GENERATING ELECTRICITY

A science investigation pack for teachers of 9-11 year olds

CENTRE *for* INDUSTRY EDUCATION COLLABORATION

Supported by the Gatsby Charitable Foundation

Contents

Introduction

AGE RANGE

The activities in this book provide opportunities for children in Year 6 to extend their understanding of electricity by applying it to the concepts of generating and using it in the electronics industry.

The activities can be adapted to suit the needs of the children, staff and the planning requirements of the school.

CONTEXT

The activities use a real life context of helping people in a developing country to use local resources available to them to produce electricity and develop electronic sensors to detect the water level in a well. The children take on the role of researchers to investigate the ways that electricity is produced, make windmills to show how wind power can be converted into energy to do work and develop a sensor to detect water.

INDUSTRIAL LINKS

Links can be made to industries that research and develop electronic devises. There are also links to generation of electricity from a range of sources from power stations to wind farms. The table indicates how these links can be made.

Industry	Activity	Possible industrial site visit
Electricity providers Power stations Renewable energy providers	Shock to the system Wonderful wind	Visit a power station or wind farm etc. to see how turbines are turned and electricity is generated on a massive scale.
National Grid representatives	Shock to the system Wonderful wind	Invite a speaker from the National Grid into school to talk about generation and distribution of electricity as well as safety and environmental issues.
Electronics companies	Shock to the system Switched on Sensors	Explore how electronic equipment creates circuits that use the same processes as the simple circuits in the classroom.

ACTIVITIES

The activities in this unit should take about 6 hours to complete and can be covered in 3-4 half-day sessions. The activities should be completed in the order given, as they develop a problem or challenge from identification and investigation through to a solution. However, each activity can be adapted to suit the needs of the children or the school.

Optional activities can be selected depending on the previous learning of the class and the planning and time constraints of the curriculum. However, they should still be covered in the order given, as they are part of the progression throughout the unit.

It is advised that children work in groups of no more than four. Some of the sessions (particularly activities 2 and 3) would benefit from additional adult support, such as teaching assistants or parent helpers.

The activity sheets included provide an initial stimulus to help and guide children through the investigation process; planning, recording ideas, observations, measurements, and drawing conclusions. By providing a suitable framework, this should improve children's understanding of all that is involved in the investigation process, as well as increasing children's enjoyment of science by solving real life problems.

They are also intended to support different styles of teaching in the classroom and can be used to differentiate learning or concentrate on specific elements of an activity.

ADDITIONAL INFORMATION

Additional information has been provided in number appendixes at the end of this publication to support delivery of this unit in the classroom.

Appendix A is a list of websites that we consider to contain suitable materials to support the activities. Some are aimed at providing information for teachers to enhance their subject knowledge or introduce ideas that are not included in this resource.

Other sites include interactive areas for children where there is a specific link the site will be mentioned in the main body of the resource.

We strongly suggest that you refer to it and pass the information on to your class during the delivery of these activities.

EXTRA ACTIVITIES

Appendix B shows how children can use a drama activity to show how electrons could run a circuit.

Appendix C makes a simple electricity generator.

Appendix D explains how to use the planning boards provided with a whole class.

ACTIVITY SUMMARY

Title	Description	Timing
1 Shock to the system	This activity revises concepts covered in Year 4. It gives children the opportunity to build circuits and use the correct vocabulary for the components. They explore issues around the safe use of electricity and sustainable production.	1 hour
2 Wonderful wind	The children construct a windmill to lift a bucket in response to a request to help solve problems in a third world country. A demonstration of how the energy from the turning of the windmill can produce electricity concludes the session.	2 hours
3 Switched on	Responding once again to the problems posed in the letter. The children build a variety of circuit switches and explore ways in which they can be incorporated into sensors.	1 hour
4 Sensors	The children follow guidelines and using the knowledge, understanding of circuits and switches that they have revised, design and build a water sensor to indicate an effective water level in the village well.	2 hour

1. Shock to the system

1 hour activity

This activity revises concepts covered in Year 4. It gives children the opportunity to build circuits and use the correct vocabulary for the components. They explore issues around the safe use of electricity and sustainable production.

OBJECTIVES

- Y4: Identify common appliances that run on electricity
- Y4: Construct a simple series electrical circuit, identifying and naming its basic parts, including cells, wires, bulbs, switches and buzzers
- Y6: Use recognised symbols when representing a simple circuit in a diagram
- Y6: Associate the brightness of a lamp or the volume of a buzzer with the number and voltage of cells used in the circuit

RESOURCES

(per group of 4 children, unless otherwise stated)

- Activity sheets 1-4
- Circuit set - including at least 2 wires, 2 batteries, 2 bulbs, buzzer or motor, and items they will require as red herrings
- At least 6 tennis balls
- A4 paper
- 30-40 small coloured stickers

ADVANCE PREPARATION

Circuit symbol cards, Activity sheet 1.

These could be laminated for future use, or allow the children to cut out the cards as part of the activity.

Stick one sticker on each tennis ball and have the rest available for the tennis ball activity.

INTRODUCING THE ACTIVITY

Discuss the importance of electricity, e.g. you could play a CD as the children come into the class room. Then suddenly turn it and the lights off.

What powered the CD and lights?

What happened when I turned it off?

Discuss which items in the room or at home require electricity. Generate a discussion about what the children know about electricity. Children to discuss in groups: 'Life without Electricity' and record as a PMI activity (positives, minuses and interesting – see Activity sheet 3).

Give groups a large sheet of paper and spend 10 minutes writing and drawing items that are powered by electricity. Sort into two groups, high voltage (potentially dangerous) and low voltage (can run off batteries and/or mains).

Children identify the dangers on scenarios showing electricity in every day use (interactive whiteboard or photocopies of Activity sheet 4). Some excellent interactive websites to use for this activity are:

https://www.switchedonkids.org.uk/electrical-safety-in-your-home

REVISING CIRCUITS

See Appendix B (+Tennis Ball Analogy) Children pass tennis balls from the battery to the bulb and stickers are used to represent the electrical charge.

MAIN ACTIVITY

Give the children a range of components (including some 'red herrings') to independently construct a circuit to make a buzzer sound, a bulb light, or turn a motor.

Ask the children *what makes a circuit?*

Encourage discussion until all elements of a working circuit have been explained.

Each group then makes a circuit. For more able pupils, ask them to adapt the circuit to make the buzzer louder/quieter, bulb brighter/dimmer or motor faster/slower and explain why it had that effect. The children may either put, more or less batteries into the circuit, more or less components in the circuit.

Ask the children to record their circuit in a diagram using mini whiteboards. This provides a good assessment of what they know or remember about circuit diagrams. They may need to be introduced to circuit diagrams as a standard way of drawing circuits, or they may need to be reminded of the circuit symbols.

Give each group a selection of circuit cards (Activity sheet 1). Ask children to use the cards to show simple circuits using battery, wires and a bulb, buzzer or motor. Take this opportunity to revise the vocabulary of electricity.

Pose different challenges such as asking the children to use their cards to show you a circuit with a brighter/dimmer bulb or louder/quieter buzzer etc. Discuss the responses the children come up with and challenge any misconceptions. The children could test out their ideas by making the circuits.

Provide Activity sheet 2, if they need help to interpret symbols.

PLENARY

Batteries

Ask the children where the energy to power the circuit comes from.

Explain that batteries contain materials that produce electricity when they mix.

Batteries are not practical for generating electricity on a big scale – explain to children using the information supplied below.

What are the advantages of using a battery instead of mains electricity?

The use of batteries will overcome the need to have a mains supply and will eliminate trailing wires.

What are the disadvantages of using a battery?

The power that they supply is lower and they run out (even re- chargeable batteries).

Batteries are not practical for providing electricity on a big scale because they would require large amounts of chemicals, produce relatively low amounts of electricity and they are not sustainable.

Other methods that can produce high power electricity continuously are necessary.

Explain how a lot of electricity is generated by converting movement energy to electrical energy. Coal, gas, oil and nuclear power stations generate electricity through heating water and converting it into steam to drive turbines. Alternatively wind and hydro-electric power stations drive turbines using natural sources.

http://www.eia.doe.gov/kids/energyfacts/index.html

Review different sources of electricity. Discuss the fact that non-renewable sources of energy use an ever depleting natural resource that cannot be replaced and will eventually run out. However, renewable sources of energy do not run out.

EXTENSION

As a homework activity children make a list of renewable and non-renewable sources of energy.

Make a battery using one of the methods on the following websites:

https://education.theiet.org/primary/teaching-resources/fruit-lights/

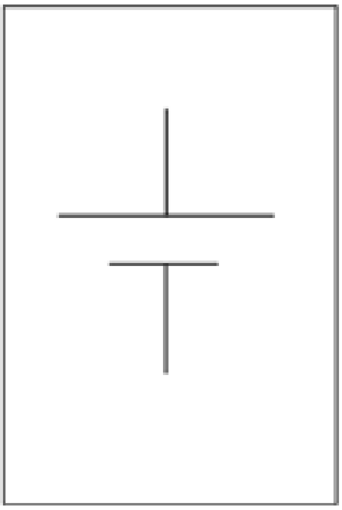
This shows how chemical energy is used to create electricity. The current of the resulting battery is very low so it will only power LCD equipment (digital watch or LCD calculators) or LEDs (light emitting diodes: tiny bulbs that fit easily into an electrical circuit - often form the numbers and light up the controls on digital clocks). LEDs can easily be obtained cheaply from many school science catalogues.

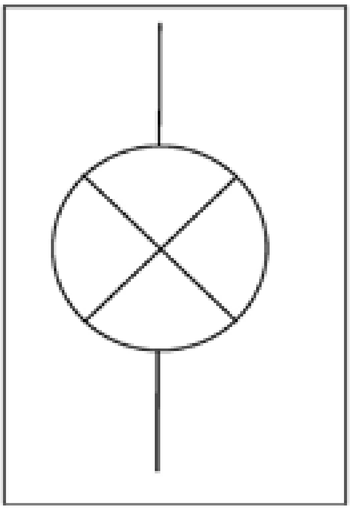
Ben Adams Generator
Alternatively try out the generator as described in Appendix C.

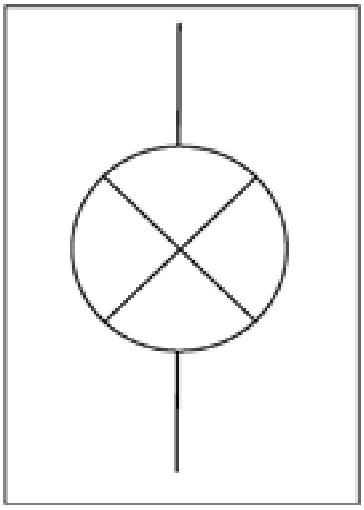
Literacy Link: Developing research skill and Discussion Texts
Research advantages and disadvantages of each energy source (using some of the websites outlined in Appendix A).

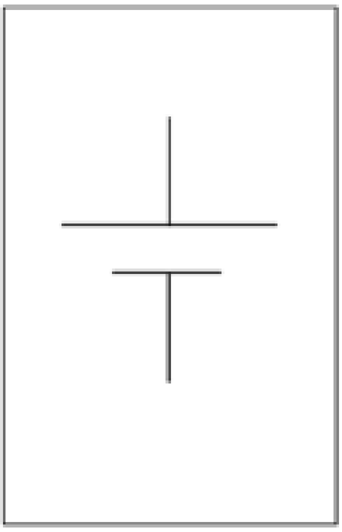
This could inform a class debate: with each group representing different sides of the arguments and pressure groups.

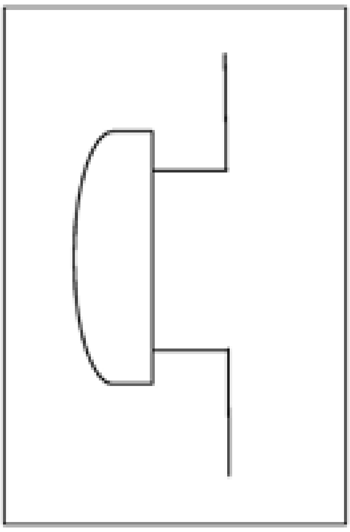
Activity 1: Circuit symbol cards

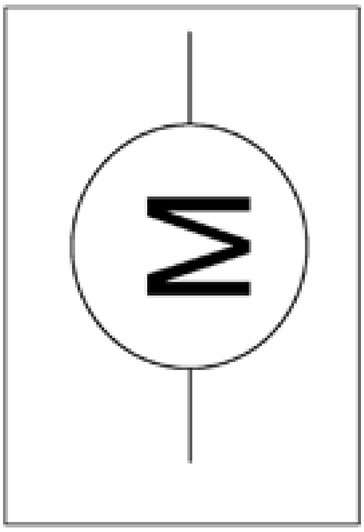


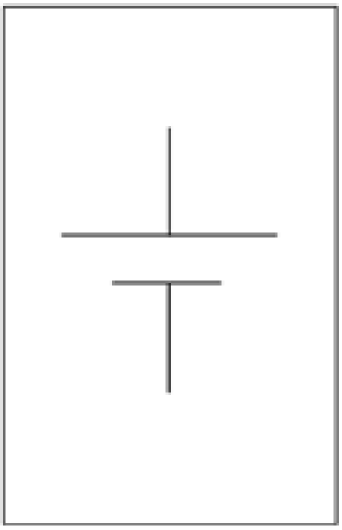


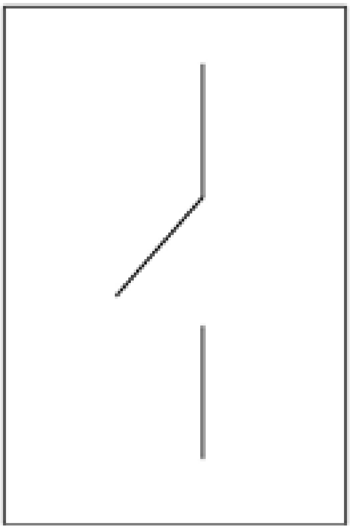


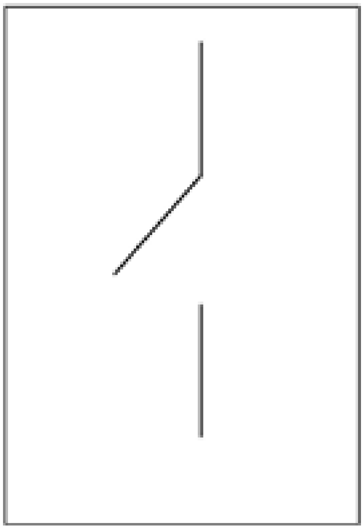




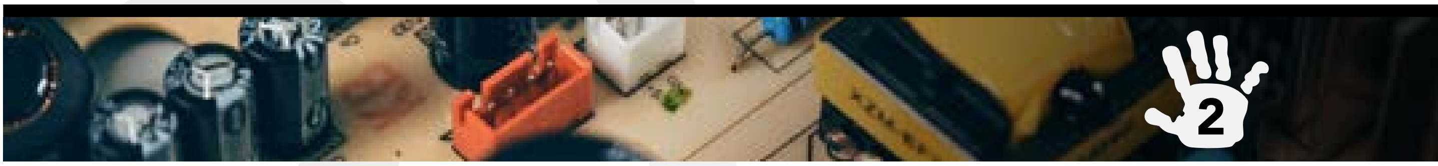




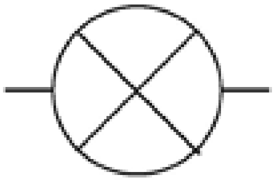




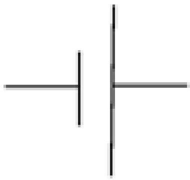
Activity 2: Electrical Circuit Symbols



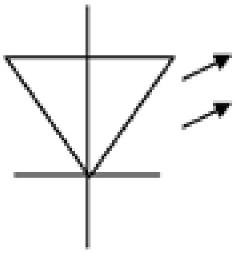
Connecting Wire



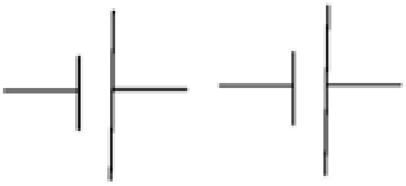
Bulb



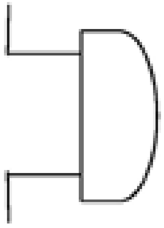
Cell



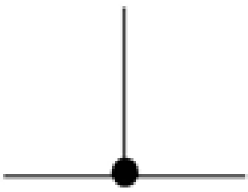
LED Light emitting diode



Battery

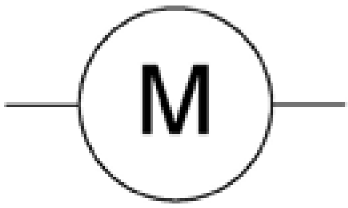


Buzzer



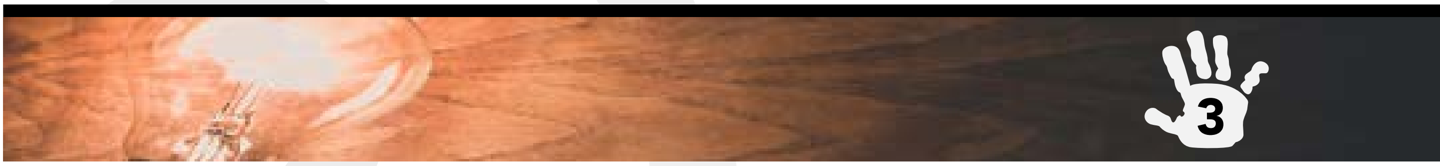
Junction (connection) between wires

Switch



Motor

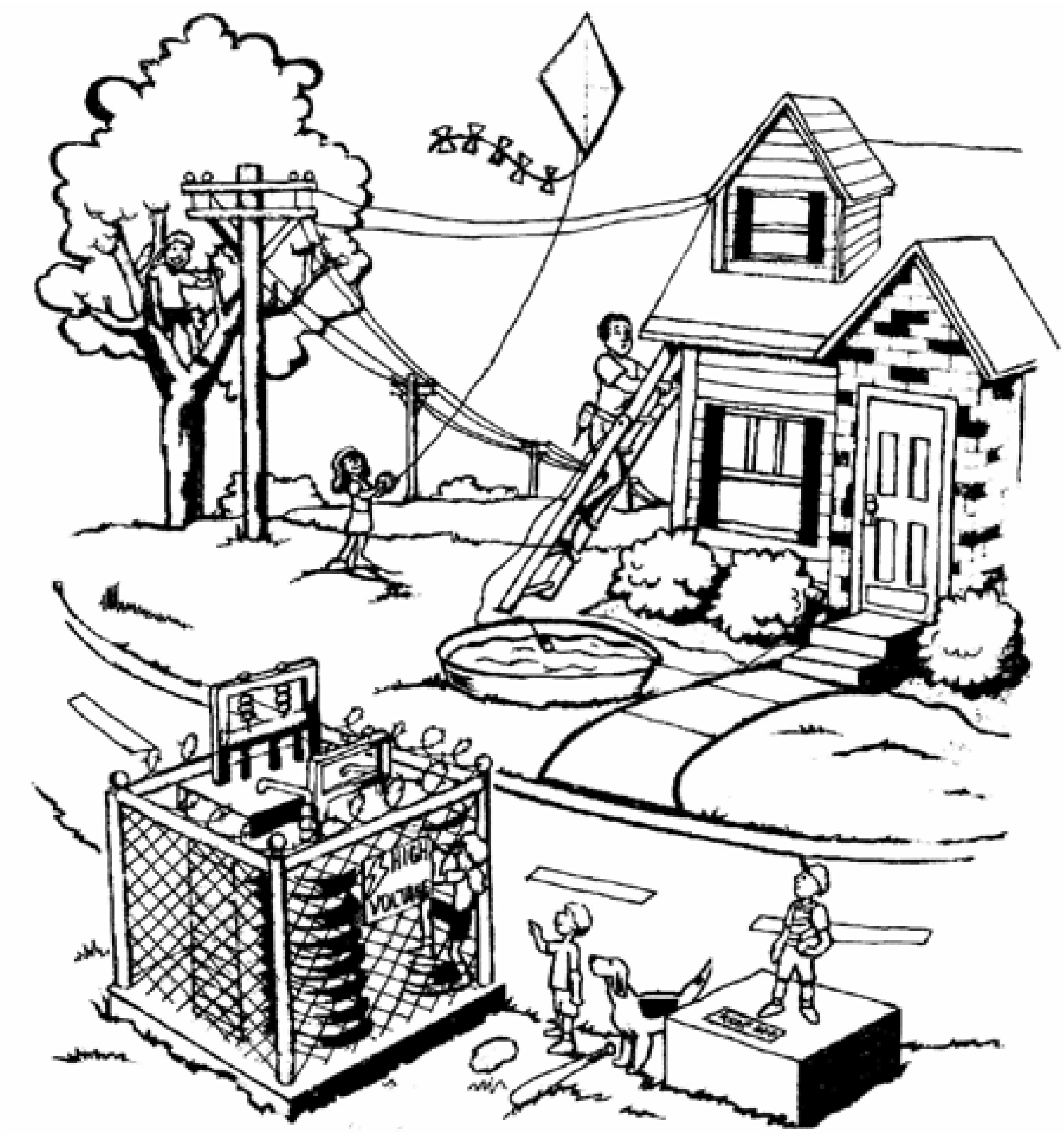
Activity 3



What would life be like without electricity?	
+ Positive ☺	- Minus ☹
Interesting!	

Activity 4: Spot the dangers

Spot the dangers



2. Wonderful wind

2 hours activity

The children construct a windmill to lift a bucket in response to a request to help solve problems in a third world country. A demonstration of how the energy from the turning of the windmill can produce electricity concludes the session.

OBJECTIVES

- To plan different types of scientific enquiries to answer questions
- To identify scientific evidence that has been used to support or refute ideas or arguments

RESOURCES

(per group of 4 children, unless otherwise stated)

- Activity sheets 5-11
- Sheets of card of 200 micron (to make sails of different sizes) Sheets of other card/paper (to vary sail material)
- 1m strong thread or string
- 1.5lt drinks bottle
- Sand or marbles
- Paper or plastic cup
- 20 cm length 8mm dowel
- 5 nylon 8mm washers (that slide onto the dowel)
- Set of weights, marbles or centicubes
- Hair dryer.(to provide wind)
- Stop watches
- Bicycle with a dynamo

Safety note

Hair dryers must pass the electrical safety test for use in school.

ADVANCE PREPARATION

Prepare the bottles by puncturing two holes, diametrically opposite and at the same level, about 5 cm from the shoulder of the bottle. Glue one of the washers over each hole to ensure smooth even edges (see Activity sheet 6).

Safety note

Do not allow the children to use sharp objects to pierce bottle.

INTRODUCING THE ACTIVITY

Read the information in the letter on Activity sheet 5. Discuss the issues and highlight some of the needs of people in various African countries and the different ways that aid can be used to help people.

Discuss why we need water and ways of producing electricity and introduce the idea of harnessing natural forces to produce electrical energy.

Establish that electrical energy is a type of energy that we can produce by harnessing other types of energy and converting them to electricity.

Introduce the activity: to harness the wind energy to lift and carry supplies of water in a bucket.

MAIN ACTIVITY

Children build a simple windmill using a soft drinks bottle and the templates on Activity sheets 5 and 6.

1. The dowel is passed through the two washers stuck to opposite sides of the bottle and at one side of the bottle a single washer is glued to the dowel about 1 cm from the end, to act as a spacer. At the other side of the bottle 2 washers are glued 2 cm and 3 cm from the end. The thread is attached to the windmill between these. See Fig 1 and Activity sheet 6.
2. Attach the windmill to the spacer end of the dowel with a drawing pin through the centre of the sail into the end of the dowel.
3. Demonstrate how we can use wind energy to turn the turbine and lift the bucket. The sand is used to weight the bottle to stabilise it.
4. Attach the cup to the end of the string to act as the bucket.

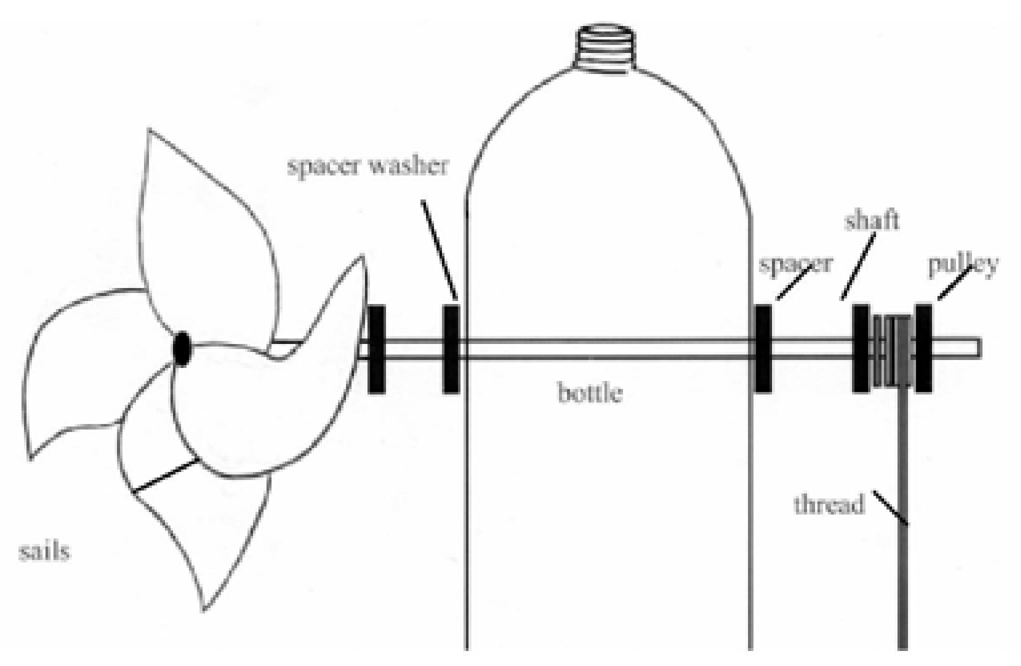


Fig 1

Ask the children to investigate ways to make the turbine move faster to lift the bucket more quickly or to lift a heavier load.

Use differentiated Activity sheets 8-10 to guide the children through the investigation.

Information about using these planning sheets is given in Appendix D.

Each group chooses which factor they want to change to investigate the question, e.g. more wind, less friction, bigger blades, blades of different material, type of thread etc.

Children may suggest other factors such as length and thickness of dowel, size of bottle – it is important to discuss which factors will actually have an effect on the speed of the turbine and which will not.

Discuss the need to keep other factors the same to make it a fair test. Provide guidance, but allow the children to choose how they go about the investigation within the parameters provided by the planning sheet. Make predictions about how changes will affect the lifting power of the windmill.

If they want to investigate the size of the blades, they could work out how to scale them up or down. If they want to investigate the friction, they could decide how to increase/ decrease the amount of friction (e.g. using margarine or Vaseline as a lubricant). If they want to test the amount of wind, they could decide how to generate wind and how to increase or decrease it (e.g. a hand fan, or hair drier – with adjustable speeds).

The children now test their windmill by:

- Adding different weights (the children could choose what to use e.g. marbles in the bucket), and find out which group's windmill can lift the heaviest weight.
- Timing to see which group can lift the bucket in the shortest time.

PLENARY

Ask the children to draw a conclusion answering the following questions.

How did changing your factor affect the weight carried in the bucket / time taken to lift the bucket?

Why do you think this happened?

How would you apply this to the problems outlined in the letter about Africa?

TO DEMONSTRATE HOW MOVEMENT CAN BE CONVERTED INTO ELECTRICAL ENERGY

The wind power that turns the windmill and produces the energy to lift a bucket can also be used to produce electricity.

You can demonstrate how electricity is generated by movement by using a bicycle with a dynamo to show how turning the wheel will power the lights.

The children can now consider how a windmill could be used to generate electricity. They need to take into consideration what happens when the axel or bicycle wheel stops turning and what happens when the wind dies down. They would have also seen this with their windmill when they stopped blowing.

Electricity cannot be stored and where it is produced in this way it needs to be supported with a back up system to fill the non- productive time.

In a power station the energy used can usually be controlled. Fuel heats water to produce steam which turns the turbines. In a hydro electric power station the dam is opened to allow water through to turn the turbines. In a battery, chemicals are used to produce electricity when the battery is put into a circuit. Wind power can be used to turn turbines to produce electricity.

The web site ***https://thekidshouldseethis.com/post/48611338726*** demonstrates this very well and could be used on an interactive whiteboard to show this to the class.

You can also generate enough electricity to light up an LED by turning a motor with enough revolutions.

Bend the LED probes and carefully attach them to the motor using insulating tape. Take care that the probes do not touch each other or the metal casing of the motor.

Attach a 50 cm length of cotton to the motor axel – secure with glue or a small piece of tape. Wind the cotton tightly around the axel until there is just enough left to hold. Give the cotton a sharp pull to turn the motor. The energy will be converted to electricity to light the diode. The order that the terminals are connected and the direction of turn are crucial. If it doesn't work first time wind the cotton the other way. This demonstration is best viewed in a darkened room.

Fig 2: Maintenance of a wind turbine in progress

Electricaid UK

York

PO Box A10

Dear Research Team,

If the world were a village of 100 people, "76 have electricity 24 do not. Of the 76 who have electricity, most use it for light at night ... In the village there are: 42 radios, 24 televisions, 30 telephones ... 10 computers" (If the World Were a Village by DJ Smith & S Armstrong, 2002)

As many as 928 million people in the world live in slums. Most of these are in poorer countries. Many of these people still live without an electricity supply. Millions of people still live without a constant supply of clean water.

Electricaid UK aims to help people in this position in the sub-Sahara countries in Africa.

One of our aid projects is to provide them with the technology to bring electricity to more towns and villages, and to be able to lift and carry supplies of water and detect the amount of water they have.

We want you to suggest suitable ways to produce cheap electricity in a hot, dry, windy climate.

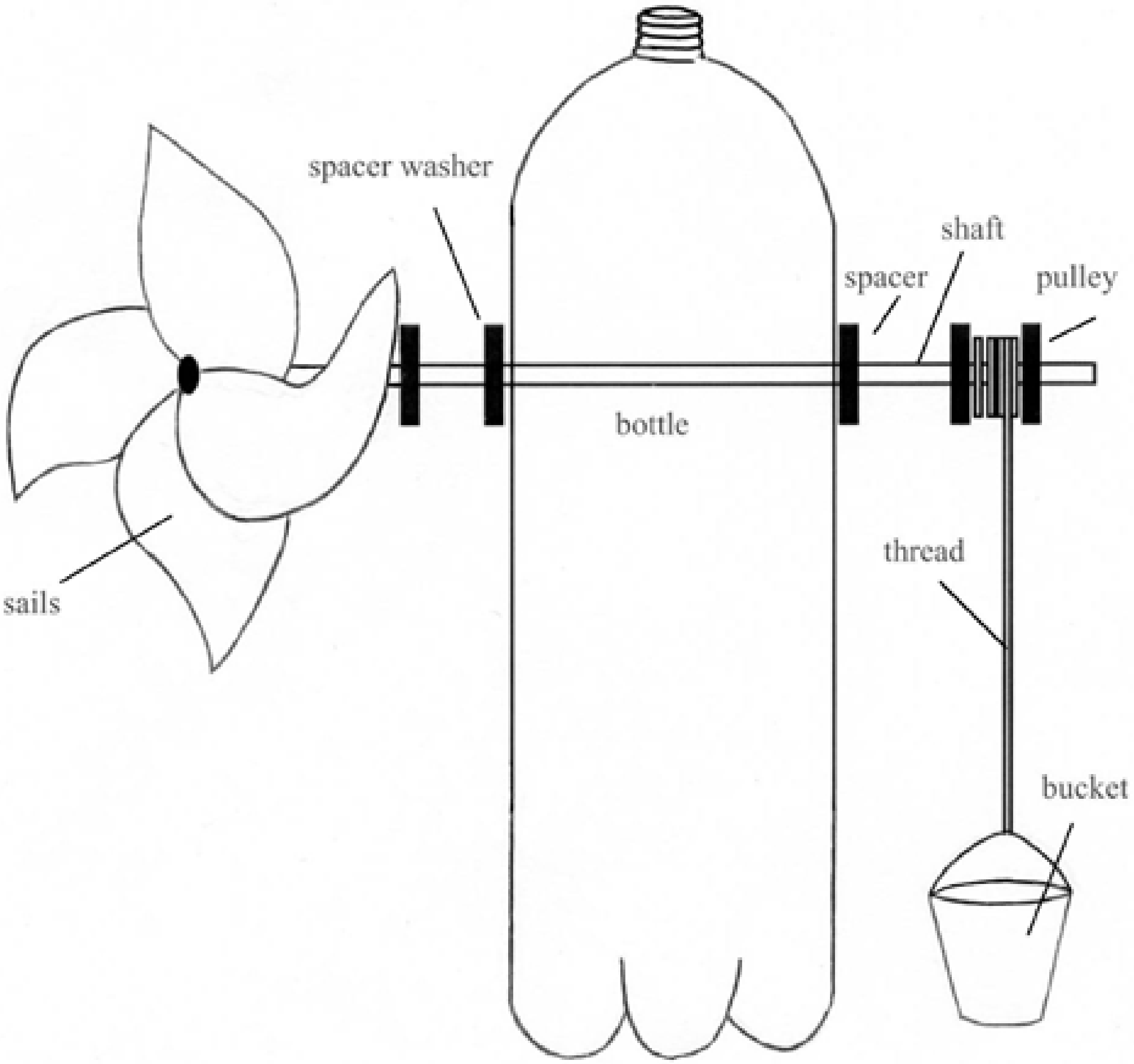
We would also like you to design an electronic sensor so that the people we help will know that their wells have sufficient fresh water.

We look forward to hearing from you with your results.

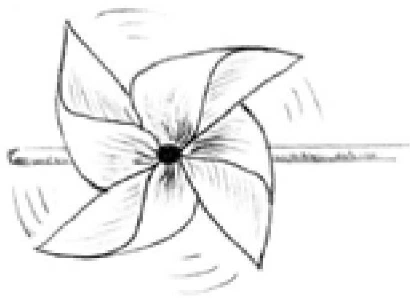
Yours sincerely,

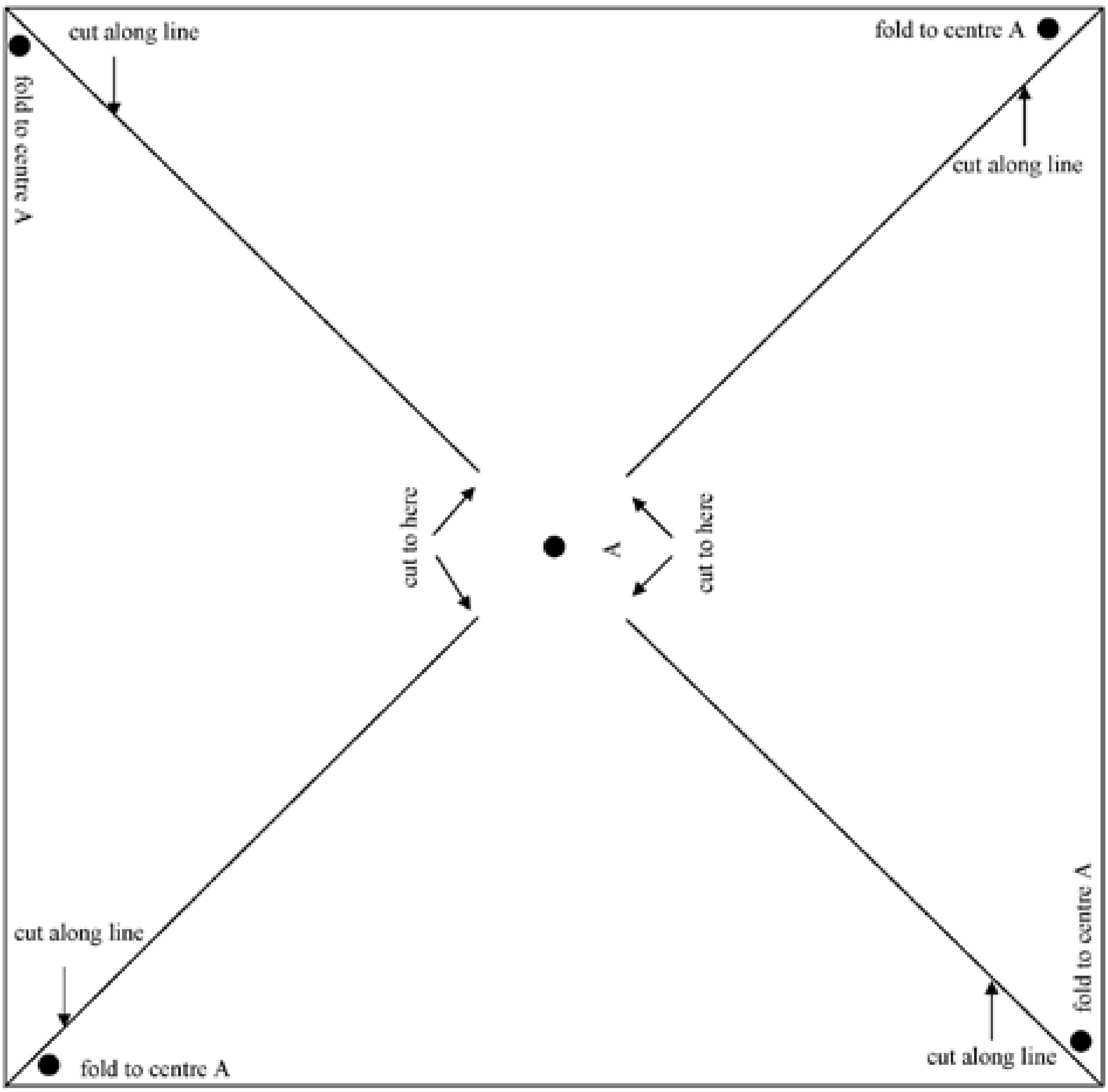
John Simmonds

(Director of Electricaid UK)


spacer washer
shaft
spacer
pulley
bottle
thread
sails
bucket

Activity 7: The sail





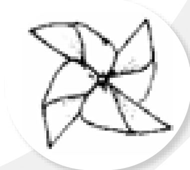
Activity 8: Windmill investigation

Investigation question

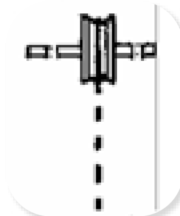
What will make the turbine turn the pulley quicker and generate more energy?

What we will change (circle 1):

Size of the blades



Amount of friction to turn the pulleys



Strength of the wind

Material of the blades

We will measure or observe (circle 1):

The time it takes for the bucket to rise

The number of marbles the bucket will carry

Fair Test:

List the things that you will keep the same

Prediction:

I think the turbines will turn quicker when

I think this because

Activity 9: Planning

What will make the turbine generate more energy?

We could change

We could measure/observe

We will change

We will measure/observe

We will keep these the same...

We I change

What will happen to?

Why?

Activity 10: Obtaining evidence

Change	Measure/observe

Activity 11: Considering evidence and evaluating

Measure

Change

When we changed

What happened to?

Was your prediction correct?

How could we improve what we did?

3. Switched on: using switches imaginatively

1 hour activity

Responding once again to the problems posed in the letter. The children build a variety of circuit switches and explore ways in which they can be incorporated into sensors.

OBJECTIVES

- Y4: Recognise that a switch opens and closes a circuit and associate this with whether or not a lamp lights in a simple series circuit
- Y4: Recognise some common conductors and insulators, and associate metals with being good conductors

RESOURCES

(per group of 4 children, unless otherwise stated)

- A collection of different switch making resources: Paper clips
- Split pins
- Stiff card
- Foil
- Metal discs - coins
- Nails/tacks
- Paper fasteners
- Card
- Paper
- Plastic sheets
- Circuit kit (e.g. at least 3 wires, bulb or buzzer, battery)

INTRODUCING THE ACTIVITY

This is an excellent opportunity to revise the difference between electrical conductors and insulators. Remind the children that a switch creates a break in the circuit and this stops the flow of electricity. Act out the tennis ball analogy first with a child acting as an insulator and then two children acting as a switch. Appendix B.

MAIN ACTIVITY

Children make a circuit to incorporate a switch that they will make by connecting the bulb to the battery with wires, but leave a space.

Children may have already made a basic switch using a paper clip, two paper fasteners and some card. Ask the children to explain this to their group and then the class how the switch works using the vocabulary: circuit, complete, conductor, insulator, break, etc.

Then provide children with a selection of different everyday insulators and conductors (e.g. paper clips, foil, metal discs, nails/tacks, paper fasteners, card, paper, plastic etc.) and ask them to make different types of switch.

Again, ask them to explain how their switch works using the key vocabulary. They could record an annotated drawing of their switch design, listing the materials needed and explain how it works. Children could also draw a circuit diagram showing the complete circuit with the switch in place.

PLENARY

Children share their design ideas. As a class they could evaluate each others switch design looking for imaginative ideas, and effective switches that are easy to use and easy to make.

Discuss switches in other electrical items. Talk about the many electrical or electronic items that use switches; they can be used to switch from one circuit to another. Often, electrical devices use switches to change the operation that is being done.

Explain that sensors use switches to connect/disconnect a circuit for different purposes, e.g. a burglar alarm, thermostat, smoke detector. If it is possible show some examples of sensors/switches working in everyday items like an electric kettle turning off when the water has boiled or a radio alarm coming on. For homework children list different electrical devices that use switches and explain how they use them. They can then think about how different switches are triggered in different sensors, e.g. heat, pressure-pads, etc.

EXTENSION

Children could make a switch that changes from one circuit to another. Make a parallel circuit using one battery, two bulbs, buzzers, etc., or a combination. Then make a break in the circuit at one of the junctions where the two parallel sections meet up, and place a two way switch in the break. To do this, use three paper fasteners, a paper-clip length away from each other on a piece of card.

Ask the children:

What could we do to get both bulbs to light?
Connect both switches at the same time.

How would this type of circuit come in useful?
It could be used in traffic lights, for example.

4. Sensors

2 hours activity

The children follow guidelines and using the knowledge, understanding of circuits and switches that they have revised, design and build a water sensor to indicate an effective water level in the village well.

OBJECTIVES

- To know that science is about thinking creatively to try to explain how living and non-living things work, and to establish links between causes and effects
- To design a sensor to solve a problem
- To make a sensor by creating a switch operated by the water level in a well, to complete a circuit and light an indicator bulb

RESOURCES

(per group of 4 children, unless otherwise stated)

- Activity sheets 12-13
- Plastic tube - wide diameter just greater than size of cork possibly made by rolling plastic sheeting or the tube from a toothpaste pump
- Cork
- 2lt clear plastic drinks bottle cut to about 20 cm height
- Circuit equipment – as before
- Foil, coin or crown bottle top (with paint sanded off to expose metal)
- Paper fasteners
- A5 stiff card
- Adhesive tape
- PVA glue

INTRODUCING THE ACTIVITY

Discuss the homework from Activity 3 about different switches and sensors and how they work.

If possible, look at a circuit board from inside an electronic device (this could be obtained from a local electronics company). Establish that although it is far more complex and has more components than the ones we have made, it works on the same principle, with electricity running round the circuit and switches change the components used each time. Discuss ways electricity travels round the circuit (which materials are conductors and which insulators).

MAIN ACTIVITY

Children discuss in groups, using Activity sheet 12, and report back their ideas. They are looking for different ways to make a switch to connect/disconnect a circuit which will operate as a sensor to detect when the water in the well has reached a certain level.

There will need to be some discussion at this point about the use of electricity for appliances that use water. Draw the children's attention to things like electric kettles, electric shavers (which run on low voltage), food processors and similar items where water is close to electricity. What do they think needs to be considered to make these items safe.

Discuss children's ideas and establish which ones are practical and safe to make in the classroom and why. The instructions on Activity sheet 13 can help or support children where required.

Children make a water sensor and come up with their own ideas of how to modify and improve the sensor, explain how it works and explain a suitable way of running it using wind power.

Safety note

Explain why water and electricity are safe in some cases.

PLENARY

Go back to the letter (Activity sheet 5). Have we answered the questions? Brainstorm what the children have learnt from carrying out these activities.

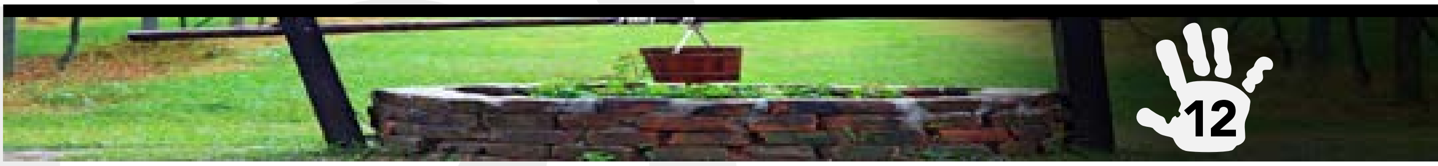
EXTENSION

Use photos and written work to create a report, booklet, power- point presentation or poster to show what the children have established in response to the industrial request.

If it is possible to visit a power station, electronics industry etc. then the information could be shown to the staff.

If not then invite a representative in to see how you have solved these problems and to talk about how these problems are tackled in industry.

Activity 12: Design your group's sensor



The purpose of your sensor:

Draw a labelled diagram of your sensor design you will need to include a circuit diagram

Explain how your sensor works

Materials you will need	Equipment you will need

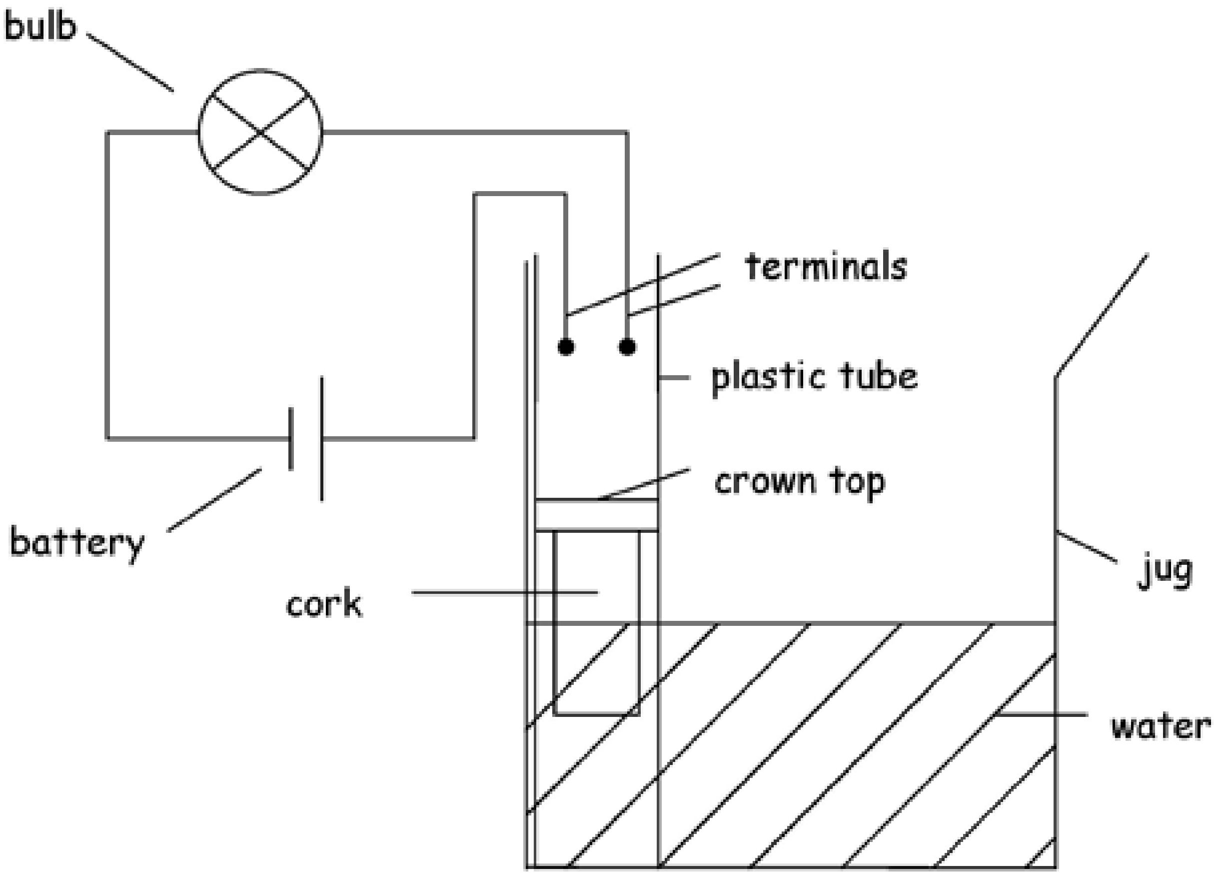
Activity 13: Instructions to make a sensor

Things you need: Plastic tube or rolled plastic sheet, cork, water tank (2lt soft drinks bottle), circuit equipment, paper fasteners and foil, coin or crown bottle top, A5 stiff card, adhesive tape.

1. Place the plastic tube upright in the tank or bottle. Attach it to the side using adhesive tape.
2. Stick the foil, coin or crown bottle top on top of the cork using PVA glue.
3. Make a circuit from the electrical components – follow the circuit diagram, (Activity sheet 8), if you need to – and stick the circuit to the card to make a circuit board. Two unconnected wires should extend from the board.
4. Attach paper fasteners to the two unconnected wires, point the two wire ends down the plastic tube, making sure they don't touch, about 2 cm. at the level where water needs to be indicated and secure.
5. Attach the circuit board to the outside of the tank or bottle with tape making sure this is well away from the water.
6. Place the cork at the bottom of the tube. Now your sensor is ready to be tested.
7. Carefully pour water into the tank or bottle. As the tube fills with water the cork will rise and when the metal top touches the two terminals the circuit will be completed.
8. Remember that the circuit must be kept away from the water at all times. The battery has a low voltage and would not give you an electric shock but mains electricity would. How could the design of this sensor ensure that the circuit was kept dry? Are there any other improvements that you would make?
9. How might you provide electricity if there was no battery?

Activity 13 (continued): Using the sensor

Carefully start adding water. Watch the indicator bulb light-up when the water reaches the set level.



Can you explain how this sensor works?

Resource requirements

Quantities are given per group of 4 children, unless otherwise stated:

ACTIVITY 1

- Activity sheets 1-4
- Circuit set - including at least two wires, 2 batteries, 2 bulbs, buzzer or motor, and items they will require as red herrings
- At least 6 tennis balls
- A4 paper
- Small coloured stickers

ACTIVITY 2

- Activity sheets 5-11
- Sheets of card of 200 micron (to make sails of different sizes) Sheets of other card/paper (to vary sail material)
- 1 m strong thread or string
- 1.5 lt drinks bottle
- Sand or marbles
- Paper or plastic cup
- 20 cm length 8mm dowel
- 5 nylon 8mm washers (that slide onto the dowel)
- Set of weights, marbles or centicubes
- Hair dryer (to provide wind)
- Stop watches
- Bicycle with a dynamo

Safety note

Hair dryers must pass the electrical safety test for use in school.

ACTIVITY 3

- A collection of different switch making resources: Paper clips
- Split pins
- Stiff card
- Foil
- Metal discs - coins
- Nails/tacks
- Paper fasteners
- Card
- Paper
- Plastic sheets
- Circuit kit (e.g. at least 3 wires, bulb or buzzer, battery)

ACTIVITY 4

- Activity sheets 12-13
- Plastic tube - wide diameter just greater than size of cork possibly made by rolling plastic sheeting or the tube from a toothpaste pump
- Cork
- 2 lt clear plastic drinks bottle cut to about 20 cm height
- Circuit equipment – as before
- foil, coin or crown bottle top (with paint sanded off to expose metal)
- Paper fasteners
- A5 stiff card
- Adhesive tape
- PVA glue

Appendix A: Websites

The table below shows useful websites with information relevant to the unit.

INFORMATIVE WEBSITES FOR TEACHERS

https://www.reachoutcpd.com/courses/upper-primary/electricity/

Mini online CPD units to boost subject knowledge and suggest practical activities for teaching electricity and circuits.

www.windpower.org/en/kids/index.htm

Interactive schematics about the building and working of turbines.

https://thekidshouldseethis.com/post/48611338726

Information about wind generators for teachers.

Hunkinsexperiments.com/default.htm

Here are more activity ideas (some quite complex) - great for science club.

https://www.sustainablelearning.com/resource/build-your-own-wind-turbine

Instructions for making a model turbine.

INTERACTIVE WEBSITES FOR CHILDREN TO USE

https://www.switchedonkids.org.uk/

Great, child friendly information, lesson plans and activity ideas about energy.

www.eia.doe.gov/kids/energyfacts/index.html

This site allows children to explore the origins and issues surrounding different energy producers.

https://thekidshouldseethis.com/post/48611338726

Animated wind turbines to generate electricity.

www.windpower.org/en/kids/index.htm

How a generator and dynamo work.

www.andythelwell.com/blobz

Information about circuits and a quiz.

http://powerup.ukpowernetworks.co.uk/powerup/en/teachers-parents/interactives/

Interactive activities to engage and challenge pupils' understanding of electricity, circuits, and safety.

Appendix B: Tennis ball circuit analogy

How do circuits work? The tennis ball analogy:

The children sit in a row with the two children at each end labelled the battery and the bulb (hats would be a good way to label). The tennis balls, each with a sticker, are given to the battery in a container. The balls are passed by the children (the wires) from the battery to the bulb. Explain that the idea is to give energy to the bulb from the battery so that it can light. The energy is represented by the stickers. This energy will have to be carried by something; in this case balls that represent electrons ('balls' of charge).

The children should notice that this can only happen for a very short while before the battery runs out of balls.

Ask how the bulb could be lit for longer. Possible answers include having more balls (i.e. a bigger battery) or having the light return the balls quickly. The first answer would work, but again only for a very short while. The second answer introduces the idea of a **circuit** - a complete path where the balls are returned to their starting point ready to be given more energy and used again. (If you connect a bulb to only one terminal of a battery, will it light? The answer is no, but in fact a little current will flow for a very short time, just as the balls moved to the bulb and stopped there in this demonstration. There is, however, not enough energy transferred to cause a glow!).

The children now sit in a circle with the battery and bulb joined from both sides by the rest of the children representing the wires. The balls are passed around the circle. The bulb removes the stickers to get the energy to light up and the battery replaces the stickers. Each child is only allowed to hold one ball at a time. This reinforces the idea that the current flows smoothly. Also if you put a switch into your circuit, when the switch stops passing balls then the current will stop flowing.

The battery will eventually run out of stickers which is what will happen when the battery goes flat. In a rechargeable battery the voltage in the electron is replaced. In a normal battery the voltage is produced by a non-reversible chemical reaction.

Now ask students how we could increase the power that the bulb is receiving, and hence light brighter. Obviously there are several possible answers.

One is to make the balls carry more energy by making them bigger - using basketballs or soccer balls, for instance. This would work but in practice we are generally limited to using electrons (tennis balls) which are small, negative charges. The bigger, positive charges don't tend to be the ones that move.

Another answer would be to use bigger stickers. This does have a direct electric counterpart - **voltage (V)**. Voltage is simply a measure of how much energy each electron is given by the battery. If we send the same number of electrons, but give each one more energy (i.e. a bigger 'push'), we obviously send more power.

A third answer is to send the balls over at a faster rate, that is, send more balls, (two per child) over each second. This corresponds to **current (I)**, or **amperage**. The electric current is simply how many electrons pass by each second (though we actually count groups of electrons, since they are so small and there are so many of them!). Clearly, if we send twice as many identical electrons each second we are sending twice the energy.

Another thing we could do is both of the last two at once - send more balls, harder. This brings up a very simple equation. The **total power (P)** is simply the product of the number of balls and how much energy each one has. In electrical talk we would say that power is the product of the current and the voltage. i.e. **$P = I \times V$**

The information provided is to help non science specialist teachers to understand the process. The activity can help children to understand how an electrical circuit works.

Appendix C: Making an electricity generator

Electricity generators work by passing a magnet quickly back and forth through a coil of wire, or by passing a coil of wire quickly through a magnetic field (between two magnets). The stronger the magnets and the more coils of wire will generate more electricity. Therefore on an industrial level the coils of wire are huge and the magnets very strong.

The difference between different forms of electricity generators is the method of producing the movement of the magnet or wire. These are often steam turbines where the steam is produced by burning fuel (coal, oil, gas, wood or even waste) or in a nuclear reactor (non-renewable energy). However turbines can be turned by wind (wind turbines) or water (wave, tidal or hydroelectric power). Solar power also generates electricity without using turbines.

The Ben Adams generator:

Attach a magnet or two together to a piece of dowling. Pass through a hole in the bottom of a plastic cup.

Wind insulated copper round the outside of the cup about 1000 turns (over the top and the base) so that the magnets are hidden from view. Remember to leave approximately 10 cm of wire either end. Sand down the ends to remove coating and attach to the LED.

Attach a wheel on the end of the dowling with a handle and spin as fast as you can.

If it doesn't work change the LED round as it will only work in one direction.

Alternative ideas can be found on the Vega science trust resource website:
http://www.vega.org.uk/video/subseries/27

These include the simplest generator under the title *Shake-A-Gen* which is made of a coil of wire, a magnet, an LED and a camera film case. It also contains another more complex generator under the title *Simple Generator*.

Appendix D: Teacher guidance for using the investigative skills sheets

Copy the templates (Activity sheets 9-11) and enlarge.

Introduce the activity, which involves planning an investigation to answer a **broad question**. Write this on a 'Post-it' note. (Try the activity on your own first to make sure the investigation suits using the posters).

List the things that you could change

Now ask the pupils to identify what factors could be changed to find out the answer to the question. Write each factor on a 'Post-it' note and add to the poster (if there are more than six factors, just squash them on).

List the things that you could measure or observe

Say to the pupils **"If we change one of these things"** (the factors already identified), **"What can we measure or observe to see if it's made a difference?"** These factors should be written on 'Post-it' notes (a different colour)and stuck on the appropriate place on the planning poster.

Choose one thing to change and one to measure or observe

Choose a factor to investigate, and what you will measure/observe, and place these 'Post-its' in the appropriate places on the planning poster.

Ask the pupils **"What do we need to keep the same to make it a fair test or comparison?"** They are likely to identify each of the factors on the left hand side of the poster in turn. Move the appropriate 'Post-its' down into the next section of the poser as the pupils list them.

The 'Post-its' can be easily replaced in their original positions, and you can exemplify the fair test/ comparison stage again, by deciding on a different factor to test. This helps more of the pupils to realise that one factor only is changing, and the rest kept constant.

Move the factors under investigation on to the results table to show how to organise results and again onto the axes of the graph to show which factors go where.

Electricity

Session 1: Shock to the system

Learning Objectives

- To understand that mains electricity is generated in different ways.
- To understand the dangers associated with mains electricity and compare different methods of electricity production (e.g. wind, solar, nuclear, coal etc.).
- To make a simple circuit and draw diagrams.

Introduction

Discuss which items in the room or at home require electricity. Generate a discussion about what the children know about electricity. Children to discuss in groups: 'Life without Electricity' and record as a PMI activity (positives, minuses and interesting – see Activity sheet 3).

Give groups a large sheet of paper and spend 10 minutes writing and drawing items that are powered by electricity. Sort into two groups, high voltage (potentially dangerous) and low voltage (can run off batteries and/or mains).

Children to ring the dangers on scenarios showing electricity in every day use (interactive whiteboard or photocopies of Activity sheet 4). Use this to revise the safety issues that surround electricity – that mains electricity can be very dangerous.

See main text for websites to use.

Group or Individual Activities

Use activity in Appendix B to show children how electricity moves from a battery around a circuit and why a complete circuit is needed.

Move to groups and construct circuits using the kit provided. Discuss what happens in the circuit using appropriate vocabulary.

Record circuits using standard diagrams.

Use the circuit cards – Activity sheet 1 to construct circuit diagrams.

Plenary Session

Ask the children where the energy to power the circuit comes from.

What are the advantages of using a battery instead of mains electricity?

By using batteries electrical items can operate without wires. The power produced by a battery is at a much lower voltage and is less dangerous. Larger batteries can still shock.

What are the disadvantages of using a battery?

The power that they supply is lower and they run out (even re-chargeable batteries).

Other methods that can produce high power electricity continuously are necessary.

Review different sources of electricity. Discuss the fact that non-renewable sources of energy use an ever depleting natural resource that cannot be replaced and will eventually run out. However, renewable sources of energy do not run out.

Resources

- Activity sheets 1-4
- Circuit set - including at least 2 wires, 2 batteries, 2 bulbs, buzzer or motor, and items they will require as red herrings
- At least 6 tennis balls
- A4 paper
- 30-40 small coloured stickers

Electricity **Session 2:** Wonderful wind	
Learning Objectives • To understand that wind energy can be harnessed and used to our benefit. • To know that wind energy is a source of electricity.	
Introduction Read the information in the letter on Activity sheet 5. Discuss the issues and highlight some of the needs of people in various African countries and the different ways that aid can be used to help people. Discuss why we need water and ways of producing electricity and introduce the idea of harnessing natural forces to produce electrical energy. Establish that electrical energy is a type of energy that we can produce by harnessing other types of energy and converting them to electricity. Introduce the activity: to harness the wind energy to lift and carry supplies of water in a bucket.	
Group or Individual Activities Children working in groups produce windmills as described on Activity sheets 5 and 6. Using different methods of turning the sail will demonstrate how the energy used to turn the sail is converted to lifting power. The groups then plan an investigation to find out how wind, which is free energy that does not have any waste products, can be captured most effectively to power the windmill. Activity sheets 8-11 are used to plan the investigation and collect the results. This is the sort of investigation that would be carried out in the development of wind turbines.	
Plenary Session Ask the children to draw a conclusion answering the following questions. How did changing your factor affect the weight carried in the bucket / time taken to lift the bucket? Why do you think this happened? How would you apply this to the problems outlined in the letter about Africa? Carry our a demonstration to show how turning power can be converted to electricity.	**Resources** • Activity sheets 5-11 • Sheets of card of 200 micron (to make sails of different sizes) • Sheets of other card/paper (to vary sail material) • 1m strong thread or string • 1.5lt drinks bottle • Sand or marbles • Paper or plastic cup • 20 cm length 8mm dowel • 5 nylon 8mm washers (that slide onto the dowel) • Set of weights, marbles or centicubes • Hair dryer (to provide wind) Stop watches • Bicycle with a dynamo

<table>
<tr><td colspan="2">Electricity
Session 3: Switched on</td></tr>
<tr><td colspan="2">Learning Objectives
• To understand that switches make and break a circuit
• To understand that sensors can operate a switch
• To design a sensor to solve a problem</td></tr>
<tr><td colspan="2">Introduction
Remind the children that a switch creates a break in the circuit and this stops the flow of electricity. Act out the tennis ball analogy first with a child acting as an insulator and then two children acting as a switch. Appendix B.
Look at the letter, Activity sheet 5 again. What would be needed to show that water had reached the right level. Think about the water turning a light or buzzer on and off. How might a sensor switch work.</td></tr>
<tr><td colspan="2">Group or Individual Activities
In groups children make circuits that include a simple switch that will make or break a contact. The circuits are then put into a sensor mechanism that will operate the switch. e.g. a pressure switch using foam, to indicate intruders, an indicator to show that a door is open or closed.
When circuits and switches are complete a circuit diagram is drawn to explain how it was made.
More able children could use parallel circuits with more than one switch.</td></tr>
<tr><td>Plenary Session
Children share their design ideas. As a class they could evaluate each others switch design looking for imaginative ideas, and effective switches that are easy to use and easy to make.
Talk about ways that water might change the position of a switch.</td><td>Resources
• A collection of different switch making resources:
• Paper clips
• Split pins
• Stiff card
• Foil
• Metal discs - coins
• Nails/tacks
• Paper fasteners
• Card
• Paper
• Plastic sheets
• Circuit kit (e.g. at least 3 wires, bulb or buzzer, battery)</td></tr>
</table>

Electricity **Session 4: Sensors**	
Learning Objectives - To make a sensor by creating a switch operated by the water level in a well, to complete a circuit and light an indicator bulb.	
Introduction Discuss the homework from Activity 3 about different switches and sensors and how they work. If possible, look at a circuit board from inside an electronic device. Establish that although it is far more complex and has more components than the ones we have made, it works on the same principle, with electricity running round the circuit and switches change the components used each time. Discuss ways electricity travels round the circuit (which materials are conductors and which insulators). Ask the children to design a sensor that is going to detect the water level in the well described in the letter.	
Group or Individual Activities Individually or in groups use Activity sheet 12 to design a sensor that can be controlled by water movement or filling up. If individual then move into groups to discuss initial ideas and come up with a best idea. Groups then present their idea to the rest of the class. At this point the groups can carry on to design the switch including a circuit and show how it would work to indicate water level. The planning would need to include circuit diagrams, lists of resources and a clear description of how it would work. Alternatively children can use Activity sheet 13 to build the water sensor switch and suggest improvements.	
Plenary Session Go back to the letter (Activity sheet 5) have we answered the questions? Brainstorm what the children have learnt from carrying out these activities. Write to Electricaid to explain how they can help.	**Resources** - Activity sheets 12-13 - Plastic tube - wide diameter just greater than size of cork possibly made by rolling plastic sheeting or the tube from a toothpaste pump - Cork - 2lt clear plastic drinks bottle cut to about 20 cm height Circuit equipment – as before Foil, coin or crown bottle top (with paint sanded off to expose metal) - Paper fasteners - A5 stiff card - Adhesive tape - PVA glue

Appendix F: Electricity - Wonderful wind

Experimental and Investigative science: Assessment of performance

Learning objectives	Level 1	Level 2	Level 3	Level 4	Level 5
Planning		Describes what they think will happen when the wind sails turn. *The different sizes might make it go faster or slower.*	Able to make simple predictions about how the sails will perform. Some based on scientific knowledge. *I think that one will catch the wind better.*	Able to make predictions based on scientific knowledge. *The bigger sails will catch the wind better so they might go faster. We need to make everything else the same.*	Make predictions based on scientific knowledge and understanding. *To turn in the wind the sail needs to be stiff and be big to catch more wind.*
Obtaining Evidence	Can state that the sail turning makes the bucket rise.	Makes observations related to a prescribed method sometimes with help. *When the bucket lifts we measure how long it takes.*	Makes relevant observations about taking measurements. *We need to start the clock just as the sail starts to turn.*	Makes a series of observations about the rates of turning. *The small sails seem to be the slowest and the bigger ones are taking longer and longer .*	Make a series of repeated accurate observations. *As the sail gets bigger, the bucket takes longer to rise. We did each one three times to check.*
Considering Evidence	Can identify differences. Not all of the sails are the same.	Can make simple comparisons. *That one is faster than that one. The bucket took longer to pull up.* Record with drawings or put data into a table provided.	Able to identify simple patterns in their observations. *I think the bigger ones are slower.* Can display results in a table and choose headings.	Relate conclusions to scientific knowledge. *It could be because they are heavier or because they've got further to go.* Suggest improvements. We should try more different sizes. May put results in a bar chart.	Able to identify patterns and use scientific knowledge to explain. *The bigger sails might go slower because it takes longer to get around or because they are heavier. We need to test lighter sail material but it will still need to be stiff.* Use line graphs – choose own coordinates.

CIEC offers support for the teaching of science across the primary age range and beyond. This support includes CPD programmes, bespoke in-school CPD, interactive websites for teachers to use with their pupils, and a wide range of downloadable resources which encourage collaborative, practical problem solving. For more information, please visit our website:

www.ciec.org.uk

or contact:

Centre for Industry Education Collaboration
CIEC Department of Chemistry
University of York
York
YO10 5DD

01904 322523

ciec@york.ac.uk

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