ATSE STELR PROJECT

# Renewable Energy Program

# Student Book

# TABLE OF CONTENTS


| TOPIC | ACTIVITIES | PAGES |
|---|---|---|
| **Global warming** | Worksheet 1: The global warming DVD | 2 |
| **Energy transformations and energy transfers** | Information Sheet: Energy transfer and energy transformation<br>Quick Activity 1: The cotton-reel car<br>Quick Activity 2: The jumping cup<br>Practical Activity 1: Energy transformations and transfers — investigating a range of situations | 5<br>6<br>7<br>8 |
| **The conservation of energy, and energy efficiency** | Practical Activity 2: Bouncing balls | 22 |
| **Energy resources** | Worksheet 2: Our energy resources project | 29 |
| **Batteries and electrical power** | Practical Activity 3: The power delivery of a battery<br>Worksheet 3: Connecting batteries<br>Practical Activity 4: Connecting batteries in series and parallel | 32<br>36<br>39 |
| **Wind turbines** | Practical Activity 5: How many blades should a wind turbine have?<br>Practical Activity 6: How does blade length affect the output of a wind turbine?<br>Worksheet 4: Are wind farms dangerous for birds? | 47<br>57<br>58 |
| **Solar cells** | Practical Activity 7: What power can you get from a solar panel?<br>Practical Activity 8: What is the best angle for solar panels? | 62<br>75 |
| **Scientists at work** | Practical Activity 9: I want to find out . . .<br>Worksheet 5: A career in renewable energy<br>**Group challenge: A model wind turbine**<br>Investigation Planner | 78<br>79<br>80<br>81 |

# GLOBAL WARMING

**The melting of Arctic ice is one consequence of global warming. Other consequences include more extreme weather events in Australia.**

## Big Ideas:

**What do you think global warming is?**

**What causes it?**

**Why is global warming a hot issue?**

**What will global warming mean for us as we get older?**

**What will it mean for our children?**

**How will it affect people in other countries?**

**Is there anything we can do about it?**

**What do we need to know before we can make decisions?**

# Worksheet 1: The global warming DVD

1 What were some new facts you learned about global warming from the DVD?
Place your answers in the table.

| |
|---|
| What is global warming? |
| What is causing global warming? |
| Why should we be concerned about global warming? |
| How do you gather evidence for global warming? |
| Who produced this video, who is the intended audience? How would you improve its message? |
| What can we do about global warming? Why? |

2 What questions do you still have about global warming?

3 Design a concept map to show how various aspects of global warming are related to each other. Incorporate the following key words into your concept map.

Can you think of any other key words? Add them into your concept map as well.

| | |
|---|---|
| Global warming | Energy from the Sun |
| Methane | Ice cores |
| Greenhouse gases | The greenhouse effect |
| The enhanced greenhouse effect | The atmosphere |
| Extreme weather events | Refugees |
| Rising sea levels | Flooding |
| Carbon dioxide | Balance |
| Temperature | Evidence |

# ENERGY TRANSFORMATIONS AND TRANSFERS

**A hydroelectric power station uses energy transformations to generate electricity. As the water flows down the pipes its gravitational potential energy is transformed into kinetic energy. In the power station, turbines and generators transform the kinetic energy of the water into electrical energy. A hydroelectric power station also uses energy transfers to generate electricity. The mechanical energy of each spinning turbine is transferred to a generator by a driving shaft.**

**PHOTO CREDIT: HYDRO TASMANIA**

## Big Ideas:

**Why do we need energy?**

**What types of energy are there?**

**What is the difference between energy transformation and energy transfer?**

**Can energy be completely used up or lost?**

**How do power stations work?**

**What are the consequences of our energy production and use?**

# ENERGY TRANSFER AND ENERGY TRANSFORMATION

**How is energy transformation different from energy transfer?**

## Changing from one form of energy to another

**Energy transformation** is the process of changing from one form of energy to another. This is shown in the following examples.

### Energy transformations in a radio:

When you turn on a radio that is plugged into a power point, electrical energy is transformed into sound energy. One simple way to represent this transformation is shown below.

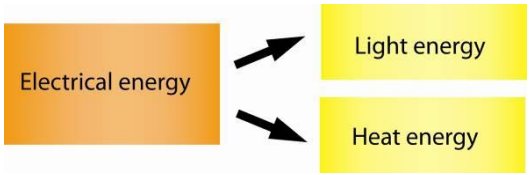
**Electrical energy → Sound energy**

If the radio is powered by a battery, however, two energy transformations take place, one after the other. This is because the battery contains certain chemicals that react with one another when the circuit is completed by turning on the switch. The chemical reaction produces electrical energy. In this case, the series of energy transformations is:

**Chemical potential energy → Electrical energy → Sound energy**

### Energy transformations in a light bulb:

Using a torch involves energy transformations to generate light. When we switch on the light, electrical energy is transferred through wires to the light bulb where it is transformed into heat energy and light energy. We can represent this by the following flow chart.




## Moving energy from one place to another

Energy **transfer** is the passing along of a particular form of energy from one place to another. This is shown in the following example.

### Energy transfers in a heated saucepan:

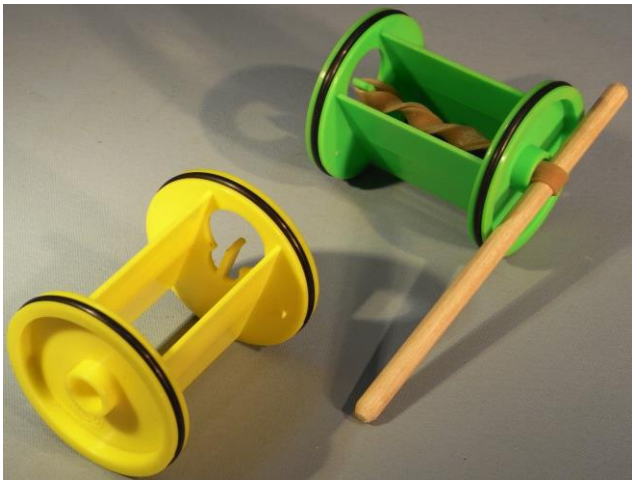
When a metal saucepan containing water is placed on a hot stove, the water and saucepan lid soon become hot. This is because the heat energy of the flame or heating element is transferred from the base of the saucepan to the water and to the saucepan lid.

Heat energy can be transferred from one place to another in three ways:

- **Conduction** – heat energy is transferred through a material or between materials due to contact at the particle level. (This happens in a heated saucepan.)
- **Convection** – liquids or gases gain heat energy and then move from one place to another.
- **Radiation** – objects give off heat energy in the form of infra-red radiation.

The last two are the reason your skin can sense the saucepan is hot without touching it.

# Quick Activity 1: The cotton-reel car



Cotton reel cars – before and after assembling

Examine the cotton-reel car and get it to move along a table.

## What do you think?

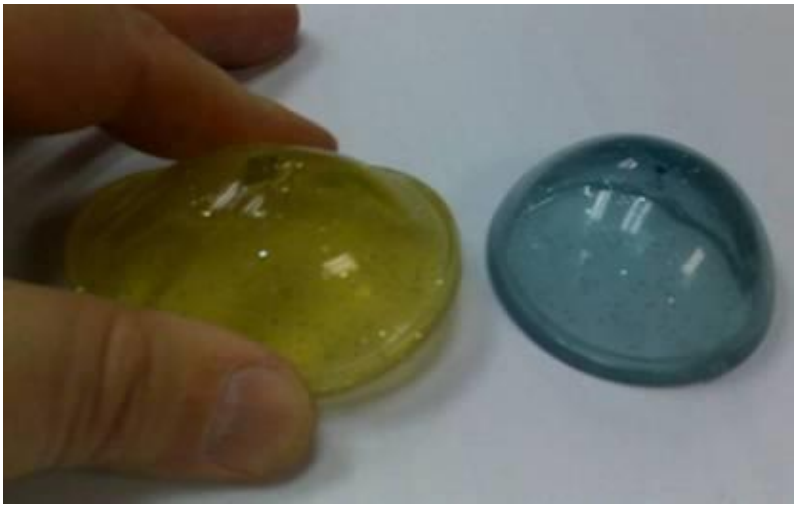
1 How do you think it works? Draw a diagram to show how you think it works.

2 What energy transformations do you think take place? Represent them in a diagram or flow chart.

3 **Challenge!**

Can you improve the design of the cotton reel car so it can go faster or further than anyone else's? What did you do?

## Quick Activity 2: The jumping cup



Take the jumping cup by its edges, turn it inside out and carefully place it on a smooth surface. Let it go. What happens?

### What do you think?

What energy transformations have you observed? Show your ideas in the space below.

# Practical Activity 1:

## Energy transformations and transfers — investigating a range of situations

**Partners:** _____ **Date:** _____

### Introduction

In this activity you will move about from one workstation to another and explore what is there. In each case you will need to decide what energy transformations and energy transfers have occurred.

In some of these workstations, you will use the STELR testing station. Figure 1 shows what it looks like from above.

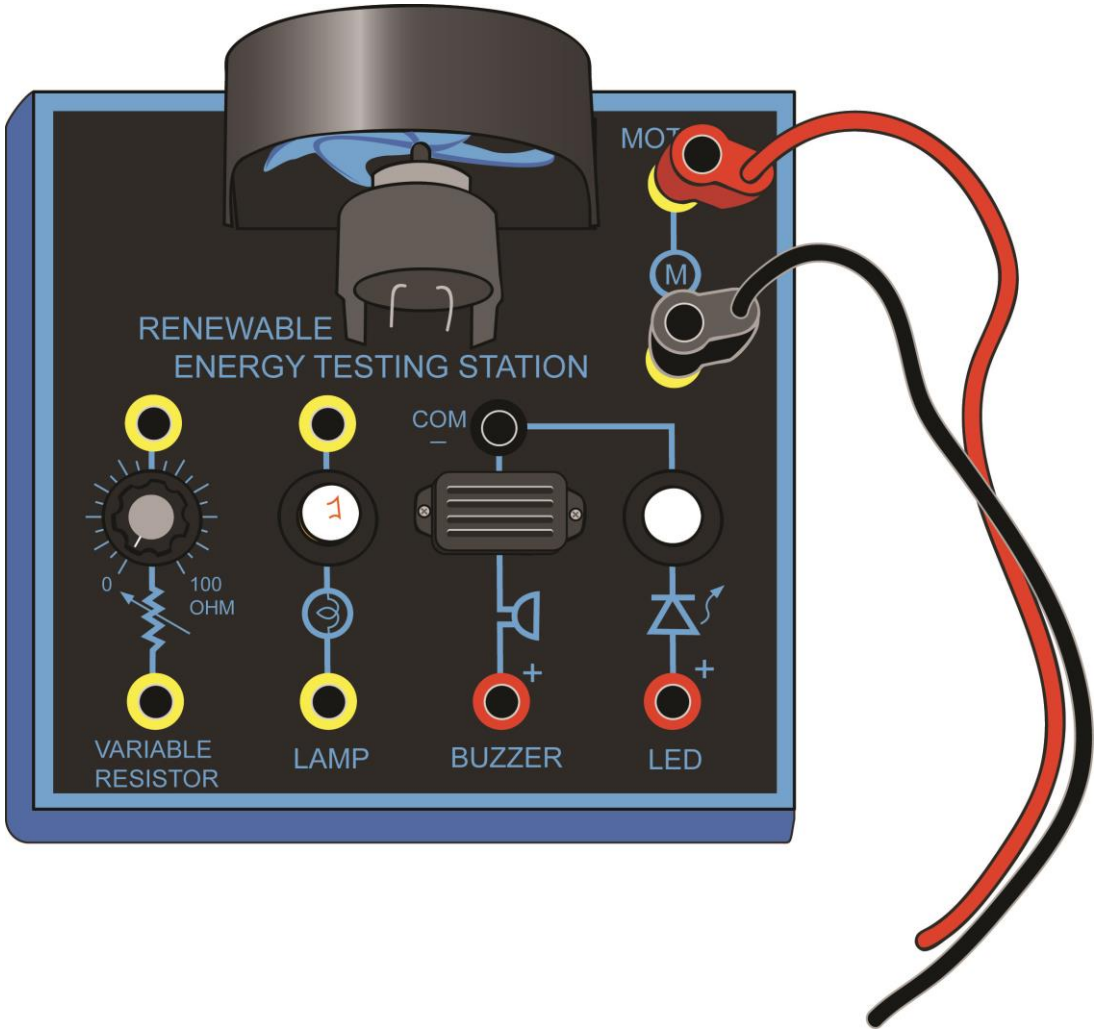



Figure 1: The STELR testing station

In Figure 1, the electrical leads are inserted in the MOTOR sockets. When the leads are also connected to a source of electrical energy, the fan will spin around.

## Station A: Mystery toys

| What to do at Station A |
| --- |
| Examine the toys and make them work. Try to work out how they work.<br>Record your findings in the results table below. |

### Results for Station A, and what you think happened

| What did the toy look like and what did it do?<br>How do you think it works? | What energy transformations do you think happened for this toy?<br>Represent them in some way. | What energy transfers do you think happened for this toy? |
| --- | --- | --- |
| | | |
| | | |

## Station B: A hand-cranked generator

### What to do at Station B

***The hand-cranked generator should be set up for you, see Figure 2.***

1 Check that the leads are connected to the MOTOR sockets on the testing station. (See Figure 1.)

2 Use the handle to rotate the black wheel clockwise. Turn it faster and faster. What do you notice?

3 What difference does it make if you rotate the black wheel in an anticlockwise direction instead?

4 If there is time, try connecting the leads to the buzzer and the light.

5 Record your findings in the results table below and on the next page (page 11).

**When you have finished this activity, leave the equipment as you found it.**

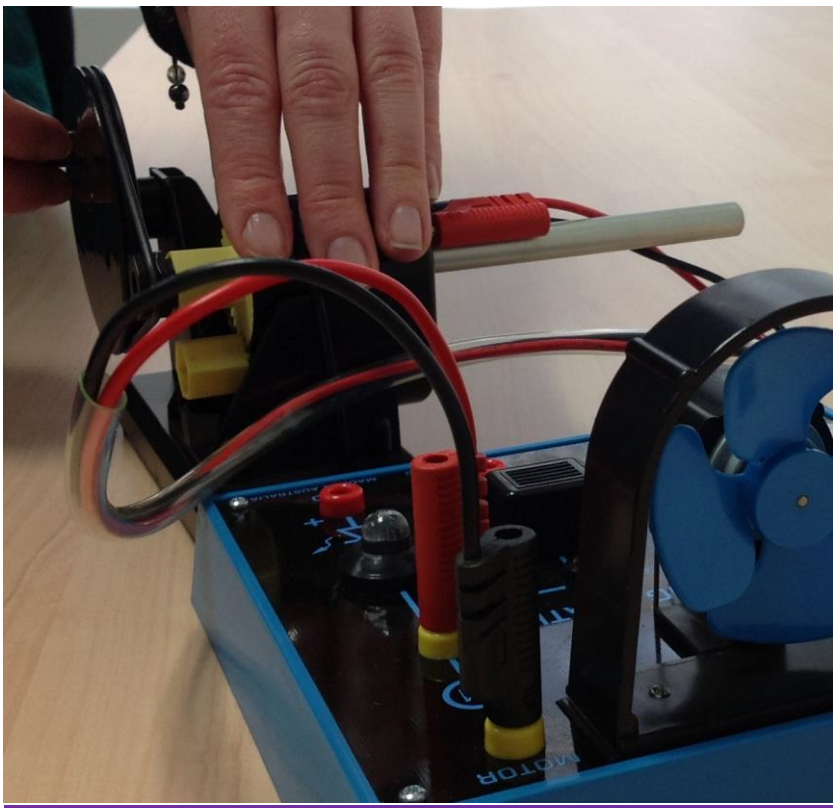



Figure 2

### Results for Station B, and what you think happened

| What did you observe? | What energy transformation(s) do you think happened? Represent them in some way. |
|---|---|
| Wheel turned clockwise; leads connected to fan | |
| Wheel turned anticlockwise, leads connected to fan | |

| | |
|---|---|
| Wheel turned clockwise; leads connected to buzzer<br><br>light | |
| Wheel turned anticlockwise; leads connected to buzzer<br><br>light | |

## Discussion questions for Station B

1 Identify one example of an energy transfer that you observed with this equipment.

2 Why do you think changing the direction in which you turned the handle had the effect you observed?

3 Did you notice anything else interesting when you tested this equipment?

## Station C: A chemical battery

### Information about Station C

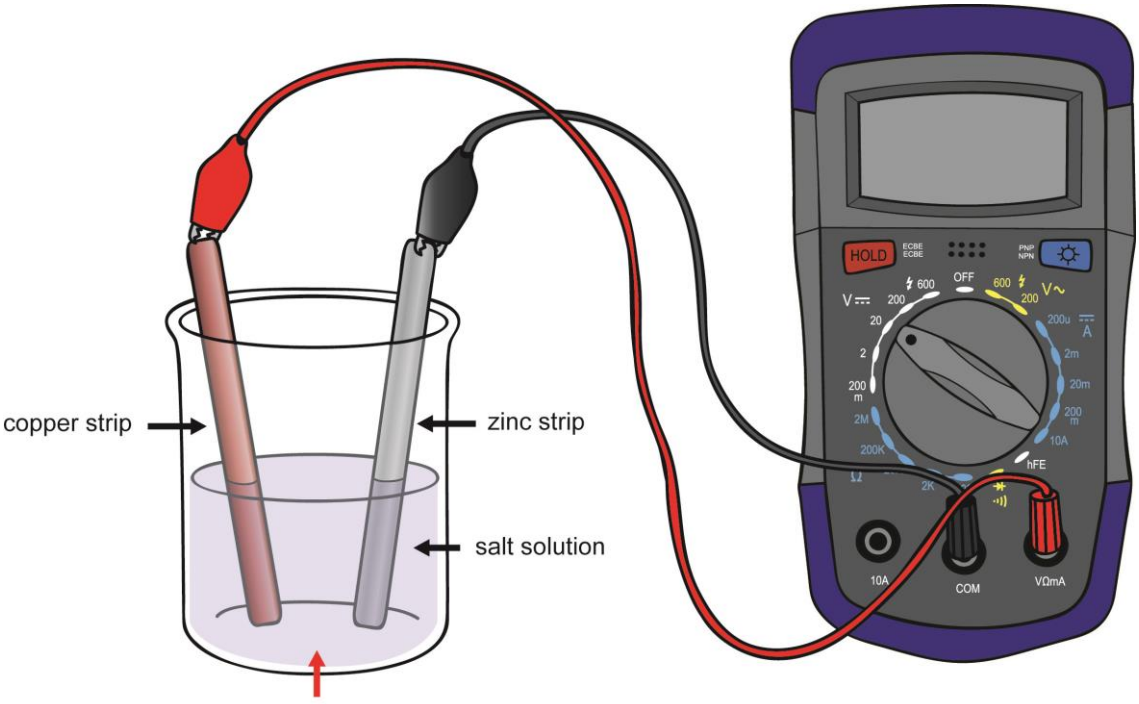



Figure 3

The STELR multimeter shown in Figure 3 is an instrument designed to measure voltage, electrical current or electrical resistance. In this activity you will simply use it to detect whether the battery is producing electricity. The battery, as you can see, consists of two different metal strips placed in a salt solution. This is like one of the earliest batteries ever used.

### What to do at Station C

1 Put on safety glasses.

2 Wipe the metal strips with the paper towel provided, then rub them with emery paper to clean their surface.

3 Measure out 60 mL of fresh salt solution into the measuring cylinder. Pour it into the 100 mL beaker then insert the metal strips as shown in Figure 3.

4 Use the leads to connect the metal strips to the multimeter, as shown in Figure 3. Turn the multimeter on to the 20 V setting. (This will show voltages up to 20 volts). If there is a reading it shows the battery is working. Record your finding in the table below.

5 Are there any changes in the solution as the battery runs? Record your observations in the results table on page 13.

6 Turn off the multimeter. Take the metal strips out of the salt solution and leave them on the paper towel.

**When you have finished this activity, tip the salt solution down the sink and rinse out the beaker. Leave it to drain on the paper towel. Remove the safety glasses and leave them for the next group.**

## Results for Station C, and what you think happened

| Was a current produced? What did you see? | What energy transformation(s) do you think happened? Represent them in some way. |
|---|---|
| | |

## Discussion questions for Station C

1 Identify one example of an energy transfer that you observed with this equipment.

2 What questions do you have about this equipment?

## Station D: A commercial battery

### Information about Station D

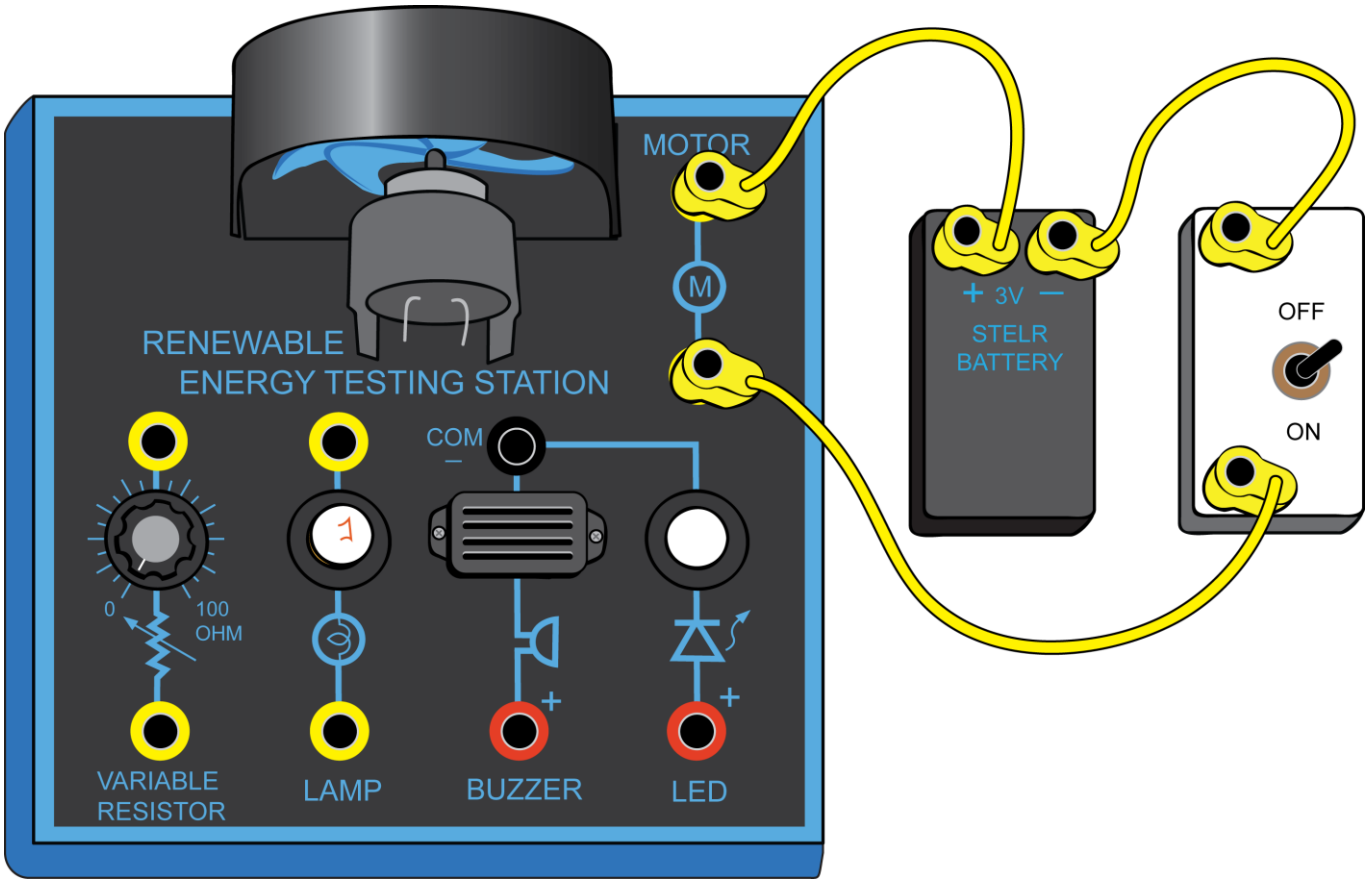



Figure 4

### What to do at Station D

1 Connect the terminals of the supplied battery to the MOTOR sockets of the testing station. What happens?

2 Does the fan work if you reverse the positions of the two leads? Try this and see. What difference does swapping the leads make?

3 Connect the black (negative) terminal of the battery to the COM socket.

4 Connect the red (positive) terminal of the holder to the BUZZER socket. Can you hear the buzzer?

5 Does the buzzer work if you reverse the positions of the leads? Try this and see. Record your findings in the results table on the next page (page 15).

**When you have finished this activity, leave the equipment as you found it.**

## Results for Station D, and what you think happened

| What did you observe? | What energy transformations do you think happened? Represent them in some way. |
|---|---|
| Leads connected to fan | |
| Leads connected to fan; leads reversed | |
| Leads connected to buzzer | |
| Leads connected to buzzer; leads reversed | |

## Discussion questions for Station D

1 Identify an example of energy transfer in this activity.

2 Was chemical energy transformed into electrical energy in each case you tested? Explain your reasons.

# Station E: A model wind turbine

## Information about Station E

A **wind turbine** is a device that uses air movement (wind) to generate electricity. The wind causes the blades of the turbine to rotate, which in turn causes a copper wire coil to rotate near a magnet. This produces an electric current in the wire coil. (You will learn more about wind turbines later in this program.)

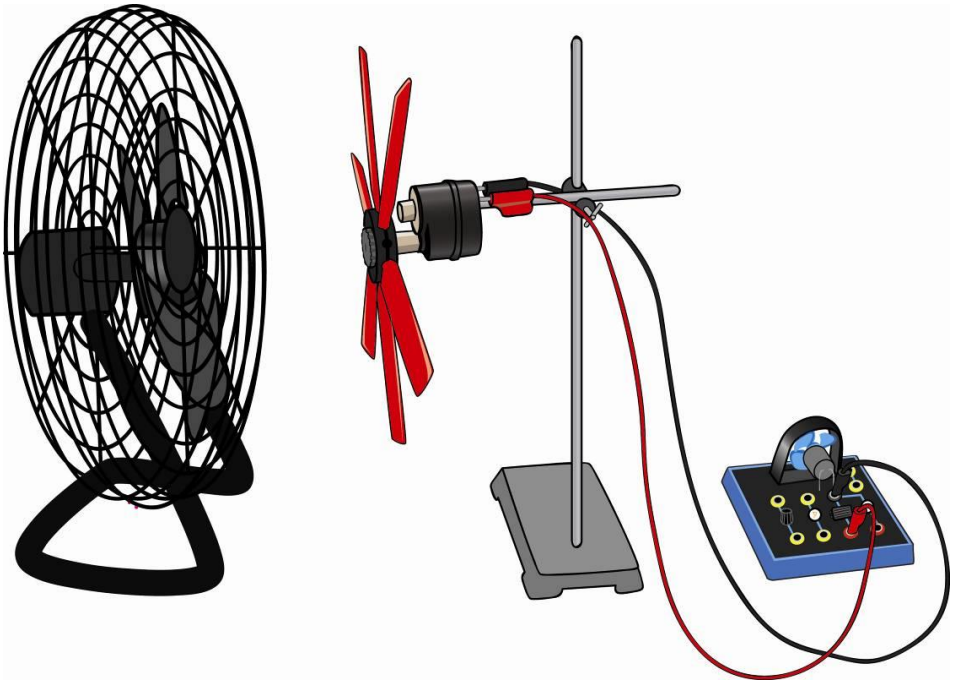


Figure 5: A STELR model wind turbine connected to the buzzer on a STELR testing station.

## What to do at Station E

***Ensure the equipment is set up as shown in Figure 5. The large fan should be switched OFF. The black lead should be connected to the COM socket of the testing station and the red lead to the BUZZER socket. The distance between the large fan and the wind turbine should be 50 cm.***

1 Set the fan to Medium and turn it on. Does the buzzer sound? (If not, reverse the leads and try again.)

2 What do you expect to happen to the noise of the buzzer if you turn the fan up to High? Try it and see.

3 Move the leads to the LAMP sockets and turn the fan back to Medium. Does the globe light?

4 What do you expect to happen to the globe if you turn the fan up to High? Try it and see.

5 Record all your findings in the results table on the next page (page 17).

**When you have finished this activity, turn off the fan and leave the equipment as you found it.**

## Results for Station E, and what you think happened

| What did you observe? | What energy transformations do you think happened? Represent them in some way. |
|---|---|
| Leads connected to buzzer; fan set at Medium | |
| Leads connected to buzzer; fan set at High | |
| Leads connected to lamp; fan set at Medium | |
| Leads connected to lamp; fan set at High | |

## Discussion questions for Station E

1 Identify two examples of an energy transfer that occurred when you used this equipment.

2 What questions do you have about the wind turbine?

# Station F: A solar panel

## Information about Station F

A **solar panel** consists of a set of **solar cells**. Each solar cell converts light energy to electrical energy.

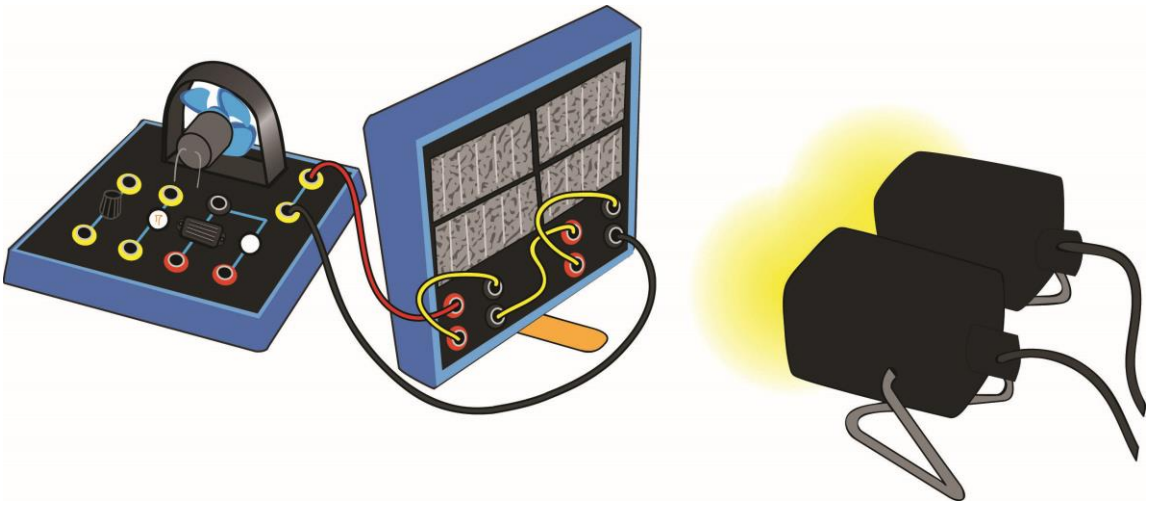


Figure 6

Figure 6 shows STELR model solar panel connected to the MOTOR sockets of the STELR testing station. The solar panel consists of four solar cells connected together in series.

Lamps are shining on the solar panel to provide the light energy it needs to work. The lamps are connected to a 12 V power pack, which cannot be seen in this image.

If it is a bright sunny day, you could use direct sunlight instead of the lamps and power pack. In that case the solar panel will be close to a window that is facing the Sun.

## What to do at Station F

***If you are using lamps as your light source, as shown in Figure 6, make sure the power pack and hence the lamps are switched off. Then turn on the power pack when you are ready to start.***

***Check that the solar panel and STELR testing station are set up as shown in Figure 6. The red and black output leads should be connected to the MOTOR sockets on the testing station.***

1 When light is shining on the solar panel, what does the fan do? (If the fan does not work at first, flick it gently.)

2 Move the leads to the LAMP sockets. Does this globe light?

3 What do you think will happen to the brightness of the globe when you move the solar panel further from the light? Try it and see. .

4 Record your findings in the results table on the next page (page 19).

**When you have finished this activity, turn off the power pack and leave the equipment as you found it.**

## Results for Station F, and what you think happened

| What did you observe? | What energy transformations do you think happened? Represent them in some way. |
|---|---|
| Leads connected to fan | |
| Leads connected to lamp, panel closer to light source | |
| Leads connected to lamp, panel further from light source | |

## Discussion questions for Station F

1 Identify two examples of an energy transfer that occurred when you used this equipment.

2 Can you suggest explanations for what you saw?

3 What questions do you have about the solar panel?

## Discussion questions for all stations

1 Name common devices in which the following energy transformation takes place:

a Electrical energy to sound energy _____

b Electrical energy to light energy _____

c Electrical energy to both sound energy and light energy _____

d Electrical energy to heat energy _____

e Kinetic energy to mechanical energy _____

f Mechanical energy to electrical energy _____

g Electrical energy to mechanical energy _____

2

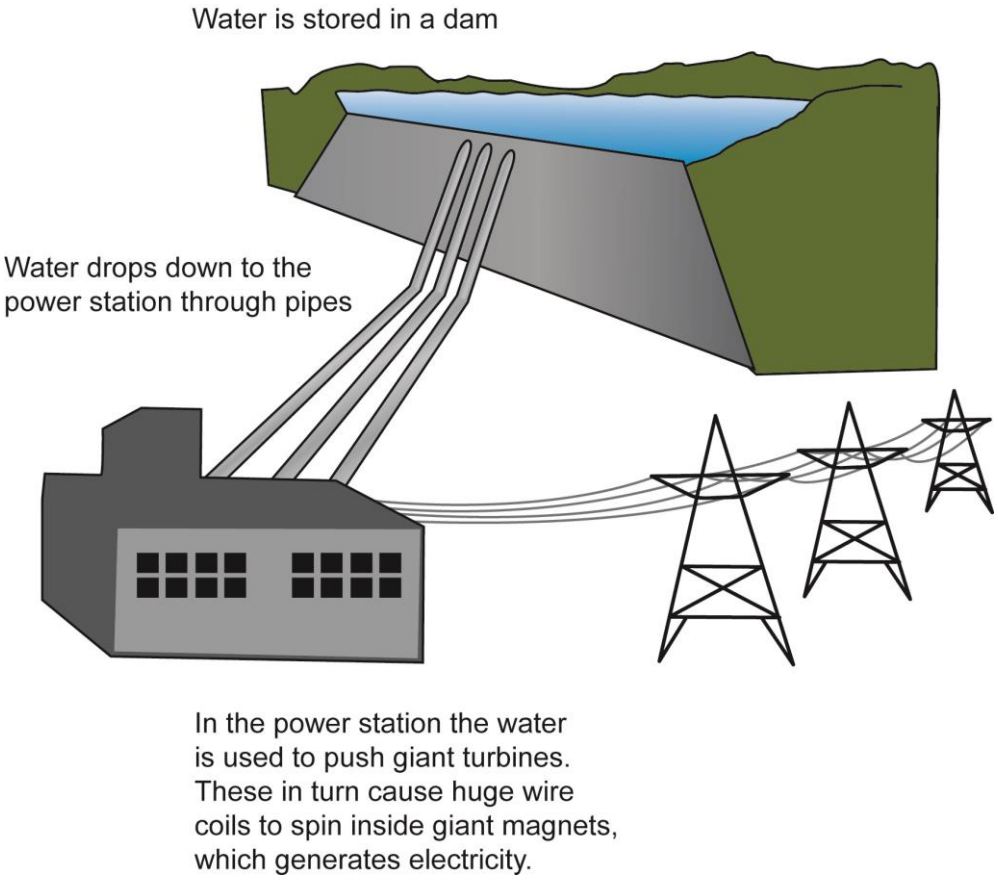



Figure 7: How a hydroelectric power station works.

A hydroelectric power station is another example of energy transformations and energy transfers in action. Figure 7 shows how it works. Identify two energy transfers and two energy transformations that occur at a hydroelectric power station, and represent them in some way.

3 Suggest an alternative way to represent one of the energy transformations you observed in this activity? This can involve, for example, modelling, a simulation or a role play.

# CONSERVATION OF ENERGY AND ENERGY EFFICIENCY

**This is a coal-fired power station in Australia. Steam is rising from the curved cooling towers in front of and behind the power station. The superheated steam that has been used to make the turbines spin is cooled in these towers, and then piped back to the furnaces to be heated again. Very hot invisible gases produced when the coal is burned in the furnaces (mainly carbon dioxide and steam) escape from the three tall chimneys above the furnaces.**

## Big Ideas:

**What is energy efficiency?**

**What has energy efficiency got to do with global warming and climate change?**

**How can you save energy?**

**In most coal-fired power stations, less than 30 per cent of the chemical potential energy of the coal is transformed into electrical energy. What is the rest of the chemical potential energy transformed into?**

**Can coal-fired power stations be made more efficient?**

# Practical Activity 2:
# Bouncing balls

**Partners:** _____ **Date:** _____

**Inquiry questions**

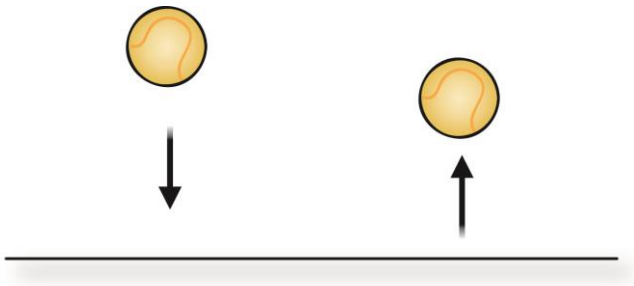
**Inquiry question 1: What kind of surface gives the greatest percentage energy efficiency for bouncing a tennis ball?**

**Inquiry question 2: Does the percentage energy efficiency of bouncing a tennis ball off the classroom floor depend on the height from which it is dropped?**

**Inquiry question 3: What kind of ball has the greatest percentage energy efficiency when bounced off a hard surface?**

**This activity is a class experiment. Each group will be assigned one of the above inquiry questions to investigate. Then the results of all the inquiries will be compared.**

## Background information



**When you drop a tennis ball onto a hard surface it does not bounce back to its original height. Why does this happen?**

When a ball falls freely from a height, its gravitational potential energy is transformed into kinetic energy.

However, at the moment the ball bounces on a solid surface:

- Both the surface and the ball will get slightly hotter. This means that some of the ball's kinetic energy is transformed into heat energy.
- The ball will be temporarily squashed. This means some of the kinetic energy of the ball is transformed into elastic potential energy.
- The ball makes a sound. This means some of its kinetic energy is transformed into sound energy.

Therefore the bouncing process has 'wasted' some of the kinetic energy of the ball.

As the ball rebounds (rises again), its speed becomes slower and slower, because its kinetic energy is being transformed back into gravitational potential energy. Eventually its speed will be zero, and it will 'hover' for an instant at its highest point. At this point, its kinetic energy will have been completely transformed into gravitational potential energy. However, because some of its kinetic energy was 'wasted' when it struck the surface, the ball is not as high as the position from which it was dropped.

A simple formula for the percentage energy efficiency of a rebound is:

$$\text{Percentage energy efficiency of rebound} = \frac{\text{maximum height of ball when it rebounds}}{\text{height of ball before dropped}} \times \frac{100}{1}$$

### Sample calculation

A ball is dropped from a height of 120 cm above a surface and rises to a height of 84 cm after it has bounced. What is the percentage energy efficiency of the rebound?

#### Solution

$$\text{Percentage energy efficiency of rebound} = \frac{\text{maximum height of ball when it rebounds}}{\text{height of ball before dropped}} \times \frac{100}{1}$$

$$= \frac{84}{120} \times \frac{100}{1}$$

$$= 70\%$$

## What you need

- A tennis ball or set of different balls, depending on whether you are in Group A, B or C
- Metre ruler or digital device for measuring ball height

## Assessing the risks

Read the facts, imagine what could happen that might hurt someone or cause damage, and think of what you could do to prevent that problem. Hence complete the table below.

| The facts | What might be the risks? | What precautions will we take? |
|---|---|---|
| 1 Balls can damage things or cause injuries when they bounce. | | |
| 2 If a ball is bounced out-of-doors, it can roll away. | | |

## What to do and what you discover

Your teacher will divide you into groups and discuss what device you will use for your measurements, and how you will record your results, perform your calculations and report your findings.

**You may also pose your own inquiry questions!**

## GROUP A

**Inquiry question 1: What kind of surface gives the greatest percentage energy efficiency for bouncing a tennis ball?**

| Step | What to do |
|---|---|
| **1** | As a group, you need to make some decisions:<br>• What surfaces will you be able to test?<br>• What do you predict will be the answer to your inquiry question for these surfaces? What is your reason?<br>• How will you test how efficiently the tennis ball bounces off the different surfaces so you can compare them fairly?<br>• How will you ensure that your measurements are as accurate as possible?<br>• What kind of graph might be the best way to display your results?<br>• Who will perform what task when you start?<br>Your teacher may ask you to fill out an investigation planner for this. A planner is on pages 81 and 82. |
| **2** | Discuss your decisions with your teacher. When your teacher approves of your plans, start your testing. First conduct one trial to see if your strategy works. Adjust it if necessary. Record if any other problems arise and how you solve them. |
| **3** | Pack up according to your teacher's instructions. |

### Results for Group A

Summarise how you performed your testing, including how you made sure your tests were fair. Describe any problems you had and what you did to overcome them. Attach or insert a copy of what you did and of your results for your records.

### Calculations and graph for Group A

Use your results to complete your calculations of percentage energy efficiency for each bounce, according to your teacher's directions. Do not include any results that you think were unreliable.

Draw a graph to display your results.

Attach or insert a copy of your calculations and graph for your records.

### Conclusion for Group A

What is your response to Inquiry question 1: What kind of surface gives the greatest percentage energy efficiency for bouncing a tennis ball?

What did you predict would happen? What was your reason?

## GROUP B

**Inquiry question 2: Does the percentage energy efficiency of bouncing a tennis ball off the classroom floor depend on the height from which it is dropped?**

| Step | What to do |
|---|---|
| **1** | As a group, you need to make some decisions:<br>• What do you predict will be the answer to the inquiry question?<br>• How many different heights should you test, so you can discover if there is a relationship between the height from which the ball is dropped and the percentage energy efficiency of the bounce?<br>• How will you ensure that the different heights are compared fairly?<br>• How will you ensure that your measurements are accurate as possible?<br>• What kind of graph might be the best way to display your results and allow you to tell if there is a relationship between the height from which the ball is dropped and the percentage energy efficiency of the bounce?<br>• Who will perform what task when you start?<br>Your teacher may ask you to fill out an investigation planner for this. A planner is on pages 81 and 82. |
| **2** | Discuss your decisions with your teacher. When your teacher approves of your plans, start your testing. First conduct one trial to see if your strategy works. Adjust it if necessary. Record if any other problems arise and how you solve them. |
| **3** | Pack up according to your teacher's instructions. |

### Results for Group B

Summarise how you performed your testing, including how you made sure your testing was fair. Describe any problems you had and what you did to overcome them. Attach or insert a copy of what you did and of your results for your records.

### Calculations and graph for Group B

Use your results to complete your calculations of percentage energy efficiency for each bounce, according to your teacher's directions. Do not include any results that you think were unreliable.

Draw a graph to display your results.

Attach or insert a copy of your calculations and graph for your records.

### Conclusion for Group B

What is your response to Inquiry question 2: Does the percentage energy efficiency of bouncing a tennis ball off the classroom floor depend on the height from which it is dropped?

_____

If it did depend on the height from which the ball was dropped, how were the two quantities related?

_____

## GROUP C

**Inquiry question 3: What kind of ball has the greatest percentage energy efficiency when bounced off a hard surface?**

| Step | What to do |
|---|---|
| **1** | As a group, you need to make some decisions:<br>• For the balls you are testing, what do you predict will be the answer to your inquiry question?<br>• How will you test how the different balls bounces off the grass in a way that you can compare them fairly?<br>• How will you ensure that your measurements are accurate as possible?<br>• What kind of graph might be the best way to display your results?<br>• Who will perform what task when you start?<br>Your teacher may ask you to fill out an investigation planner for this. A planner is on pages 81 and 82. |
| **2** | Discuss your decisions with your teacher. When your teacher approves of your plans, start your testing. First conduct one trial to see if your strategy works. Adjust it if necessary. Record if any other problems arise and how you solve them. |
| **3** | Pack up according to your teacher's instructions. |

### Results for Group C

Summarise how you performed your testing, including how you made sure your tests were fair. Describe any problems you had and what you did to overcome them. Attach or insert a copy of what you did and of your results for your records.

### Calculations and graph for Group C

Use your results to complete your calculations of percentage energy efficiency for each bounce, according to your teacher's directions. Do not include any results that you think were unreliable.

Draw a graph to display your results.

Attach or insert a copy of your calculations and graph for your records.

### Conclusion for Group C

What is your response to Inquiry question 3: What kind of ball has the greatest percentage energy efficiency when bounced off a hard surface?

_____

What did you predict would happen? What was your reason?

_____

## Discussion questions

1 Did your group's prediction come true? If not, can you suggest an explanation?

_____

_____

2 Did any results obtained by the other groups surprise you? What did they discover and what did you expect would happen?

_____

_____

_____

3 Draw an energy transformation flow chart for a bouncing a ball. (Refer to the example on page 5.)

4 Sketch a series of pictures to show what happens to a ball during a bounce. (This is like taking slow-motion shots of it.) Use up and down arrows to show the direction in which the ball is moving. Write the form(s) of energy that the ball possesses on each picture.

5 When a certain ball is dropped onto concrete from a height of 2 m, it rebounds to a height of 110 cm.

a Calculate the percentage energy efficiency of the ball bouncing on the concrete.

b If the same ball were dropped onto a soft surface such as grass, what effect might this have on the percentage energy efficiency of the rebound? Would the energy efficiency be more than, less than, or the same as for bouncing on concrete? Justify your answer.

_____

_____

# ENERGY RESOURCES

**The energy resources that can be used to generate electricity include solar power, wind power, tidal power, hydroelectric power, geothermal power, wave power, fuel cells, burning fossil fuels, burning biogas and nuclear power. Energy resources are not only used to generate electricity, however. Some are used to 'drive' our transport and others are used in manufacturing, for heating, and so on.**

## Big Ideas:

### You are a delegate at a conference: 'Selecting Resources for our Energy Future.'

**How do the different energy resources generate electricity?**

**What are the advantages and disadvantages of using the different energy resources?**

**Should we generate electricity from an energy resource that also is needed for other purposes, such as transport?**

**Should we only use non-renewable energy resources?**

**How will energy production and use be different in the future?**

**What would you recommend to the conference? Why?**

# Worksheet 2: Our energy resources project

## What does the project involve?

Your group must select one energy resource and investigate different aspects of that resource, through the internet, the STELR website, and so on. You are encouraged to contact experts in the field as well, where this is possible. You will then investigate this resource and give a presentation about that energy resource to the class

Each group in the class should investigate a different energy resource.

## Suitable energy resources include:

- Solar (photovoltaic) panels for generating electricity
- Solar heating
- Solar thermal power stations
- Wind turbines
- Geothermal power stations
- Hydroelectric power stations
- Biogas for generating electricity and producing heat energy
- Petrol for transport
- A biofuel used for transport (such as bioethanol or biodiesel)
- Tidal power
- Wave power
- Nuclear power stations
- Coal-fired power stations
- Gas-fired power stations

## What do we need to find out about our energy resource?

**You need to find out (where the information is available):**

### 1 What is the science and technology behind the resource?

- How does this energy resource work? What devices are used?
- What are the main energy transformations and energy transfers that take place? (This should include a flow chart showing the energy transformations that occur.)
- Is this energy resource classified as renewable or non-renewable, and why?

### 2 How is the energy resource used?

- Is this energy resource used in Australia, and if so, to what extent? (Is it a large-scale energy resource, or just used on a small scale? Where in Australia is it used – across most of Australia, or just in a small part of Australia?)
- Is this energy resource used across the world and if so, to what extent? Which countries are the main ones using it? Is there a reason why some countries are using it and others are not?

### 3 What are the benefits and problems associated with this energy resource?

- What are the main advantages of using this energy resource? Will increased use of the resource help reduce global warming?
- What health and safety concerns are associated with this energy resource?
- What environmental concerns are associated with this energy resource?

### 4 What does your community think about this resource?

- What are the views of members of your school and/or local community on the setting up and using the energy resource to supply electricity or other useful forms of energy, especially if it were to be established nearby?

### 5 What is the likely future of the resource?

- Is the energy resource likely to be a useful and widely used energy source for Australia and across the world in the future? Why?

**You also may think of other questions that suit your energy resource.**

## Resources

- See the student portal of the STELR website at www.stelr.org.au for a list of useful websites.
- See the background information tab of the STELR website for extra information about different renewable energy resources.

## How do we present our project?

You should consider a range of ways of communicating your information that will capture the interest of your audience. Here are some examples:

- Digital images
- Diagrams, models, flow charts and maps
- Tables and graphs of data
- Website capture
- Video clips
- Posters
- Your own recordings of interviews and site visits
- PowerPoint presentation

## How will the project be assessed?

See the assessment document provided by your teacher.

# BATTERIES AND ELECTRICAL POWER

**The Tesla Roadster is an electric car (top image). Electrical energy is supplied by a set of rechargeable batteries that are connected together (bottom left). The car can be charged by plugging in to a power point (bottom right). A fully charged battery gives the car a range of almost 400 kilometres. The battery pack has a mass of 450 kg.**

## Big Ideas:

**Why and how do we use batteries?**

**What difference does the size of the battery make?**

**What difference does using several batteries make?**

**How can batteries be connected together?**

**What have batteries got to do with global warming?**

**How would we manage without batteries?**

**Should we all drive electric cars?**

# Practical Activity 3:
# The power delivery of a battery

**Partners:** _____ **Date:** _____

**Inquiry question: What electrical power can be delivered by a STELR battery pack?**

## Introduction

In this activity you will be setting up the circuit shown in Figure 1 and measuring the current and voltage delivered by the STELR battery pack to the globe on the STELR testing station.

You can see from the circuit symbols that an ammeter and a voltmeter will be placed in the circuit. (This is to avoid the diagram being too crowded.) In this activity you will use a STELR multimeter set as an ammeter and another STELR multimeter set as a voltmeter.

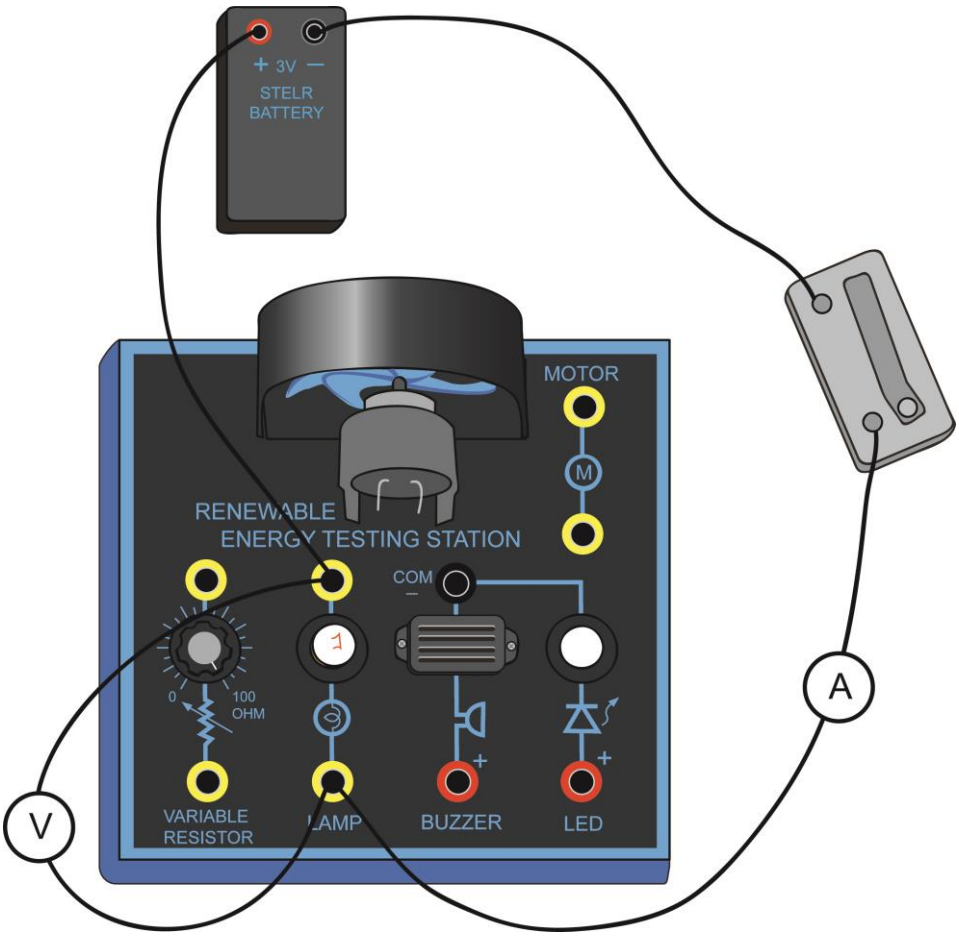



Figure 1: The circuit you will use to measure the electrical power delivered by the STELR battery to the globe on the testing station. You can see that the leads are connected to the LAMP sockets in the testing station.

A simplified circuit diagram is shown on the next page.

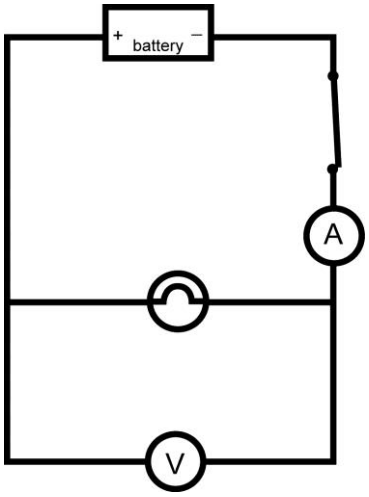



Figure 2: The circuit diagram for the circuit in Figure 1, in which a simplified symbol for the STELR battery has been used.

### The calculations in this experiment

You will use the following formula for electrical power:

$P = V \times I$ where $P$ = electrical power, in **milliwatts**
$V$ = voltage, in volts
$I$ = current, in **milliamps**

### The units of measurement in the experiment:

In this experiment, the current is likely to be small. The ammeter will read it in milliamps, symbol mA.
(A **milliamp** is one thousandth of an ampere.)

For this reason, the electrical power will be given in milliwatts.
(A **milliwatt** is one thousandth of a watt.)

### Sample calculation:

A student set up the circuit shown as in Figure 1. The final steady voltage was found to be 3.06 V. The final steady current was 33.3 mA.

What power was being delivered by the battery to the globe on the testing station? Give your answer in milliwatts.

### Solution:

$P = V \times I$ where $P$ = electrical power, in milliwatts
$V$ = voltage = 3.06 V
$I$ = current = 33.3 mA

Hence $P = 3.06 \times 33.3$
$= 102$ mW

**Answer:** The power delivered by the battery to the globe was 102 mW.

## Assessing the risks

Read the facts, imagine what could happen that might hurt someone or cause damage, and think of what you could do to prevent that problem. Hence complete the table below.

| The facts | What might be the risks? | What precautions will we take? |
|---|---|---|
| 1 Multimeters are very sensitive digital instruments. They always should be placed correctly in the circuit. They should be turned off after use. | | |
| 2 The equipment can be permanently damaged if dropped or carelessly handled. | | |
| 3 Batteries can go flat if left on too long. | | |

## What you need

- STELR testing station
- 2 x STELR multimeters
- Switch
- STELR battery
- Connecting leads
- Stopwatch or clock

## What to do

| Step | What to do | How to do it |
|---|---|---|
| **1** | Set up the circuit shown in Figure 1.<br><br>Don't turn the multimeters on yet – just place them in the circuit with the leads connected to them as in Figure 3. So at this stage they should both look like the multimeter in Figure 3. | <br>Figure 3: The STELR multimeter at the OFF position. |
| **2** | The voltmeter is in parallel with the lamp and the STELR battery.<br><br>Set the voltmeter as follows: turn the dial anticlockwise onto the white scale to the **20** setting. (The voltmeter will now measure voltages up to 20 V.) | |
| **3** | The ammeter is in series with the lamp and the STELR battery.<br><br>Set the ammeter as follows: turn the dial clockwise onto the blue scale to the **200m** setting. (The ammeter will now measure currents up to 200 mA.) | |
| **4** | Close (turn on) the switch and look at the displays on the ammeter and voltmeter. Record the current and voltage once a steady reading is obtained, in the results table (page 35). | |

| | | |
|---|---|---|
| **5** | Open (turn off) the switch and return both the ammeter and voltmeter to the OFF position.<br><br>**Dismantle the circuit and pack up as instructed by your teacher.** | |

## Results and calculations

| Current (final steady value) (mA) | Voltage (final steady value) (V) |
|---|---|
| | |

1 Calculate the power delivered by the STELR battery to the globe. Give your answer in milliwatts. (See the example on page 33.)

2 Do you think the answer would be different if you had connected the battery to the buzzer or fan? Discuss.
If you have time, try this out.

## Conclusion

What is your answer to the inquiry question: What electrical power can be delivered by a STELR battery?

_____ mW

# Worksheet 3: Connecting batteries

## Background information on batteries

Single batteries usually deliver a voltage of 1.5 volts. The problem with this is that they do not deliver enough electrical power to run most devices. This is why you have to insert more than one battery into most devices to get them to work.

Look at the circuit shown in Figure 1. When they are connected together like this, we say the two single batteries are connected **in series**. This means they are connected along the same path in the same way, with the (-) terminal of one battery connected to the (+) terminal of the other. As a result they are both sending the electrical current in the same direction.

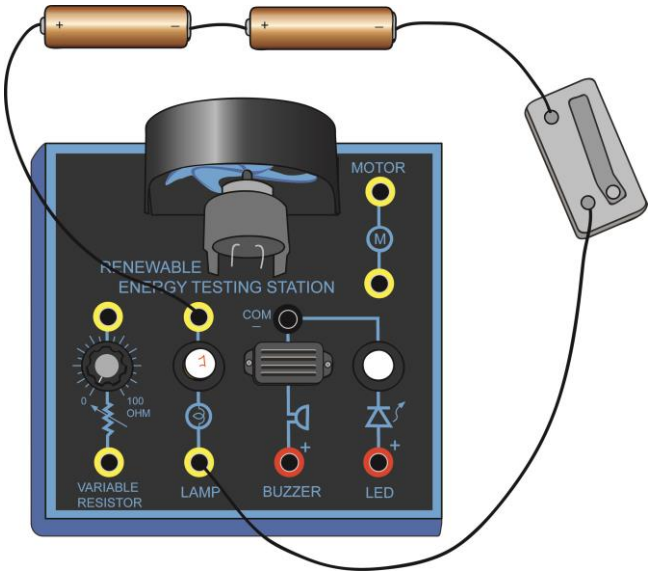



Figure 1: Two batteries connected in series with a switch and the globe on the STELR testing station.

Figure 2 shows the circuit diagram for the circuit in Figure 1, when the switch is closed (on).

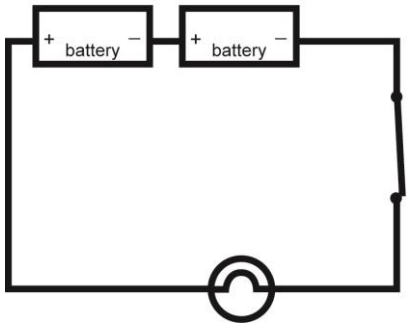
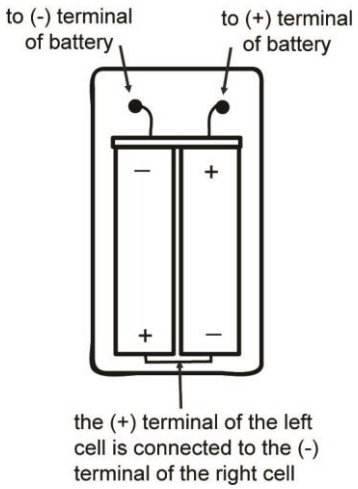



Figure 2

The problem with connecting single batteries in series like this is that it is difficult to connect leads to the separate batteries. Imagine getting the leads to stay in place! It is much easier to connect leads into a battery holder with sockets to plug into. This is why the STELR battery holder was produced. Inside the STELR battery holder, there are two batteries connected in series. This is shown in Figure 3.

Figure 3: The STELR battery.



## Connecting batteries in series

To connect 3 V (3 volt) batteries in series, we connect the (-) terminal of the first battery to the (+) terminal of the next, and so on.

Figure 4 shows two STELR batteries connected in series with the globe on the STELR testing station, and a switch.

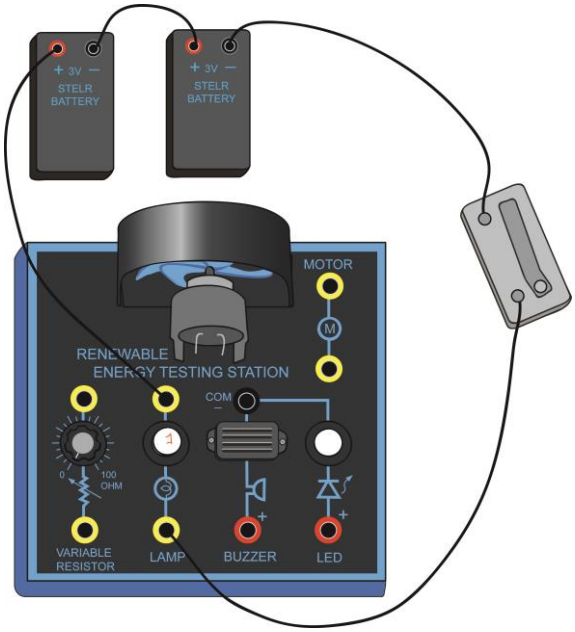



Figure 4

Figure 5 shows a simplified circuit diagram for this circuit, when the switch is closed (on).

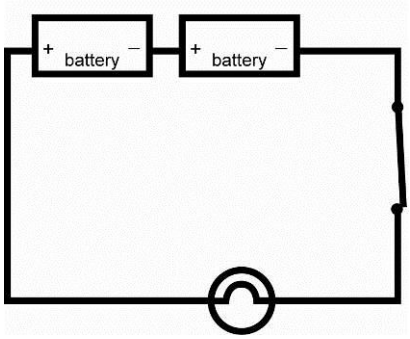



Figure 5

**Note: This is not a formal circuit diagram!**

There is more than one possible formal symbol for the two 3 V batteries in series. Figure 6 shows one symbol.

Figure 6

## Connecting batteries in parallel

If batteries are connected **in parallel** with one another, they are connected along separate paths in such a way that they all 'send' the current in the same direction through the other components of the circuit.

Figure 7 shows two STELR batteries connected in parallel.

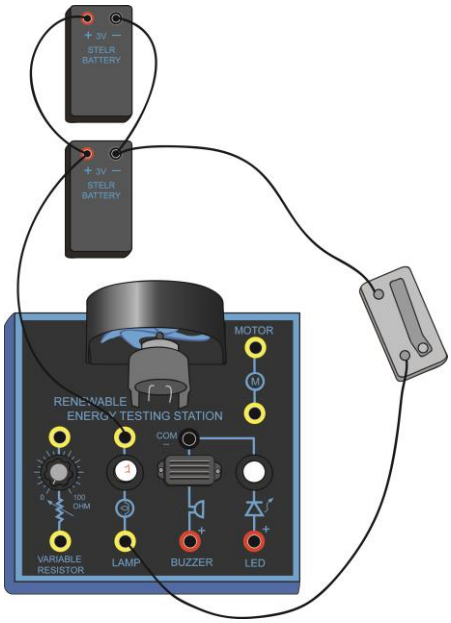



Figure 7

Figure 8 shows a simplified circuit diagram for the circuit in Figure 7. The two paths for the electrical current are highlighted.

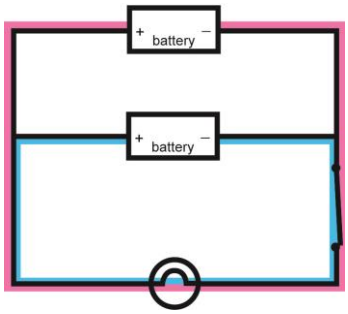



Figure 8

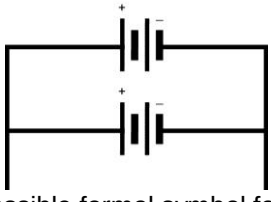


Figure 9: One possible formal symbol for two batteries in parallel.

## Discussion questions

1 Draw circuit diagrams for the following circuits.

a Three batteries connected in series with each other and with a globe and a closed switch.

b Four batteries connected in series with each other and with a globe, a closed switch and an ammeter.

2 Draw simplified circuit diagrams for the following circuits. In each case shade the different paths a different colour.

a Three batteries connected in parallel with each other and with a globe and a closed switch. (The globe and switch are in series with one another.)

b Three batteries connected in parallel with each other and with a globe, a closed switch and an ammeter. (The globe, switch and ammeter are in series with one another.)

# Practical Activity 4:
# Connecting batteries in series and parallel

**Partners** _____ **Date** _____

## Inquiry questions

**Inquiry question 1: What delivers the biggest voltage - connecting batteries in series or in parallel?**

**Inquiry question 2: What delivers the biggest current - connecting batteries in series or in parallel?**

**Inquiry question 3: What delivers the most electrical power – connecting batteries in series or in parallel?**

## Introduction

After testing the voltage delivered by each of the STELR batteries you will use, which will be labelled Battery A and Battery B, you will set up the same circuit you used in Practical Activity 3, using Battery A. Figure 1 shows the circuit again.

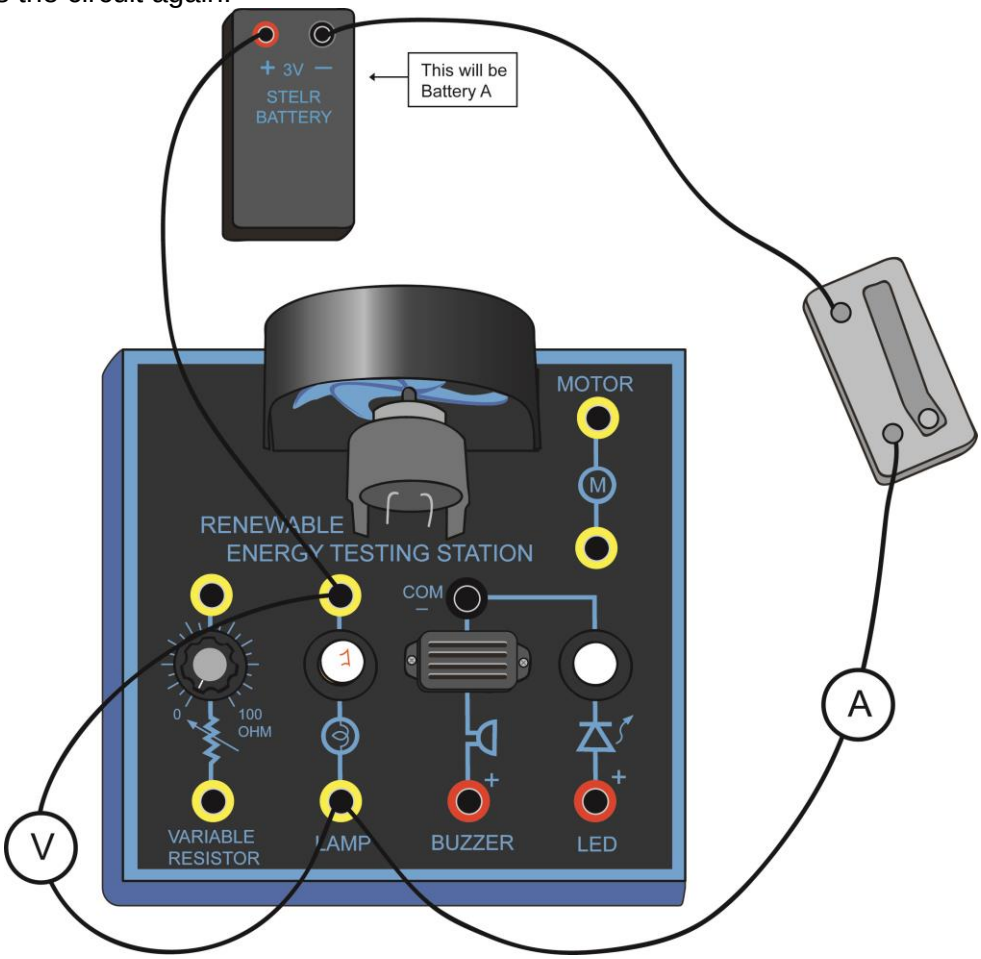



Figure 1: The start-up circuit.

You then will see what happens to the voltage and current when you connect Battery B into the circuit, between Battery A and the switch, in series with Battery A.

After you have tried this, you will remove Battery B from this position then connect it into the circuit as shown in Figure 2. This means that Battery B will now be in parallel with Battery A.

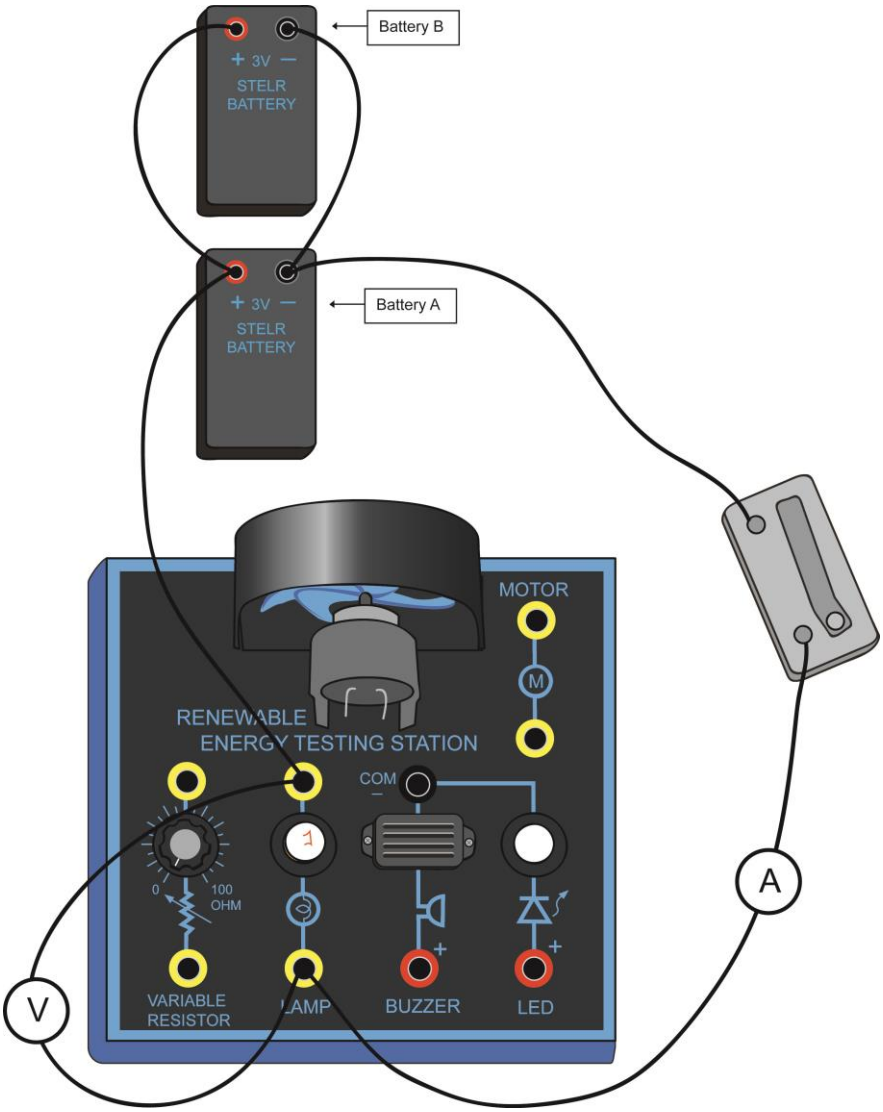



Figure 2: The circuit for measuring current, voltage and power in a circuit that has two batteries in parallel with each other.

### The calculations in this experiment

Because you will be required to calculate the electrical power delivered for three different cases, you will perform your calculations in the results table for Part B of this experiment, still using the formula:

***P = V x I*** where ***P*** = electrical power, in **milliwatts**
***V*** = voltage, in volts
***I*** = current, in **milliamps**

A sample calculation is shown in this results table. (See page 44.)

## Predicting the outcomes of this experiment

**Before you start:**

1 What do you think will happen to the brightness of the globe on the testing station when you connect the second battery in series with the first?

2 What do you think will happen to the brightness of the globe on the testing station when you connect the second battery in parallel with the first?

3 Which way of connecting the batteries do you think will deliver the biggest voltage? Or do you think you will get the same voltage no matter how they are connected? What voltage do you expect?

4 Which way of connecting the batteries do you think will deliver the biggest current? Or do you think you will get the same current no matter how they are connected?

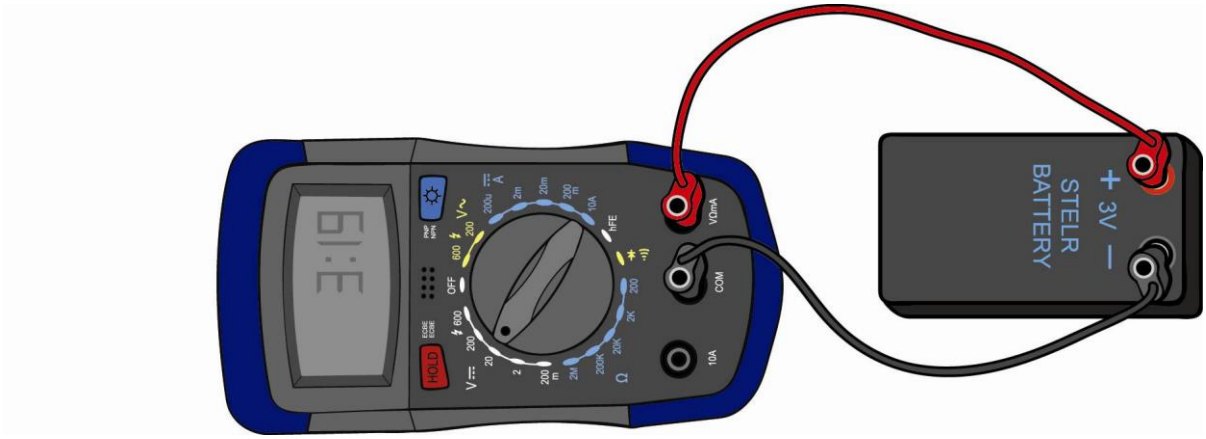
5 Which way of connecting the batteries do you think will deliver the most power? Or do you think you will get the same power no matter how they are connected?

## What you need

- STELR testing station
- 2 x STELR multimeters
- Switch
- 2 x STELR batteries (labelled A and B)
- Connecting leads

## PART A Testing the batteries

### Instructions for Part A

| Step | What to do |
|---|---|
| 1 | Connect Battery A to a multimeter set as a voltmeter, as shown in Figure 3.<br>  <br><br>Figure 3 |
| 2 | Turn the dial on the multimeter anticlockwise onto the white scale to the **20** setting. (The voltmeter will now read voltages up to 20 V.) Record the voltage of Battery A in the table below, then turn the voltmeter off. |
| 3 | Repeat Steps 1 and 2 with Battery B. |
| 4 | **The rest of this experiment will work best if both STELR batteries deliver close to 3 volts. If this is not the case, then ask your teacher for a replacement battery and measure its voltage before proceeding to Part B.** |

### Results for Part A

| Voltage for Battery A (volts) | Voltage for Battery B (volts) |
|---|---|
| | |

## Part B Connecting batteries

**Inquiry question 1: What delivers the biggest voltage - connecting batteries in series or in parallel?**

**Inquiry question 2: What delivers the biggest current - connecting batteries in series or in parallel?**

**Inquiry question 3: What delivers the most electrical power – connecting batteries in series or in parallel?**

### Instructions for Part B

| Step | What to do |
|---|---|
| **1** | Using Battery A, set up the circuit shown in Figure 1 on page 39. |
| **2** | Set the voltmeter to the **20** setting. (This allows a maximum reading of 20 V.) |
| **3** | Set the ammeter to the **200m** setting. (This allows a maximum reading of 200 mA.) |
| **4** | Close (turn on) the switch and look at the displays on the ammeter and voltmeter. Record the current and voltage once a steady reading is obtained, in the results table.<br><br>Also note and record how dim or bright the lamp is.<br><br>Open (turn off) the switch. |
| **5** | Connect Battery B into the circuit between Battery A and the switch, so that it is in series with Battery A. |
| **7** | Close the switch and record the results.<br><br>Open the switch. |
| **8** | Move Battery B so that it is in parallel with Battery A, as shown in Figure 2 on page 40. |
| **9** | Close the switch and record the results.<br><br>Open the switch. |
| **10** | **Dismantle the circuit and pack up according to your teacher's directions. Remember to turn off the multimeters!** |

## Results and calculations for Part B

| Battery arrangement | Brightness of globe | Voltage *V* (final steady value) (V) | Current *I* (final steady value) (mA) | Electrical power *P* (mW) *P = V x I* |
|---|---|---|---|---|
| **Single battery** | | | | |
| **Two batteries in series** | | | | |
| **Two batteries in parallel** | | | | |
| **Sample calculation** | | **3.06** | **33.3** | **3.06 x 33.3 = 102** |

## Conclusion

What is your answer to Inquiry question 1? What delivers the biggest voltage - connecting batteries in series or in parallel?

_____

What is your answer to Inquiry question 2? What delivers the biggest current - connecting batteries in series or in parallel?

_____

What is your answer to Inquiry question 3? What delivers the most power - connecting batteries in series or in parallel?

_____

## Discussion questions

1 Compare your results with those obtained by the rest of the class. Did you all draw the same conclusions?

_____

_____

2 How accurate were your predictions? Did the results surprise you? Discuss.

_____

_____

3 Did the brightness of the globe seem to relate more to the power or the voltage or current delivered to it? Discuss.

4 Suggest an explanation for what you discovered.

## Batteries – the inside story

Although it surprises many people, batteries just contain chemicals. The main two chemicals in them are one chemical that releases electrons and another chemical that takes in electrons. **Electrons** are extremely tiny particles that have a negative charge. They are present in all substances.

Batteries are very cleverly designed. The two main chemicals inside them are kept apart so the electrons have to travel around the circuit between them! This electron movement can only happen if there is a complete path between the positive and negative terminals of the battery. This is shown in Figure 4.

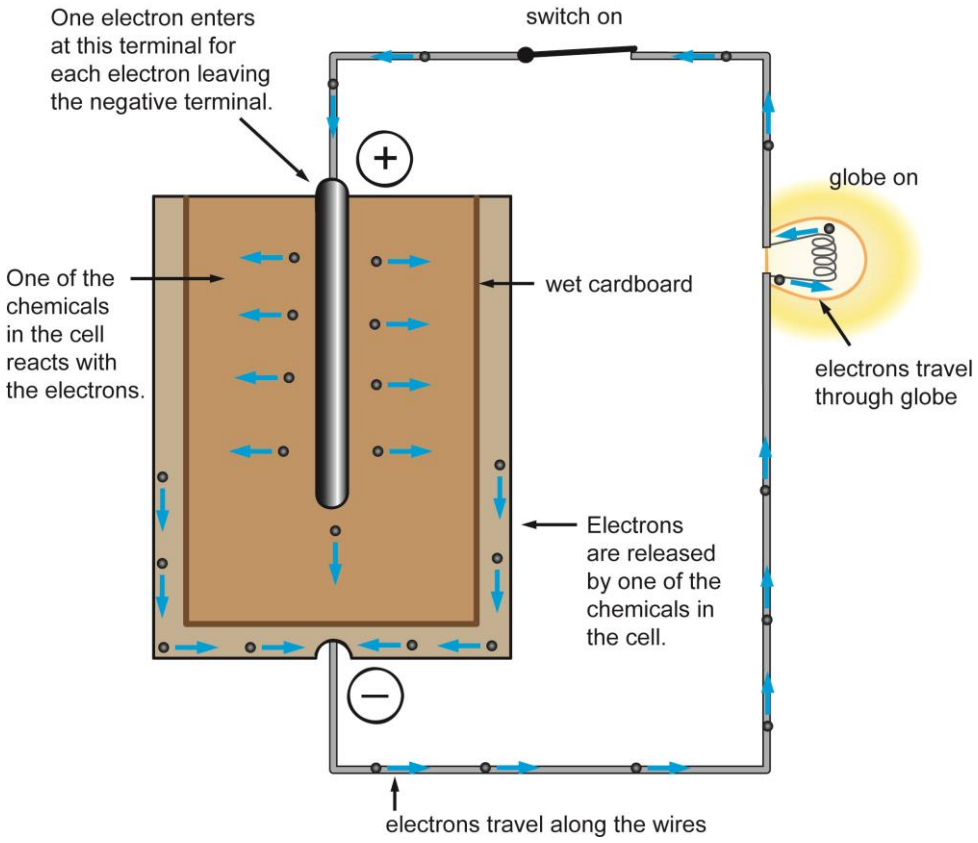



Figure 4: The movement of electrons within a battery around a circuit. The black dots represent the electrons and the blue arrows show their direction of movement.

Note: Technically speaking, the correct name for a single battery is a **cell.**

# WIND TURBINES

Photograph courtesy of Hydro Tasmania

Photograph courtesy of The Age

## Big Ideas:

**How do wind turbines deliver electrical energy?**

**Is there a best design for wind turbines?**

**What are the advantages and disadvantages of wind turbines?**

**Are the claims about wind turbines shown in the above photograph backed by scientific evidence?**

**Should we establish more wind farms?**

# Practical Activity 5:
# How many blades should a wind turbine have?

**Partners:** _____ **Date:** _____

## Inquiry questions

**Inquiry question 1: What electrical power can be delivered by a STELR model wind turbine operating with 6 blades?**

**Inquiry question 2: What is the relationship between the number of blades on the STELR model wind turbine and the electrical power it delivers?**

**Inquiry question 3: How many blades give the greatest amount of power?**

## Introduction

You will be setting up the circuit containing STELR model wind turbine shown in Figure 1.

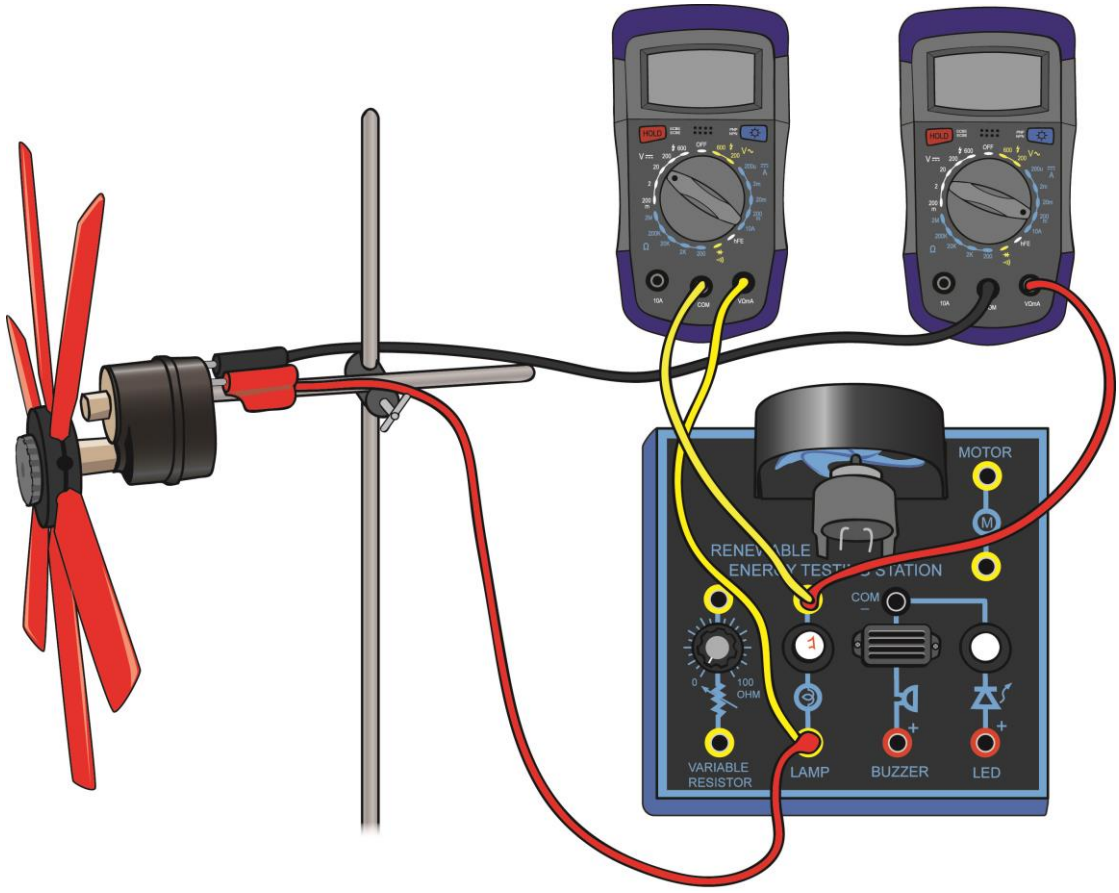



Figure 1: The circuit you will use to measure the electrical power delivered by the STELR model wind turbine. The wind will be produced by a fan near the turbine.

In Figure 1, trace with a pencil the leads that go from the wind turbine to the globe on the STELR testing station (labelled LAMP) then to the ammeter (the STELR multimeter on the ammeter setting), then back to the wind turbine. You can see they form a large loop. This means that the wind turbine, globe and ammeter are all connected in series with each other; the electrical current will flow through them one by one.

Notice that the voltmeter (the STELR multimeter on the voltmeter setting) is just connected across the globe on a separate small loop. This means it is parallel with the lamp. Figure 2 shows the circuit diagram for this circuit.

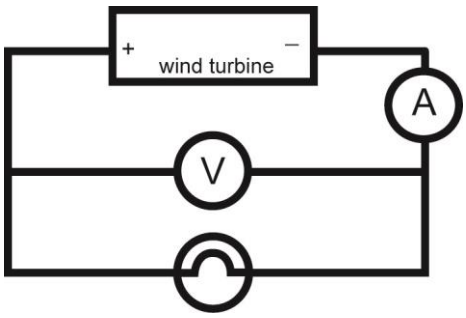



Figure 2: A circuit diagram for the circuit shown in Figure 1.

### The calculations in this experiment

You will again use the following formula for electrical power:

$P = V \times I$ where $P$ = electrical power, in **milliwatts**
$V$ = voltage, in volts
$I$ = current, in **milliamps**

In Part B of this experiment, you will be required to calculate the electrical power delivered for five different cases. For this reason, you will only be required to perform the calculation in a table. The sample calculation below is shown again in that table, to show you how to set it out.

**Sample calculation:**

A student set up the circuit shown as in Figures 1 and 2. The wind turbine had 6 blades in the hub. The final steady voltage was found to be 1.72 V. The final steady current was 26.2 mA.

What power was being delivered by the model wind turbine? Give your answer in milliwatts.

**Solution:**

$P = V \times I$ where $P$ = electrical power, in milliwatts
$V$ = voltage = 1.72 V
$I$ = current = 26.2 mA

Hence $P$ = 1.72 x 26.2
= 45.1 mW

**Answer:** The power delivered by the model wind turbine was 45.1 mW.

### Predicting the outcomes of this experiment

Before you start, predict what you think will happen to the power delivered by the model wind turbine, as you reduce the number of blades. Explain why you think this.

_____

_____

## What are the variables?

List the factors you think could affect the results of this experiment. Which of these is the test variable? Highlight it on the list.

_____

_____

## What you need

- STELR testing station
- 2 x STELR multimeters
- 6 x 150 mm turbine blades set into a hub
- Extra 150 mm turbine blades
- STELR model wind turbine
- Connecting leads
- Three-speed electric fan
- Tape measure or metre ruler

## Assessing the risks

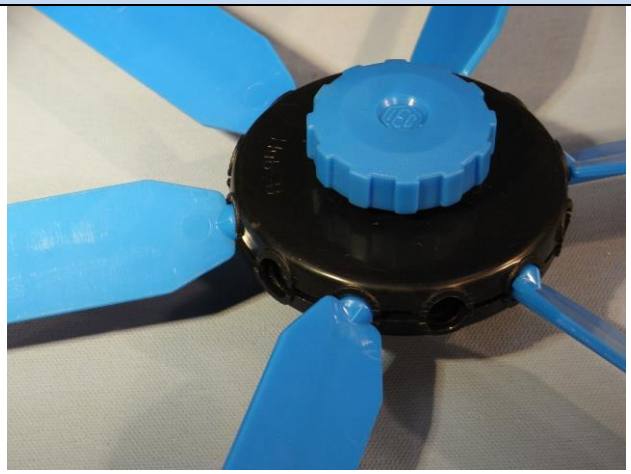
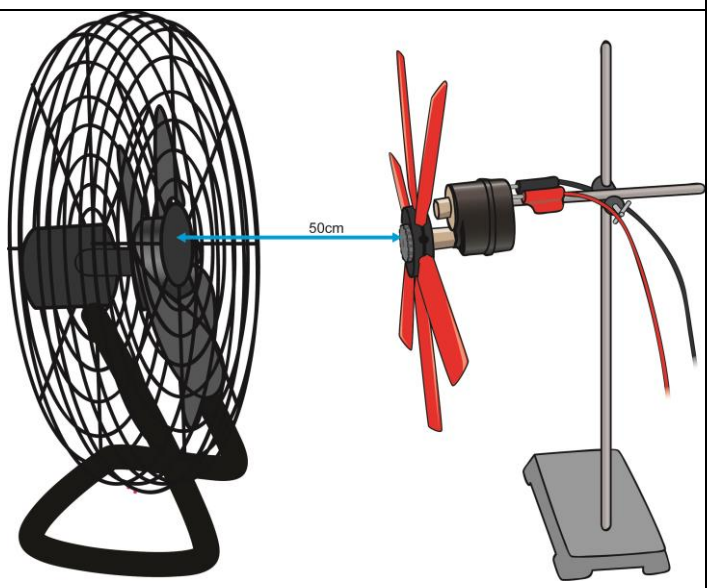
Read the facts, imagine what could cause damage, and think of what you could do to prevent that problem. Hence complete the following table.

| The facts | What might be the risks? | What precautions will we take? |
|---|---|---|
| 1 The model wind turbines could break if mishandled. | | |
| 2 Inserting the blades into the hub of the model wind turbine, or pulling them out, can cause breakages as well as hand injuries. | | |
| 3 If the blades are not inserted firmly into the hubs, they may fly out at a high speed whilst the turbine is spinning, and cause eye injuries. | | |
| 4 A fast-spinning electric fan will be used in this experiment. | | |

## PART A Testing with 6 blades

**Inquiry question 1: What electrical power can be delivered by a STELR model wind turbine operating with 6 blades?**

### Instructions for Part A

<table>
<tr><th>Step</th><th>What to do</th><th>How to do it</th></tr>
<tr><td>1</td><td>Make sure the 6 blades are tight in the hub of the turbine and are all at 45º to the face of the hub, like those in Figure 3.<br><br>Then set up the model wind turbine in the stand, as shown in Figure 1.<br><br>Make sure that the hub is tight on the motor drive shaft and that you are using the bottom shaft, as shown in Figures 1 and 4, which means the model wind turbine will be ungeared.</td><td rowspan="2">  <br>Figure 3: These blades have been set into the hub at the same angle (45º).</td></tr>
<tr><td>2</td><td>Connect the circuit as shown in Figure 1, with the plugs inserted into the LAMP sockets of the STELR testing station.</td></tr>
<tr><td>3</td><td>Place the three-speed fan on the bench so that the front of the fan is 50 cm from the front of the hub on the wind turbine, as shown in Figure 4.<br><br>Do not turn on the fan, yet!<br><br>DO NOT CHANGE THE DISTANCE BETWEEN THE FAN AND THE TURBINE OVER THE COURSE OF THE EXPERIMENT!</td><td rowspan="2"> 
<br>Figure 4: The correct relative positions of the fan and the turbine.</td></tr>
<tr><td>4</td><td>Raise or lower the turbine on the retort stand so the centre of the hub of the turbine is at the same height above the bench as the centre of hub of the electric fan. This means the two hubs should be in a direct line with each other, as in Figure 4.</td></tr>
</table>

| | |
|---|---|
| **5** | Set the ammeter to the **200m** setting. (This allows a maximum reading of 200 mA.) |
| **6** | Set the voltmeter to the **20** setting. (This allows a maximum reading of 20 V.) |
| **7** | Have the teacher check your circuit. |
| **8** | When your teacher has given permission, turn the fan on to the highest setting. |
| **9** | Record the current and voltage once a steady reading is obtained, in the results table below |
| **10** | Turn off the fan and return both the ammeter and voltmeter to the OFF position.<br><br>**KEEP THE SET-UP WITHOUT ALTERING IT, READY FOR PART B!** |

## Results for Part A

| Current (final steady value) (mA) | Voltage (final steady value) (V) |
|---|---|
| | |

## Calculations for Part A

Calculate the electrical power delivered by the STELR model turbine, in milliwatts. (See the sample calculation on page 48.)

## Conclusion for Part A

What is your answer to Inquiry question 1: What electrical power can be delivered by a STELR model wind turbine operating with 6 blades?

## Discussion questions for Part A

1 Did you have any practical difficulties in performing this part of the experiment? If so, how did you resolve them?

_____

_____

_____

2 What do you think would have happened to the amount of electrical power if the fan has been set at the medium setting instead of on the highest setting? If you have time, test if your prediction is correct!

_____

_____

_____

## PART B Testing with other numbers of blades

**Inquiry question 2: What is the relationship between the number of blades on the STELR model wind turbine and the electrical power it delivers?**

**Inquiry question 3: How many blades give the most power?**

### Instructions for Part B

| Step | What to do |
|---|---|
| **1** | Carefully detach the hub from the turbine's motor drive shaft.<br><br>Loosen the blades a little by the turning the screw that holds them firmly in place.<br><br>Add six more blades to the hub so you now have 12 blades equally spaced, still set at 45 °.<br><br>Then tighten the screw so the blades are firmly held again, and insert the hub and blades back onto the bottom turbine shaft, as shown in Figure 1.<br><br>Make sure that the hub is tight on the shaft. |
| **2** | Reset the ammeter to the **200m** setting.<br><br>Reset the voltmeter to the **20** setting. |
| **3** | Turn the fan onto the highest setting and record the current and voltage once a steady reading is obtained, in the results table on page 54. |
| **4** | Repeat Steps 1 and 2, for four, then three then two evenly spaced blades in the hub, still set at 45°. Record your results in the table on page 54. |
| **5** | Pack up according to your teacher's directions. You will then process your results and discuss them with the class. |

## Results for Part B

For 6 blades, copy your results from Part A, and the value you calculated for the power delivered.

For 12, 4, 3 and 2 blades, enter your results from Part B in the table below, then calculate the electrical power in each case. The sample calculation on page 48 is shown again here for you.

Alternatively, use a spreadsheet.

| Number of turbine blades | Voltage *V* (V) | Current *I* (mA) | Electrical power *P* *P = V x I* (mW) |
|---|---|---|---|
| Sample calculation | 1.72 | 26.2 | 1.72 x 26.2 = 45.1 |
| 12 | | | |
| 6 | | | |
| 4 | | | |
| 3 | | | |
| 2 | | | |

## Graphing the results from Parts A and B

Use graph paper to draw the graph of the electrical power against the number of turbine blades. (Alternatively use a graphing program.)

To draw a graph you first must complete a table of values. Since the number of turbine blades was chosen, it is the independent variable, so will be on the horizontal axis.

**Table of values for the graph of electrical power against the number of turbine blades**

| Number of turbine blades | 2 | 3 | 4 | 6 | 12 |
|---|---|---|---|---|---|
| Electrical power (mW) | | | | | |

Now decide on your graph scales and draw your graph. **But don't join the graph points!**

The reason for this is stated on the next page.

You can still use the positions of the graph points to decide if there is any pattern or relationship between the number of blades and the electrical power produced.

**Why shouldn't the graph points be joined?**

Graphs can only be joined if it is possible to have 'in-between' values.

For example, you can have any length (fractions and whole numbers) in-between any measurements you might take. Length is said to be a **continuous** quantity.

Electrical power also is a continuous quantity.

However, you can't have half a turbine blade or any other fraction of a turbine blade! If you were to join the graph points you would imply you can have fractions of a blade. The number of blades is described as a **discrete** quantity.

## Conclusion for Part B

From the graph you drew, what is your answer to Inquiry question 2: What is the relationship between the number of blades on the STELR model wind turbine and the electrical power it delivers?

_____

From the graph you drew, what is your answer to Inquiry question 3: How many blades give the greatest amount of power?

_____

## Discussion questions

1 Did the prediction you made at the start of this experiment come true? Or were you surprised with the results for this model turbine? Can you suggest a reason why the prediction did or did not come true?

_____

_____

2 Did all the groups in the class agree on the best number of blades? _____

If not, identify at least two sources of error for this experiment, which would help account for any differences in the results.

_____

_____

3 a List the variables that were kept the same as you performed the experiment.

_____

_____

b Were there any other variables that might have affected the result, that were not controlled? If so, state what they were and describe what effect they could have had on the results.

_____

_____

4 Do you think the results would have been the same if the set of blades had been shorter than the set you used in this experiment? Discuss.

_____

_____

5 Do you think the results would have been the same if the blades had been set at a different angle than the angle used in this experiment? Discuss.

_____

_____

6 Suggest why you were not asked to test 1, 5 or 7 turbine blades.

_____

7 Suggest why large wind turbines usually have 3 blades.

_____

# Practical Activity 6:
# How does blade length affect the output of a wind turbine?

**Partners** _____ **Date** _____

## Your task

**You are to investigate which blade length, of the three lengths supplied, will deliver the most power for the STELR model wind turbine. To do this, you will draw on the experience you gained in Practical Activity 5.**

**In your investigation, you need to decide:**

- **What your hypothesis is and what you expect to discover.**
- **What other variables will be operating and how you will control them so your tests are fair.**
- **What and how many measurements you need to take in order to draw a reasonable conclusion.**

## What to do

**1 As a group, work through the process outlined on the first page of the investigation planner on pages 81 and 82 and present your plans to your teacher.**

**2 When your teacher gives permission, perform the experiment and work through and complete the second page of the investigation planner. (You will need to attach your results, any graphs you draw, and so on.)**

## Discussion questions

1 Did your findings surprise you? Can you suggest an explanation for what you discovered?

_____

_____

2 Summarise the conclusions drawn by the overall class and hence answer the question: Of the three lengths supplied, what is the best blade length for the STELR model wind turbine?

_____

_____

3 What is one modification you would make to how you conducted your experiment, in the light of your experience?

_____

4 What are the implications of your findings for commercial wind turbines? Discuss.

_____

# Worksheet 4: Are wind farms dangerous for birds?

**Many people answer this kind of question by their own gut feeling. They have no evidence to back up their opinion. A true scientist, however, will only express an opinion on an issue if they have worked through a process called critical thinking.**

**In this activity you will use critical thinking to examine an important issue about wind farms and their effect on bird populations.**

## What is critical thinking?

**Critical thinking** does NOT mean the same thing as criticism (finding fault with something). Instead it means examining something very carefully in order to understand and improve it.

Critical thinking is an essential tool used by people in many disciplines, including science.

The process of critical thinking includes:

- Finding out relevant facts.
- Thinking about how and why something occurs.
- Reflecting on what the possible consequences might be.
- Considering how it fits in with the wider picture.
- Identifying any biases or prejudices that might be operating, including your own.

## The case of the rare orange-bellied parrot

The rare orange-bellied parrot

In 2006 a large wind farm proposal in Victoria was halted by the then Australian Federal Minister for the Environment, Senator Ian Campbell, based on concerns for the rare orange-bellied parrot that was claimed to have a flight path through the proposed site.

Senator Campbell stated: “On the basis of the information that has been presented to me on the orange-bellied parrot, I have decided not to approve the Bald Hills wind farm. I understand that this will be a disappointing outcome for the proponents of the wind farm but it is very clear to me from reading this report that every precaution should be taken to help prevent the extinction of this rare bird."

This sparked a huge public debate. The 52 turbine wind farm had been approved by the Victorian Government two years earlier.

In an interview on the ABC, the then Victorian Planning Minister, Rob Hulls, referred to the report into the collective impact of wind farms on some of Australia's threatened bird species, on which the decision was based. He claimed that it was a political decision that ignored the evidence presented in the report.

In the ABC interview, Hulls said: "The actual report says that not a single orange-bellied parrot was observed near the proposed Bald Hills wind farm. At best, scientists found a few historic records of sightings and a couple of potential foraging sites 10 to 35 kilometres away."

***See some reports of this debate online!***

http://www.theage.com.au/articles/2006/04/05/1143916574751.html

http://www.abc.net.au/worldtoday/content/2006/s1610250.htm

After a few months, the decision was overturned. Yet many members of the general public were angry that the wind farm was able to go ahead. They still believe that birds cannot see turbine blades when they spin, and get chopped to pieces by them.

***Is their opinion justified?***

## What to do

### Step 1 Find out the facts

Search the internet and other sources to investigate the answers to the following questions. It may be helpful to restrict your research to sources in the US or in Australia to obtain this information. Some possible websites are listed below.

1 For a typical 1 MW (megawatt) or bigger wind turbine in a wind farm, about how times on average do the blades rotate each minute? How high are the blades above the ground? What is their width and height?

2 How many birds die each year from flying into buildings?

3 How many birds die each year after being hit by a car?

4 How many birds are killed each year by cats?

5 How many birds are killed each year by wind turbines?

6 How many pedestrians die each year in road accidents?

**Web resources**

Following is a list of some useful websites to help answer these questions. You might also find other sources. It is always advisable to use websites from reliable sources, such as government websites, recognised scientific organisations such as the CSIRO, acknowledged experts in the field, and respected news services such as the ABC and the BBC. (You might like to think about why this is advisable.)

- http://www.omafra.gov.on.ca/english/engineer/facts/03-047.htm
- http://en.wikipedia.org/wiki/Wind_turbine
- http://www.walkinginfo.org/facts/facts.cfm
- http://www.currykerlinger.com/birds.htm
- http://science.howstuffworks.com/environmental/green-science/wind-turbine-kill-birds.htm

## Step 2 Reflect on the facts, examine your own attitudes, then draw your own conclusions

The following questions should guide you through this process.

1 Should cars be banned because pedestrians and birds are accidentally killed by them?

2 Should cats be banned?

3 Should wind turbines be banned?

4 Have your answers to these questions been influenced by your personal experiences or by the opinions of other people? How?

5 What might be the consequences if no-one was allowed to have a car or to keep pet cats?

6 Why do you think questions were asked about other causes of bird deaths and about the deaths of pedestrians?

7 The claim made by many people that birds get chopped to bits sounds like it could be true, but is it supported by the evidence you uncovered in your investigation?

8 What other facts might have helped you understand why the Minister made his decision?

9 Is it likely that if this ban had been continued, the orange-bellied parrot would be saved from extinction?

10 What might be the consequences if wind turbines were banned in Australia?

# SOLAR CELLS

**Solar panels in Germany – one of the countries that uses solar panels extensively, even though Germany is much less sunny than Australia.**

## Big Ideas:

**How do solar panels work?**

**Why aren't solar panels everywhere now?**

**What are the advantages and disadvantages of solar panels?**

**Does it matter how solar cells are connected in solar panels?**

**How can you get the most power from your solar panels?**

# Practical Activity 7:
# What power can you get from a solar panel?

**Partners:** _____ **Date:** _____

## Inquiry questions

**Inquiry question 1: What electrical power can be delivered by a single STELR solar cell?**

**Inquiry question 2: What electrical power can be delivered by a STELR solar panel in which the four solar cells are connected in series?**

**Inquiry question 3: What electrical power can be delivered by a STELR solar panel in which the four solar cells are connected in parallel?**

## Introduction

**In this class activity, all groups will investigate Inquiry question 1. Then some groups will investigate Inquiry Question 2 and the rest of the class groups will investigate Inquiry Question 3. You will then report your findings to the class and compare your results.**

Figure 1 shows a STELR solar panel. You can see that it is made up of a grid of four solar cells. In this activity you will measure the power delivered by just the first cell, then the power delivered by all four cells connected together (either in series or in parallel).

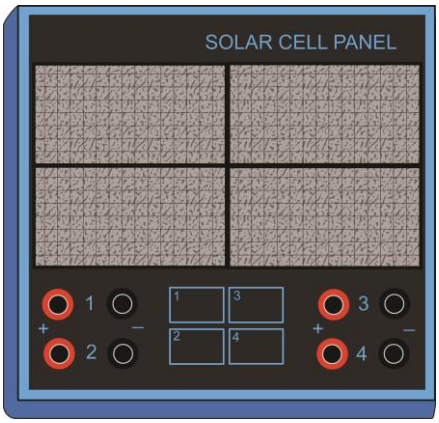



Figure 1: The STELR solar panel. The diagram in the centre shows how the cells are laid out. As indicated, the red sockets are the positive terminals and the black sockets are the negative terminals.

**To answer Inquiry Question 1, you will set up the circuit shown in Figure 2. The circuit includes the lamp on the testing station.**

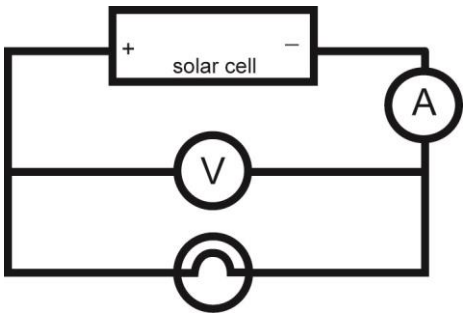



Figure 2: A simplified circuit diagram showing the circuit that will be used to measure the power delivered by one solar cell.

**To answer Inquiry Question 2, class groups in Group A will up the circuit shown in Figure 3, in which the four solar cells are connected in series.**

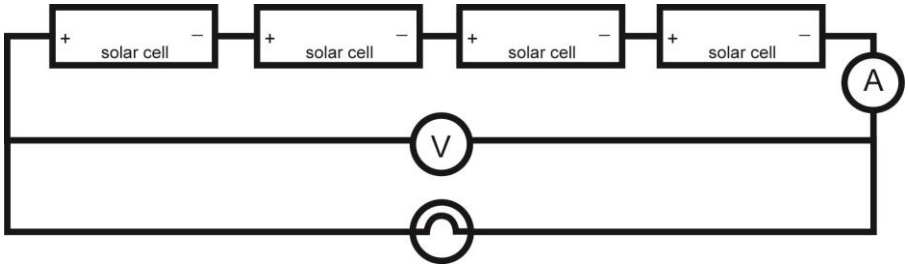



Figure 3: A simplified circuit diagram showing the circuit required to measure the power delivered by the STELR solar panel in which the four solar cells are connected in series.

**To answer Inquiry Question 3, class groups in Group B will set up the circuit shown in Figure 4, in which the four solar cells are connected in parallel.**

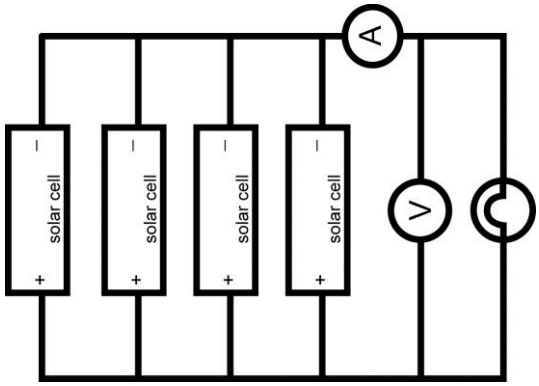



Figure 4: A simplified circuit diagram showing the circuit required to measure the power delivered by the STELR solar panel in which the four solar cells are connected in parallel.

### The calculations in this experiment

In this activity you again will directly calculate the power in milliwatts, as shown below.

$P = V \times I$ where ***P*** = electrical power, in **milliwatts**
***V*** = voltage, in volts
***I*** = current, in **milliamps**

### Sample calculation:

A student set up the circuit shown as in Figure 2. The final steady voltage was found to be 0.48 V. The final steady current was 27.1 mA.

What power was being delivered by the solar cell? Give your answer in milliwatts.

**Solution:**

$P = V \times I$ where ***P*** = electrical power, in milliwatts
***V*** = voltage = 0.48 V
***I*** = current = 27.1 mA

Hence $P = 0.48 \times 27.1$
$= 13$ mW

**Answer:** The power delivered by the solar cell was 13 mW.

## Predicting the outcomes of this experiment

Before you start, predict what you think will be true of the power delivered by the solar panels. Circle the responses that match your ideas.

A The solar panel connected in series will deliver 4 times the power delivered by one cell.

B The solar panel connected in series will deliver more power than that delivered by one cell, but not 4 times as much.

C The solar panel connected in parallel will deliver 4 times the power delivered by one cell.

D The solar panel connected in parallel will deliver more power than that delivered by one cell, but not 4 times as much.

E The solar panel connected in series will deliver the most power, followed by the solar panel connected in parallel, followed by the single cell.

F The solar panel connected in parallel will deliver the most power, followed by the solar panel connected in series, followed by the single cell.

G The solar panel connected in parallel will deliver the same power as the solar panel connected in series.

State your reasons.

## What are the variables?

List the factors you think could affect the results of this experiment. Which of these is the test variable? Highlight it on the list.

## What you need

- STELR testing station
- 2 x STELR multimeters
- 2 x halogen lamps
- STELR solar panel
- Connecting leads
- 6-volt power pack

## Assessing the risks

Read the facts, imagine what could cause damage, and think of what you could do to prevent that problem. Hence complete the following table.

| The facts | What might be the risks? | What precautions will we take? |
|---|---|---|
| 1 Multimeters are very sensitive digital instruments. | | |
| 2 The solar panel could break if mishandled. | | |
| 3 The halogen lamps get very hot | | |
| 4 The halogen lamps are connected to a power pack, which in turn is connected to a mains electricity power point. | | |

# PART 1: TESTING A SINGLE SOLAR CELL

## Instructions for Groups A and B

**Your first inquiry question is:**
**Inquiry question 1: What electrical power can be delivered by a single STELR solar cell?**

**Figure 5 shows the circuit you will be setting up. Figure 2 on page 62 shows the matching circuit diagram.**

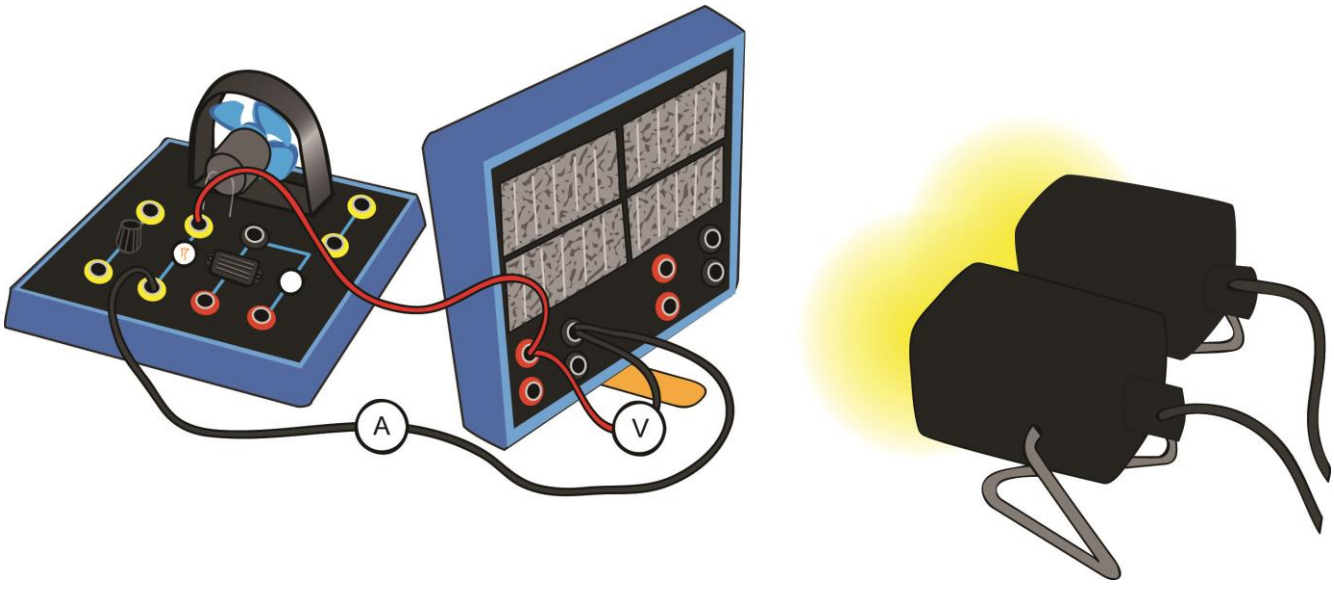
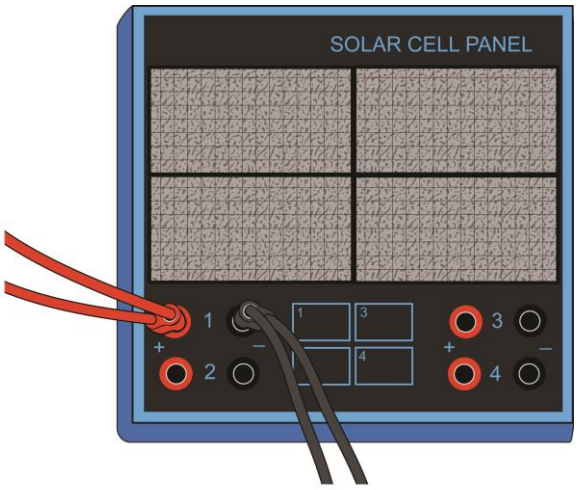



Figure 5: The circuit for measuring the power delivered by a single solar cell.
(To simplify the diagram, only the symbols of the ammeter and voltmeter are shown.)

| Step | What to do | How to do it |
|---|---|---|
| **1** | Insert two red leads into the red socket for Cell 1, and two black leads into the black socket for Cell 1, as shown in Figure 6.<br><br>The top two leads will be connected to the voltmeter. The bottom two leads will be connected to the testing station and ammeter. |  <br>Figure 6 |
| **2** | Set up the circuit shown in Figure 5, with the plugs inserted into the sockets for the globe (labelled LAMP) on the STELR testing station. | |
| **3** | Connect the halogen lamps to the power pack, and place them so they will shine evenly on all the cells of the solar panel.<br><br>**DO NOT TURN THEM ON YET!**<br><br>**Be careful not to move the halogen lamps or the solar panel during this part and the next part of the experiment.**<br>***(Think about why this is important!)*** | |
| **4** | Trace the leads with your fingers to ensure that you have created two distinct pathways:<br>• One will go from the red terminal on the solar cell to the globe on the testing station to the ammeter then to the black terminal on the solar cell.<br>• The other will be a small loop connecting the solar cell to the voltmeter. | |
| **5** | Set the ammeter to the **200m** setting. (This allows a maximum reading of 200 mA.) | |
| **6** | Set the voltmeter to the **20** setting. (This allows a maximum reading of 20 V.) | |
| **7** | Have your teacher check the circuit. | |
| **8** | Turn on the halogen lamps. Wait until the ammeter and voltmeter readings are steady, and then record the results in the table on page 67. | |
| **9** | **Turn off the lamps and the ammeter and voltmeter.**<br>**Do not change the circuit or move the solar panel or lamps. You will use them in the next part of the experiment.** | |

## Results and calculations for Groups A and B

Enter your results in the table below and calculate the power delivered, as shown in the example.

| **Voltage *V*** **(V)** | **Current *I*** **(mA)** | **Electrical power *P*** ***P = V x I*** **(mW)** |
|---|---|---|
| **0.48** ***(Example from page 63 )*** | **27** | **0.48 x 27 = 13** |
| | | |

## Conclusion for Groups A and B

What is your answer to Inquiry question 1: What electrical power can be delivered by a single STELR solar cell?

_____ mW

## PART 2: TESTING A SOLAR PANEL

## GROUP A *ONLY*

### Instructions for Group A

**Your second inquiry question is:**
**Inquiry question 2: What electrical power can be delivered by a STELR solar panel in which the four solar cells are connected in series?**

**Figure 7 shows the circuit Group A will now use. Figure 3 on page 63 shows the matching circuit diagram.**

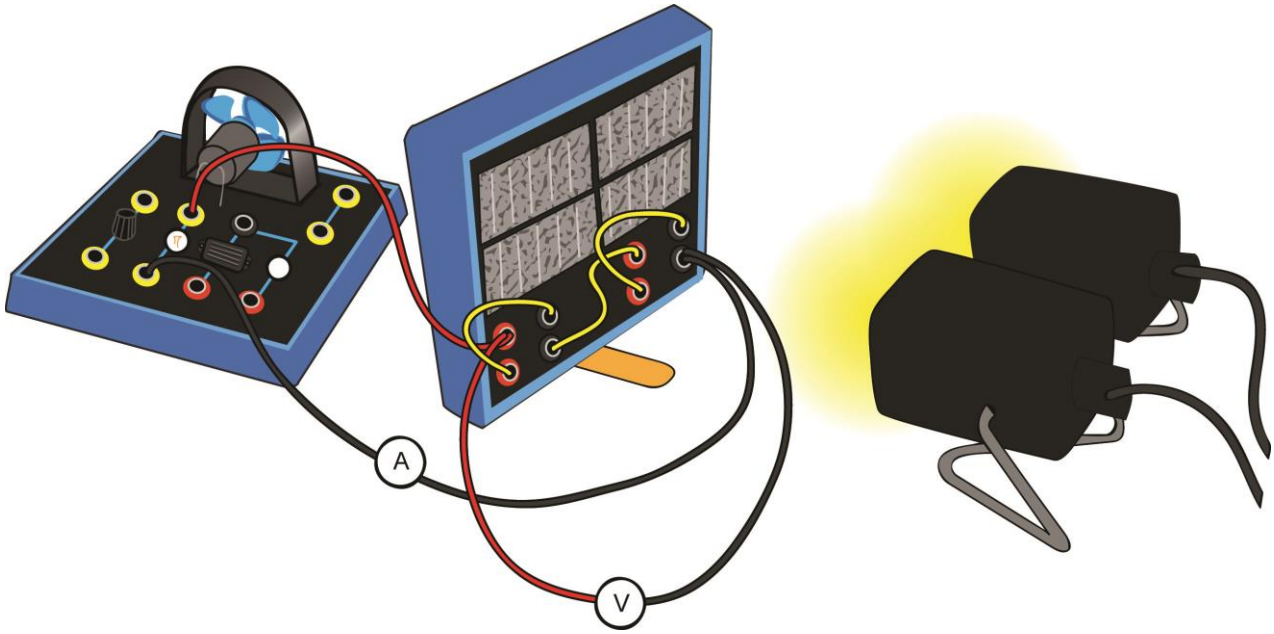
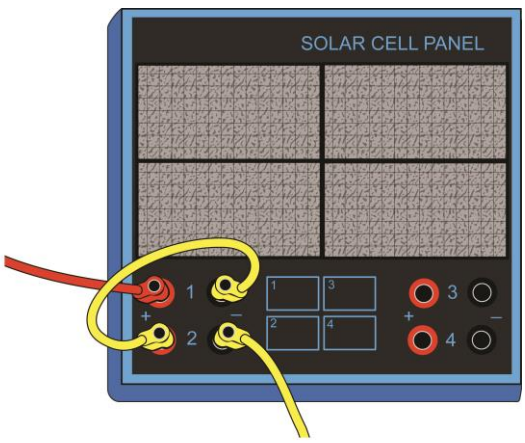
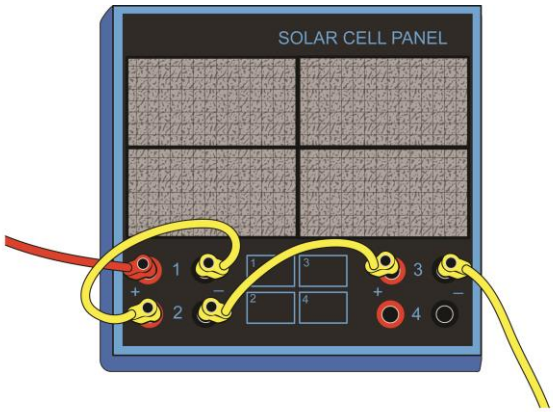
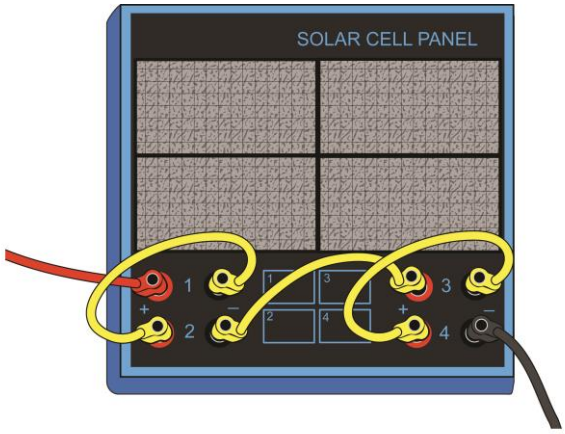



Figure 7: The circuit for measuring the power delivered by a solar cell connected in series
(To simplify the diagram, only the symbols of the ammeter and voltmeter are shown.)

| Step | What to do | How to do it |
|---|---|---|
| 1 | Mark the position of the solar panel on the bench, then carefully remove it from the circuit so you can connect the solar panels together. But leave one of the red leads connected to the red socket in Cell 1. |  Figure 8 |
| 2 | As shown in Figure 8, now connect the (-) terminal of Cell 1 to the (+) terminal of Cell 2. Then connect another lead to the (-) terminal of Cell 2, ready for the next connection. | |

| | | |
|---|---|---|
| **3** | As shown in Figure 9, connect the (-) terminal of Cell 2 to the (+) terminal of Cell 3. Then connect another lead to the (-) terminal of Cell 3, ready for the next connection. |  <br>Figure 9 |
| **4** | As shown in Figure 10, connect the (-) terminal of Cell 3 to the (+) terminal of Cell 4. Then connect a black lead to the (-) terminal of Cell 4.<br><br>**YOU NOW HAVE CONNECTED YOUR SOLAR PANEL IN SERIES.**<br><br>**NOTICE THAT THE TERMINALS ARE CONNECTED (-) TO (+) FROM ONE CELL TO THE NEXT.** |  <br>Figure 10 |
| **5** | Connect the solar panel into the circuit as shown in Figure 7:<br>• First complete the circuit containing the solar panel, ammeter and the globe on the testing station.<br>• Then connect the voltmeter across the solar panel.<br><br>**Ensure that the solar panel and the lamps are in the same positions as before!** | |
| **6** | Trace the leads with your fingers to ensure that you have created two distinct pathways:<br>• One will go from the red terminal on Cell 1 on the solar panel to the globe on the testing station to the ammeter then to the black terminal on Cell 4 on the solar panel.<br>• The other will be a small loop connecting the solar panel to the voltmeter. | |
| **7** | Reset the ammeter to the **200m** setting. | |
| **8** | Reset the voltmeter to the **20** setting. | |
| **9** | Have your teacher check the circuit. | |
| **10** | Turn on the halogen lamps. Wait until the ammeter and voltmeter readings are steady, then record the results in the table on page 70. | |
| **11** | **Turn off the halogen lamps, voltmeter and ammeter and pack up according to your teacher's directions.**<br><br>**DANGER: The halogen lamps might be very hot!** | |

## Results and calculations for Group A

Enter your results in the table below and then calculate the power delivered, as you did on page 67.

**Results and calculations for Group A, when the four solar cells were connected in series**

| **Voltage *V*** **(V)** | **Current *I*** **(mA)** | **Electrical power *P*** ***P = V x I*** **(mW)** |
|---|---|---|
| | | |

## Conclusion for Group A

What is your answer to Inquiry question 2: What electrical power can be delivered by a STELR solar panel in which the four solar cells are connected in series?

_____ mW

## GROUP B *ONLY*

### Instructions for Group B

**Your second inquiry question is:**
**Inquiry question 3: What electrical power can be delivered by a STELR solar panel in which the four solar cells are connected in parallel?**

**Figure 11 shows the circuit Group B will now use. Figure 4 on page 63 shows the matching circuit diagram.**

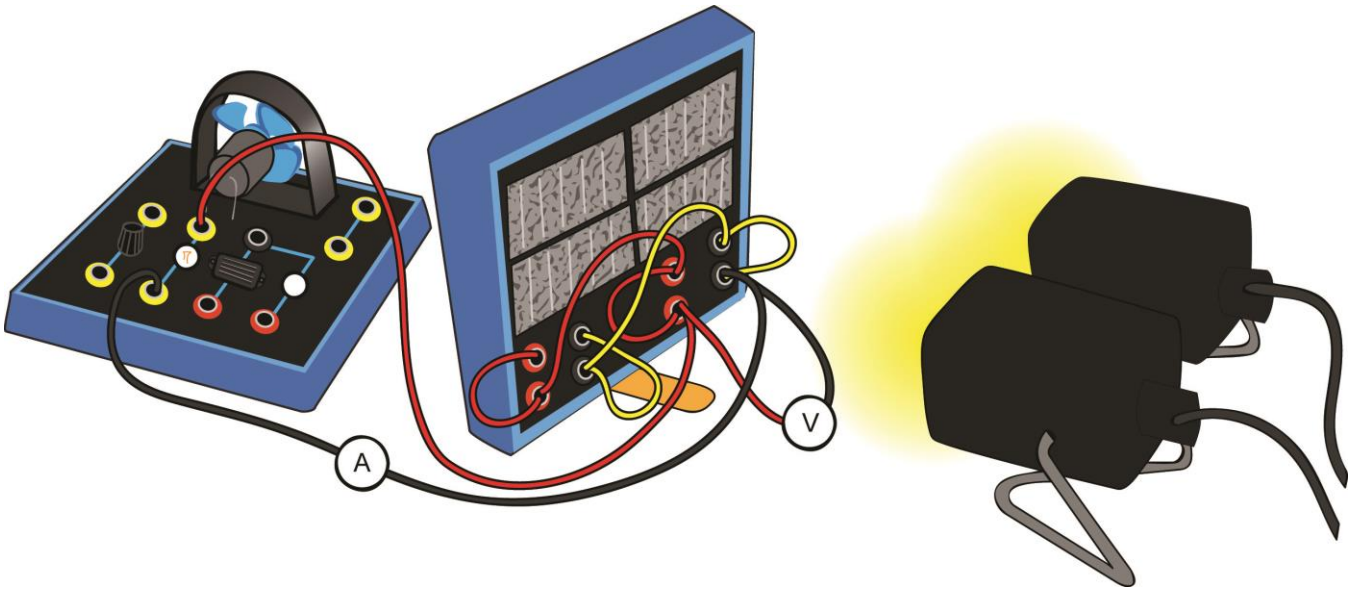
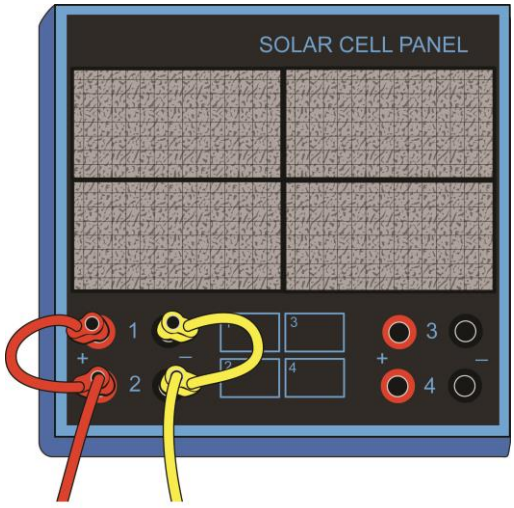
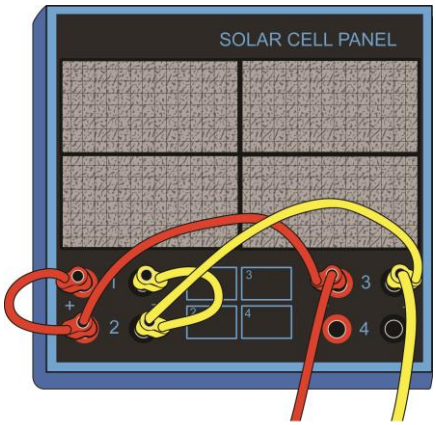
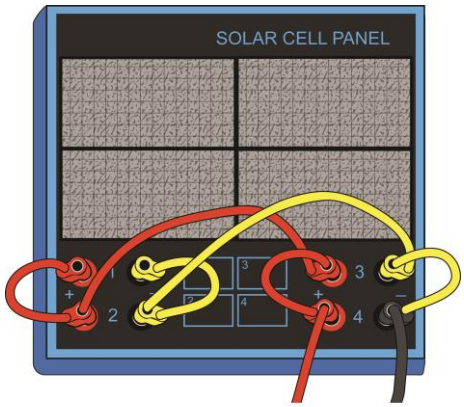



Figure 11: The circuit for measuring the power delivered by a solar cell connected in parallel. To simplify the diagram, only the symbols of the ammeter and voltmeter are shown.

| Step | What to do | How to do it |
|---|---|---|
| **1** | Mark the position of the solar panel on the bench, then carefully remove it from the circuit so you can connect the solar panels together. |  Figure 12 |
| **2** | As shown by the red leads in Figure 12, connect the (+) terminal of Cell 1 to the (+) terminal of Cell 2. Then connect another red lead to the (+) terminal of Cell 2, ready for the next connection.<br><br>Repeat this for the (-) terminals of these two cells, as shown by the yellow leads in Figure 12. | |

| | | |
|---|---|---|
| **3** | As shown by the red leads in Figure 13, connect the (+) terminal of Cell 2 to the (+) terminal of Cell 3. Then connect another lead to the (+) terminal of Cell 3, ready for the next connection.<br><br>Repeat this for the (-) terminals of Cells 2 and 3, as shown by the yellow leads in Figure 13. |  <br>Figure 13 |
| **4** | As shown by the red leads in Figure 14, connect the (+) terminal of Cell 3 to the (+) terminal of Cell 4. Then connect another red lead to the (+) terminal of Cell 4.<br><br>Connect the (-) terminal of Cell 3 to the (-) terminal of Cell 4 with a yellow lead. . Then connect a black lead to the (-) terminal of Cell 4 (on top of the yellow lead already inserted into it).<br><br>**YOU NOW HAVE CONNECTED YOUR SOLAR PANEL IN PARALLEL.**<br><br>**NOTICE THAT THE TERMINALS ARE CONNECTED (+) TO (+) , and (-) to (-), FROM ONE CELL TO THE NEXT.** |  <br>Figure 14 |
| **5** | Connect the solar panel into the circuit as shown in Figure 11:<br>• First complete the circuit containing the solar panel, ammeter and globe on the testing station.<br>•Then complete the second pathway connecting the solar panel to the voltmeter.<br><br>**Ensure that the solar panel and the lamps are in the same positions as before!** | |
| **6** | Trace the leads with your fingers to ensure that you have created two distinct pathways:<br>• One will go from the red terminal on Cell 4 on the solar panel to the globe on the testing station to the ammeter then to the black terminal on Cell 4 on the solar panel.<br>• The other will be a small loop connecting the solar panel to the voltmeter. | |
| **7** | Reset the ammeter to the **200m** setting. | |
| **8** | Reset the voltmeter to the **20** setting. | |
| **9** | Have your teacher check the circuit. | |
| **10** | Turn on the halogen lamps. Wait until the ammeter and voltmeter readings are steady, then record the results in the table on page 73. | |
| **11** | **Turn off the lamps, voltmeter and ammeter and pack up according to your teacher's directions**.<br><br>**DANGER: The halogen lamps might be very hot!** | |

## Results and Calculations for Group B

Enter your results in the table below and then calculate the power delivered, as you did on page 67.

**Results and calculations for Group B, when the four solar cells were connected in parallel**

| **Voltage *V*** **(V)** | **Current *I*** **(mA)** | **Electrical power *P*** ***P = V x I*** **(mW)** |
|---|---|---|
| | | |

## Conclusion for Group B

What is your answer to Inquiry question 3: What electrical power can be delivered by a STELR solar panel in which the four solar cells are connected in parallel?

_____ mW

## Discussion and conclusion for both groups

1 Summarise the results of the class in this table:

| Class group | Group of students | Electrical power delivered by single solar cell | Electrical power delivered by solar cells connected in series | Electrical power delivered by solar cells connected in parallel |
|---|---|---|---|---|
| **A** | | | | ***Not applicable*** |
| | | | | |
| | | | | |
| | | | | |
| **B** | | | ***Not applicable*** | |
| | | | | |
| | | | | |
| | | | | |

2 What general conclusions can you draw from the class results?

3 Compare these conclusions with your predictions? Are you surprised? Can you explain the results?

4 Did you have any practical difficulties in performing this part of the experiment? If so, how did you resolve them?

5 Identify at least two sources of error for this experiment, which would help account for any differences in the results.

# Practical Activity 8:
# What is the best angle for a solar panel?

**Partners:** _____ **Date:** _____

Figure 1: This solar panel can be moved to deliver maximum electrical power throughout the day.

## Your task

**You are to investigate what is the best angle of tilt of a STELR solar panel for delivering the most power. Figure 2 shows what is meant by 'angle of tilt'. The angle will be between 0º and 180º.**

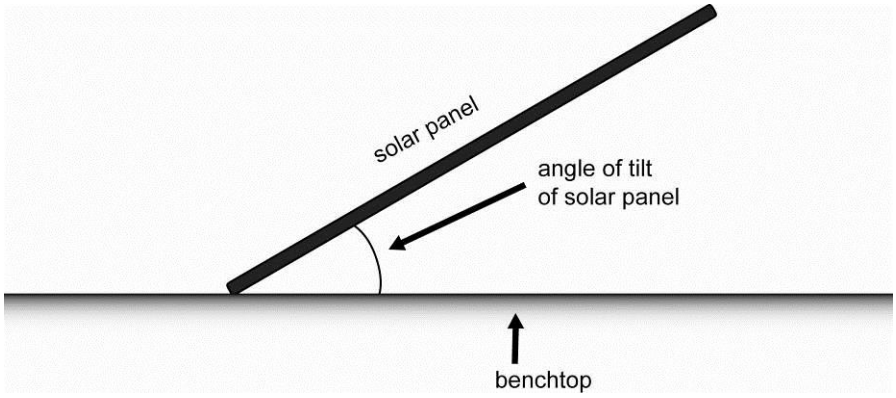



Figure 2: The angle of tilt of a STELR solar panel. The light source is not shown, but is to the right of the solar panel shown here.

**Draw on your findings in Practical Activity 7.**

In your investigation, you need to make many decisions:
- What is your hypothesis and what do you expect to discover?
- What other variables will be operating and how you will control them so your tests are fair?
- Will you use lamps or sunlight as your light source?
- How will you achieve different angles?
- How can you easily and accurately measure the angle of the panel?
- What other measurements will you need to make?
- How many measurements will you need to take in order to draw a reasonable conclusion?

## What to do

**1 As a group, work through the process on the first page of the investigation planner on pages 81 and 82 and present your plans to your teacher.**

**2 When your teacher gives permission, now perform the experiment and work through and complete the second page of the investigation planner. (You will need to attach your results, any graphs you draw, and so on.)**

## Discussion and conclusion

1 Did your findings surprise you? Can you suggest an explanation for what you discovered?

2 Summarise the conclusions drawn by the overall class and hence answer the inquiry question: What is the best angle for a solar panel?

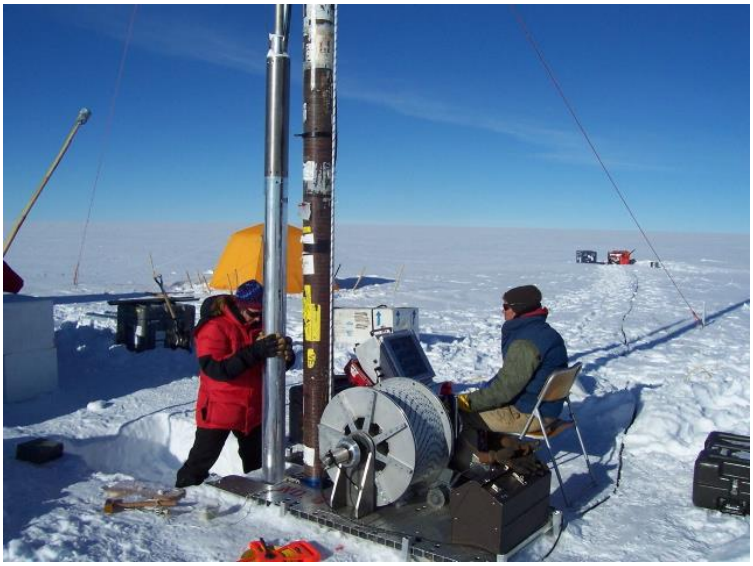
3 What is one further investigation you could perform that would help make the conclusions drawn by the class more reliable?

4 What are the implications of your findings for solar panel installations on rooftops and other locations? Discuss.

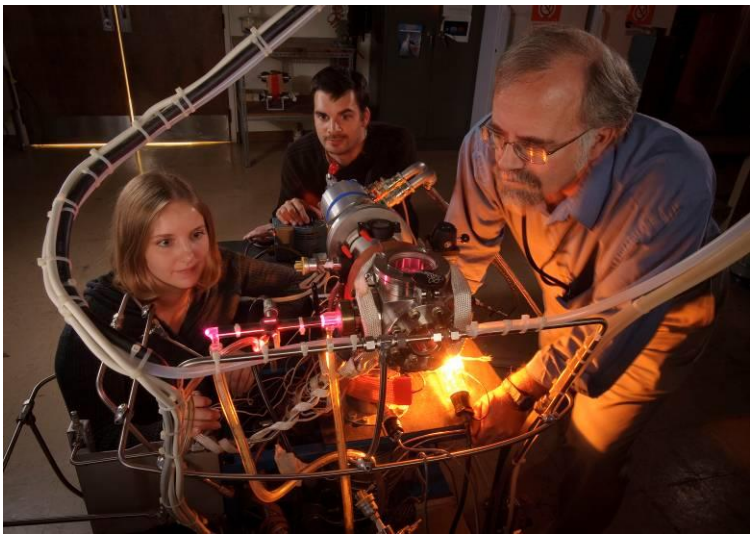
## Find out!

At what angle are solar panels generally installed, or does this depend on the location of the solar panel? What is the reason for this?

# SCIENTISTS AT WORK



Scientists at work extracting an ice core sample



Scientists at work analysing an ice core sample

## Big Ideas:

**Why do scientists keep testing their ideas with experiments?**

**How do scientists design their experiments?**

**Is knowledge more important for scientists than imagination?**

**Why is it important that scientists only conduct ethical experiments and report their findings honestly?**

**How would you prove that global warming is happening?**

# Practical Activity 9: I want to find out…

**Partners:** _____ **Date:** _____

## I want to find out

_____

_____

How do solar panels perform when they are dirty or when it is cloudy?

## Your task

You are to decide what new aspect of solar cells or wind turbines you would like to investigate.

For example, you may wish to investigate:
- What is the effect of clouds on the power delivered by a solar cell?
- What is the best angle for turbine blades, and does this change if their length is different?
- Will combinations of different blade lengths generate more power?
- How do gears affect the output of a wind turbine?
- How does the temperature of a solar panel affect its power output?

To do this, you will draw on all the experience you have gained in the STELR program.

In your investigation, you need to make many decisions. These include:
- What will you investigate?
- What is your hypothesis and what do you expect to discover?
- What variables will be operating and how you will control them so your tests are fair?
- What measurements will you need to make?
- How many measurements will you need to take in order to draw a reasonable conclusion?
- How will you present your findings?

## What to do

1 As a group, work through the process on the first page of the investigation planner on pages 81 and 82 and present your plans to your teacher.

2 When your teacher gives permission, now perform the experiment, complete the second page of the investigation planner, and present your findings to the class.

# Worksheet 5: A career in renewable energy

## Your task

In this activity you will be investigating the work of someone who works in renewable energy and write a career profile for that person.

## What to do

Select one of the following options. If possible, conduct an interview of the person you select. Alternatively, you may use the internet or other resources to find your information, including the STELR website.

### Option 1

Research the career profile of someone who works in the renewable energy industry. Their job can involve any aspect of the industry, such as research, manufacture, engineering, management, installation, technical service and marketing.

### Option 2

Research the career profile of an Australian scientist whose work focuses on renewable energy. Their job might involve research and development, field assessment of possible locations of wind farms or other renewable energy resources, researching the impact of the industry on the environment, and so on.

## Your report

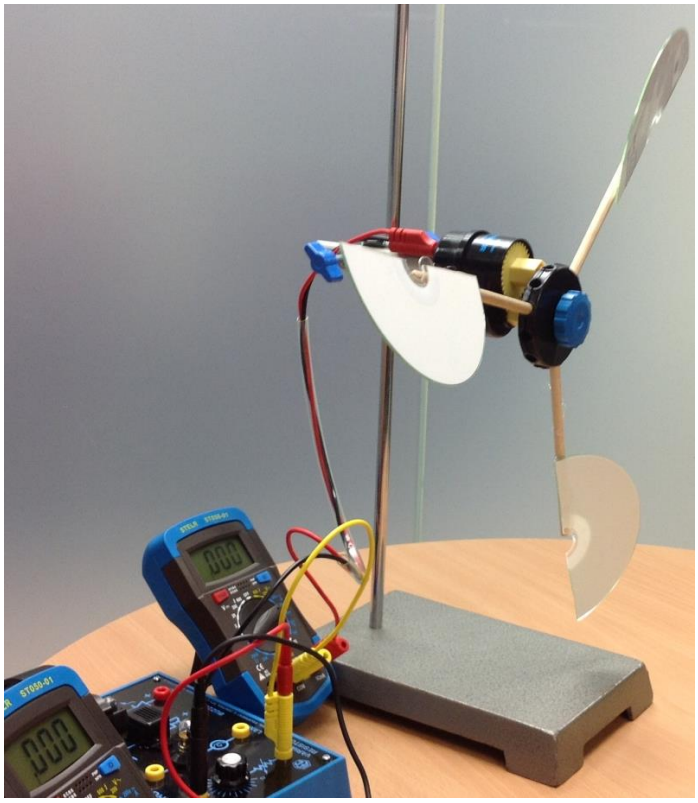
Select a suitable report format for your findings. The information you find out should include, if possible:

- Name of the organisation where the person works and brief description of what the organisation does
- Position in the organisation
- Subjects they studied at upper secondary school level
- Course(s) taken after leaving secondary school
- Duties involved in their job
- Why they chose this job
- The most enjoyable aspects of the job
- The challenges they face in the job
- How they think this job will change over the next decade
- Salary range of people working in this kind of job

## Resource

You can find sample career profiles of people working in the renewable energy industry on the ATSE STELR website at: http://www.stelr.org.au/career-profiles/.

# GROUP CHALLENGE: A MODEL WIND TURBINE



This is a model wind turbine that was designed and built by STELR students

**Your challenge!**

**Can you design and build a model wind turbine that generates more electrical power than anyone else's?**

## Advice

1 As a group, design your new wind turbine, taking into account any discoveries you made using the STELR model wind turbine. Record any drawings you do and the reasons behind the different design features in a log book.

2 Make a list of materials you will need and then get them. This needs to be discussed with your teacher.

3 Build your model, recording in your log book any changes you make to your design and the reasons for them.

4 Test the model to see what power it delivers. Compare these results with the results you obtained for the STELR wind turbine. All results and calculations should be recorded in your report.

5 Think about your results. What modifications might deliver even more power? Try these out and record the power you achieve**.**

# Investigation Planner

| What you are investigating | |
|---|---|
| What are you going to investigate? | What do you think will happen? Explain why. |
| What is your hypothesis? | What is the aim of your investigation? |
| **Designing your experiment** | |
| What variables might affect the outcome of your investigation? | Which variable(s) will you test? |
| How will you make your tests fair? | What observations and measurements will you need to take? |
| How will you ensure that your measurements are reliable? | What calculations (if any) will you need to perform? |
| What risks might be involved in conducting your investigation? Hence, what safety precautions do you plan to take? | What materials, including equipment will you need? |

## Your results

| | |
|---|---|
| How will you record your observations and measurements?<br>Design any suitable tables and draw them up ready in your journal.<br>Can you use symbols and a key to avoid repeated writing of your observations? If so, have these ready under the appropriate tables. | What graphs can you draw and what spreadsheets can you design to display your results and to enable you to identify any patterns and relationships? |

## Conducting your investigation

Once your teacher has approved your plans and supplied the materials, conduct your investigation.
Record how you performed the investigation, in your journal. Be sure to include any modifications you made to your plans and the reasons for them.

## Analysing your results: your conclusions

| | |
|---|---|
| Examine your results. Use them to answer your aim. | From your conclusions, were your predictions and hypothesis correct? Does your hypothesis need to be modified? Discuss. |

## Evaluating the investigation

| | |
|---|---|
| How reliable do you think your results were? Discuss. | How could you modify your procedure to make your results more reliable? |

If you were given the opportunity, what further investigation would you carry out to build on what you learned from this investigation?

# Glossary

| Term | Meaning |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |