Just Hot Air?

Activities on the Greenhouse Effect, Climate Change and Active Citizenship

Australian Cooperative Research Centre for Renewable Energy
Established and Supported under the Australian Government's Cooperative Research Centres Program

Welcome

Welcome to Just Hot Air, a teaching resource on the Greenhouse Effect and Global Warming.

This resource covers a number of different areas from Greenhouse Science, Global Warming and Greenhouse Gas Emissions and Making Changes.

The resource and activities were developed for upper primary and lower secondary students, but may be suitable for use with middle primary or upper secondary students as part of Senior Science.

The activities and materials contained in this resource aim to promote the following objectives:

- To provide teachers with an introduction to the Enhanced Greenhouse Effect, Climate Change and active citizenship relating to greenhouse gas emissions.

- To provide teachers with activities and resources for teaching about the Enhanced Greenhouse Effect, Climate Change and active citizenship relating to greenhouse gas emissions in Australian Schools

This resource was developed by the Australian Cooperative Research Centre for Renewable Energy in 1997 and significantly revised and updated in 2000.

Further Information or suggestions on resources for schools on renewable energy, energy efficiency and the Climate Change can be obtained by contacting:

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This section of the resource package includes a number of activities designed to increase the students knowledge of the Greenhouse Effect and some of the issues related to climate change such as: how we know the Earth is getting warmer, and some of the changes that we can expect to observe.

One of the commonly held beliefs on climate change is that it doesn't feel like it's getting warmer. As an educator, you may like to retell the story of the *Frog in the Frypan* below and discuss the importance of helping to find solutions to environmental problems when we first notice them.

Frog in the Frypan

This is is a story all about the cooking of frogs (which is quite common in France) and it presents an interesting analogy to the slow increase in global temperature as a result of global warming, and addresses one of the main sources of confusion regarding the Greenhouse Effect, that it doesn't feel like its getting warmer. Just because you can't feel it, doesn't mean that it isn't happening! Props such as a toy frog and frypan often aid the telling of the story which goes something like this:

How many of you have heard of a French delicacy known as "cuisses de grenouilles", or Frogs Legs? Well, when you are trying to cook frogs, you can't place them straight into a hot frying pan because they immediately jump out because its too hot, just like when you dip your toe into the bath to test how hot it is and pull it out because its too hot. So when you cook them, you have to put them into a cold frying pan and warm it gently. The frog likes the warmth and it starts to settle down as the frying pan is slowly getting warmer. Unfortunately the frog doesn't realise that it's being cooked until its too late!

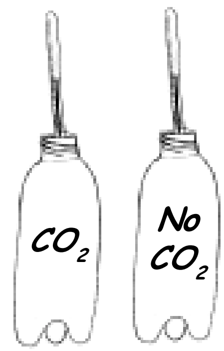
The Greenhouse Effect

In 1896, a Swedish Chemist (who later went on to win the Nobel Prize for Chemistry in 1903) by the name of Svante Arrhenius predicted that the burning of carbon based fossil fuels would significantly increase the concentration of carbon dioxide in the atmosphere, hence leading to a warming in the average global temperature. Arrhenius' prediction of Global Warming was largely ignored by his contemporaries and virtually nothing was done to reduce carbon dioxide emissions.

The effect that Arrhenius predicted is now known as the *Greenhouse Effect*, because carbon dioxide in the atmosphere acts like the glass in a greenhouse, letting the warm sun light in, but preventing the re-radiated heat from escaping into space. The Greenhouse Effect is a very important natural phenomenon, without it life on the Earth would be very different to the way it is today, as the Earth would be about 30°C colder than it is! However, the *Enhanced Greenhouse Effect*, or Global Warming could have dire consequences on the inhabitants of Planet Earth.

Materials

Two PETplastic drink bottles (with their labels removed)
Plasticine
Vinegar
Bicarbonate of Soda
Two thermometers
Plastic Wrap
Sunlight
Graph Paper



Method

1. Label one bottle *no* CO_2 and label the other bottle CO_2.
2. In the bottle labelled CO_2, carefully pour in two teaspoons of bicarbonate of soda and then two teaspoons of vinegar.
3. Quickly cover the neck of the bottle with plasticine to stop any of the carbon dioxide leaking out.
4. In the bottle labelled *no* CO_2, carefully pour in two teaspoons of vinegar and cover the neck of the bottle with plasticine.
5. Carefully make a small hole in the plasticine that covers the neck of both bottles and poke the thermometers through the holes.
6. Place the bottles in the sunlight.
7. Record the temperature of the two thermometers every five minutes throughout the session in the table provided.
8. Graph the temperatures over the two bottles against time.

Results and Discussion

Record the temperature (in °C) in the table of each of the thermometers at the start of the session and every five minutes after that until the table is complete. When you have all of your results, draw a graph of the temperature inside each of the bottles, with both curves on the same graph, as a function of time, using different colours or symbols to represent the different bottles.

Results

	Start	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.
No CO2							
CO2							

Discussion

1. At the end of collecting and graphing your results, what inferences can you make about the effect of carbon dioxide on temperature in the atmosphere?

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2. Why was vinegar added to the bottle labelled no CO_2?

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3. Carbon dioxide is generated in this experiment by the reaction of sodium bicarbonate ($NaHCO_3$) with vinegar (CH_3COOH) according to the reaction:

$$NaHCO_{3\,(s)} + CH_3COOH_{(aq)} \rightarrow CO_{2\,(g)} + Na^+CH_3COO^-_{(aq)} + H_2O_{(l)}$$

What other types of reactions generate carbon dioxide?
Hint there are three main ones, and these can be represented by the following reactions:

$$C_6H_{12}O_{6\,(aq)} \xrightarrow{Enzymes} 2C_2H_5OH_{(aq)} + CO_{2\,(g)}$$ . . . .

$$C_{(s)} + O_{2\,(g)} \xrightarrow{Heat} CO_{2\,(g)}$$ . . . .

$$\text{Carbohydrates } (C_6H_{12}O_6)_{(aq)} + O_{2\,(g)}(g) \xrightarrow{Living\ Cells} \text{Energy} + 6H_2O_{(l)} + 6CO_{2\,(g)}$$

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You have probably noticed that, 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	Black Plastic or Cardboard
Aluminium Foil	Clear OHP Plastic
Masking Tape	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. (Fig. 1)

2. Cut a square of clear OHP plastic that is about 1cm in each direction larger than the flap you have just cut in the 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! (Fig 2)

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). (Fig 3).

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

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.

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

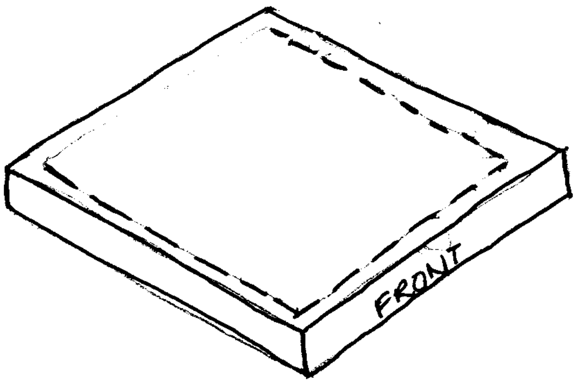

Figure 1

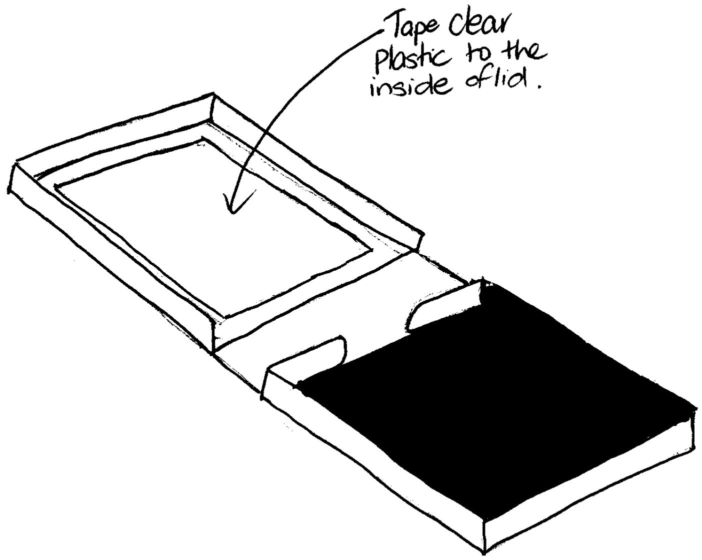

Figure 2

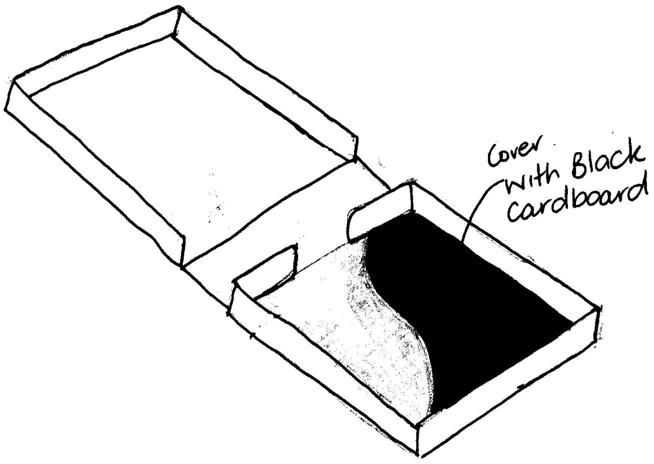

Figure 3

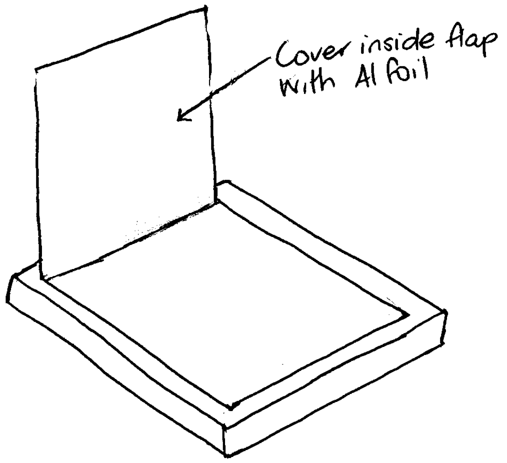

Figure 4

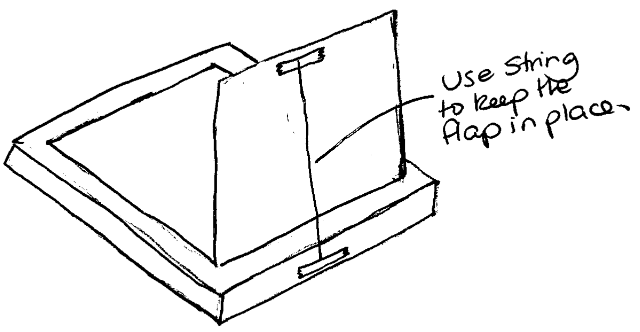

Figure 5

How Small?

The science of climate change and global warming usually deals with volumes and masses that are either very large or very small.

When scientists talk about concentrations, or amounts of carbon dioxide and other gases in the atmosphere, they use the unit's part per million (ppm) or part per billion (ppb). In this activity, we are going to use water and food colouring to help us investigate the amount of carbon dioxide in the atmosphere.

Materials

Eye dropper
Water
4 disposable cups
Food colouring
4 Labels

Method

1. On the labels, write 1/100 on one, 1/10 000 on another, 1/1 000 000 on the next and 1 /1 000 000 000 on the last label.
2. Place the labels on the cups and line them up along your bench.
3. In the first cup, labelled 1 /100, use the eyedropper to place 99 drops of water in the cup.
4. Add one drop of food colouring to the first container. This first solution has a concentration of one part per hundred. You should be able to see that it is a coloured solution.
5. Rinse your eyedropper so that there is no food colouring left inside it.
6. Add 99 drops of clean water to the second cup, labelled 1 /10 000, and one drop of the first solution that you have just made. This new solution has a concentration of one part per ten thousand.
7. In the third cup, place 99 clean water and one drop from the second solution. Congratulations, you have made a solution which has a food colouring concentration of one part per million.
8. In your last cup, add one drop of your part per million solution to 99 drops of clean water. This last solution has a concentration of one part per billion.

Some questions to think about.

1. Can you see any sign of the original colour in the 1/ 1 000 000 solution?

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2. Based on your answer for question one, why do you think scientists are concerned about carbon dioxide in the atmosphere, which has a concentration of about 350 ppm? You can make a 350 ppm solution by adding 35 drops of water to the first cup with 65 drops of clean water, then following steps 5 to 7 to make your 350 ppm solution.

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3. Is this solution coloured? . . . .

Sea Level Change - Melting Sea Ice

One of the greatest threats to the environment from Global Warming is the effect that an increased global temperature will have on sea level. Many scientists believe that low lying countries, such as Bangladesh will be flooded because of an increase in the Earth's sea level as a result of melting ice.

This activity looks at what effect melting sea ice, or icebergs will have on the sea level. In Melting Sheet Ice , you will investigate what effect melting land ice will have on the sea level.

Materials

Large bowl
Ice cubes
Water

Method

1. Place the ice cubes in bottom of the bowl and place the bowl out into the sun light
2. Carefully fill the bowl with water until the water is level with the top of the bowl
3. Note the amount of ice floating in the bowl
4. Check the water level and the amount of ice remaining every ten minutes throughout the session

Results and Discussion

Record your observations of the water level and the amount of ice remaining in the bowl in the table below:

	Start	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.
Water Level							
Amount of Ice							

1. Did the water level in the bowl change as the ice melted? . . . .

2. How can you explain your observation in question 1? . . . .

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After you have completed the Melting Sheet Ice activity, complete the following question:

1. Will melting sea ice or melting sheet ice have the greatest effect on the sea level? Why?

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Sea Level Change - Melting Sheet Ice

All of the world's ice can be divided into two different types: Sea Ice (Icebergs) and Sheet Ice (ice on land). Both types of ice are at risk of melting if there is an increase in the average global temperature of the Earth, but they have very different effects on the global sea level.

This activity looks at what effect melting sheet ice, or land ice will have on the sea level. In Melting Sea Ice activity, you will investigate what effect melting sea ice will have on the sea level.

Materials

Large bowl
Flat piece of wood
Ruler
Ice cubes
Water

Method

1. On your block of wood, mark out the compass points around the four edges of the block.
2. Along the N-S edge, draw or score lines every 2 mm so that you can measure the water level.
3. On the E-W face, mark lines every 1 cm.
4. Carefully fill the bowl with water until the water is about 2.5 cm from the top of the bowl.
5. Place the wood in the bowl and place the bowl out into the sun light.
6. Put 1 to 2 blocks of ice on the Northern most edge of the block of wood.
7. Note the level of water on the North and South edges of the block.
8. Re-check the water level and the amount of ice remaining every ten minutes throughout the session

Results and Discussion

Record your observations of the water level on the Northern and Southern edges of the block of wood in the table below:

	Start	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.
Water Level							
North Edge							
South Edge							

1. Did the water level in the bowl change as the ice melted? . . . .

2. How can you explain your observation in question 1? . . . .

After you have completed the Melting Sheet Ice activity, complete the following question:

1. Suggest some reasons why the melting of the two different ice types have such different effects on the sea level.

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Climate Change & Greenhouse Gas Emissions

This section of the resource package includes 2 activities designed to increase the students understanding of the link between increased carbon dioxide in the atmosphere and global warming as well as quantifying personal carbon dioxide emissions from electricity consumption.

It should be noted that carbon dioxide is not the only greenhouse gas, which includes a variety of hydrocarbons, such as methane, but also other gaseouss environmental pollutants, such as chlorofluorocarbons and ozone. To avoid confusion with the equally concerning, but unrelated issue of thining of atmospheric ozone over the polar regions, only carbon dioxide emissions are discussed.

Carbon Dioxide: You're getting warmer!

Carbon dioxide is the most important of the Greenhouse Gases, or those gases which contribute to the Greenhouse Effect, even though it only makes up about 0.035% of all of the gases in the atmosphere! Carbon dioxide (CO_2) is one of the gases that scientist believe is contributing to Global Warming.

One way of determining how much carbon dioxide has been in the atmosphere in the past is by examining how much carbon dioxide has been preserved in the annual layers of the ice of polar regions, such as Antarctica and Greenland. The ice cores from the Vostok station (a Soviet base in Antarctica) show us a snap shot of the climatic variations of the last 160 000 years. Using these ice cores, we can also determine the average temperature of the air when the snow fell, by examining the concentration of deuterium, a heavy isotope of hydrogen in the ice core.

Materials

Atmospheric carbon dioxide concentration data
Graph paper

Method

1. Using the Atmospheric carbon dioxide concentration data, plot a graph of year versus concentration of carbon dioxide on some graph paper with the concentration along the left hand side.
2. On the same graph, plot a graph of the year versus the average global temperature.

Results and Discussion

1. What can you see happening to the level of carbon dioxide in the atmosphere since the Industrial Revolution in the late 1700's?

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2. What does your graph of the average global temperature tell you about what has been happening to the temperature of the Earth since the industrial revolution?

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3. Unfortunately, scientists cannot predict the future, so we cannot be sure if the slight increases in the average global temperature are due to global warming. What other factors could contribute to a change in the average global temperature of the Earth?

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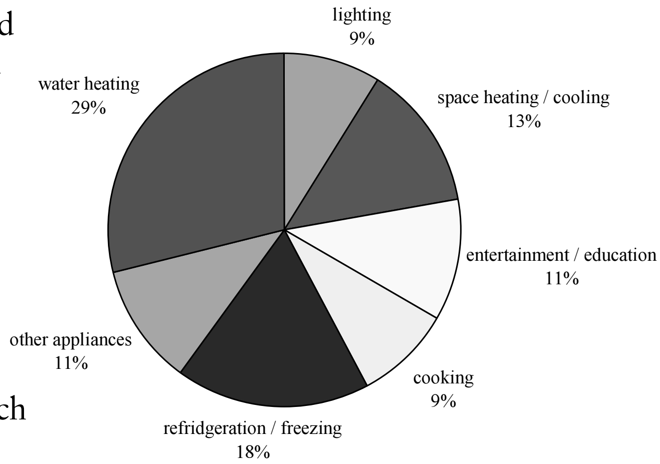
Carbon Dioxide Concentration Data

Year	CO_2 (ppmv)	Ave. Global Temperature (°C)
1740	280	
1760	280	
1820	285	
1850	290	
1890	295	14.6
1915	300	15.0
1930	305	15.0
1950	310	14.9
1960	317	15.0
1965	315	14.9
1970	325	15.0
1975	330	14.9
1980	338.5	15.2
1985	350	15.1
1990	353	15.4

How much CO_2 do I produce?

The average Australian household produces around 8 tonnes of greenhouse gases every year from electricity consumption alone. This accounts for about 10% of Australia's total emissions.



The vast majority of the greenhouse emissions from electricity is due to the heating of water for showers as well as washing clothes and dishes.

Using the energy audit overleaf you can calculate your home electricity use and determine how much carbon dioxide your family produces each year.

Materials

Energy Audit Worksheet
Pen
Calculator

Method

1. Estimate how many hours per day each of the electrical appliances are turned on and record these estimates in the table. If you have more than one of appliance operating at a time, work out the total number of hours for that appliance and record that number in the table. For example, if you have four lights on each day for 6 hours each, then there are (6x4) 24 hours of lighting per day in your home. For appliances which are used only a few hours per week, like washing machines, estimate the per day use by dividing the number of hours per week by 7.

2. Calculate the number of kilowatt hours (kWh) per day for each of the appliances by multiplying the kiloWatts by the hours per day. Don't forget to convert the Watts to kiloWatts.

3. Calculate your total electricity usage per day by adding up all of the totals for each of the appliances.

4. Your household's greenhouse gas emissions in kg are equal to the number of kiloWatt hours of electricity your house consumes each day.

5. Calculate the percentages of the total for each of the different groups of appliances and compare your graph to the *average* Australian houshold and to other people in your class.

Results

Electrical Appliance	Wattage (W)	hours per day	kwh per day
Incandescent globes	60		
CFL Globes	15		
Flourescent lights	18		
TV	150		
Computer	150		
Video	25		
Radio	20		
Stereo	75		
Electric heater	2000		
Air conditioner	2000		
Ceiling fan	90		
Portable Fan	60		
Family Fridge	400		
Extra Freezer	400		
Bar Fridge	250		
Pool pump	1500		
Microwave oven	750		
Water heating	3600		
Electric oven / cooktop	1000		
Toaster	1000		
Kettle	2000		
Washing Machine	600		
Clothes Dryer	4000		
Iron	1000		
		Total Electricity Used	

Discussion

Our household consumes_______kWh of electricity each day which is equivalent to _______kg of greenhouse gases every day.

Carbon dioxide emission by catergory
Calculate your family's emissions in each of the following catergories (in kg and as a percentage). Using the information in this table, graph your results.

Category	kg of carbon dioxide	% of total emissions
Lighting		
Refrigeration		
Space Heating / Cooling		
Cooking		
Water heating		
Other appliances		

1. How did your percentages of total emission compare to the percentages for the average household? If they were different, how could you explain your differences?

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2. Compare your emission totals to others in the class. Is your family Green (produce only small amounts of gases) or Grey (produce large amounts of greenhouse gases) compared to the rest of the class?

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3. If Australia is to reduce its Greenhouse Gas emissions by 30% one suggestion is to limit each individuals emissions by this amount. Under this system, how many tonnes of Greenhouse Gases will your family be allowed to produce?

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4. List at least one example in each of the categories of Greenhouse Gas sources where you and your familycould reduce Greenhouse Gas emissions.

Carbon Dioxide Sources (percentage of total by mass)

Water heating . . . .

Lighting . . . .

Refrigeration . . . .

Heating . . . .

Cooking . . . .

Other appliances . . . .

Making Changes

In this section, there are 2 actvities on choosing energy efficient options which will help to reduce carbon dioxide emissions. The final part of the section looks at developing an emission reduction strategy for the home. You may also like to produce one for your school or classroom.

One of the easiest ways to reduce your carbon dioxide emissions is to install Compact Fluorescent Lamps (CFLs) instead of the traditional incandescent, or tungsten filament globes.

CFLs are mini versions of the fluorescent lights that are used in shops and classrooms, which have screw or pin fittings so that they can fit inside your regular light fittings. But do they really make a difference

Incandescent globes last on average 1000 hours and cheaper versions cost about 70c. However, CFLs have a lifetime of around 8000 hours but they cost around $20 per light but only use a small proportion of electricity to give the same brightness as an incandescent globe (a 75W incandescent globe can be replaced by a 15W CFL for the same brightness!) .

Materials

Calculator
Pencil or Pen

Method

1. Using the information contained on this sheet, calculate the amount of electricity consumed (in kWh) in operating a CFL and an incandescent globe for 8000 hours. Record your result in the table.

2. Using the results you obtained in the first question and the information on this sheet, calculate the amount of carbon dioxide that is released into the atmosphere when you operate the CFL over its entire life. Record your result in the table.

3. Calculate the amount of carbon dioxide that is released into the atmosphere when you operate an incandescent globe over the same time span. Record your result in the table.

Hints

- Different fossil fuels produce different amounts of carbon dioxide per unit. Here is a list of common fossil fuels with the amount of carbon dioxide they produce:

Electricity	1.0kg per kilowatt hour (kWh)
Gas	0.06kg per Mega Joule (MJ)
Petrol	2.5kg per Litre (L)
LPG	1.7kg per Litre (L)
Diesel	2.9kg per Litre (L)

Results and Discussion

Fill in the table when you have calculated the amounts of electricity and carbon dioxide produced by the CFLs and incandescent globes over 8000 hours.

	Amount of Electricity (kWh)	Amount of CO_2 (kg)
CFL		
Incandescent		

1. How many kilowatt hours of electricity do you save by converting to CFLs?

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2. If each kilowatt hour costs you 12.29c, how much money do you save by converting to CFLs?

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3. Is the saving you make in electricity cost by switching to CFLs enough to offset the initial cost of the globe?

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4. By replacing all of your incandescent globes to CFLs, how many kilograms (kg) of carbon dioxide are you saving from going into the atmosphere?

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5. Many countries around the world are proposing to reduce the amount of carbon dioxide released into the atmosphere by 60% by the year 2050. Can you make a 60% reduction in your emissions due to lighting by switching to CFLs? Hint: Calculate what percentage of the incandescent emissions the CFLs produce.

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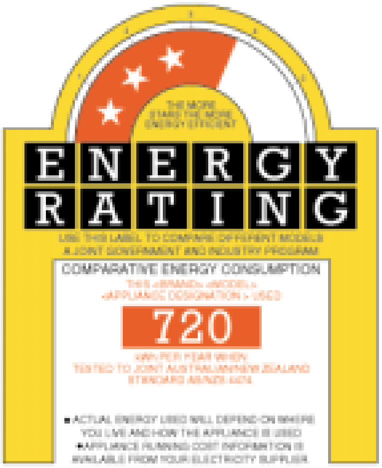
First introduced in 1986, Energy Rating Labels let people to compare the energy efficiency of different brands of whitegoods and air conditioners when they are buying these appliances. In most states of Australia, it is compuslory to display the star rating labels on refrigerators, freezer, clothes washers, clothes dryers, dishwashers and room air conditioners. These appliances contribute approximately 40% of greenhouse gas emissions from electricity consumption in Australian houses.

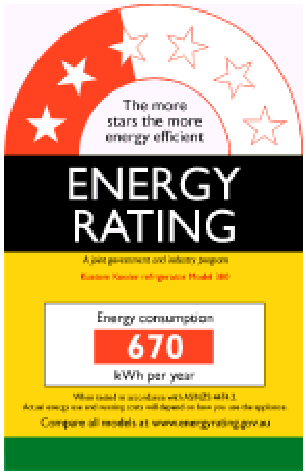
Energy Rating Labels have two main features:



Energy Rating Label
1986 - 2000

A Star Rating gives a quick comparative assessment of the model's energy efficiency. The more stars the more efficient.

Comparative energy consumption data (kilowatt hours / year) provides an estimate of the annual energy consumption of the appliance based on the tested energy consumption and information about the typical use of the appliance in the home.



Energy Rating Label
2000

In the year 2000, a new energy rating scheme was introduced as many companies had developed products with a rating of 6 stars. The new rating system is much tougher and products with a 6 star rating in the past may only be 3 or 4 stars now.

The Australian Greenhouse Office has established a website on the energy rating scheme, which includes a database of appliances as well as information on their rating and energy consumption. This website is located at http://www.energyrating.gov.au/

Your Task

Using the information as this site, determine the most efficient appliances below and complete the table:

500L Frost Free 2 door Fridge/Freezer (type 5)
5 -6 kg Washing Machine
5 - 6 Kg Clothes Dryer
Dishwasher
2-3kW Reverse Cycle Air Conditioner

Appliance	Brand	Model	Star Rating	Star Rating Index (SRI)	Energy Consumption (kWh/y)	Yearly Running Cost
Fridge / Freezer						
Washing Machine						
Clothes Dryer						
Dishwasher						
Air conditioner						

Questions to Thinkabout

What factors did you consider when you were selecting each of the appliances?

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In general, what types of washing machines are the most efficient?

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The energy rating scheme for air conditioners is slightly different to the scheme for the other appliances. What is the major difference and explain why there is a difference?

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Making Changes

Now that you have seen that you can reduce your Greenhouse Gas emissions by replacing your light globes to CFLs and selecting energy efficient appliances without any compromise to your standard of living, draft your own Greenhouse Gas reduction strategy so that you can reduce your emissions from electricity to at least two thirds of what they are today.