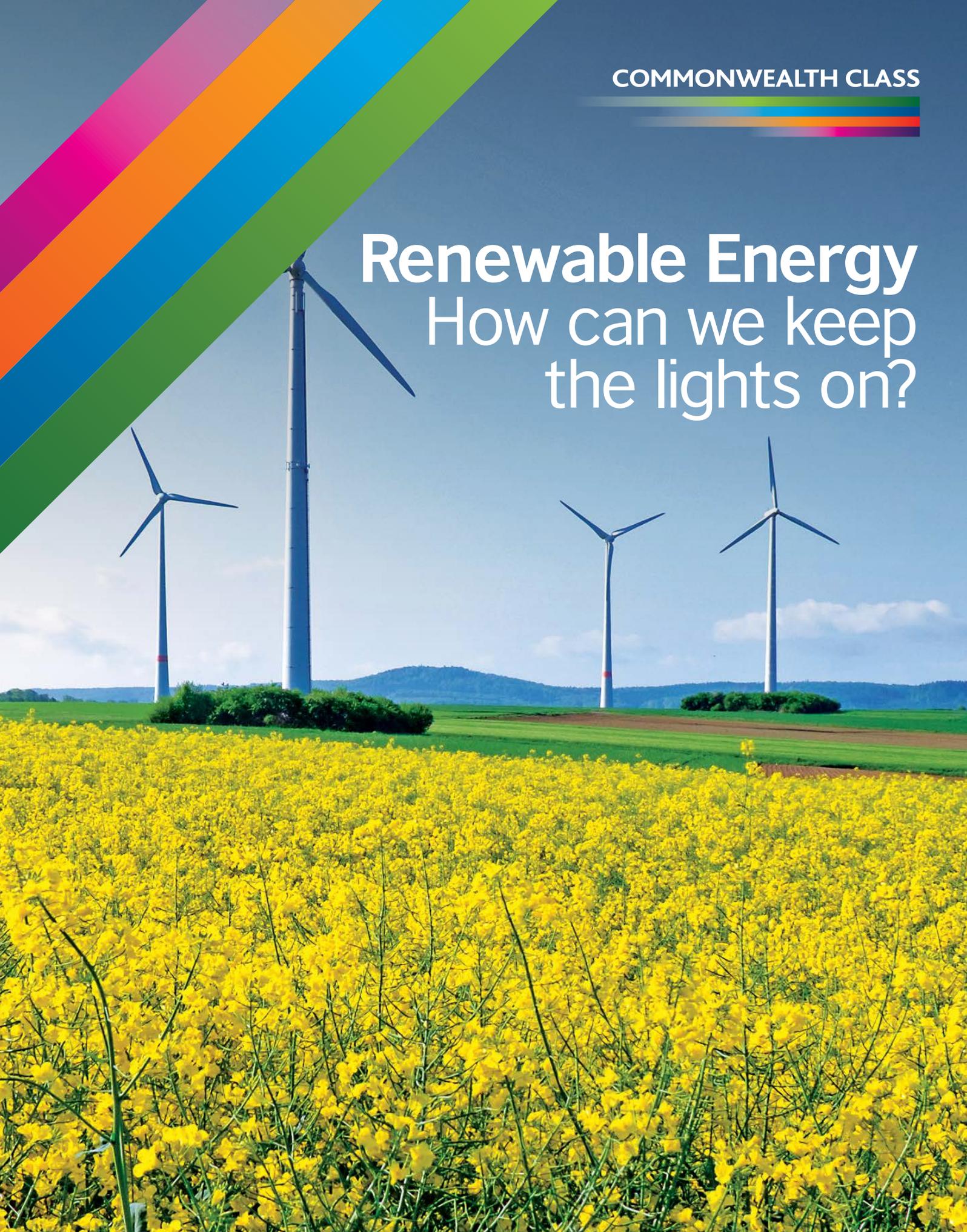


Renewable Energy

How can we keep the lights on?



In collaboration with



THE
ROYAL
SOCIETY



Introduction

Commonwealth values: Sustainable development, protecting the environment, valuing the importance and contributions of young people

Curriculum links: Science, English and drama, design and technology, geography, citizenship, ICT, personal social and health education

Core skills: Communication and collaboration, critical thinking and problem solving, digital literacy, global citizenship and civic responsibility

Fossil fuels (coal, oil and natural gas) are non-renewable energy resources, which means their supply is limited and they will eventually run out. Fossil fuels do not renew themselves, while fuels such as wood can be renewed if new trees are planted. Coal and oil release sulphur dioxide gas when they burn, which causes breathing problems for living creatures and contributes to acid rain.

Fossil fuels release carbon dioxide when they burn, which adds to the greenhouse effect and increases global warming. Of the three fossil fuels, for a given amount of energy released, coal produces the most carbon dioxide and natural gas produces the least.

Carbon capture and storage is developing technology that separates carbon dioxide from the waste gases produced when burning fossil fuels. The carbon dioxide is then transported and stored underground, for example in old oil fields or gas fields such as those found under the North Sea.

One of the UN's Sustainable Development Goals is to ensure access to affordable, reliable, sustainable and modern energy for all.

Contents

Overview: importance and scientific background	3	
Activity 1: what keeps your lights on?	7	
Activity 2: windmill energy challenge	8	
Activity 3: solar heating	9	
Cross-curricular activities	10	
Appendix	12	

OVERVIEW

Why is it important?

Greenhouse gases such as carbon dioxide absorb heat (infrared radiation) emitted from the Earth's surface. Increases in the atmospheric concentrations of these gases cause Earth to warm by trapping more of this heat. Detailed analyses have shown that the warming during this period is mainly a result of the increased concentrations of carbon dioxide and other greenhouse gases. Continued emissions of these gases will cause further climate change, including substantial increases in global average surface temperature and important changes in regional climate.

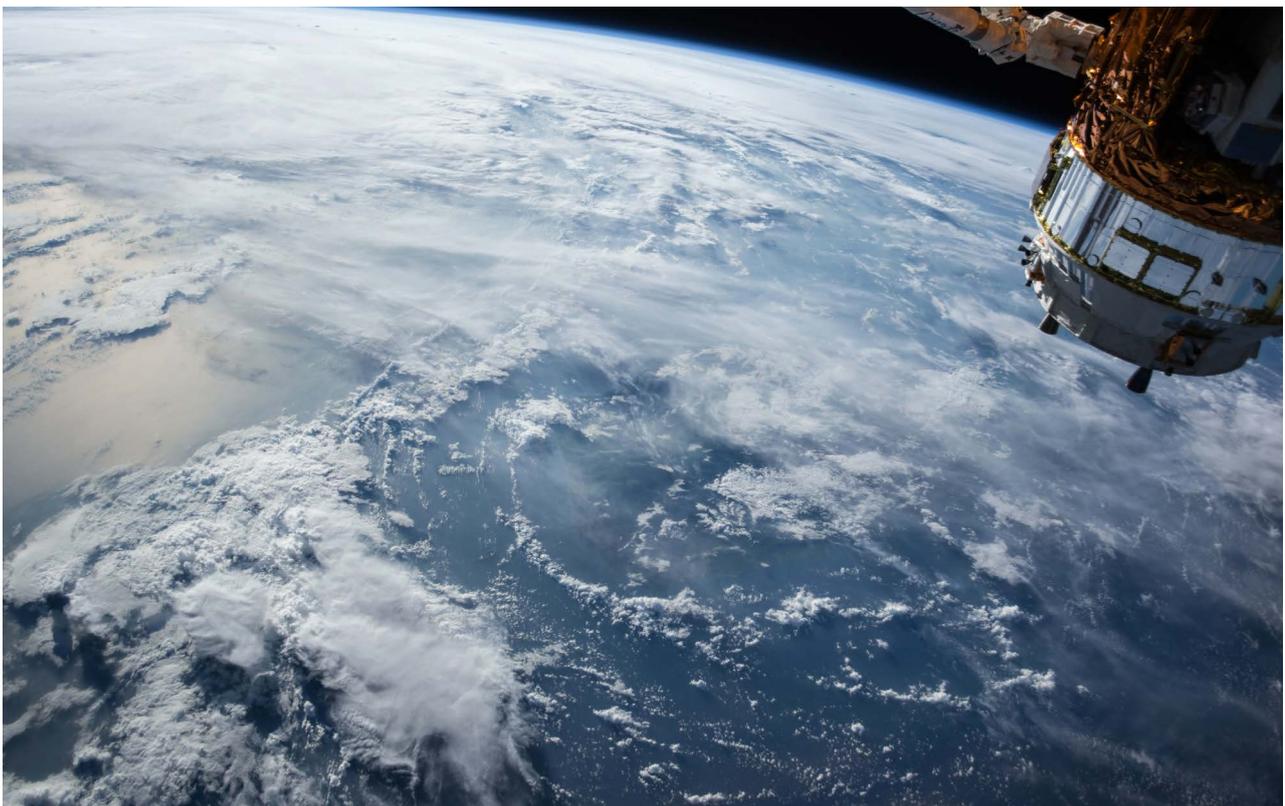
Human activities have significantly disturbed the natural carbon cycle by extracting long-buried fossil fuels and burning them for energy, thus releasing carbon dioxide to the atmosphere. The additional carbon dioxide from fossil fuel burning and deforestation has

disturbed the balance of the carbon cycle – the natural processes that could restore the balance are too slow compared to the rates at which human activities are adding carbon dioxide to the atmosphere. As a result, a substantial fraction of the carbon dioxide emitted from human activities accumulates in the atmosphere, where some of it will remain not just for decades or centuries, but for thousands of years.

The present level of atmospheric carbon dioxide concentration is almost certainly unprecedented in the past million years, during which time modern humans evolved and societies developed. The atmospheric carbon dioxide concentration was, however, higher in Earth's more distant past (many millions of years ago), at which time palaeoclimatic and geological data indicate that temperatures and sea levels were also higher than they are today.

Fossil fuels are also limited in supply. Different estimates are given for when oil, natural gas and coal are likely to run out. It depends on estimates of demand, estimates of supply available (often in remote areas) and use of renewable energy.

In December 2015, 195 nations from around the world came together in Paris and adopted a new and universal agreement on climate change. The new agreement aims to put the world on track to a low-carbon future that holds global temperature rise well below 2°C, with individual countries submitting national climate action plans. Example actions include increasing the amount of power produced by geothermal and solar sources, and increasing the use of energy efficient lighting.



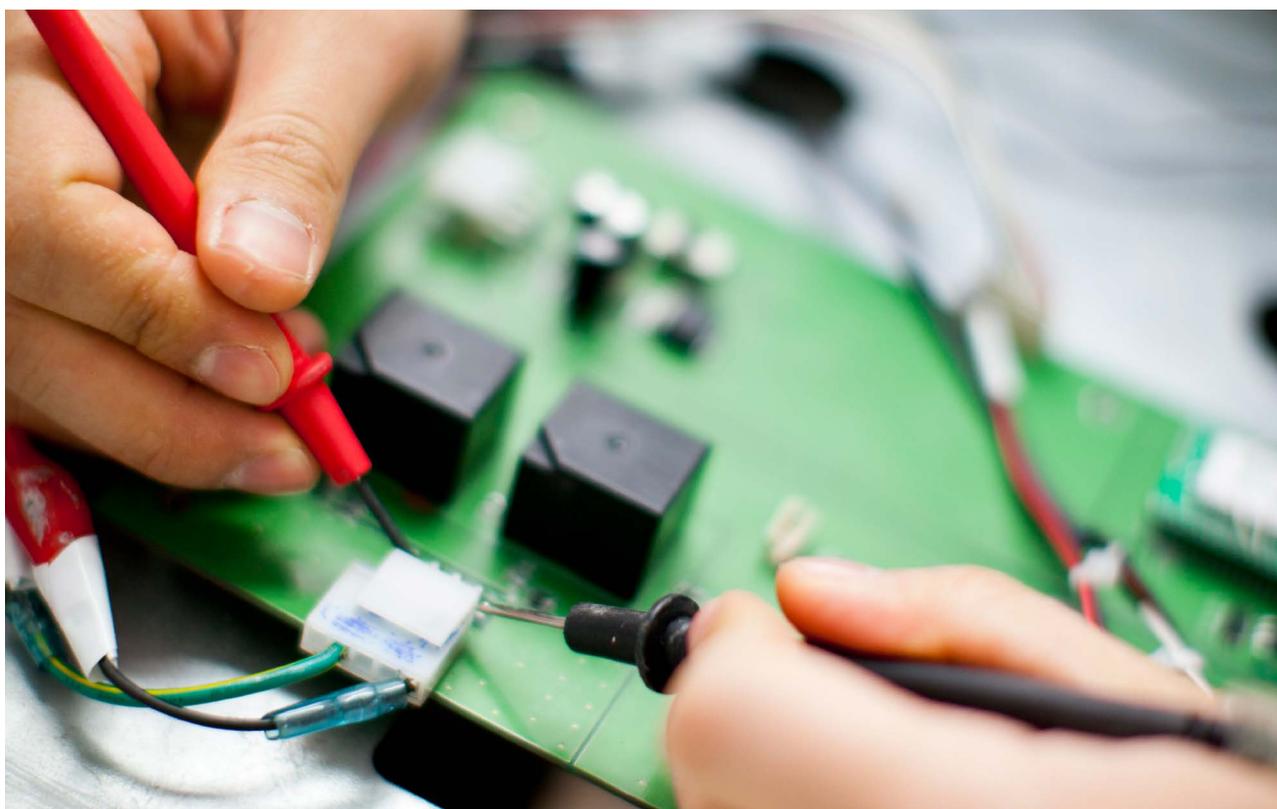
Scientific background to the problem

Energy sources are either non-renewable or renewable. Non-renewable energy is produced by burning fossil fuels (coal, gas or oil). This also produces carbon dioxide as a side product, which contributes to climate change. Nuclear sources can also be a non-renewable energy. They generate electricity in a similar way to fossil fuels, although they do not produce carbon dioxide. Renewable energy sources include: wind turbines, solar panels and hydroelectric power (dams). Biomass is also a renewable fuel but it is burnt in a similar way to fossil fuels and also produces carbon dioxide.

Most ways of generating electricity work by having a magnet and a coil wire, and creating movement between the two. This movement induces a current in the coil of wire. When fossil fuels burn, it heats water, producing steam. The steam turns turbines, which causes the magnets to move in relation to the coil of wire, generating electricity. Similarly, nuclear power uses the energy produced from splitting nuclei to heat water to produce the steam. Wind turbines and hydroelectric power use wind and water to turn the turbines. Solar power however uses special material in photovoltaic cells to produce electricity. Solar power can also be used directly for heating water.

Possible solutions

There are a number of existing renewable energy sources, but they have different advantages and disadvantages (see page 6). As yet, they are not enough to produce all the world's energy supply. There are also measures that could be taken to use energy more efficiently and changes to behaviour that could reduce energy demand.



ENERGY SOURCE	ADVANTAGES	DISADVANTAGES
Solar cells.	Infinite energy supply. Does not produce carbon dioxide. No fuel costs.	Currently costly to manufacture panels. Not sufficient power at higher latitudes. Currently not very efficient. Need storage methods to store overnight.
Wind farm.	Infinite energy supply. Does not produce carbon dioxide. No fuel costs.	Can cause local opposition due to visual impact on the landscape. Not always sufficient wind. Amount of electricity produced depends on the strength of the wind. Better wind offshore, but more of a challenge in technology.
Tidal energy works by using a tidal barrage (a kind of dam) and building this across estuaries, forcing water through gaps.	Reliable and can be easily switched on. Does not produce carbon dioxide. No fuel costs.	Can destroy the habitat of estuary species.
Wave energy works by harnessing the power of seawater moving in and out of cavities which drives a turbine.	Does not produce carbon dioxide. No fuel costs.	Difficult to scale up technology to produce large amounts of electricity.
In volcanic parts of earth it is possible to use the natural heat of the earth. Cold water is pumped underground and comes out as steam. Steam can be used for heating or to power turbines, creating electricity.	Potentially infinite supply. No fuel costs.	Currently expensive to set up. Only works in parts of the world where there is volcanic activity. It can also be dangerous; the elements found underground must be disposed of carefully.
Biomass is decaying plant or animal waste.	Readily available.	Only a renewable source if crops are replaced. Depending on the type of biomass, fuel production could be in competition with food production.
Hydroelectric power is produced through the movement of water through lakes, rivers and dams.	Reliable and can be easily switched on. Does not produce carbon dioxide. No fuel costs.	Currently costly to build. Can cause flooding to communities.
Wood.	Readily available.	Only renewable if trees are replanted. Gives off greenhouse gases when burnt. Can reduce natural habitats.

ACTIVITY 1: WHAT KEEPS YOUR LIGHTS ON?

Overview

This is a research activity to investigate the electricity supply local to you. Students will need to research online as well as ask questions and should share their findings with schools in other countries.

Activity

Different countries across the world have different sources for their electricity. This can lead to a difference in the amount of electricity that is available in homes and schools. Some areas may be connected to mains electricity supplies, while others may have a separate generator or run off solar powered lights.

Ask your students to investigate what the electricity supply is like at their home and school. If mains electricity is available, the investigation should include what sources of electricity their country uses to generate mains electricity (online sources may need to be used for this).

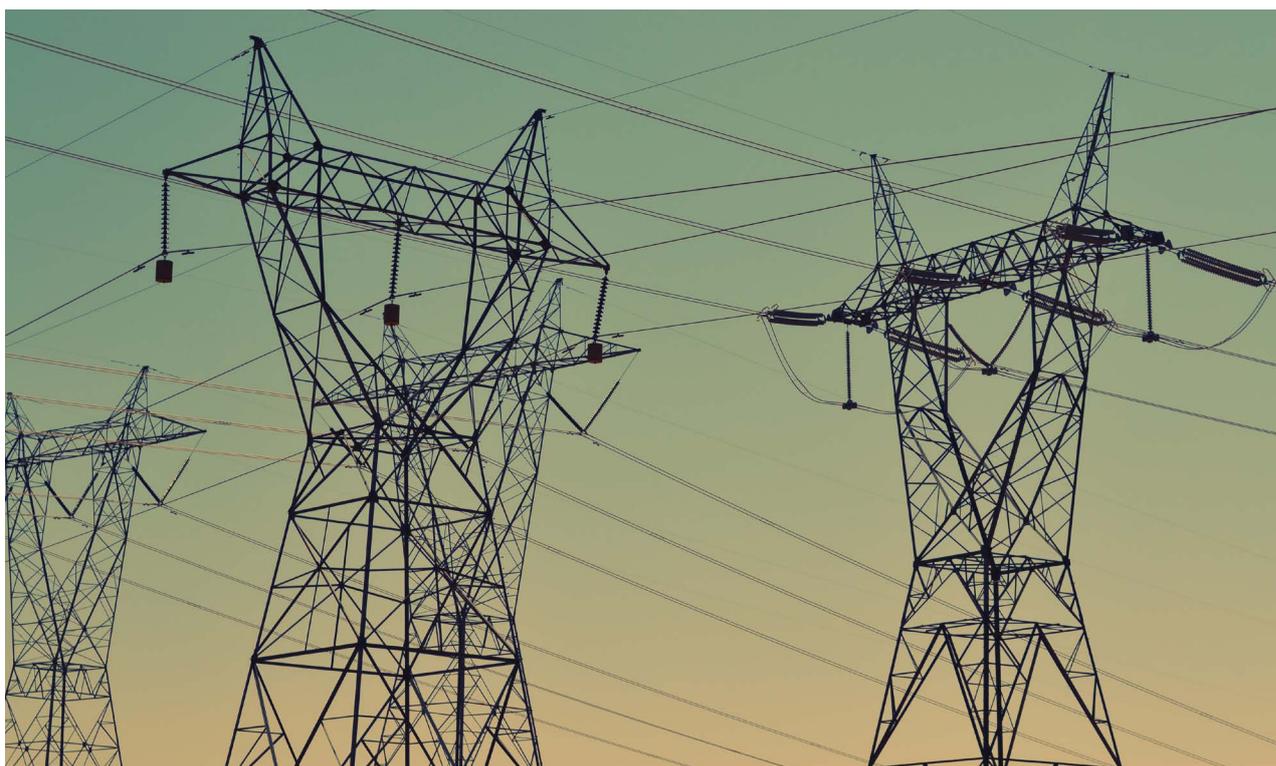
Sample questions to investigate and record might include:

- Do you have access to electricity all the time at home and school?
- Where does that electricity come from?
- Do you know anyone who gets their electricity from a different source?
- Is mains electricity available in your area?
- What source(s) are used to generate the mains electricity?
- How often do you use electricity and for what?
- Do you know how much electricity your school uses in a week, term or year? How might energy demand be reduced in your school?

Extension: If you have access to an energy monitor, you can measure the amount of electricity used in your school and see what you can change to reduce it.

Sharing your results

Results should be shared and discussed with other countries via the teacher forum on [Schools Online](#) or through your links with partner schools. You might like to consider what differences there are between your area and other countries and why that might be.



ACTIVITY 2: WINDMILL ENERGY CHALLENGE

Overview

Students will build a basic windmill and investigate how to make it more efficient.

Learning objectives

To construct miniature wind turbine blades and evaluate their proficiency. To develop practical skills by investigating the blades and recording and presenting their data.

Activity

Lead a class discussion on how electricity is produced using fuel to heat water into high-pressure steam, which then turns a turbine. This movement is used to produce electricity by a generator. A visible example of this process is a wind turbine. The rotating blades turn a generator and produce electricity. You can demonstrate to your

students that a turning motion can be converted into electricity by using a bicycle dynamo and cycle wheel, or a wind-up electrical device such as a wind-up torch.

Organise students into small groups for the investigation. Give each group a copy of the **activity sheet** (Appendix A) with instructions and equipment to carry out their investigation. Encourage them to make and test a range of different wind turbine blades for comparison using different materials, shapes or angles of blades.

Ask them to think about and discuss the following questions when planning their investigation:

- How will you make a fair comparison between different designs?
- What will you keep the same?

- What will you change?
- How will you decide which is the best?
- What measurements will you take?

Challenge your students to suggest ways that the amount of electricity produced by the dynamo or wind-up device could be increased (greater speed of turning). They could also consider how efficient these would be as power sources in their area.

After sharing their designs, compare with those produced at other schools:

- How similar are they?
- Do you think yours works better or worse than theirs?
- Why might that be?



ACTIVITY 3: SOLAR HEATING

Overview

Students will build a solar heater model and investigate how to make it most effective.

Activity

Challenge students to find the best way of heating water from the sun. Working individually or in teams, ask your students to make a small watertight container. Depending on the materials available, this could be a can, a plastic pot or a glass beaker. They should then choose whether to paint it, before filling it with water and leaving it in the sun. They should measure the temperature of the water regularly at times throughout the day. They can plot a graph of temperature against time.

Equipment:

- container e.g. cans, pots, beakers, bottles
- water
- paint in a number of different colours (optional)
- thermometer.

Instructions:

1. Select the type of container you want to use. You should consider the material the container is made of and the area of the container compared to the volume.
2. Paint the pot if you wish to. Consider what colour paint might be most effective.
3. Fill the container with water.
4. Measure the temperature of the water.

5. Place the container in the sunshine.
6. Measure the temperature of the water regularly throughout the day.

Extension: you could also bring the water back inside once it has warmed up and continue to measure the temperature to see how fast the water cools.

Share your results

You could share your results with schools in other countries. Compare your designs and see which was more effective. Why might this have been? How does the weather in your country relate to your results?



CROSS-CURRICULAR ACTIVITIES

Research and raising awareness:

Ask your students to find out more about *The Paris Agreement on Climate Change* and the new *Sustainable Development Goals* (2015).

If possible, show the animated film written by Sir Ken Robinson and introduced by Malala Yousafza which champions these goals at: <https://vimeo.com/138852758>.

Discuss why Goal 7: 'Ensure access to affordable, reliable sustainable modern energy' is so important to the future of everyone.

Ask your students to design a creative campaign poster or product to raise awareness of this

goal. They could make a piece of artwork or a slideshow, take photographs, or create a podcast or music video.

Role-play:

New developments that affect the production of energy can be controversial. Find out about examples such as *The Three Gorges* project in China or the proposals for a wind farm on the Scottish island of Lewis.

Research the arguments that have been made both for and against these developments. Set up a role-play debate in your class where students take on the roles of characters that will be affected by the building of a new wind farm in

their locality. Roles could include local farmers who own the land, owners of the plant, local councillors and Members of Parliament, bird watchers, scientists, local business owners and unemployed local residents.

Ask students to decide how their character might be affected if the new development goes ahead and the points they might raise within the debate. At the end of the session, take a vote in role for whether the new scheme should go ahead and evaluate which side produced the most robust arguments.



Student Energy Champions:

The government's carbon management strategy for schools in the UK has set an ambitious target to cut schools' current emissions from energy use by 53% by 2020.

Can you find out if your country has targets to cut energy use in schools? Encourage your students to become Energy Champions to help their schools save energy and money and combat climate change. Groups could carry out activities such as:

- Checking if lights and whiteboards are left on in classrooms when people aren't using them and computers turned off when not in use. They could make and award certificates to the most eco-friendly class or year group.

- Finding out the total heating cost for the school, carrying out an energy audit and recording and sharing the results with the rest of the school.
- If they usually have access to a constant source of electricity, try experiencing what a day or even a lesson in school would be like without any electricity.

Examples and case studies of schools who have achieved the Eco-schools energy award by working to reduce energy consumption and their carbon emissions can be found on the Eco-Schools website at: <http://www.eco-schools.org.uk/>

One secondary school's energy saving initiatives have led to an £88,000 annual cost saving and an increase in the uptake of science, technology, engineering and mathematics (STEM) subjects.

On some days their energy supplier now pays them when they generate more electricity from solar panels than they use.

In India, the Centre for Science and Environment also organises a Green School Programme environmental audit which encourages students to carry out a survey of their school's environmental practices to help conservation and minimise wastage. It gives annual local and national awards to recognise schools who are leaders in this field.

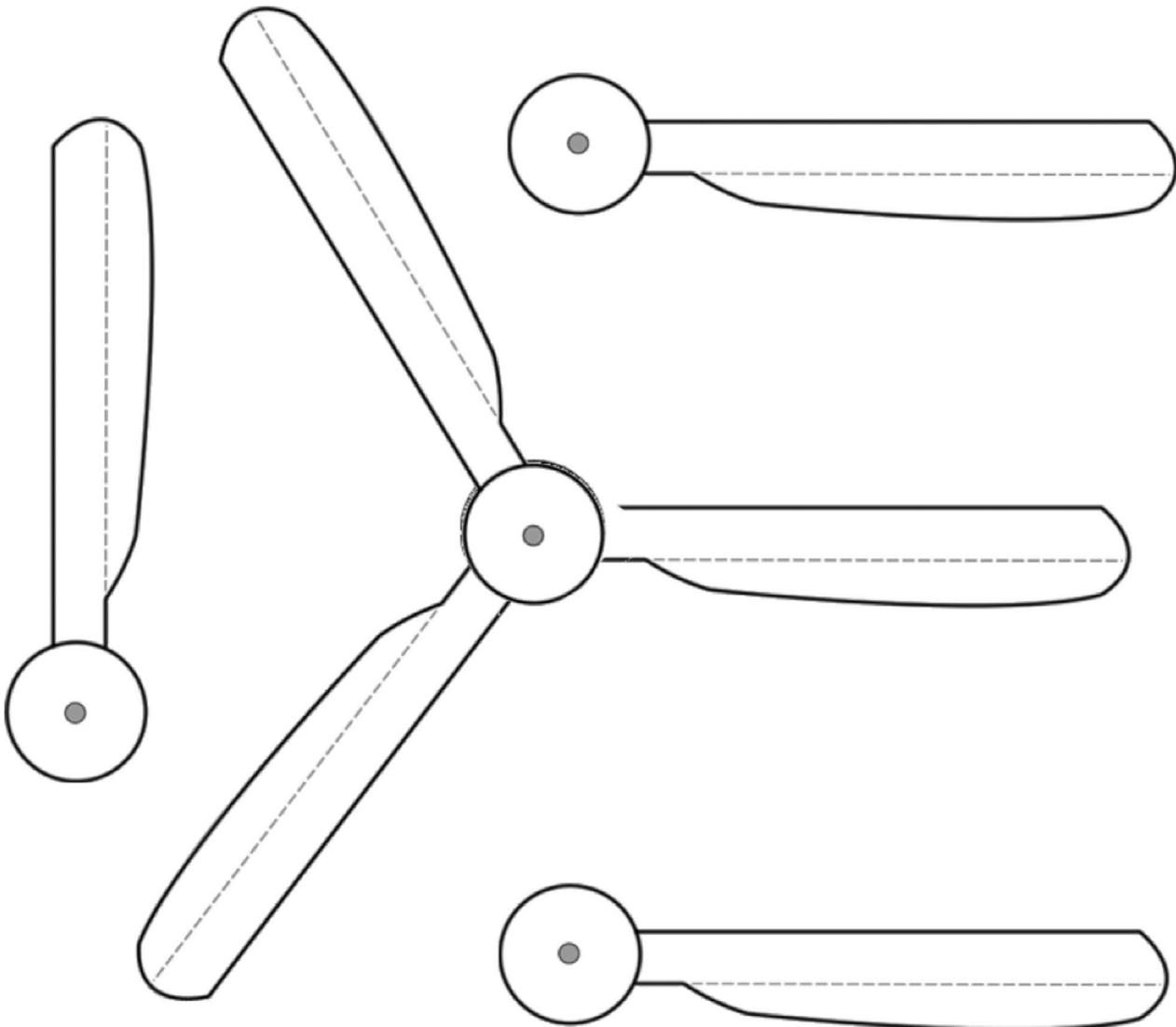
If you are working with a partner school you could:

- Share your posters or products to promote Sustainable Development Goal 7
- Exchange photographs and results of your wind farm debate
- Swap results of your energy audits and plans to reduce your school's energy consumption.



APPENDICES

Appendix A: activity sheet



One of the largest wind turbines in the world is in Hawaii. It stands 20 stories tall and has blades the length of a football field. Follow the instructions below to make your own miniature wind turbine.

Equipment:

- straws / lollipop sticks / wooden rods
- card / corrugated plastic
- flat-ended push pin (or drawing pin)
- sellotape and glue
- scissors
- wind source such as a desk fan.

Instructions:

1. Draw the turbine blade patterns you want to use onto thick card and cut them out.
2. Use a push pin or similar to attach these to a wooden rod.
3. Place the windmill in the stream of air from a desk fan or hairdryer.
4. Measure the number of rotations in a set period of time.

Share your results

Take a picture or video of your best design and present your findings to the rest of the class.

Find Out More

Further activities and teacher resources

- Climate change project:
<http://www.metlink.org/climate/climate-change-schools-project/>
- Practical action:
<http://practicalaction.org/stem>

Further reading

- Royal Society, Climate Change Q&As: <https://royalsociety.org/topics-policy/projects/climate-evidence-causes/>
- The Royal Society and The US National Academy of Sciences, Climate Change: Evidence and causes: https://royalsociety.org/~media/Royal_Society_Content/policy/projects/climate-evidence-causes/climate-change-evidence-causes.pdf
- Biello D. 10 Solutions for Climate Change: <http://www.scientificamerican.com/article/10-solutions-for-climate-change/>
- BBC GCSE Bitesize: Fossil fuels: <http://www.bbc.co.uk/schools/gcsebitesize/science/aqa/mains/generatingelectricityrev1.shtml>
- Eco-Schools is an international award programme that guides schools on their sustainable journey, providing a framework to help embed these principles into the heart of school life. Find out more at: <http://www.eco-schools.org.uk/>
- For more information about the Sustainable Development Goals and Goal number 7 go to: <http://www.globalgoals.org/> and <http://www.globalgoals.org/global-goals/modern-energy/>
- Further information about India's Green Schools Programme can be found at: <http://www.greenschoolsprogramme.org/>
- National climate action plans, following the December 2015 meeting on climate change, can be found here: <http://www4.unfccc.int/submissions/india/india%20Submission%20Pages/submissions.aspx> 