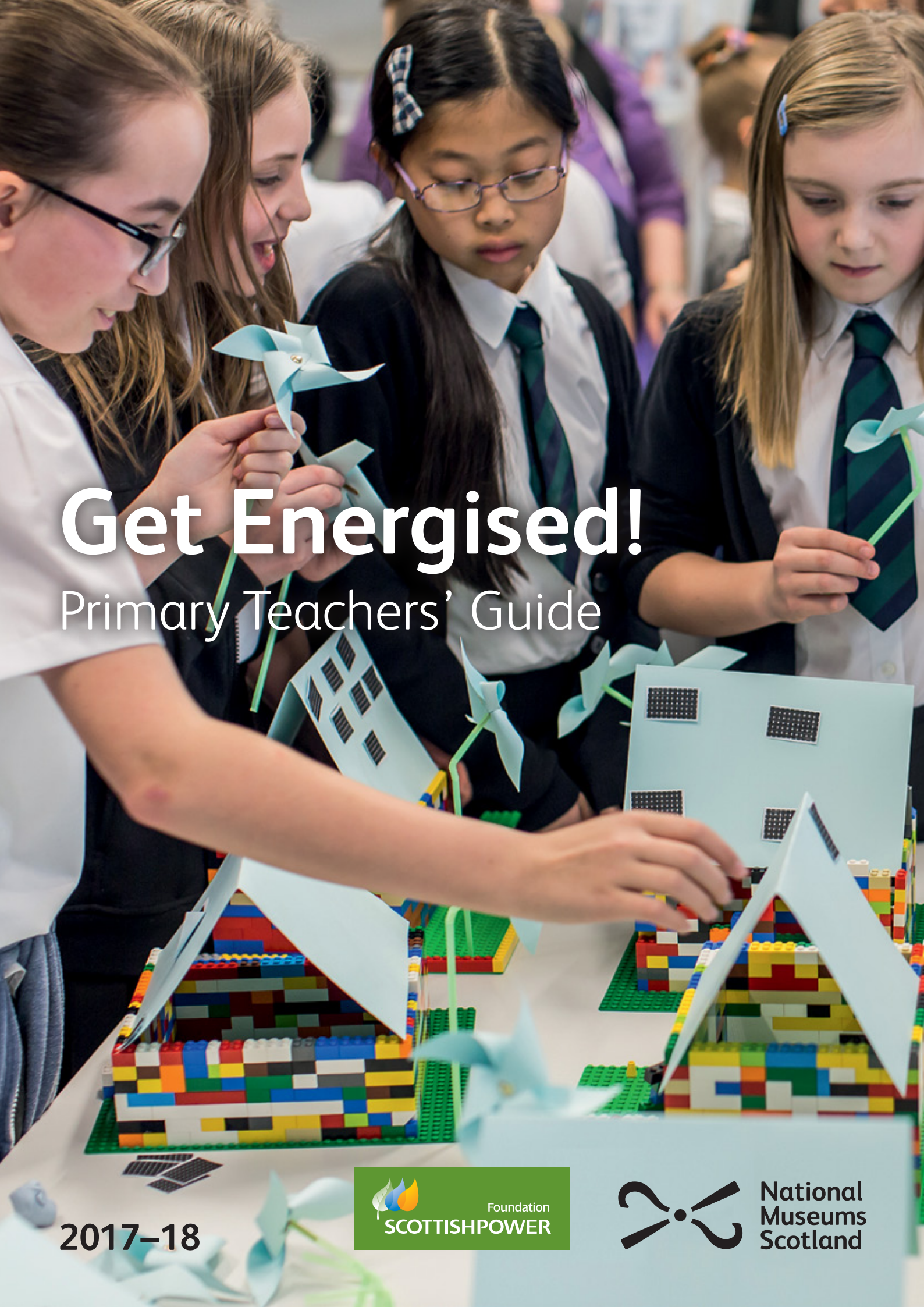

# Get Energised!

## Primary Teachers' Guide

2017–18

Foundation SCOTTISHPOWER

National Museums Scotland

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National Museums Scotland

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## Primary Teachers' Guide

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 free Get Energised sessions, visit **www.nms.ac.uk/GetEnergised**

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

# Introduction

The use of renewable energy as a source for generating electricity has been growing significantly in recent years in Scotland. The Scottish government has a target that we should be generating 100% of the electricity we use from renewable sources by the year 2020. In 2010 Scotland achieved around 24% and by 2015 this had more than doubled to 57%. 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 opportunity for cross-curricular study, as can be seen from the curriculum links listed below, as well as being an area of topical science. There are 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 quick activities in class and at the end of the guide you will find 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<br>Forces, electricity and waves<br>Topical science |
| Social studies | People, past events and societies<br>People, place and environment |
| Technologies | Technological developments in society |

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

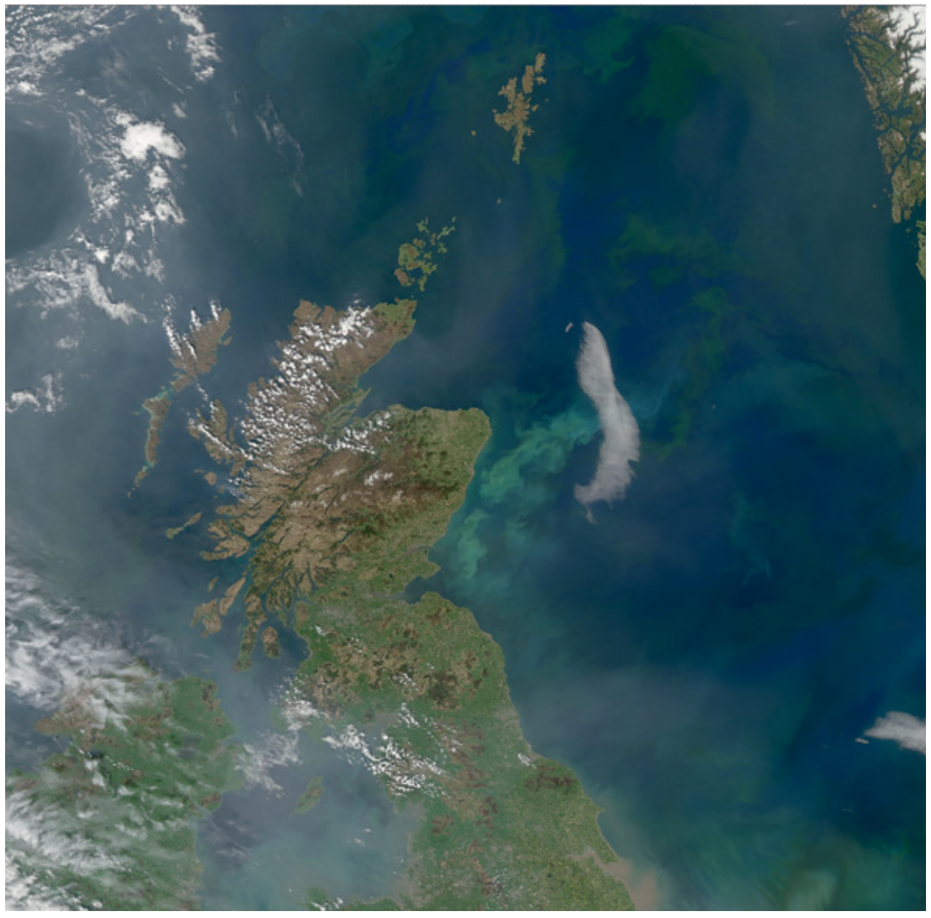


# Scotland's Landscape

Over the course of billions of years, different processes have formed the landscape of Scotland. Volcanic activity, the movement and collision of landmasses, and ice and water moving across the surface all 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*

# National Grid

The National Grid is the network of cables that carries electricity around the UK from the place it is generated to the homes and businesses where it is used. The place it is generated could be a nuclear power station or a wind farm. Due to the increase in electricity coming from renewable sources, more and more connections are being made to the grid. The large metal pylons will be a familiar sight as they carry cables the length and breadth of the country.

## History

In 1928, the first pylon in Scotland was built 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 out of cities. As demand increased, the network was upgraded in the 1950s-60s to look more like what we see today.

*Metal pylons carrying cables*

*Workers in a power 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 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.

### Quick Activity

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 in groups where each item has something in common with the others in that group. It is up to the pupils how they group them. Groups can then feedback to the rest of the class about how they have grouped the different items.



# Hydroelectric Power

This method takes advantage of the natural resources available in Scotland to generate electricity.

## Landscape

There are more than 80 hydropower stations in Scotland, 7 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 per cent 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 of a power station.

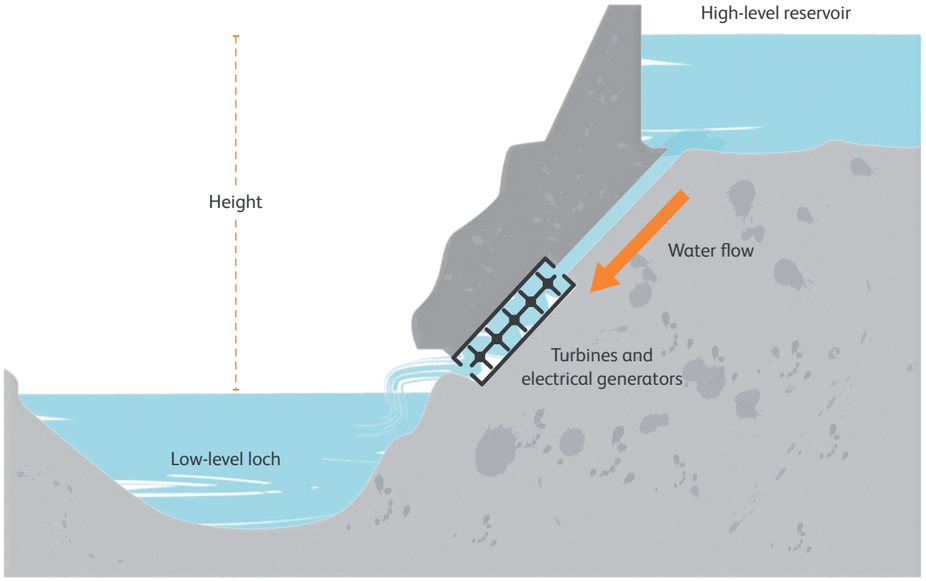
## History

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. 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 an excellent way of providing electricity in remote locations. This development of power stations was possible because of backing from the government at the time. Many of the hydropower sites are still in use today but the technology used to generate electricity has been upgraded. Just over 40% of electricity from renewable sources comes from hydroelectric power stations. These are found all over Scotland, 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.
- 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.
- In addition to the Highlands having the right landscape for hydropower, it also has the right weather conditions. It is important that the lochs and reservoirs used can refill with water.
- 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.



### 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. | Once built, there are no further $CO_2$ emissions. |

### Quick Activity

### Research:

Where is the nearest hydropower station to your school?

Is it on a river or a loch?

Can you find out how many houses it can provide electricity for?

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

# Wind Power

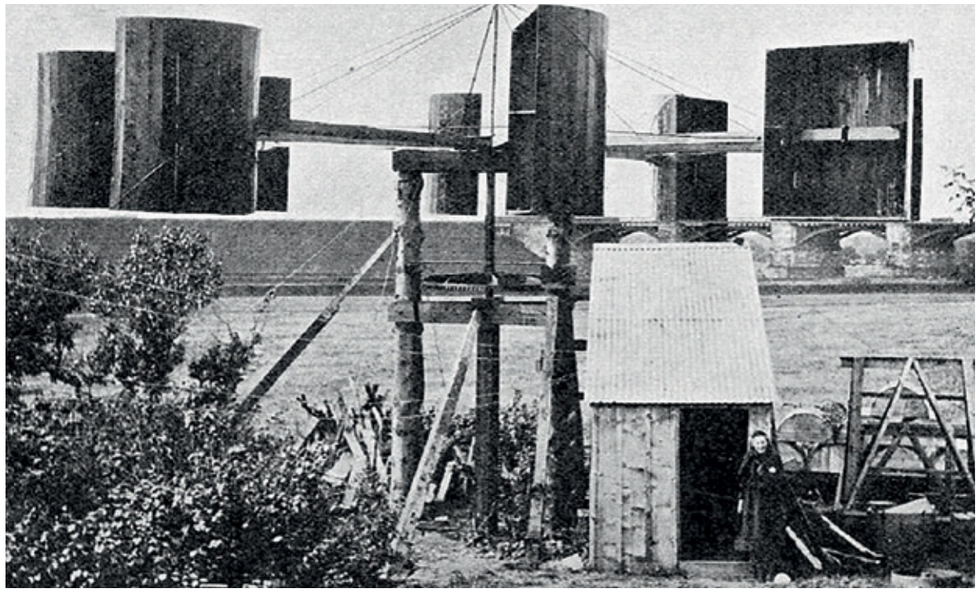
The combination of weather and landscape in Scotland makes it very suitable for using wind power to generate electricity.

## Weather and Landscape

Wind turbines need a minimum wind speed in order to work. Due to the weather conditions in Scotland, our average wind speed is high enough. However, not everywhere is suitable for a wind turbine. When choosing a site for a new wind farm, it should 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. Wind farms can also be found off-shore in the sea. Areas are again chosen because they have high average wind speeds.

## 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.



SSE Power Distribution

*James Blyth's wind turbine, built in 1891*

## 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.
- There are now over eighty wind farms in Scotland, making wind power responsible for over 55% 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 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. | Electricity connections can be provided to remote communities by using local resources. |
| There is no way to store the output of the wind farms for when it is needed most. | It doesn't cost much to maintain and repair the turbines once installed. |
| Wind farms are expensive to install and they can impact on the local environment. | Once built, there are no further $CO_2$ emissions. |

### Quick Activity

Wind farms are usually placed on a tall hill to take advantage of the wind there.

Are there any wind farms near to your school?

If not, can your class decide on a suitable location for one?

# Solar Power

Scotland is a good location for using the power of the Sun to generate electricity. We 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.

## Landscape and History

Solar panel technology has been used as a way to generate electricity for decades. 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. This is due to the position of the Sun in the sky. After rising in the east it 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 forty 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 un-used 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 this 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. 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. In the future, large-scale installations will more commonly be found in desert regions where there are large areas available.

## 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 latest solar panel models have an efficiency of 19%.
- 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.



### Risks and benefits

| *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. |

### Quick Activity

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

# Marine Power

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 5 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*

## 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" used over 80% of the energy from the wave to generate electricity.
- 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 has so far has been 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 the 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.

### 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. | As waves are generated by the wind, installing wave power generators next to off-shore 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. | Once built, there are no further $CO_2$ emissions. |

### Quick Activity

We are still trying to develop the technology to get electricity from waves and tides. But what are the differences between waves and tides?

Split the class into two, where one group works on waves the other on tides. They can make posters explaining each and report back to the whole class.



# 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**
- The Solar Spark:
  **www.thesolarspark.co.uk**
- 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.<br>• 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).<br>• 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.<br>• 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.<br>• Draws on increasing knowledge and understanding to suggest ways in which they can reduce their own energy use and live more sustainably. |

| 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.<br>• Discusses how people use science in their everyday lives.<br>• 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.<br>• Demonstrates understanding of how science impacts on every aspect of our lives.<br>• 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.<br>• Shares opinions about a variety of topical scientific issues considering, for example, moral, ethical, societal, cultural, economic and environmental aspects. |