meets demand is a monumental task!

Classroom Activity

Electrical Brainstorming: Challenge your pupils to find some images or draw what they associate with the word electricity. Once they have a range of images or drawings ask them to arrange them into groups where each item has something in common with the others in that group. It is up to the pupils how they group them but suggested headings could be provided such as homes, transport, work, production etc. Groups can then feedback to the rest of the class about how they have grouped their items.

Generating Static: Play about with static electricity using balloons, jumpers and/or hair. Challenge students to move small items such as feathers or small bits of paper using the charge they make. Link this type of static electricity to lightening, a natural power we are, as yet, unable to harness as useful source of power.

Hydroelectric Power

This method takes advantage of a natural resource available in Scotland to generate electricity – water.

Landscape

There are more than 80 hydropower stations in Scotland. This compares to only seven in Wales and no large-scale sites at all in England. The output of the combined small-scale sites in England is only 0.7 % of the total available output in Scotland. The reason that Scotland generates so much more electricity from hydropower than England is due to our landscape and geography. We naturally have many lochs (particularly in the Highlands) and the space around them to build the infrastructure required for a power station.

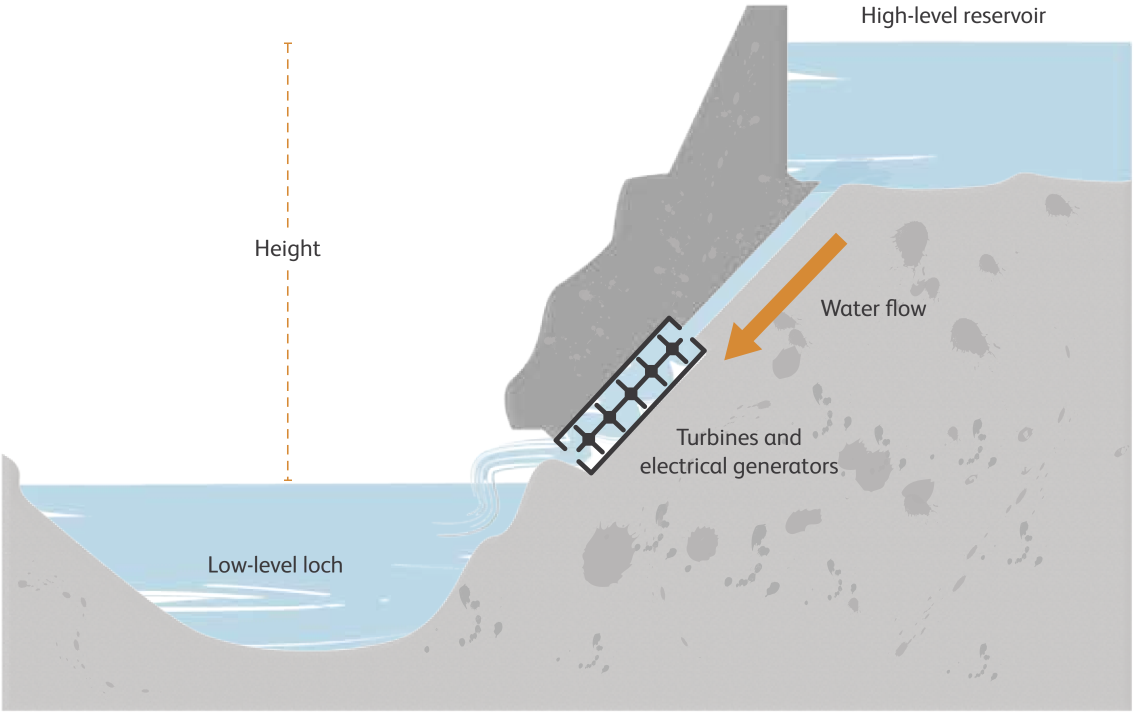
History

The first large-scale hydropower schemes were introduced in Scotland in the 1940s. At this time only 40 % of households in Scotland had electricity connections. Thanks to major government backing, by the 1960s the major developments to install hydropower schemes around Scotland were complete and over 90 % of households had an electricity connection. Hydropower was found to be a particularly effective way of providing electricity in remote locations. Many of the hydropower sites are still in use today but the technology used to generate electricity has been upgraded. Just over 40 % of renewable electricity in Scotland come from hydroelectric power stations which are found all over the country including in Pitlochry, Galloway, on Loch Ness and at the River Clyde near Lanark.

Pitlochry hydroelectric power station

Energy, Forces and Efficiency

- Hydropower uses gravitational forces to generate electricity.
- Water from a loch or reservoir is released down a channel to a turbine. This turbine uses the energy from the moving water to generate electricity by spinning magnets around each other.
- The water continues past the turbine and into a lower loch.
- The electricity is moved from the hydropower station along cables to homes and businesses where it is used. Sometimes, instead of a reservoir or loch, water is diverted from a river through a power station.



Hydropower station

- Generating electricity using moving water is a very efficient process.
  80-90% of the energy from the moving water is transferred into electricity. This means that the losses due to friction in the turbines is very small. If you were to stand near a turbine whilst it was generating electricity, it would be hot and noisy due to friction.
- Electricity can be generated quickly and cheaply by pumping water back up the pipes during times of low demand. The water can then be released at peak times. This can be controlled by the people who monitor the grid.
- The Highlands has the right landscape and weather for hydropower
- The Highlands is one of the wettest places in Europe. The total annual rainfall in this area is more than 4,500 mm. This is a lot more than the Lothians and Fife: less than 900 mm falls across these areas each year. This is important as it means the lochs and reservoirs used are replenished with water.
- In 2018, hydroelectric power accounted for more than 15% of Scotland's renewable electricity production.

Risks and Benefits

There are a variety of risks and benefits of hydropower:

Risks	*Benefits*
The amount of electricity available can depend on the season or the weather.	Electricity connections can be provided to remote communities by using local resources.
Most hydropower stations have no way of storing their output for when it is needed most.	Hydropower stations are responsive in that they can come online quickly and begin generating electricity.
It is expensive to build new hydropower stations and they can impact on existing wildlife. Most ideal locations in Scotland have already been taken.	Once built, there are no further CO_2 emissions.

Classroom Activity

Powered by water: Where is the nearest hydropower station to your school?

Is it on a river or a loch?

When was it built? Can you find out how many houses it can provide electricity for? Is the same body of water used for other resources/activities?

What else would you like to find out about it and where could you find this out?

Wind Power

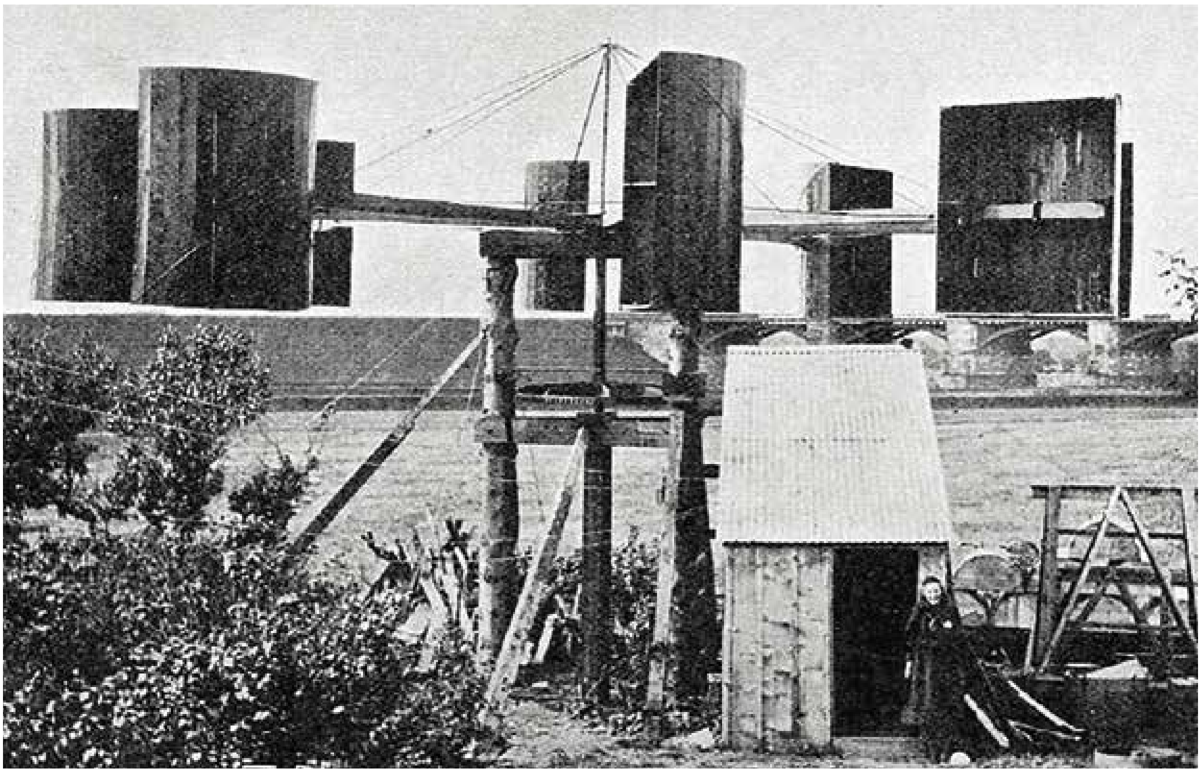
The combination of weather and landscape in Scotland makes it very suitable for using wind power to generate electricity.

Weather and Landscape

Wind turbines need a minimum wind speed in order to work and for the most part, our windy weather in Scotland provides enough gust to provide an average wind speed to make turbines a viable renewables choice. However, not everywhere is suitable for a wind turbine, for example, close to buildings or in a valley. When choosing a site for a new wind farm, it should be open and free of obstacles and have medium to high wind speeds. Wind speed increases the higher you go, therefore wind farms are often placed on top or on the side of a hill.

History

The first electricity generating wind turbine was invented and installed by Scottish Engineer James Blyth in 1887. He built the turbine next to his house in Marykirk. It was built using wood, metal and canvas. When working, it produced enough electricity for ten 25-volt bulbs. James Blyth was an early pioneer in the use of wind to generate electricity but he had an interest in using renewable sources in general. Wind pumps have been used to provide water for domestic and agriculture for a long time, but this was the first time it was used in this way. However, it wasn't until the mid-20th century that wind turbines began to be used across the UK. Prior to this they were considered too expensive. The UK's first grid connected wind turbine was in the 1950s at Costahead in Orkney, Scotland.



SSE Power Distribution

James Blyth wind turbine, built in 1891

Wind farms can also be found offshore in the sea. Areas are chosen for their high average wind speeds. Offshore windfarms can either be fixed to the seabed or floating turbines. The first off-shore wind farm in Scotland was completed in April 2010. The Robin Rigg is an example of fixed foundation offshore windfarm in the Solway Firth.

A floating wind turbine – image courtesy of Principle Power

This type of wind farm has wind turbines mounted to floating structures and are used out at sea where the depth of the water prevents turbines being fixed to the seabed. By not being restricted to shallower waters, there is a larger area of sea in which they can be placed. They are also have the advantage of being placed where winds are strongest, away from fishing and shipping lanes. The concept of offshore floating wind turbines was originally developed in 1972 by Professor William E Heronemus at the University of Massachusetts Amherst. Since the mid-1990s the technology has been under development but it is still early days for the commercial floating turbine industry. The world's first operational floating windfarm, the Hywind, was constructed off the coast of Peterhead, Scotland in 2017 and consists of five floating turbines. Further offshore floating windfarms are planned for Scotland. However, further development is still required before larger scale floating windfarms can become viable.

Energy, Forces and Efficiency

- The technology used in modern wind turbines hasn't changed much in recent years. The sight of a tall white tower with a housing at the top connected to three blades that turn in the wind is a familiar one across Scotland.
- As of October 2017 there were 460 operational and planned wind farms in Scotland, making wind power responsible for over 75% of the electricity output from renewable sources.
- As the wind blows past a turbine, the friction between the air and the blades causes them to turn.
- The electricity is produced when the turning blades drive a generator inside the turbine.
- Unlike hydropower where 80-90% of the energy from the moving water is converted into electricity, around 30% of the energy from the wind is converted into electricity by wind turbines.
- Friction of the mechanical parts produces energy losses in the form of heat and sound.

Risks and benefits

There are a variety of risks and benefits of wind power:

Risks	*Benefits*
The amount of electricity available can depend on the season or the weather. For example, it is windier in autumn and winter.	Although wind is variable, it is predictable so you know how much electricity will be available.
There is no way to store the output of the wind farms for when it is needed most. Although it is more common now to store the energy produced in batteries in co-located sites.	Electricity connections can be provided to remote communities by using local resources, if there is a grid connection.
Wind farms are expensive to install but they are cheaper than gas power plants and nuclear.	It doesn't cost much to maintain and repair the turbines once installed.
They can impact on the local environment and the places they are best built are often considered areas of natural beauty and some complain of them being an eyesore.	Once built, there are no further CO_2 emissions.

Classroom Activity

Mapping it out: Wind farms are usually placed on a hill to take advantage of the wind there. Are there any wind farms near to your school? Have a look at a map of your local area and decide where might be best to put a new wind farm. Consider factors such as height of land, what else is nearby and who might be affected by it.

Pinwheel turbine Ask students to build their own windmill using paper, a pencil and a paper fastener (templates available online). Investigate which direction you have to blow on the windmill to get it to turn and how a minimum amount of breath is required to get it to turn – just like a real wind turbine

Horizontal axis wind turbine

Solar Power

Perhaps surprisingly, Scotland is a good location for using the power of the Sun to generate electricity. Although we don't tend to have overly sunny days, we do have long days in the summer giving us a high number of daylight hours. However, there are other aspects, such as the landscape, that mean it is not something that will likely be done on a large scale in this country.

Landscape and History

Solar panel technology has been used as a way to generate electricity for decades. Initial development work on solar panels was carried out by organisations such as NASA in order to power spacecraft and satellites. On Earth, they are most commonly seen on the roofs of buildings, normally facing south or south west to best fit the position of the Sun in the sky. After rising in the east the sun travels across the southern sky before setting in the west. Therefore, panels are positioned to capture as much sunlight as possible.

The cost of solar panels has greatly reduced in the last 40 years. This is mainly due to larger volumes of panels being manufactured and used in countries such as China. In recent years in the UK, homeowners have been able to cover the cost of the panels themselves by selling any unused electricity to the National Grid. This has resulted in a large increase in the use of solar panels to generate electricity. Solar panels in Scotland are responsible for generating around 3% of the electricity that comes from renewables. This is currently quite small but has grown rapidly in recent years and is expected to continue to grow.

It is unlikely that there will be many large-scale commercial solar panel power stations in Scotland – unless they are co-located with wind turbines – as these sites require large areas of flat land. The landscape in Scotland is very hilly and any available flat land is normally used for agricultural purposes. Currently the largest commercial solar farm in Scotland is on the Errol Estate, Perthshire and there is another larger solar farm planned in Moray.

Energy, Forces and Efficiency

- A solar panel collects the light from the Sun and uses its energy to generate electricity. The most commonly used type is called a photovoltaic (PV).
- The most efficient solar panel models have an efficiency of over 22% and the average efficiency of solar panels is 15% to 18%.
- This is an improvement on earlier types of panels but future versions will not be able to improve much on this.
- Efficiency is limited because even though the panel is exposed to all of the light from the Sun, the material the panel is made from can only use some of the light.
- The technology is improving all the time and in the future it may be possible to have solar panel windows.

Risks and benefits

There are a variety of risks and benefits to solar power:

Risks	*Benefits*
The amount of electricity available can depend on the time of year. For example we have longer days in the summer and shorter days in the winter.	As they are generally installed on existing buildings, the local environmental impact is low.
Houses need a local storage system (batteries) to store electricity generated during the day so that the house can be powered once it is dark outside.	It doesn't cost much to maintain the solar panels once installed.
The technology can be expensive for individuals to invest in, however this cost is coming down.	Once built, there are no further CO_2 emissions.

Classroom Activity

Solar powered walk: Take the pupils on a walk, or a virtual walk via google maps, around the local area to make records of the number of solar panels. This is an activity the class could repeat over 6-12 months to see if there are any changes. Do any pupils in the class have solar panels on their house?

If so, you could ask them to find out what differences it has made to their household bills.

If not, you could ask pupils to research why people are choosing to have them put on their roof.

Solar power bank: You can buy solar battery banks relatively cheaply online. They can be kept by the classroom window and used to charge a phone.

Marine Power

Strong waves and tides around the coast of Scotland provide lots of potential opportunities for generating electricity.

Landscape

Due to the geography of the land and the position of the UK there are areas – on the west and north coasts of Scotland – that experience large waves and fast moving tides.

- Waves form when wind blows across the surface of the sea. By the time waves reach the west and north coasts of Scotland, they have been travelling for thousands of miles across the Atlantic Ocean so have had time to grow in height.
- Tides result from the pull of the Moon and Sun due to gravity. The speed of the tide depends on various factors but fast flows can be found where there is an inlet between an island and the mainland. One excellent example in Scotland is the Pentland Firth. This is the region between the Orkney Islands and the north coast. The tide in this area can travel up to five metres per second (11 miles per hour).

History

The development and use of marine power is not as advanced as hydro, solar or wind. Each of these uses a fairly standard set of technology with minor variations between them. As yet there is no standard wave or tidal technology in use. In the 1970s there was a period of large investment in marine power development. This was prompted by the Oil Crisis, which saw access to oil restricted and as a result the price increased. Scientists and engineers were encouraged to develop ideas to generate electricity that didn't rely on oil. One of the solutions proposed was by Professor Stephen Salter of the University of Edinburgh. His design known as "Salter's Duck" converted wave power into electricity. The "Duck" sits on the surface of the sea and rolls with the waves. As it rolls, gyroscopes inside the device begin to rotate, driving an electrical generator. Unfortunately, Professor Salter's ideas were never fully realised. You can see a model of Salter's Duck alongside recent developments in wave technology in the Energise gallery at the National Museum of Scotland. The Oil Crisis passed and there was less funding available for study. However, marine energy is currently a very active area of research for Scottish universities and businesses but it does require a large amount of financial backing.

Pelamis Wave Power

Pelamis Sea Snake

MeyGen in the Pentland Firth was the world's first commercial tidal site and it consists of four turbines. It first started generating energy in December 2016 and was fully operational by February 2017. The European Marine Energy Centre, in Orkney, was set up in 2003-2004 as the world's first test sites for both wave and tidal energy. A range of different devices have been tested and there is now potential for more commercial marine energy to be developed.

Energy, Forces and Efficiency

- The wave power machines that have been developed so far have ranged from objects that sit on the surface to others that are suspended below. There are many different designs being tested.
- The normal process for this is that when a company or university has an idea, they build a model and test it.
- Over time the model can become larger and more complicated. The aim for them is to have a working version that can be deployed and tested at sea.
- Salter wasn't able to test a large scale version, but small scale models showed that the "Duck" showed it to be a very efficient way to generate electricity.
- The Pelamis sea snake is a wave turbine developed by members of Professor Salter's team. It was the first offshore wave machine that generated electricity into the grid. Although the company (now no longer operating) was Scottish, the technology was most successfully used off the coast of Portugal.
- As with other types of renewable energy technology, there will be losses due to friction in mechanical parts and also between the sea and the object.
- Tidal technology is often based on what we have learned from wind turbines.
- In the same way that turbine blades turn when fast moving air goes past it, a submerged turbine will turn as the water from a tidal stream moves past it.
- Similarly to wave technology, this is a very efficient process with over 80% of the energy from the tide being used to generate electricity.
- One of the main issues for marine energy production is survivability. The stronger the waves the more power that can be produced. However, storm waves also have the ability to destroy turbines. Researchers are currently finding ways to have the majority of the turbine positioned beneath the surface of the water or to have the ability to dock themselves below the surface of the water during storms to prevent the turbines being damaged.

Risks and benefits

There are a variety of risks and benefits to marine power:

Risks	*Benefits*
The areas where we have large wave heights and faster tidal currents are far away from the main population centres. This means we would need to invest in the National Grid to be able to move the electricity from the west and north of Scotland.	Electricity connections can be provided to remote communities by using local resources.
There is no main wave power technology emerging for use. This means that large investment is required in order to develop and test ideas. However, there are two companies very close.	As waves are generated by the wind, installing wave power generators next to offshore wind farms will maximise the output of the wind and reduce the maintenance and grid connection costs by sharing a site.
Marine power can be expensive to install and maintain and could have an impact on the local environment. Impacts to marine life still very uncertain and a lot more work needs done to make sure negative effects are small.	Tides can be predicted decades into the future unlike wind, wave or solar.
	Estimates of 20 % of UK electricity could come from wave and tidal. Scotland has the best resources for this. Pentland firth holds around 50 % of UK and 25 % of Europe's tidal energy that could be harnessed once built, there are no further CO_2 emissions.

Classroom Activity

Making waves: Use shallow water filled trays and rulers to make waves. Investigate how the size of the waves change depending on the depth of the water used. Adding some food colour will allow you to better see the wave patterns and currents forming.

Split the class into two, where one group makes a poster about waves and the other tides.

Biomass

Biomass energy is made by releasing the stored energy in plant and animal waste through burning or other forms of controlled breakdown

Landscape and History

Use of biomass energy dates back to ancient times, with early people burning wood for heat and light. Nowadays it can be derived from garbage, wood, waste, landfill gases and alcohol fuels. It is considered a renewable energy source as the materials used to derive the energy are not finite like fossil fuels, so for example new trees can be planted and we continue to produce food waste. Biomass can be converted to liquid biofuels or biogas.

Burning biomass fuels releases energy as heat. Heat production from biomass comes from a variety of sources. For example, individuals using wood burning stoves in their homes, businesses installing biomass boilers, up to large scale plants creating biogas that feeds into the gas grid and is used to supply gas to homes. The first gas-to-grid plant in Scotland was Keithick Biogas Limited in Coupar Angus, Perthshire which came into production in December 2014. The biomass plant uses a process called anaerobic digestion, where the biomass is broken down in the absence of oxygen by bacteria to produce biogas (biogas mainly contains methane and carbon dioxide). The technology has been used for years but Keithick was the first plant in Scotland to pipe the gas into the supply network that supplies gas to our homes. Anaerobic digestion often uses waste (e.g. food or farm waste) to produce the biogas that can then also be used to generate renewable electricity. In this case the biogas is combusted with air to generate hot gases, and the heat energy in the hot gases is converted to electricity by a generator.

Fast growing trees (e.g. Miscanthus) can also be used for electricity generation. In this case, trees are chopped and burnt to release heat, which is converted to electricity. This practice is sustainable only if the biomass is grown at the same rate at which it is harvested.

Biodiesel to fuel vehicles is produced using waste fats and oils. You may have seen lorries on the roads stating that they use biofuels. The waste oils and fats go through a chemical process called esterification, which causes the fats to be broken down using alcohol. Argent energy in Motherwell, Scotland, was established in 2001 and was the first biofuel producer in Europe use category one tallow – a hard fat derived from animal fats that has a high risk to human life (for example, infected with BSE). Using this tallow allows something that is potentially dangerous to human health to be disposed of at the same time as producing a biofuel.

Another biofuel (fuel produced from biomass) is bioethanol. Bioethanol is produced from cereals (e.g. corn, wheat) or sugarcane and can be used as a substitute for petrol. In the UK, unleaded petrol can contain up to 5% (in volume) bioethanol. After harvesting, cereals or sugarcane are brought to the bioethanol production plant where ethanol is produced by microorganisms from the carbohydrates in the crop. The ethanol is then purified from water and used as fuel. Bioethanol is produced mainly in the USA and in Brazil, but also in the EU and UK.

Energy, Forces and Efficiency

- In Scotland, 84 % of renewable heat comes from burning biomass or biofuels.
- In 2016, renewable heat accounted for 4.8 % and 5 % of non-electrical heat demand in Scotland.
- The biogas produced by anaerobic digestion is not as pure as natural gas, therefore the biogas must be cleaned before being fed into the supply network, to remove waster, carbon dioxide, hydrogen sulphide and siloxanes.
- Biofuels (biodiesel and bioethanol) are considered by some to be a greener fuel than diesel and petrol as they burn more completely, producing fewer emissions, and growing biofuel crops takes up any carbon dioxide generated by burning the fuels. Although there is an argument that you need put energy into growing the biofuel crops and this energy consumption may produce more carbon dioxide than fossils fuels most studies estimate that the energy required to grow biocrops is only about 20-30 % of the energy generated by burning the fuel and so the emissions are also low

Risks and Benefits

There are a variety of risks and benefits of hydropower:

Risks	*Benefits*
Sustainable use of wood for energy generation must ensures that wood is grown at the same rate at which it is harvested.	Biodiesel and bioethanol are considered by to be a greener fuel than diesel and petrol as they burn more completely, producing fewer emissions.
Land used for growing biofuel crops could be used for food production.	In contrast to other renewable energy sources, there is no requirement to site biomass sites to optimise weather or landscape features, i.e. strong winds for wind power, or flat areas of land for solar power
You need to put energy into growing the biofuel crops and these produce carbon dioxide. Also burning the biofuels to produce energy produces emissions.	Biogas can be used in remote areas where existing gas supplies are limited. Biogas can be produced from waste, coupling energy generation with waste treatment.

Classroom Activity *Plant power*

Plant power: Using the energy listing on the packaging along with other research, look at how much energy is in plant-based foods and crops and consider which would make the best biofuel. Good options to include would be different types of oils and vegetables.

Look at the waste from your classroom and/or school and think about which of it could be burnt as a biofuel.

Further Sources

Background information:

- Energy statistics for Scotland:

  www.scotland.gov.uk/Topics/Statistics/Browse/Business/Energy

- Met Office weather data:

  www.metoffice.gov.uk/learning/weather-for-schools

- European Marine Energy Centre:

  www.emec.org.uk/marine-energy/

- National Grid

  www.nationalgrid75.com/

- Renewable UK

  www.renewableUK.com

Further activities and resources:

- National STEM Centre e-library:

  www.stem.org.uk/resources

- Scottish Schools Education Research Centre (SSERC):

  www.sserc.org.uk

Find out more about the Get Energised programme, including our range of resources, online:
www.nms.ac.uk/GetEnergised

You can find out more about careers in the renewable energy sector in Scotland at the following links:
www.myworldofwork.co.uk/my-career-options/energy

This will give pupils an overview of the industry, the range of jobs available and video clips of people working in the industry.

Appendix A

Science Benchmarks

Curriculum Organisers	Experiences and Outcomes	Benchmarks
Energy Sources and Sustainability	**SCN 1-04a:** I am aware of different types of energy around me and can show their importance to everyday life and my survival.	• Identifies and talks about types of energy that we get from different energy sources, for example, light, sound, heat and electrical. • Uses knowledge of different energy sources, for example, sun, food, fuel, wind and waves, to discuss the importance of different types of energy for everyday life and survival.
	SCN 2-04a: By considering examples where energy is conserved, I can identify the energy source, how it is transferred and ways of reducing wasted energy.	• Demonstrates understanding of the law of conservation of energy (energy can be converted from one form to another but cannot be created or destroyed). • Identifies the common types of energy (kinetic, potential, electrical, chemical, light, sound and heat) used in energy transfers and transformations that occur in everyday appliances. • Explains that when energy transfers and transformations take place, energy is converted into 'useful' and 'wasted' energy, for example a mechanical braking system transforms kinetic energy into heat energy which is dissipated to the atmosphere as 'waste' heat.
	SCN 2-04b: Through exploring non-renewable energy sources, I can describe how they are used in Scotland today and express an informed view on the implications for their future use.	• Researches non-renewable sources of energy, such as fossil fuels and nuclear, and discusses how these are used in Scotland. • Draws on increasing knowledge and understanding to suggest ways in which they can reduce their own energy use and live more sustainably.

Science Benchmarks (continued)

Curriculum Organisers	Experiences and Outcomes	Benchmarks
Topical Science	**SCN 1-20a:** I have contributed to discussions of current scientific news items to help develop my awareness of science.	• Discusses and expresses opinions about science topics in real-life contexts, including those featured in the media. • Discusses how people use science in their everyday lives. • Describes a variety of jobs and careers which require scientific knowledge and skills.
	SCN 2-20a: through research and discussion, I have an appreciation of the contribution that individuals are making to scientific discovery and invention and the impact this has made on society.	• Describes the impact of scientific discovery, creativity and invention on society past and present, for example, in design, medicine and agriculture. • Demonstrates understanding of how science impacts on every aspect of our lives. • Relates the development of scientific skills in the classroom to an increasingly wide variety of science, technology, engineering and mathematics (STEM) careers.
	SCN 2-20b: I can report and comment on current scientific news items to develop my knowledge and understanding of topical science.	• Explores items of current scientific interest within the school, local community, nationally or in the global media and collates, organises and summarises findings, with assistance. • Shares opinions about a variety of topical scientific issues considering, for example, moral, ethical, societal, cultural, economic and environmental aspects.

Technology Benchmarks

Curriculum Organisers	Experiences and Outcomes	Benchmarks
Awareness of technological developments (Past, Present and Future), including how they work.	**TCH 1-05a:** I can explore the latest technologies and consider the ways in which they have developed.	• Identifies changes to technologies for example, televisions and mobile phones.
Impact, contribution, and relationship of technologies on business, the economy, politics, and the environment.	**TCH 1-06a:** I can take appropriate action to ensure conservation of materials and resources, considering the impact of my actions on the environment.	• Identifies ways in which energy can be saved. • Understands how and where we waste materials and resources.
	TCH 1-07a: I understand how technologies help provide for our needs and wants, and how they can affect the environment in which we live.	• Demonstrates an understanding of how technologies, by meeting our needs and wants, affect the environment in which we live.
	TCH 2-07a: I can make suggestions as to how individuals and organisations may use technologies to support sustainability and reduce the impact on our environment.	• Discusses the advantages and disadvantages of how technologies impact on the environment for example, renewable energy technologies.

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