BRIGHT HORIZONS™

Year 8 Students

HORIZON POWER

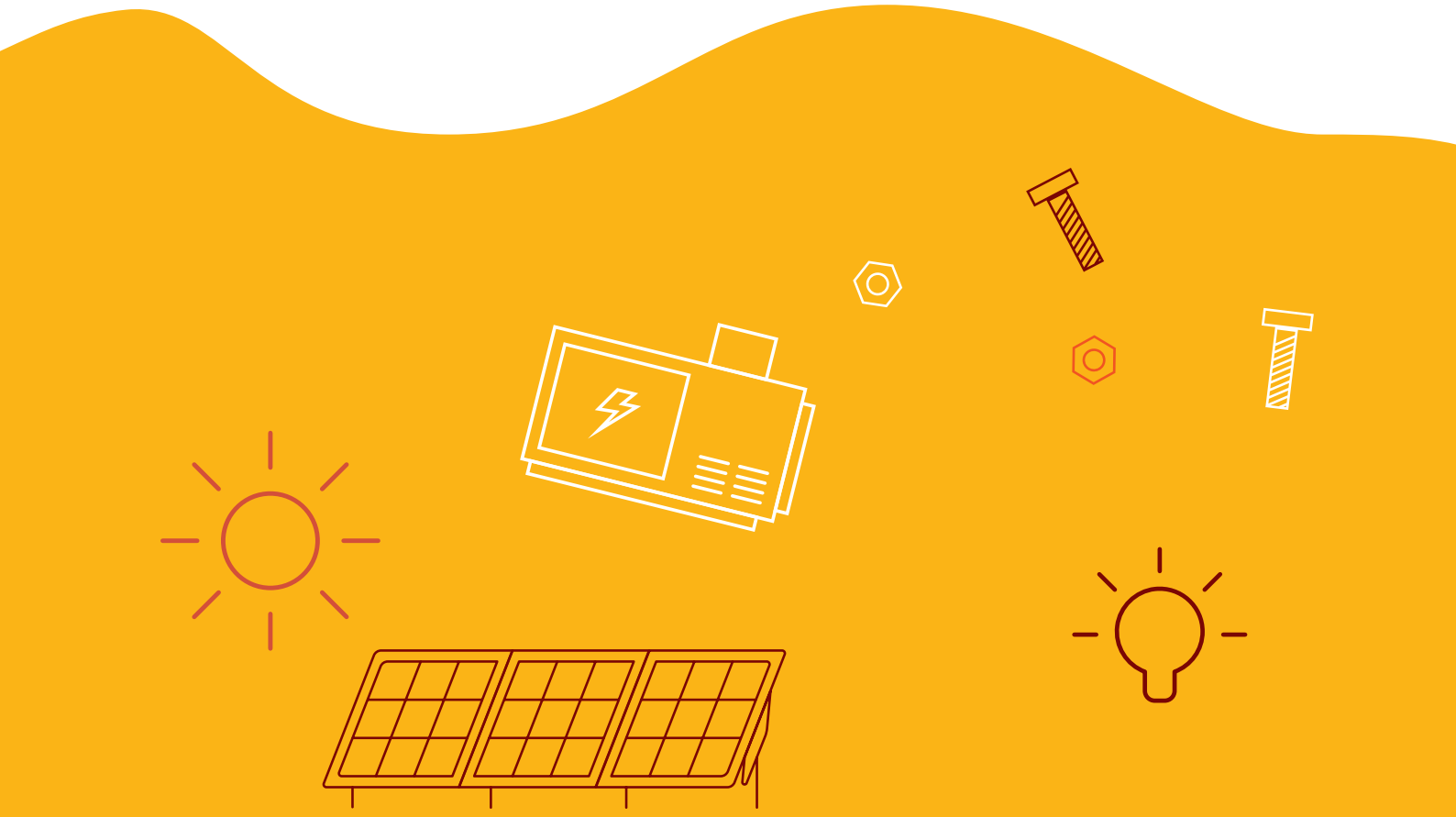
STAWA
SCIENCE TEACHERS' ASSOCIATION OF WESTERN AUSTRALIA

Name _____

Horizon Power acknowledges the traditional custodians throughout Western Australia and their continuing connection to the land, waters and community. We pay our respects to all members of the Aboriginal communities and their cultures; and to Elders both past, present and emerging.

Acknowledgement

The following teaching and learning materials have been modelled on the STEM Learning Project resources template. The STEM Learning Project resources were produced by a consortium of STAWA, MAWA, ECAWA and Scitech under contract to the Education Department of WA.



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Activities

Activity 1 Research

Rooftop solar PV (photovoltaic) panels, batteries and appliance power needs

Research rooftop solar PV panels and battery storage for the provision of household electrical energy needs.

Activity 2 Investigate

Investigating factors affecting the power output of solar panels

Conduct investigations into conditions that affect the electrical power output of solar panels.

Activity 3 Imagine & Create

Project 1: What a Car!

Explore the design process and apply it to designing and building a model solar car.

Project 2: Model Solar Car Body

Explore the design process and apply it to designing and building a body structure for a model solar car. Make it more attractive and marketable as a functioning model.

Activity 4 Evaluate & Communicate

What's the Verdict?

Demonstrate, test and evaluate the solar car from your chosen project. Compare the value of different designs. Evaluate your results and present their solution to an audience using multimedia.

Activity 1
Research

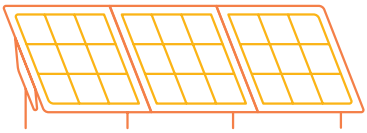
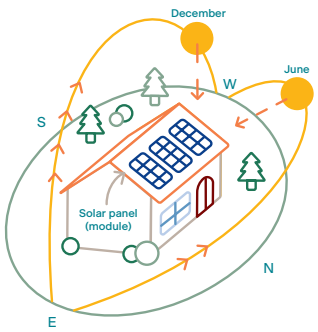
Rooftop solar PV panels, batteries and appliance power needs

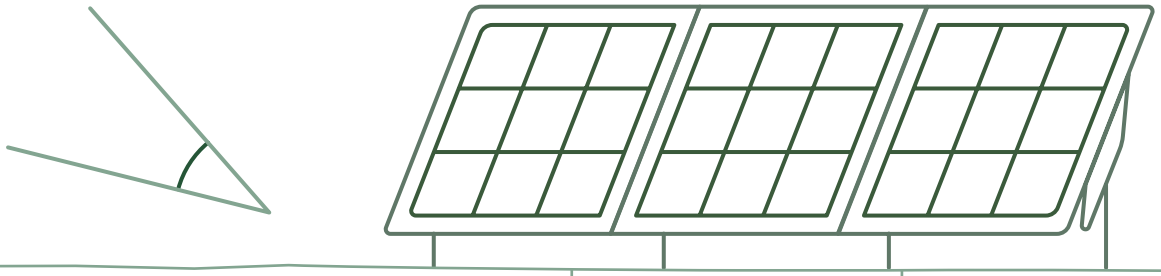
Research rooftop solar PV panels and battery storage for the provision of household electrical energy needs.

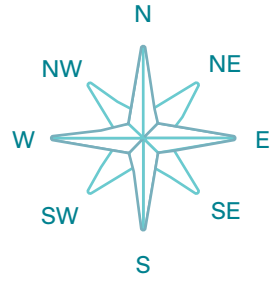
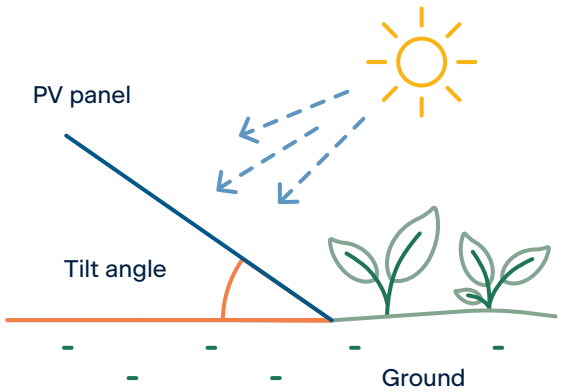
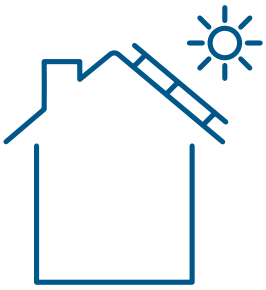
Part 1: My school's rooftop solar PV system

Working in groups, research the following aspects of your current (or future) school's Horizon Power solar PV system. Present your findings and understanding as a set of plans/drawings.

Research the set of questions in the table that matches your school.

	YES	NO
	Our school has solar electricity Research the following questions if your school has solar PV panels installed	Our school does not have solar electricity Research the following questions if your school does not have solar PV panels installed
1 	What do solar PV panels do?	What do solar PV panels do?
2 	Where have the solar PV panels been installed? Record the position of any large trees.	Where would you recommend the solar PV panels been installed? Record the position of any large trees.



		YES	NO
3		In what direction or directions are the solar panels facing? Should the solar panels be facing? Explain your recommendation.	In what direction or directions would you recommend the solar panels be facing? Explain your recommendation.
4		Are the solar panels • tilted on an angle? • at an angle of approximately 15°, 20° or 30°? • flat on the roof using its slope (angle) or on a frame? Explain why you think the solar panels have been placed on a tilt.	What tilt angle would you recommended installing solar panels in your area? Explain your recommendation.
5		Explain why the solar PV panels have been installed in the • location, • direction and • angle that they have?	Explain why solar PV panels should be installed according to your recommended • location, • direction and • angle?

Activity 1

My school's rooftop solar panel plans

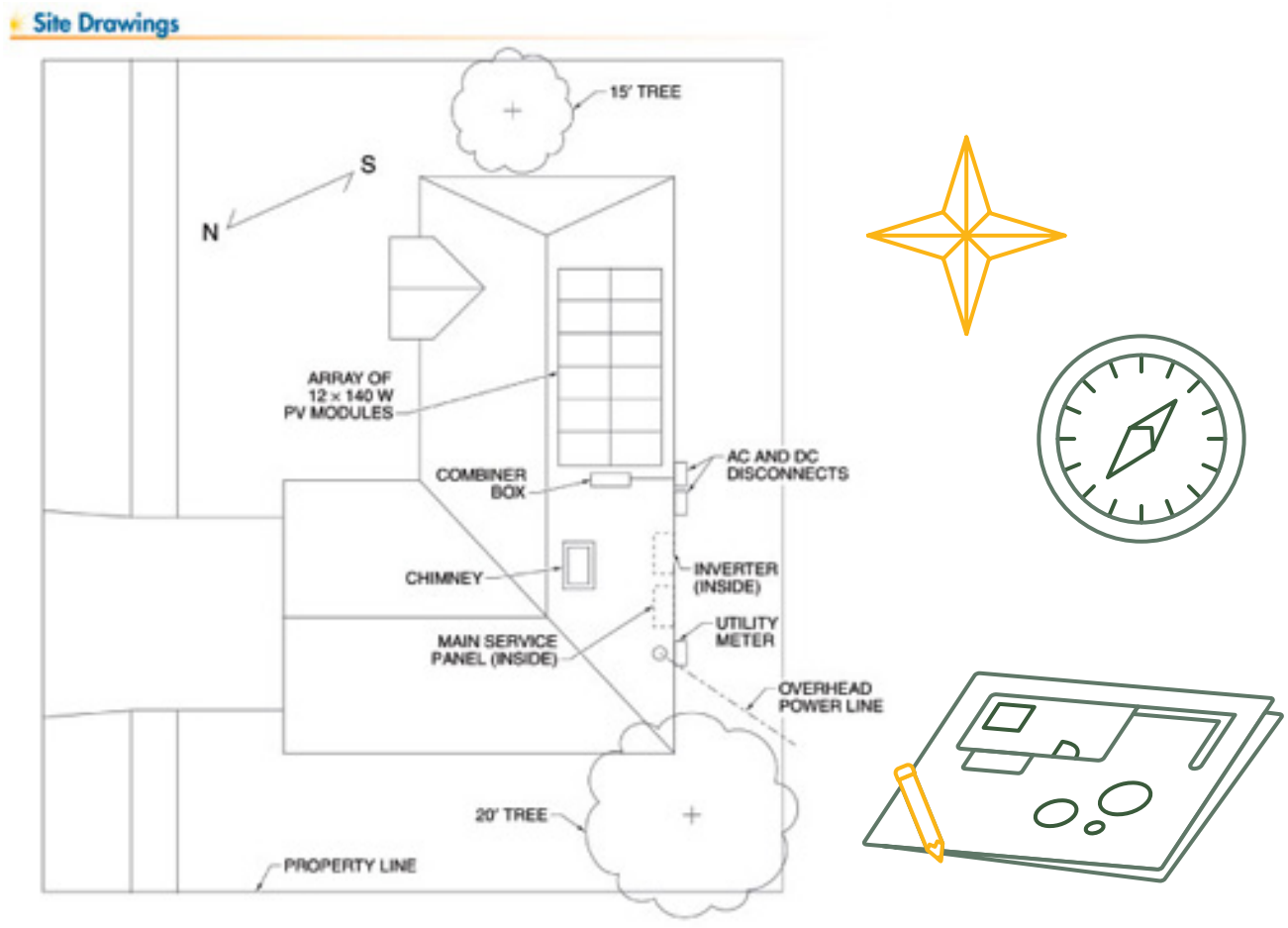
Present your findings and understanding of a school solar PV system as a set of plans or drawings. If you can do it to scale, excellent, otherwise create a sketch with approximate measurements. This can be done on either an A3 or an A4 sheet of paper. Your teacher will decide if you are to do an individual plan or a group plan.

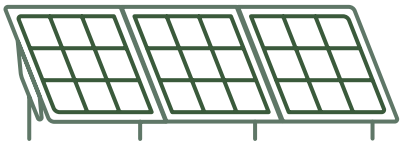
Title your plan and label all parts. The following should be included in your plan:

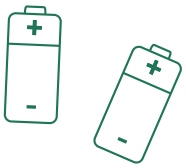
- compass bearings (North, South, East and West)
- locations of building on which the rooftop solar PV panels will be/are installed
- location of large trees
- measurements (estimates or actual)
- a separate diagram showing the angle of the panel
- any other important items.

At the bottom or back of your plan write a purpose for your plan by completing the following:

This plan can be used to identify things that need to be considered when installing rooftop solar PV panels, including (write a dot point list of all the things shown in your plan).







Part 2: Why rooftop solar PV systems and batteries?

Work together collaboratively to research sustainability and solar energy and to record information about *rooftop solar PV panels, systems and batteries*.

Hot Potato

In hot potato, you will be working in your groups. Each group has a sheet of paper to write a different topic or a question at the top of the page. The questions and topic are listed below.

1. **Define sustainable resource and list sustainable methods of generating electricity.**
2. **What is a solar photovoltaic cell (PV cell) and how does it work?**
3. **What conditions effect the power output of a solar panel?**
4. **What is a battery and why are they used with rooftop solar systems to supply household electricity?**
5. **Friction often produces unwanted heat. Give examples where friction is useful and where friction is a problem when designing and driving motor cars.**

You will be given a short length of time to brainstorm and write down all the key points you can think of that are related to the topic on your sheet. You will then be asked to pass your paper on to the next person. Each time you receive a new topic, read what is already written and add your statements. Do not repeat key points. The paper keeps getting passed around until the sheet you started with arrives back with you.

Part 2: What are the power needs of household appliances?

Working in groups or on your own complete the following research worksheet on aspects of energy, electrical power and household and appliance power needs.

1. Types of Energy

Gravitational Potential Energy is the energy a body has because of its position above the ground. List five other forms of energy. Compare your list with others in your group.

Gravitational Potential Energy		

Activity 1

2. Energy Transfer and Transformation

Energy transfer is the movement of energy from one place to another.
Energy transformation is when energy changes from one form to another.

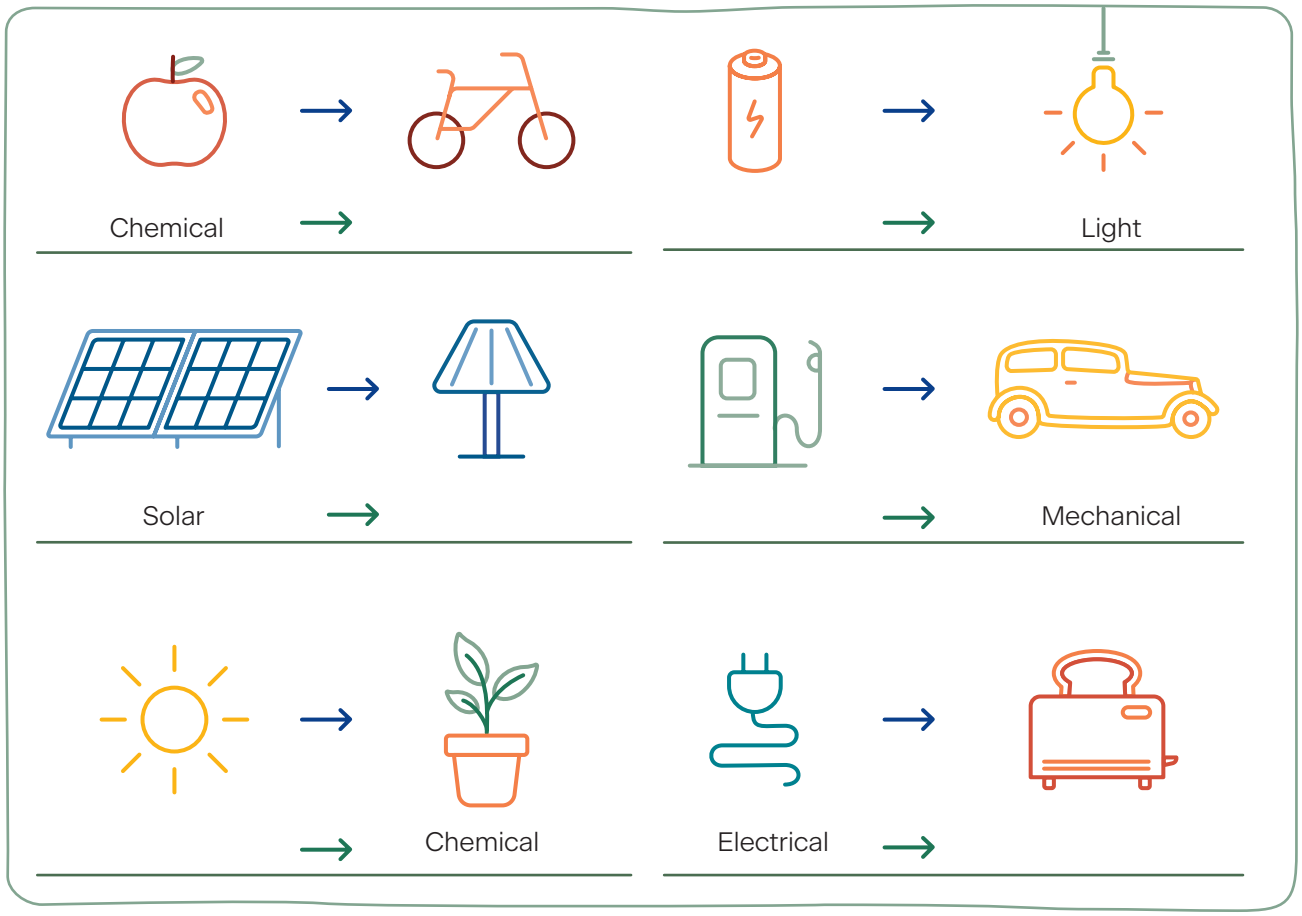
Electricity can be transferred (moved) through wires from a power station to your house. Electricity also flows (moves) through cables from a power socket to a device like a TV. Note the energy starts as electrical energy moves from one place to another and arrives as electrical energy - it has been transferred.

When energy changes form it is said to be transformed. Devices like TVs, phones, motor cars, solar panels and our bodies are all energy convertors. For example, once electrical energy arrives at a device like a TV it is converted by the TV into other forms of energy including light, sound and heat energy. The electrical energy is transformed into the other forms of energy by the TV, energy convertor.

Exercises:

Diagrams can be used to show how energy is transformed from one form to another. An energy flow diagram uses arrows to show the energy changes. Arrows starts at one energy form and points to the new energy form showing the energy transfer and how it has been transformed. The diagrams below are examples of energy flow diagrams.

Complete the diagrams showing how one form of energy can be converted to a different form of energy.

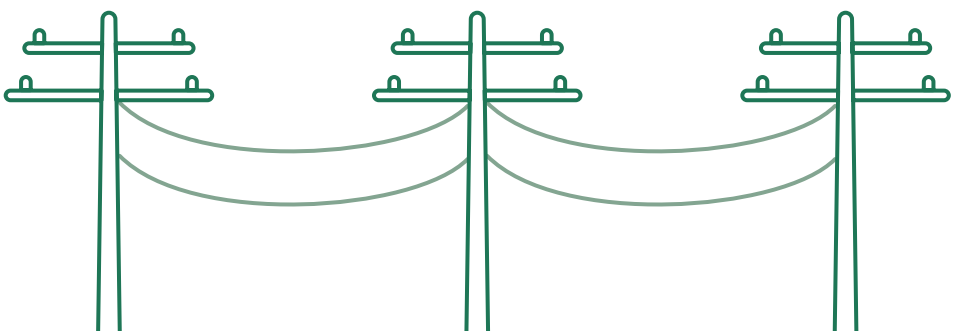


2. The energy diagrams in question 1 are very simple flow diagrams and show the main form of energy produced. No device is 100% efficient so other waste forms of energy are produced. The more waste energy produced the less efficient the device. On the diagrams, label other waste energies that could be produced.

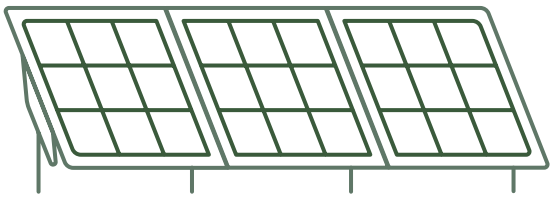
3. Solar Energy

The original source of **energy** on earth is the **sun**. The sun's energy is transferred from the sun to the earth as light energy. Plants transform light energy from the sun into chemical energy stored in the food they make. Plants use the food energy they make to grow and reproduce. Animals rely on plants and other animals for their food. Our energy comes from the food we eat.

Draw an energy flow diagram to show how we get our energy from the sun.



Activity 1



4. Energy, Work and Power

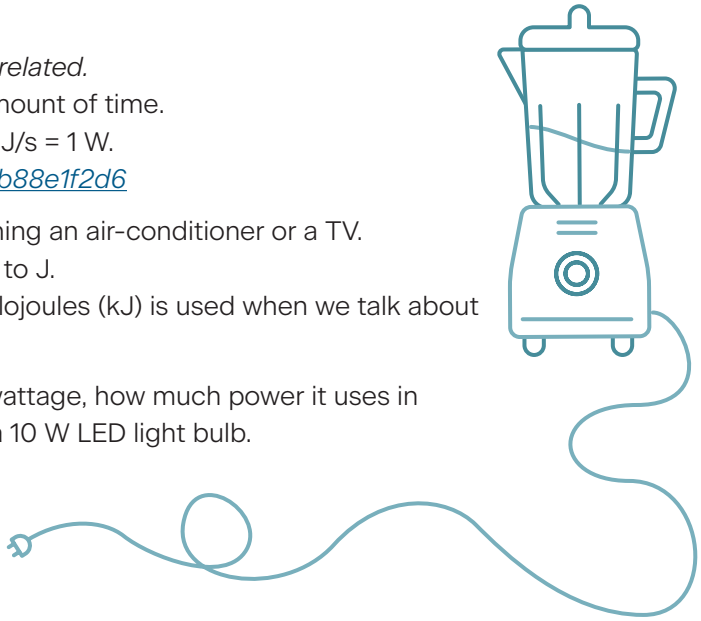
Energy is the ability to do work.

Your body needs energy so that you have the ability to run around the oval at school. Running is doing work.

We also use electricity. Electricity is electrical energy. We put electrical energy to work when we switch on a light or a toaster.

Most people's electricity is made in **power** stations and transmitted through the grid of power lines to our homes, where we put it to **work**. More remote communities get their electrical energy from solar PV panels.

What is power?



Energy and Power are not the same, but they are related.
Power is the amount of energy used in a given amount of time.
Power has the unit's joules per second or watts. 1 J/s = 1 W.
Watch the video: *https://vimeo.com/548221149/8b88e1f2d6*

Electrical energy is needed to do the work of running an air-conditioner or a TV.
The basic unit of energy is the Joule, abbreviated to J.
A Joule is a small amount of energy, so the unit kilojoules (kJ) is used when we talk about larger amounts of energy. 1,000 J = 1 kJ

Machines and appliances are labelled with their wattage, how much power it uses in watts (W). For example, an 1,800 W hair dryer or a 10 W LED light bulb.

Question

1. Match the word with its definition:

Definition	Match the word to its definition by drawing a line between them
The ability to do work	Watt (W)
The amount of energy used in a given amount of time	Energy
The basic unit of energy	Joule (J)
The original source of energy on earth	Power
The unit of power	Sun

2. Electrical power can be calculated using the equation:

P = V x I

Voltage (V) is measured in volts and has the unit symbol V.

Current (I) is measured in amps and has the unit symbol A.

Power (P) is measured in watts and has the unit symbol W.

Calculate the electrical power output of a

a) solar panel that generates 25 V and 10 A of current.

b) 12 V, 16 A, caravan solar panel

c) fold up solar panel producing 12 V and 11 A

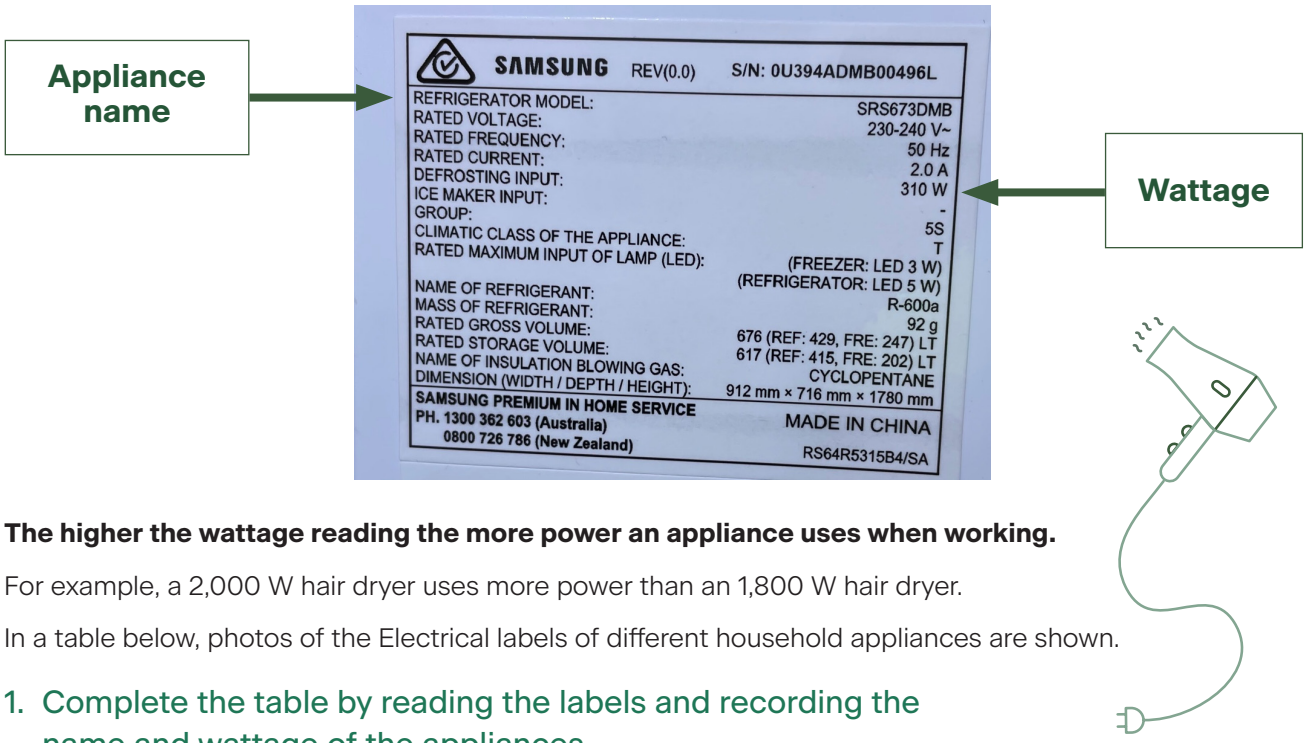
Activity 1

5. Appliance labels

Machines and appliances are labelled with their wattage, how much power it uses in watts (W). For example, an 1,800 W hair dryer or a 10 W LED light bulb.

For most appliances this information will be on a label similar to that in Figure 1.

Figure 1: Room Heater model and electrical label with its name and wattage pointed out



The higher the wattage reading the more power an appliance uses when working.

For example, a 2,000 W hair dryer uses more power than an 1,800 W hair dryer.

In a table below, photos of the Electrical labels of different household appliances are shown.

1. Complete the table by reading the labels and recording the name and wattage of the appliances.

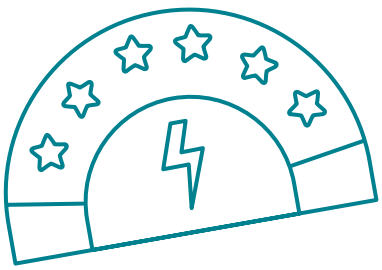
Appliance	Appliance Name	Wattage
	Television	
		

Appliance	Appliance Name	Power
		
		
	**Refrigerator**	

2. Remember the higher the wattage reading the more power an appliance uses when it is working.

   a) Which appliance in your table uses the most power? _____

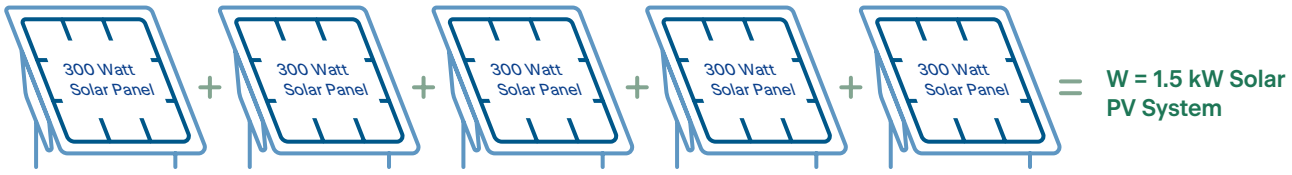
   b) Which appliance in your table uses the least power? _____



Activity 1

3. Can a 6.0 kW rooftop solar PV system run all of the appliances listed in the table at the same time? Show your working out.

4. The diagram below shows that a 1.5 kW solar PV system could be created using five (5) 300 W solar panels. How many 300 kW solar panels would you need to create a 6.0 kW Solar PV system?



6. How to read solar panel specifications

Look at the back of your mini solar panels. You will see a number of values.

Voc is the open circuit voltage. This is the number of volts the solar panel outputs when it is not connected in a circuit, the switch is off. To measure the Voc of a panel, simply connect a multimeter (set to read volts) across the plus (red) and minus (black) leads.

Isc is the short circuit current. This is the current (number of amps) the solar panel produces when not connected in a circuit. If you measure the current (amps) across the plus and minus leads, with a multimeter you will be reading Isc. This is the highest current the solar panels will produce under standard test conditions.

Vm is the voltage when the power output is the greatest. It is the actual voltage you want to see when it is connected in a circuit with the solar equipment.

Pm is the optimal solar panel power output. It is where the combination of the volts and amps results in the highest power output, wattage (Volts x Amps = Watts).

The wattage that a solar panel is listed at is the Pm where Pm = Vm x Im (see the label above).

Note: All solar panels are tested to the same standard test conditions (STC). Conditions include a cell temperature of 25° celsius and light intensity of 1000 watts per square meter.

Experiment: My solar panels.

Measure the Voc and Isc of your solar panels. Record your results in a table. Explain any differences that you might have observed between the label values and your measured values.

	Label Values	Measured Values
Voc (open circuit voltage)		
Isc (short circuit current)		

Part 3: Reflection and journaling

In your learning journals or portfolio review your definitions of sustainability and electrical power, describe examples of renewable and non-renewable energy resources and reflect on your understanding of:

- solar panels and how they work
- how to maximise the power output of rooftop solar panels,
- the energy rating label and
- appliance labels.

Activity 2

Investigate

Investigating factors affecting the power output of solar panels

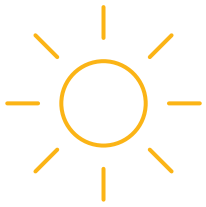
Conduct investigations into conditions that affect the electrical power output of solar panels.

Part 1: Designing an Investigation

Background Learning

Terms:

- testable question
- variables
  - independent
  - dependent
  - controlled
- fair test
- observations
- results



You have researched solar panels. To answer questions that you might have, as a scientist, you will need to carry out investigations.

How do scientists design their investigations?

Testable Question

Scientists first write a *Testable Question* - a question that can be answered by designing and conducting an experiment.

Testable questions are about changing one thing to see what the effect is on another thing.

For example:

If I increase the weight of a ball, will it affect how far I can throw it?

How do I write a testable question? The easiest way is to use one of the following formats.

- If I change _____, will it affect _____?
- Does changing _____ affect _____?
- How does changing _____ affect _____?

The two blank parts in a Testable Question have special names. The first part is the independent variable, while the second part is the dependent variable. The independent variable is what you change (cause). The dependent variable is what changes (effect).

The dependent variable is also the variable that is being measured in your experiment as a result of the change you make using the independent variable.

The Testable Question format now becomes:

- If I change (independent variable), will it affect (dependent variable)?
- Does changing (independent variable), affect (dependent variable)?
- How does changing (independent variable), affect (dependant variable)?

Identifying the variables in the example:

If I increase the weight of a ball, will it affect how far I can throw it?

The independent variable in the example is the weight of a ball.

The dependent variable is how far I can throw it.

Fair Test

A good experiment has only one independent variable!

When investigating the answer to a scientific question, a fair test is used. A fair test is a test that controls all variables except the one independent variable. Only changing one variable allows you to know that no other variable has affected the results of the test (investigation).

The mnemonic, Cows Moo Softly, will help you remember how to conduct a fair test:

- **C**ows - **C**hange one thing (independent variable)
- **M**oo - **M**easure something (dependent variable)
- **S**oftly - Keep everything else the **s**ame (controlled variable)

Once you have identified your independent and dependent variables you should keep all other variables that could affect your experiment, constant. These variables are called controlled variables.

Activity 2

Controlled variables, the things to keep the same.

In the example “If I increase the weight of a ball, will it affect how far I can throw it?” controlled variables would include:

The size of the ball, the person throwing the ball, the person measuring (how far the ball is thrown and the weight of the ball) and the instrument used to do the measuring.

Some investigations require you to create something to help make it a fair test. In this ball throwing experiment, you would need to create a way to increase the weight of the ball without changing its shape or size. For example, you might choose a ball that can be filled with water or different balls of the same size and grip with different weights.

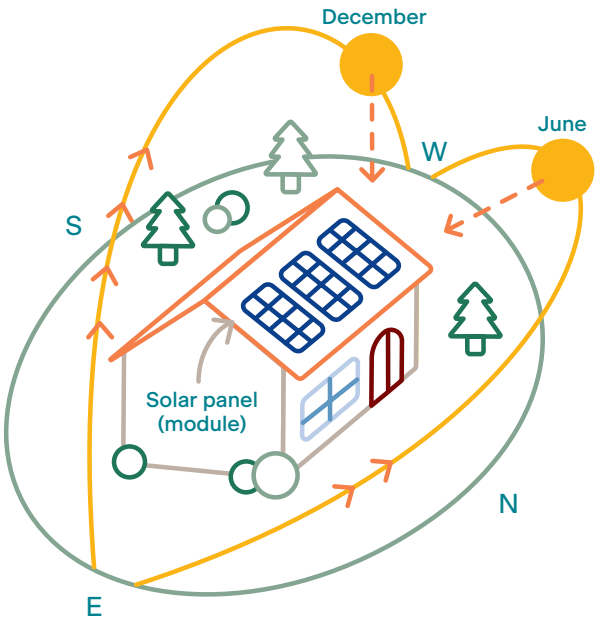
Making observations and recording results?

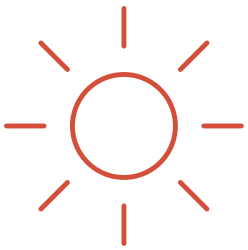
When conducting an investigation, you should make and record observations of what is happening. You need to record all measurements and changes to the independent and dependent variables. In most investigations results can be recorded in a table. Don’t forget to include units for measurements made. Tables should be prepared before you conduct your investigation.

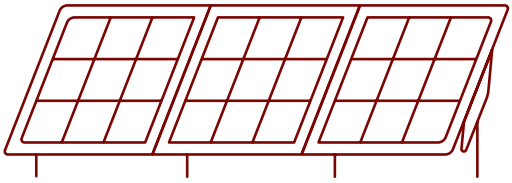
Preparing your solar panel experiment for Part 2.

Rooftop solar panels need sunlight to produce electricity.

You are going to work in your groups to write testable questions to investigate factors that affect the electrical power output of solar panels.







Step 1:

On a large sheet of paper draw a table, similar to the one below.
Use the table to record your groups ideas.

Factors that affect the electrical power output of solar panels	Independent Variable (Change)	Dependent Variable (Measure)	Testable question	Controlled Variables (Keep the same)

Step 2:

Brainstorm a list of factors that can affect the amount of sunlight falling on a solar panel.

Step 3:

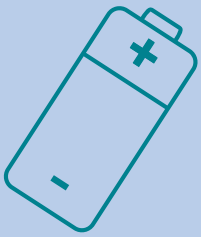
For each factor work together to identify the independent and dependant variables and record them on your sheet.

Step 4:

Work together to write a testable question.

Step 5:

Brainstorm a list of variables that need to be controlled or kept the same.



Activity 2

Part 2: Investigating the electrical power output of solar panels

Introduction

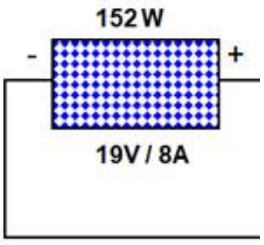
Photovoltaic cells make up solar panels and transform light energy into electrical energy. The electrical output of solar panels can be determined by measuring their voltage (V) output and current (I) output. When multiplied together these measurements give electrical power output in watts.

P = V x I

Voltage (V) is measured in volts and has the unit symbol V.

Current (I) is measured in amps and has the unit symbol A.

Power (P) is measured in watts and has the unit symbol W.



Voltage (V)	19 V
Current (A)	8 A
Power (W) P = V x I	P = 19 V x 8 A = 152 W

Electrical appliances require a certain amount of power to operate, for example, some LED light globes require 6 watts, while a hair dryer might need 1,000 watts.

Purpose

The purpose of this experiment is to investigate variables that affect the electrical power output of solar panels. You brainstormed factors that you thought could affect the electrical power output of solar panels in Part 1 of Activity 2.

List those factors that you would like to investigate, or the one your teacher has asked you to investigate.

Question and prediction

What is your investigation question? Write your testable question below.

What is your prediction?

Planning

Variables

What is your independent variable?

What observations or measurements will you make of your independent variable?

What is your dependent variable?

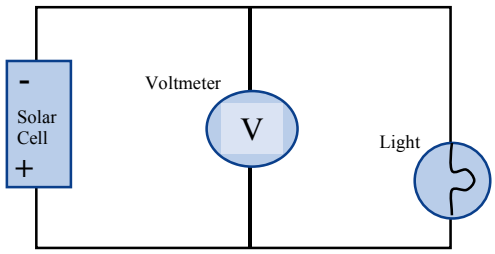
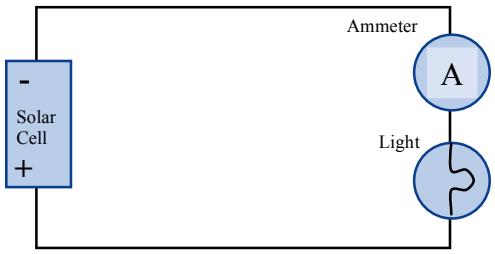
What measurements will you take of your dependent variable?

What are your controlled variables, things you will need to keep the same to make it a fair test?

Activity 2

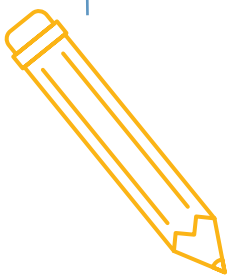
Set up

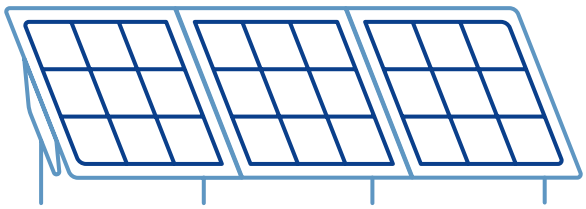
Set up your electrical circuit as shown in the circuit diagrams below. When measuring voltage and current you change the position of the multimeter.

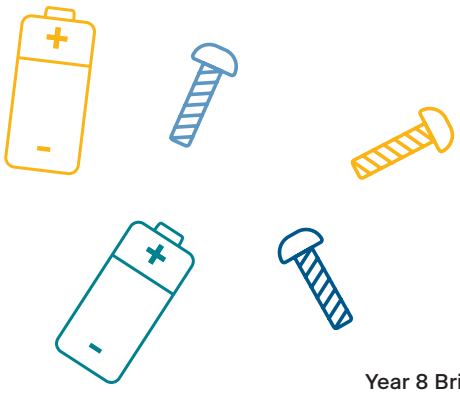
Circuit diagram when testing **voltage.** Voltage is measured in parallel.	Circuit diagram when testing **current.** Current is measured in series.
	

Materials:

In the space below write a list of materials and equipment that you will need:







Safety notes:

- **When outside in the sun _____.**
- **Don't touch the light bulb as it will get _____.**
- **Always turn the multimeter off when not being used, especially when measuring current to avoid blowing its fuse.**
- **Always connect the multimeter in series when measuring current and in parallel when measuring voltage.**

Results

For each of your tests, you will be measuring the electrical output of the solar panel in volts (voltage) and amps (current). Because of the small size of the solar panels the current will be measured in milliamps.

Once you have completed the measurements you will then be able to calculate the power output (P) of the panel. Because the current was measured in milliamps, power (P) will be calculated in milliwatts (mW) using:

Power = Voltage x Current

Units: (mW) = (V) x (mA)

Formula Graphic: P = V x I

Draw a table to record your results.

The results table will need a title and the column headings: name of the independent variable, voltage, current and power. Don't forget to include units.

Activity 2

Analysis and interpretation of results

1. What do your results show about the effect of the independent variable on the electrical output of the solar panels?

2. Which of your results show this?

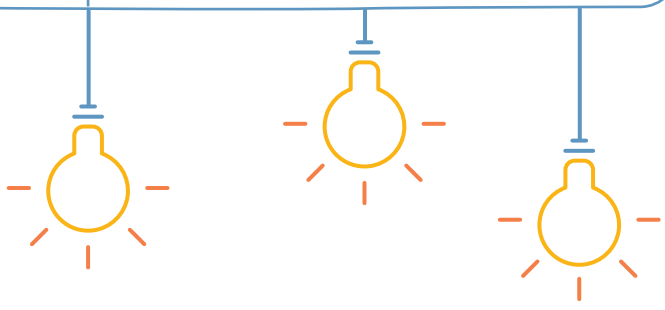
3. Was your prediction correct?

4. Convert the maximum power achieved by your model solar panel to watts (W) where 1 W = 1000 mW (milliwatts).

   Show your calculations and include units:

5. Consider the power required to operate common household appliances. Some examples are shown below:

Appliance	Power Requirement
Laptop computer	50 W
Dishwasher	1200 W
LED lightbulb	7 W
Alarm clock radio	1 W
Electric oven	2200 W
Charge a mobile phone	2W



6. Calculate how many model solar panels are required to generate the power output required to light the LED lightbulb. Show your working and include units.

7. Think about an appliance you use frequently. Calculate how many model solar panels are required to generate the power needed to run this appliance. Show your working and include units.

8. Explain scientifically, how photovoltaic cells (solar panels) transfer and transform light energy into electrical energy to power your appliance.

Evaluation

Think about how you conducted your investigation. How could you have improved your procedure so that there was better control of variables and measurements?

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Activity 3
Imagine & Create

Project 1: What a Car!

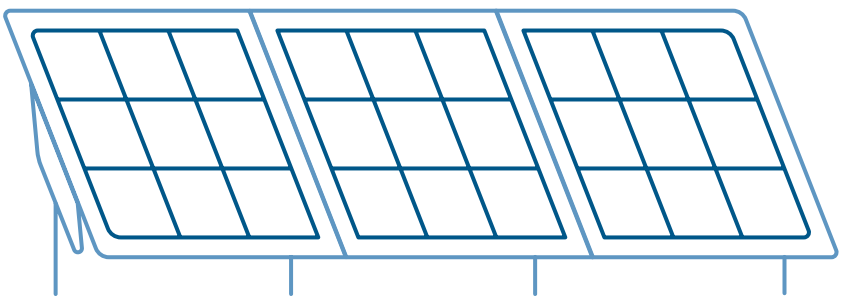
Explore and apply the design process to design, build, test and modify a model solar car to make it as fast as possible.

Background Information

Most of our cars over the last 100 years have been powered by an internal combustion engine using fossil fuels like petrol and diesel. The power comes from the conversion of chemical energy in the fuel to kinetic energy to move the car. Today we are seeing more and more electric cars. An electric vehicle (EV) uses one or more electric motors as the energy source. An electric car for example can be powered with solar panels and batteries. Some EVs can be plugged into mains power or EV charging stations to charge the batteries.

EVs are becoming more important and affordable because of technological developments, an increased focus on renewable energy, climate change and other environmental issues.

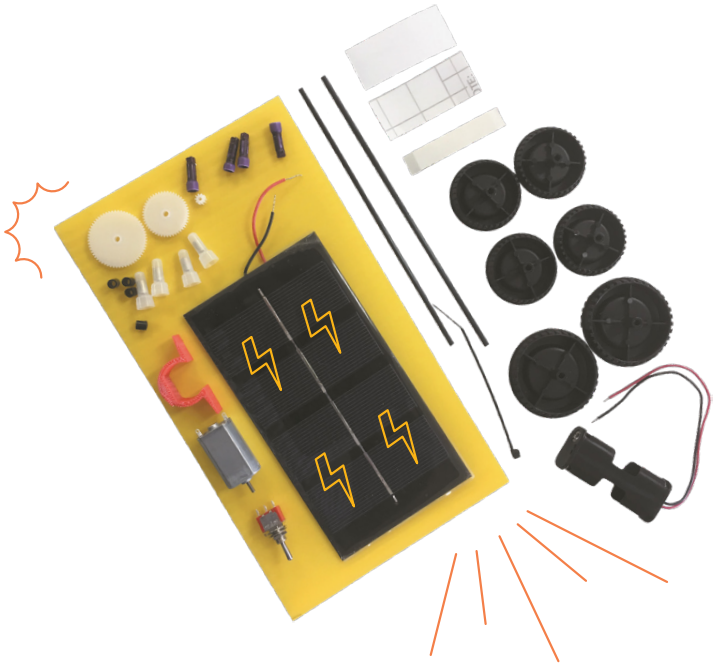
This is one of Horizon Power's Electric Vehicles.
It can travel 450km on a single charge.



Build model solar race car

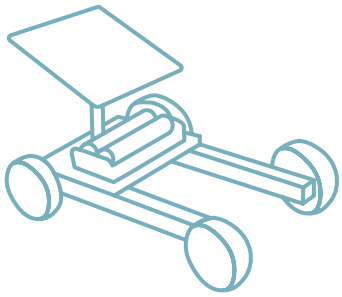
Solar cars are powered by electricity through the use of solar energy. Solar panels are usually attached to the top of the car. Solar PV panels transform light energy from the sun into electrical energy. When building a car of any kind there are many variables to consider.

In your Horizon Power Bright Horizons Energy school pack, you have a model solar car kit. In this activity your job is to make your model go as fast as possible. You are only permitted to use the main components in the kit provided, that is the motor, gears, panel, chassis material and wheels. But you are allowed to choose the best combination of wheels and gears, front or rear wheel drive to make it as fast as possible.



Write down the names of your solar race car team

Activity 3



Design, build, test and modify your model solar car

Development of a design idea before you start building

Choose a starting design for your car

Wheels: I will use _____

_____

Gears: I will use _____

_____

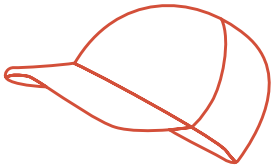
Front or rear wheel drive: _____

Panel angle: I will _____

Include a photograph of your starting model.

Safety notes

- **Wear sun safe clothing including a hat and sunscreen if collecting data in the sun.**
- **Follow all safety instructions when using cutting tools such as scissors.**



Ready, set, build!

Build: Carefully build your model solar car. Follow the instructions and ask your teacher for help if needed.

Materials

- ☐ Bright Horizon's Model Solar Car kit
- ☐ Foam or cardboard (optional).

When testing your car you will need a

- ☐ Stopwatch
- ☐ Tape measure
- ☐ Sunshade paddle
- ☐ Pliers (optional)

Activity 3

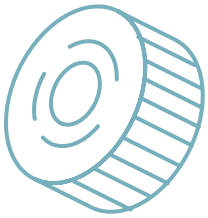
Testing your model solar car

You need to race and test the speed of your model car before you make any modifications. Your first design might be your fastest car.

Record your results in a table similar to the following:

Model Solar Car Modification	Independent Variable	Time (s) for car to travel 20 m				Light intensity (lux)	Rank fastest modification to slowest modification
		Trial 1	Trial 2	Trial 3	Average		
No modifications							
Modification 1							
Modification 2							

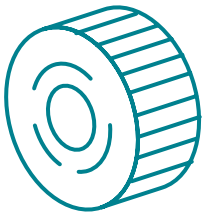
Modifying your model solar car



Variables to Test:

Wheels: Your kit has 6 wheels. This means that you can build your model with three different wheel combinations.

Gears: Your kit has 3 gear wheels. The smallest is a pinion gear that goes onto the motor shaft. This leaves the two larger spur gears for the axel. You can build your model with one of the different spur gears.



Front and rear wheel drive: By changing connections between motor and panel you can change your vehicle between front or rear wheel drive.

Solar panel angle: Use your findings from investigations in Activity 2.

Other possible variables:

To test your car you need a sunny day and a smooth track area. Your track will need open space outside, such as a tennis court or outside basketball court or a wide and long pathway.

Remember for a fair test and for good investigation design test only one variable at a time.

Make sure that you keep all other variables constant.
Test as many variables as possible.

You need to practice using the stopwatch to time your car. You may wish to have a group member stand to the side of the track to measure time as the car travels the length of the solar race track.

Modification 1 - Investigation (Variable 1)

What are you going to investigate? (Write this as a question)

What is your independent variable?

What observations or measurements will you make of your independent variable?

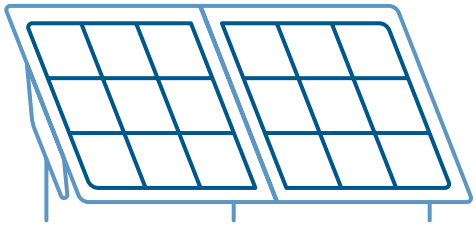
What is your dependent variable?

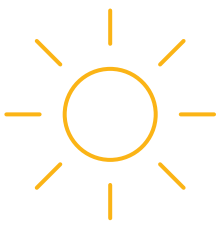
What measurements will you take of your dependent variable?

What are your controlled variables, things you will need to keep the same to make it a fair test?

Investigation 2 (Variable 2)

Repeat the above steps described for Modification 1 for other investigations of as many variables as you have time for.





Activity 3

Project 2: My Model Solar Car Body

Explore the design process and apply it to designing and building a body structure for a model solar car to make it more attractive and marketable as a functioning model.

This is a marketing challenge. It is all about making your vehicle appealing to a consumer such as a school student your age or younger.

Aim

Your design aim is to make your model look more like a car or truck.

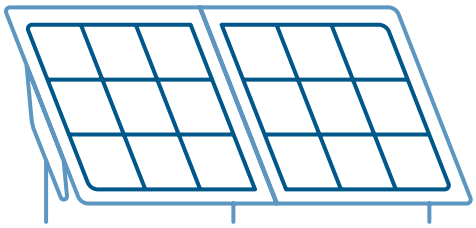
Use the mini solar car model from Project 1 provided in the Bright Horizon school pack.

Safety notes

- **When outside in the sun** _____
- **Don't touch the light bulb as it will get** _____
- **Follow all safety instructions when using cutting tools such as scissors.**

Materials

List those materials that you will use for your model



Planning:

Construction plan

Sketch of my model vehicle body showing

- **The solar panel**
- **Labels and dimensions**

Your vehicles name

The target age group

Notes explaining any special design features

Hint: use a children's remote-controlled vehicle for labelling and packing ideas.

Design and Build a model solar vehicle body

Design and build a body to help market the model solar car.

Your model must still work. This means that the solar panels need to be exposed to sunlight and not permanently covered.

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Activity 4

Evaluate & Communicate

What's the Verdict?

Demonstrate, test and evaluate the model solar car.

Evaluate your results and present your model and conclusions to an audience using multimedia.

Evaluation

Reflect on the process taken and the success of your design. Write the steps you took to make the fastest model solar car.

Glue a photograph of your model solar car.
Label the parts you chose to use in your design.

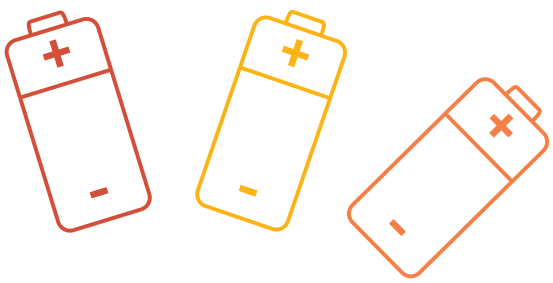
How many modifications did you test? _____

List the modifications (variables) you tested.

Activity 4

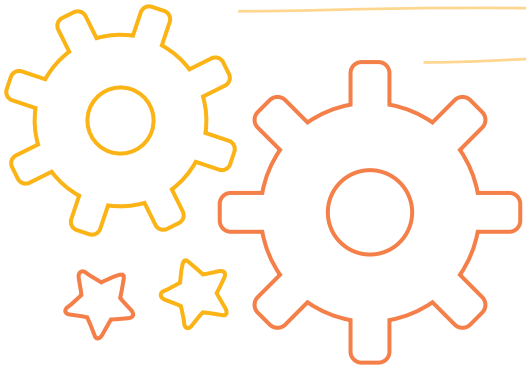
What modifications did you decide to include in the final model?

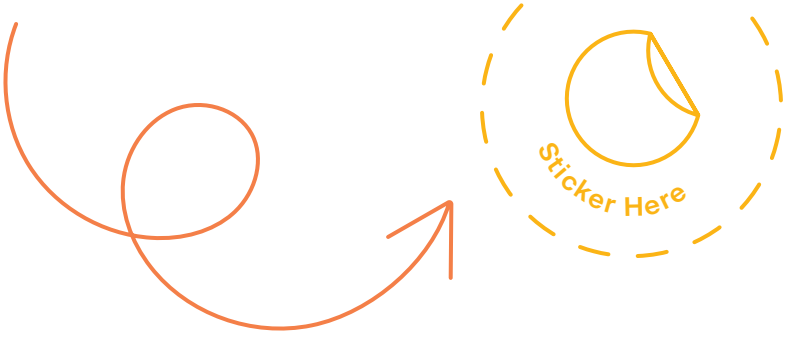
Why were they included and others not?



Is your final model different from the first one you built? _____

How and why?





Notes

Notes

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Date	13/08/21
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any changes	any changes	any changes	any changes	

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