Green Power:

Introduction to Renewable Energy

Australian CRC for Renewable Energy Ltd

Australian Cooperative Research Centre for Renewable Energy
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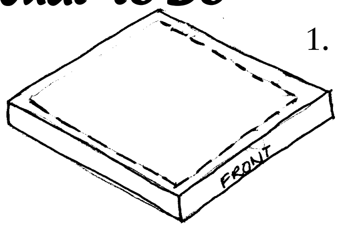
Even on cold days, the inside of a car which has been parked in the sun is a lot warmer than it is on the outside of the car. This is because clear materials, such as glass and plastic can trap the heat from the sun, just like the greenhouse gases do in our atmosphere. We can use this principle to cook a variety of foods in solar ovens.

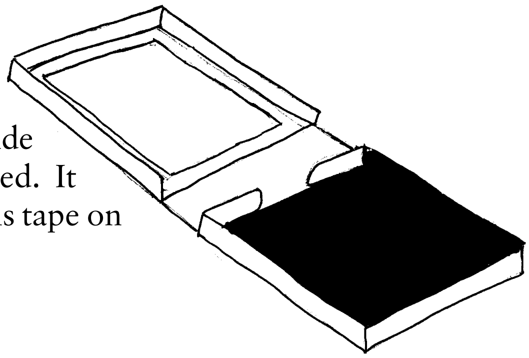
Materials

Medium Sized Pizza Box
Aluminium Foil
Masking Tape
Sunny Day
Thick Black Plastic or Cardboard
Clear Overhead Project Sheet Plastic
Craft Knife

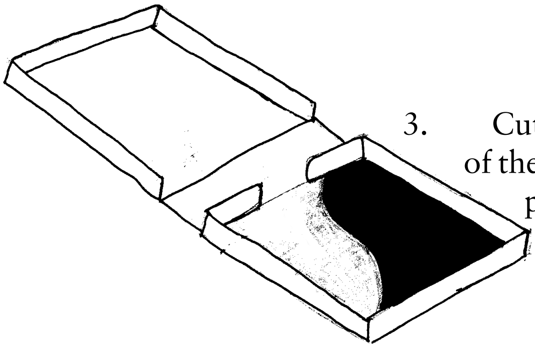
What to Do



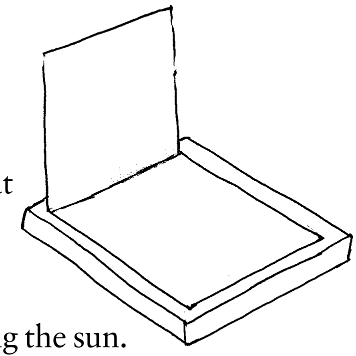
1. Using a craft knife, carefully cut a U shape on the lid of the Pizza box, by drawing a square 5 cm in from all of the edges. Cut along line at the front and sides of the box.



2. Cut a square of clear plastic that is slightly smaller than the dimensions of the pizza box. Tape the clear plastic on the inside of the box so that it is covering the flap you have just created. It must be air tight, so you will need to make sure that there is tape on all four sides of the plastic



3. Cut a square of black plastic about the same size as the bottom of the box and tape it to the bottom of the box (opposite the clear plastic).



4. Tear a sheet of aluminium foil and fold it around the flap (the face that faces inside the closed box).

5. Take the oven out into the sun and place the box with the window facing the sun.

6. Use the flap to reflect more sunlight into the window, by slowly tilting it backwards and forwards until you can see the reflection in the box.

Hint

As Pizza Box solar ovens do not get very hot, try melting or heating foods rather than cooking raw food. Chocolate covered marshmallow biscuits are perfect for testing your solar ovens.

Life on Earth depends on the energy radiated by the Sun. Plants need sunlight for growth. The chemical energy stored in planets provides food for animals so that they can live and grow. Also, most of the energy which humans use everyday, whether it comes from oil, coal, gas or wood was originally produced in the Sun.

In this activity, we will look at solar cells. Solar cells, which are usually made of silicon, use light from the sun to make electricity.

Building a PV Module

1. Use the plastic spanner supplied in your kit to undo the nut and remove the copper link and the washer from the back of all of the cells. Place all of the “bits” off to one side where they will not get accidentally lost or damaged. See Figure A.

2. Insert the solar cells into the plastic tray to make the solar panel which is shown in Figure B. On the back of each of the solar cells a positive (+) and negative (-) are shown. Make sure that you pay careful attention to the polarity (negative and positive terminals) of the solar panel before you begin connecting the circuit.

3. Connect the solar cells using the links and washers, being careful not to over-tighten the nuts with the spanner. See Figure C.

4. Connect the wires, washers and nuts to the solar panel. See Figure D.

5. Insert the motor into the plastic motor holder as shown in Figure E.

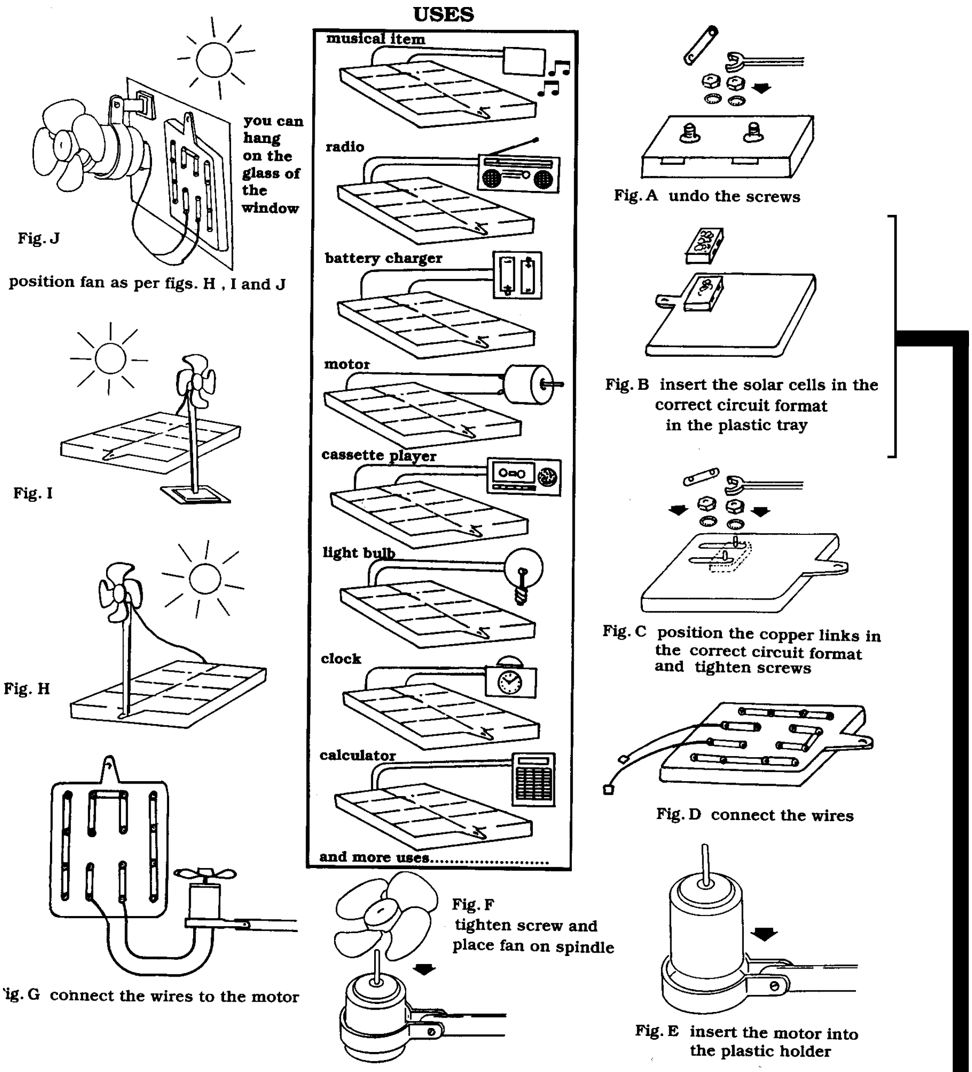
6. Join the plastic motor holder and stand together with the screw and nut.

7. Put the fan on the motor spindle. See Figure F.

8. Connect the wire clips to the motor’s conductor. See Figure G

9. Insert the stand into the keyhole attached to one end of the array.

10. Place the solar panel so that direct sunlight strikes the cells and watch what happens to the fan.



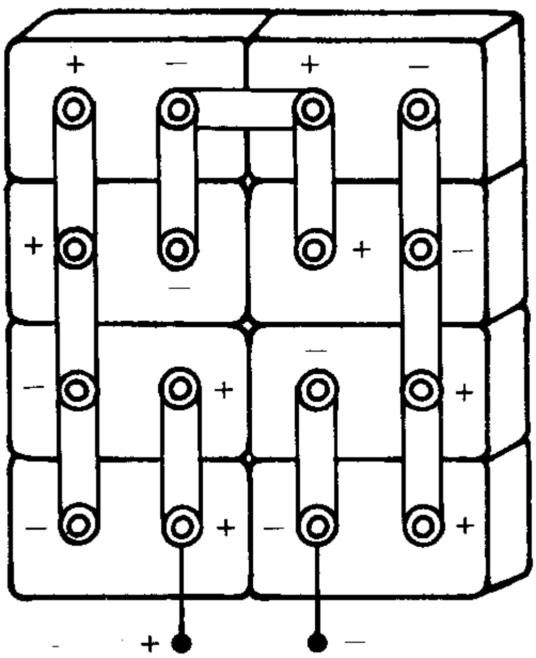


Figure B (enlarged for detail)

So how did you go?

When you tested your solar module did it work straight away? If not, what do you think you could do to make it work?

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Did this solution work?

Renewable sources of energy, like solar energy, are being used more often now than they were 20 years ago. List as many places as you can where you have seen solar panels or wind turbines in the table below. Can you think of any other places where renewable energy sources could be used in place of fossil fuels, or where there is not any electricity, but there is a need?

Electricity involves the flow of electrons, the negatively charged particles which orbit around the nucleus of an atom. The movement of these electrons through a conductor, like a wire, is known as the electric current, or current for short. The number of electrons that move through the wire at one time is measured in amperes, or amps. It has the symbol A. The force that moves the electrons through the wire is known as the voltage and is measured in volts, with the symbol V.

When you can see that the panels are generating electricity (ie the fan is spinning), take the panels out of the sun and disconnect the fan and motor. Leave the wires connected so that you can test the voltage and the current of the module.

Testing Current

1. Using the wires which you used to connect the fan and the motor, connect the PV module to the multimeter.
2. Again, place the solar panel flat on the ground so that direct sunlight strikes the cells and carefully read the current from the millammeter.

Current (Flat) . . . . mA

3. This time measure the current with the panels at an angle of 90°.

Current (90°) . . . . mA.

4. Are the two measurements for the current produced by the PV module different? What factors do you think effect the amount of current being produced by the modules ?

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Testing Voltage

1. Using the wires which you used to connect the fan and the motor, connect the PV module to the multimeter.
2. Again, place the solar panel flat on the ground so that direct sunlight strikes the cells and carefully read the voltage from the voltmeter.

Voltage (Flat) V

3. This time measure the voltage with the panels at an angle of 90°.

Voltage (90°) V

4. Are the two measurements for the Voltage produced by the PV module different? Why do you think you obtained the result that you did ?

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Things to Talk About

The module that you have just constructed has been rated as producing a current of 200mA and a voltage of 1.6 V. Did your array produce those specifications? If it didn't, can you think of some reasons why you did not achieve the specifications?

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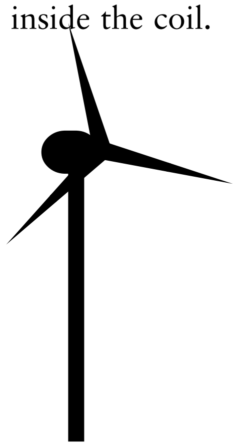
PV arrays are used for many different applications. Next time you drive down the Freeway, or along major highways which are away from powerlines, look for the solar panels which are used to power the emergency telephones. You may also have seen PV panels attached to billboards, or even ice cream vans!

The earliest wind turbines were used around 200 BC in Persia (modern day Iran). These turbines used sails mounted on a giant merry go round and were used for grinding grain. Vertical axis windmills, like the ones we use today were developed around the 10th century in the Meditteranean Sea and the 13th Century in Europe.

The Dutch Windmills were invented around the 15th Century and were still in widespread use up until the early 1900s. Australian water pumping windmills, like those found on outback stations, have been manufactured in Australia since about 1903.

Modern wind turbine generators produce electrical energy through a series of steps:

* Wind causes the blades of the turbine to spin due to kinetic energy, or the energy of movement
* Spinning blades cause an axle and magnets to rotate inside a coil of conducting wire
* Electricity is generated in the wire when the magnets spin around inside the coil.



Things to Get

Examples of turbine blades
Blu Tac
1.5 V DC Motor
Multimeter
Fan
Set of Alligator Clips

Things to Do

1. Connect the two blade propellor to the small motor by carefully inserting the axle of the motor through the small hole in the centre of the propellor.
2. Secure the propellor, by placing a small amount of blu tac over the axle and the propellor.
3. Carefully insert the motor into the plastic motor stand (You will need to loosen the screw on the stand to allow the motor to slide through easier) FIGURE A.
4. Connect the multimeter to the motor by clipping one of the alligator clips to one of the pins at the back of the motor.
5. Connect the other alligator clips to the other pin at the back of the motor FIGURE B.
6. Place your wind turbine model in front of the fan and turn the fan on.
7. Using the table, record the current and voltage being generated by this propellor using the multimeter.
8. Now record the current and voltage being generated when you switch the fan to the highest setting.
9. Repeat the experiment using the other two types of propellor.
10. When you have completed the table, calculate the amount of power being generated for each of the blades and the different wind speeds.
11. Using the results on the amount of power being generated, graph the number of blades versus power for both wind speeds.

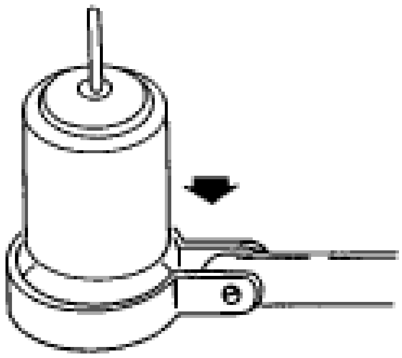


Figure A

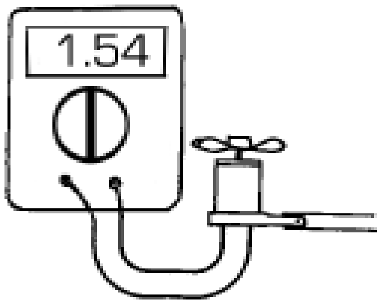


Figure B

Results

Record your results in the following table:

Number of Blades	Low Speed		High Speed	
	Current (I)	Voltage (V)	Current (I)	Voltage (V)
2				
4				
6				

Calculations

Using the results from Table 1, determine the power generated by the different propellors at the different wind speeds. For fixed resistence in a circuit, power is proportional to both current and voltage according to the relation:

$$P = VI$$

Blades on Propellor	Power Generated	
	Low Speed	High Speed
2		
4		
6		

Things to Talk About

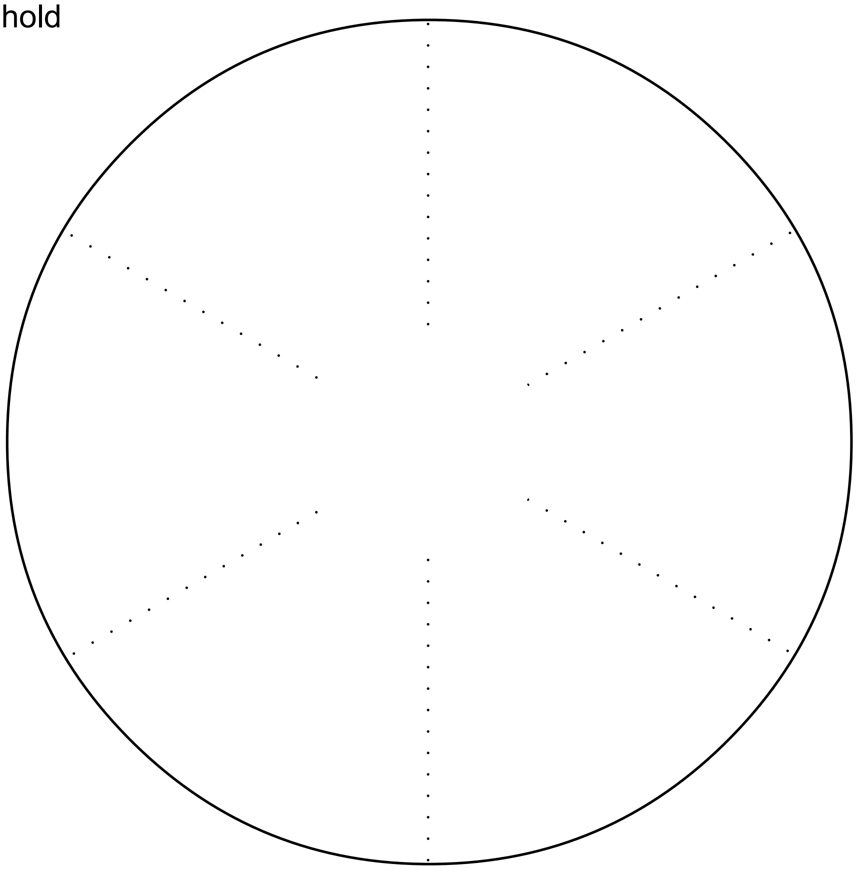
Which fan produced the largest current? How do you think it was able to produce more current?

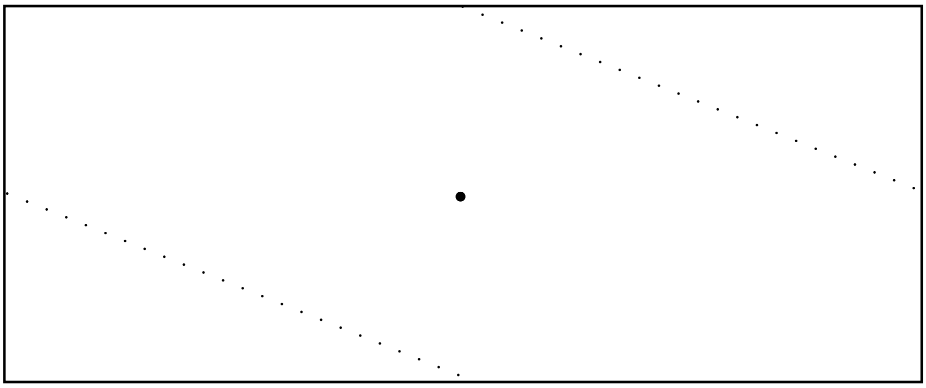
Which fan produced the largest voltage? How do you think it was able to produce more voltage?

If you were asked to design a Wind Turbine which could be used to generate electricity for a remote light house on the south west coast of WA, what would it look like? (Use the space below to draw your turbine)

6 Blade Propellor

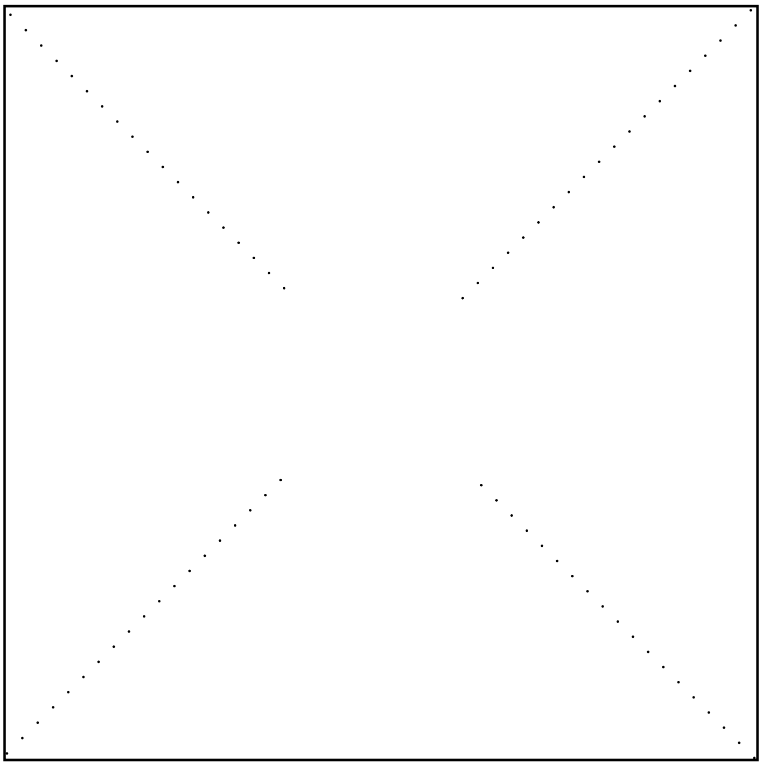
1. Cut along dotted lines and fold one corner of each flap in towards the centre.
2. Staple centre to hold blades in place.





2 Blade Propellor

1. Fold along dotted lines so that one fold is on each side of the of the blade



4 BLADE PROPELLOR

1. Cut along dotted lines and fold one corner of each flap in towards the centre.
2. Staple centre to hold blades in place.

Biomass energy is any energy which comes from plant or animal sources. We don't think about it much, but Biomass is really a form of Solar Energy, after all somewhere down the food chain plants (which use energy from the sun to grow) are eaten. Whilst we don't need to eat biomass to use its energy (it can be burnt like firwood or methane gas) it is probably the most common use of Biomass energy. After all, we need to eat to have the energy to get out of bed in the morning, to walk to school and to run around the playground!

Energy in foods comes from three different sources: Fat, Protein and Carbohydrates.
Fats provide approximately 37 kiloJoules (kJ) of energy per gram.
Carbohydrates (any food source that grows out of the ground) and Proteins (any food source which has ever lived, moved, breathed) have about 17kJ of energy per gram.

Today we will examine the energy content of foods.

Things to Get

Nutritional Information Panel
Calculator

Things to Do

1. Find the Nutritional Information Panel on one of the packets in front of you, it looks a bit like this:

12 SERVES PER PACKETS - 25g SERVING SIZE		
PER SERVING (APPROX 2 BISCUITS)		
	PER SERVE	PER 100g
ENERGY	450 kJ (108 Cal)	1800kJ (430 Cal)
PROTEIN	3.0 g	12.0 g
FAT	2.5 g	10.0 g
CARBOHYDRATES -TOTAL	18.0 g	72.0 g
-SUGARS	1.0 g	3.8 g
DIETARY FIBRE	3.1 g	12.2 g
THIAMIN	0.1 mg	0.2 mg
NIACIN	1.3 mg	5.0 mg
IRON	1.0 mg	3.8 mg
PHOSPHORUS	80 mg	320 mg
SODIUM	113 mg	450 mg
POTASSIUM	105 mg	420 mg

The left column lists the major nutritional components of the product, the middle column lists the weight of each of the components per serve and the right column lists the weightof each of the components in 100g of the food. The Energy Content of the food is also listed in the table for both a single serve, and for 100g.

Why do you think that the label lists values for both a 'per serve' and ' per 100g' ?

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Nutritional information panels list the values for both the 'per serve' and 'per 100g' so that you can compare the nutritional information for two different brands of a similar food product, like two different brands of crispbread.

We are going to use the information in the 'per 100g' to investigate and analyse the Energy Content of two different foods.

Record in your worksheet what two food products does your group have?

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Product A   Product B

Complete the table listing the total amount of Energy, Protein, Fat and Carbohydrates in 100g of Product A and Product B.

	Energy (kJ)	Protein (g)	Fat (g)	Carbohydrates (g)
Product A				
Product B				

Once you have completed the table, calculate an approximate Energy Content in (kJ) for the two products using the example below to help you:

Energy Content (kJ) from Protein = (grams of Protein) x 17 A

Energy Content (kJ) from Carbohydrates = (grams of Carbohydrates) x 17 B

Energy Content (kJ) from Carbohydrates = grams of Fat) x 37 C

Total Energy Content = A + B + C

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How Did You Go?

Did you get the same result as the Energy Content on the label?
Compare your result and the value given on the label and write one or two sentences below on how accurate you think your result is, and why it could be different to the value the manufacturer lists inthe food label.

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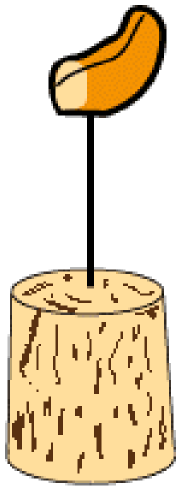
This experiment looks at the energy content in peanuts.



Things to Get

Unshelled Peanut
Cork
Needle
Two Empty Steel Cans (one small, one larger)
Retort Stand
Matches
Thermometer

Things to Do

1. Carefully push the eye of the needle into the smaller end of the cork.
2. The gently push the pointed end of the needle into a peanut. If you push too hard the peanut will break in pieces. If it does, use another peanut (HINT: It's also better to have the peanut at a slight angle to increase the width of the heat source).
3. Place the larger can around the peanut with the holes at the bottom. These are air holes that will make the can act like a chimney and will contain the heat energy focusing it on the smaller can.
4. Remove the top end of the small can (if it is not already removed).
5. Pour 100mL of water into the small can.
6. Put the thermometer into the water and record the temperature in the results section.
7. Place the cork and peanut on a nonflammable surface. Light the peanut with a match or lighter. Sometimes the peanut can be difficult to light, so the lighter may be easier to use.
8. As soon as the peanut has caught fire, immediately place the large can around the nut.
9. Clamp the smaller can in the retort stand, near the top of the can and lower this can over the burning peanut.
10. Allow the nut to burn for several minutes or until it goes out.
11. Stir the water gently with the thermometer and record the temperature of the water again.

Results

Start Temperature	End Temperature	Temperature Change	Time Taken

Calculations

Determine the amount of energy generated by burning the peanut using the following relation:

Energy (Joules) = Volume H_2O (mL) x 4.2 x Change in Temperature.

Energy (Joules) = (100 x4.2) x Change in Temperature.

The amount of energy generated by our penaut was . . . .

We can also determine the power generated by the peanut, by dividing the amount of energy generated by the time taken.

$$\text{Power (Watts)} = \frac{\text{Energy (Joules)}}{\text{Time Taken (seconds)}}$$

Our peanut created . . . . Watts of Power.

Things to Think About

What factors would effect the amount of energy and power generated by the combustion of the peanut. Write a sentence explaining how they would effect your results.

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Your results are only as accurate as the equipment you have used to record your results. The accuracy of a piece of equipment is usually about half the distance between its smallest markings. For example a ruler with mm markings is accurate to +/- 0.5 mm. Make an estimate of the error margin on your results. (HINT: Look at the equipment used to measure things!)

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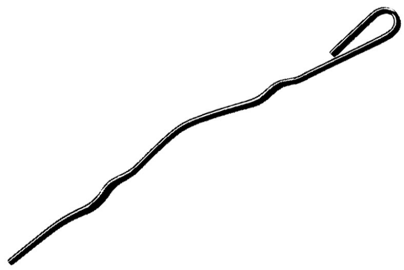
The conversion of kinetic energy into mechanical energy is not a new idea. As far back as some 2000 years ago wooden waterwheels were used to convert kinetic energy into mechanical energy. The exact origin of water wheels is not known, but the earliest reference to their use comes from ancient Greece.

For centuries since then, waterwheels turning shafts attached to millstones have been used to grind grain into flour. Also, as far back as the sixteenth century, early in the Industrial Revolution in Britain, factories used waterwheels to turn machinery for the production of cloth. The rotating power of waterwheels has also been used in saw mills, and at forges in iron foundries.

Today, when most people think of hydroelectricity, they think of the Snowy Mountain Scheme, or the Ord River Hydroelectric project, with large dams of water turning horizontally orientated water wheels. However, there are also a large number of small scale or micro hydro systems attached to streams and narrow rivers.

Things to Get

Model Pelton Wheel
~1mm ID Tubing
1.5 V DC Motor
Half Straightened Paper Clips with small end squashed too look like figure on the right.
Multimeter
Set of Alligator Clips



Things to Do

1. Connect the Pelton to the small motor by carefully inserting a paper clip into both ends of the cork motor through the small hole in the centre of the propellor.
2. Carefully insert the motor into the plastic motor stand (You will need to loosen the screw on the stand to allow the motor to slide through easier)
3. Connect the multimeter to the motor by clipping one of the alligator clips to one of the pins at the back of the motor.
4. Connect the other alligator clips to the other pin at the back of the motor.
5. Place your Pelton Wheel model under a steady stream of running water (you don't want too much pressure)
6. Record the current and voltage being generated by the Pelton Wheel using the multimeter.
7. When you have recorded your results , calculate the amount of power being generated by the Pelton Wheel.

Results

Complete the Table by recording the current and voltage produced by the Pelton Wheel.

Current	
Voltage	
Power	

Calculations

Using the resultsfor Current and Voltage, determine the power generated by the Pelton Wheel using the relation:

$$P = VI$$

Things to Talk About

What factors do you think will determine the amount of power generated by the Pelton Wheel?

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Using your answers from the first question, what improvements or additions should be made to incease the amount of power from the Pelton Wheel?

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Extension

Build your improved design and compare your results with those of the rest of the class.

Hot dry rock energy is a type of geothermal energy which uses the heat contained in rocks, which are buried up to 5km below the Earth's surface. Water is pumped down to these rocks, which is then heated. The heated water is then pumped to the surface where it can be used to generate electricity.

Things to Get

Microwaveable granite heating pad
Small pyrex, or similar container
Thermometer
Microwave
Water

Things to Do

1. Pour the water into the small pyrex container and measure the temperature of the water.
2. Place the heating pad in the microwave and follow the instructions that it came with to heat it up.
3. When the microwave has finished, carefully remove it and place the container with the water on it. Wait 5 minutes, and record the temperature of the water again.

Things to Talk About

1. In Hot Dry Rock power plants, the water is pumped through a hole and allowed to flow freely through the rocks. Can you think of any reasons why this is better than placing the water in containers and lowering the containers down to the hot rocks?

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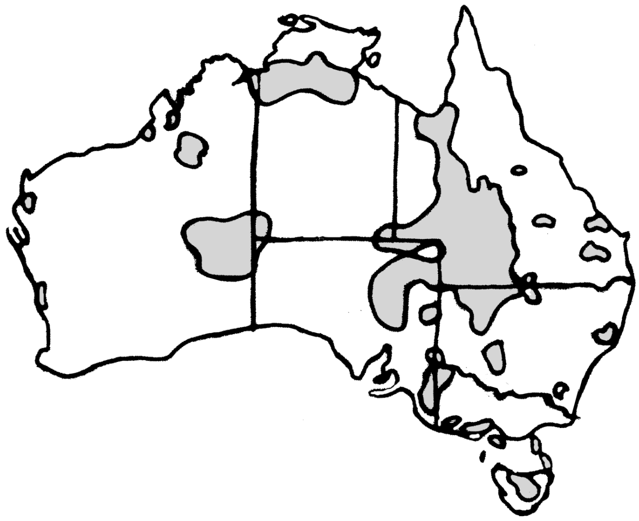
2. Using the map of Australian below, what can you say about the use of hot dry rocks for generating electricity in your state. (Hint the grey areas are areas which have rocks which are hotter than 300°C, 5km below the surface.



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