BRIGHT HORIZONS™

Year 6 Students

HORIZON POWER

STAWA SCIENCE TEACHERS' ASSOCIATION OF WESTERN AUSTRALIA

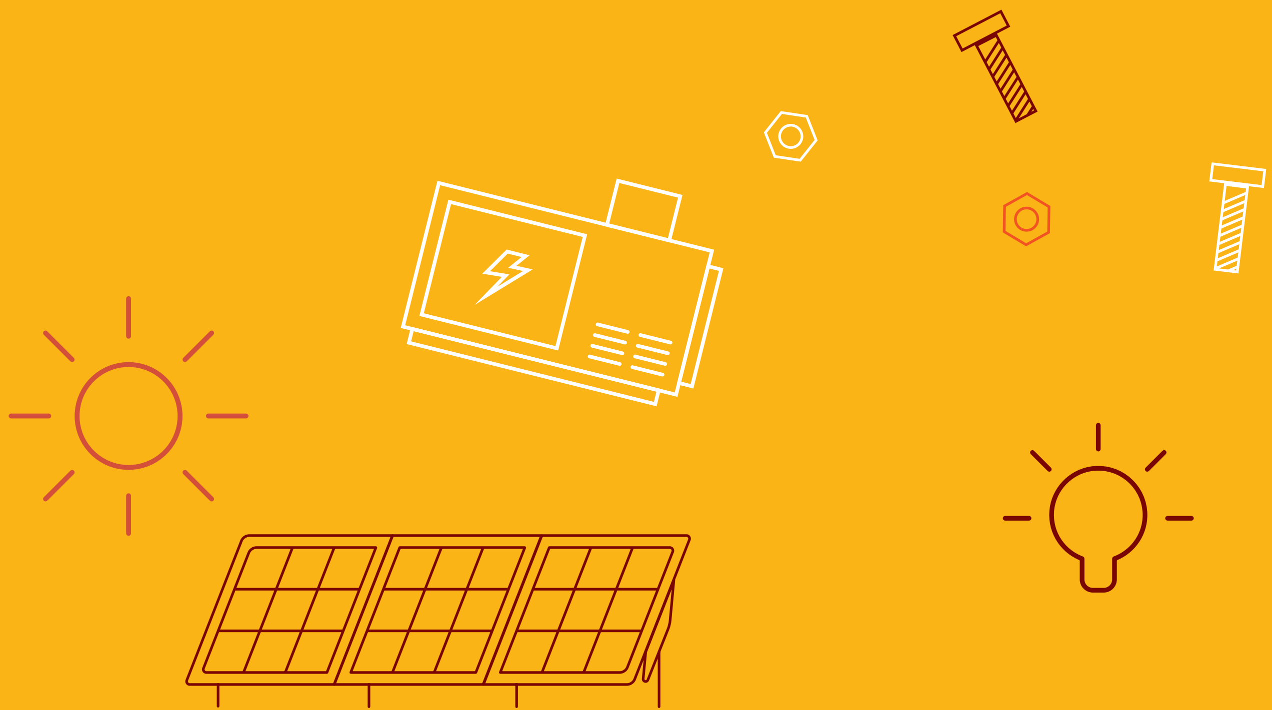
Name ______________________________

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

STAWA SCIENCE TEACHERS' ASSOCIATION OF WESTERN AUSTRALIA

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's the Angle?

Explore the design process and apply it to designing and building a device that adjusts the angle of a mini solar panel to maximise its power output.

Project 2: What's the System?

Explore the design process and apply it to designing and building a model house with a 2.8 W solar PV system.

Activity 4 Evaluate & Communicate

Project 1: What's the Verdict?

Demonstrate, test and evaluate the model solar panel tilting device. Present your model and conclusions to an audience using multimedia.

Project 2: My Model Solar House

Demonstrate, test and evaluate the model solar PV system and house. Present your model and conclusions to an audience using multimedia.

Activity 1

Research

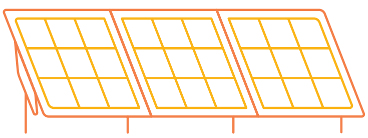
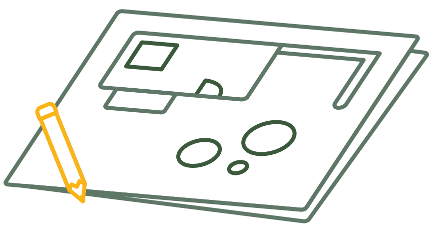
Rooftop solar PV panels, batteries and appliance power needs

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) schools 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.

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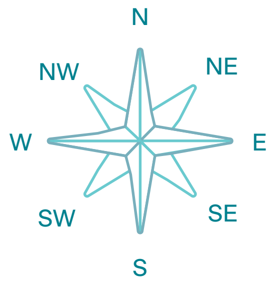
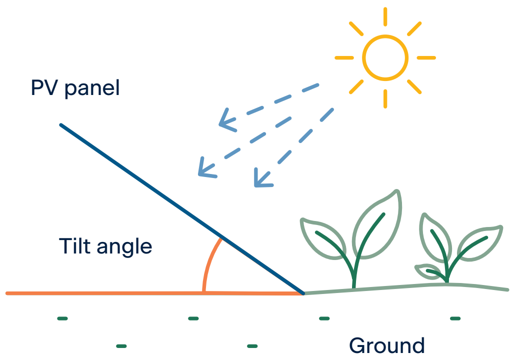
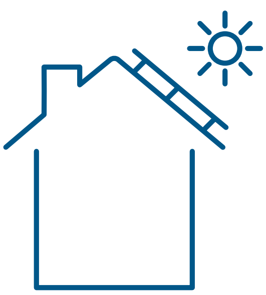
		YES	NO
3	 	In what direction or directions are the solar panels facing? Should the solar panels be facing? Explain.	In what direction or directions would you recommend the solar panels be facing? Explain your recommendation.
4	 	Are the solar panels • tilted on an angle? • at an angle of approximately 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

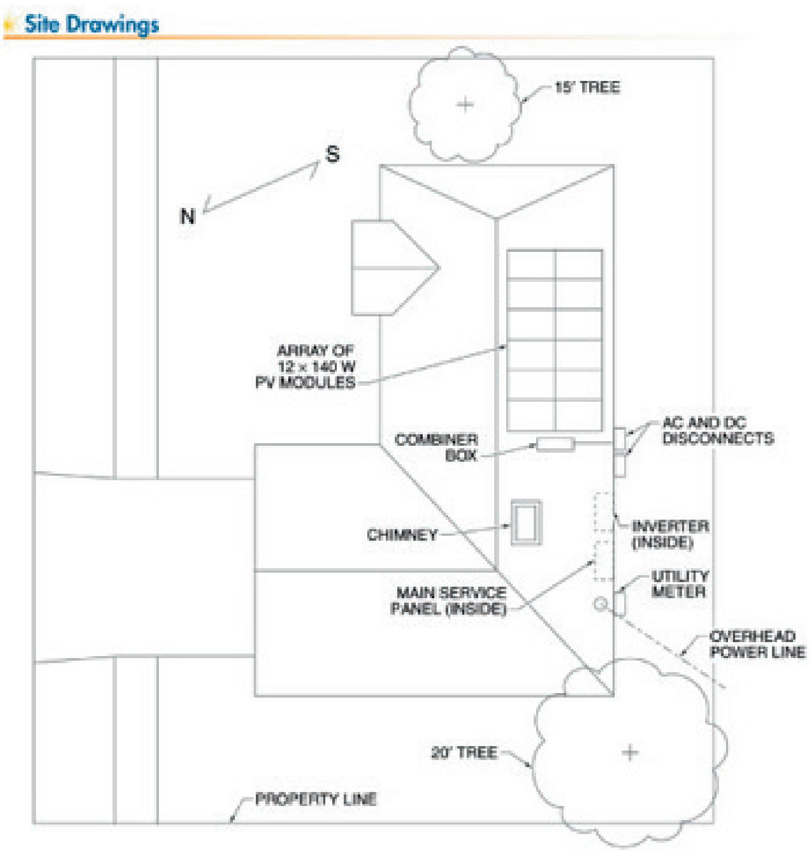
Present your findings and understanding a school solar PV system as a set of plans or drawings. If you can do it to scale, excellent, otherwise create a sketch with approximate measurements. This can be done on either an A3 or an A4 sheet of paper. Your teacher will decide if you are to do an individual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

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

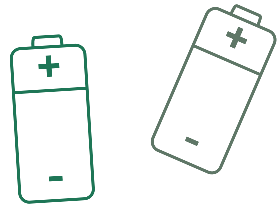
- compass bearings (North South East and West),
- locations of building on which the rooftop solar PV panels will be/are installed,
- location of large trees,
- measurements (estimates or actual)
- a separate diagram showing the angle of the panel
- any other important items.

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?



Working in groups, research sustainability and solar energy by considering the following topics (questions).

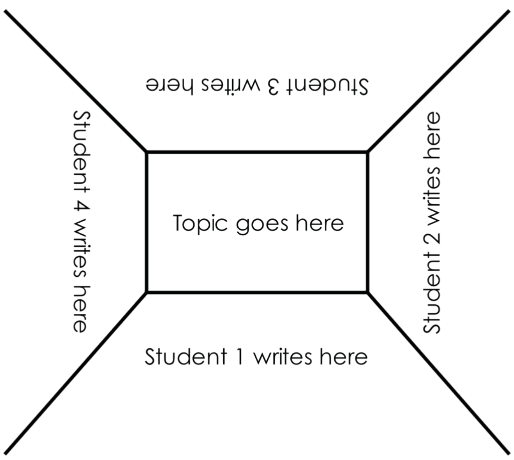
- What makes a resource sustainable?
- What are sustainable methods of generating electricity?
- What is a solar photovoltaic cell and how does it work?
- Many conditions are considered when installing solar panels as their placement can affect the power output of a solar panel. Using your plan from Part 1 answer the following questions:
  - In what direction or directions were the solar panels facing? Why?
  - What angle were the solar panels installed on? Why?
  - Why do you think tall trees and other tall buildings should be included on your diagram?
- What is a battery?
- Why are batteries also used with rooftop solar systems to supply household electricity?

Step 1: Placemat

Work together collaboratively to record on a placemat, information about *rooftop solar PV panels, systems and batteries* that you:

- already know (prior knowledge),
- brainstorm ideas and
- find out through research.

On a large sheet of paper create a placemat using the template below, for the topic or topics (questions) given to you by your teacher.



Activity 1

Step 2: Visual Display

Working in your group, using the placemat information, create a poster, or video to show your understanding of the topic or topics assigned to you. Your teacher might ask you to share your presentation with the class.

Part 3: What are the power needs of household appliances?

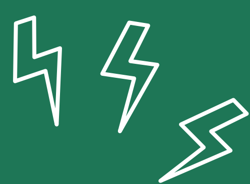
Working in groups or on your own complete the following research worksheet on aspects of energy, electrical power and household and appliance power needs.

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		

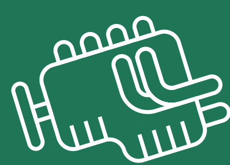
2. Energy Transfer and Transformation



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

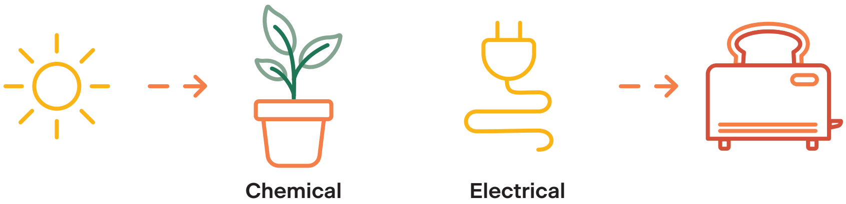
Electricity can be transferred (moved) through wires from a power station to your house. Electricity also flows (moves) through cables from a power socket to a device like a TV. Note the energy starts as electrical energy moves from one place to another and arrives as electrical energy - it has been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

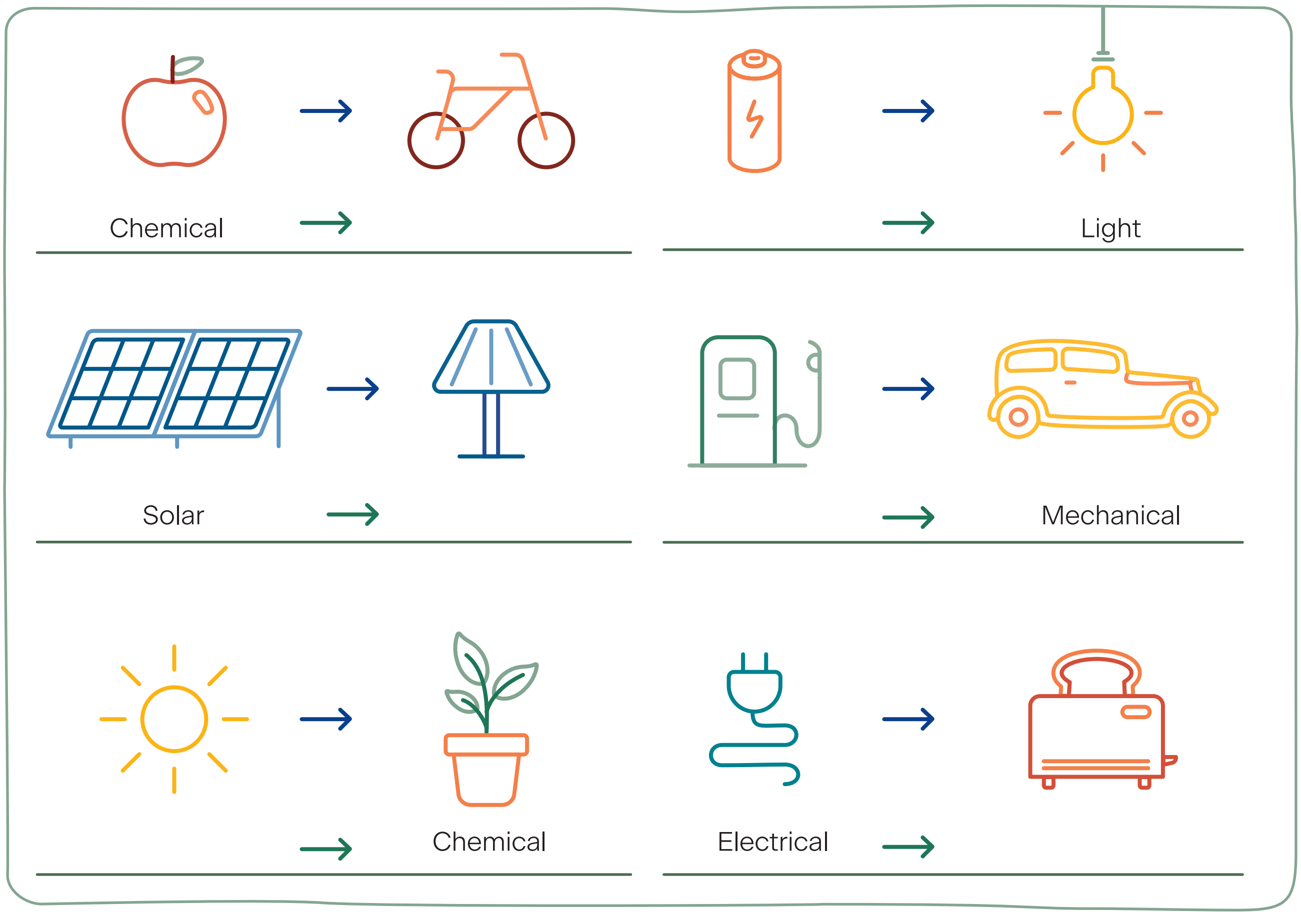


Exercises:

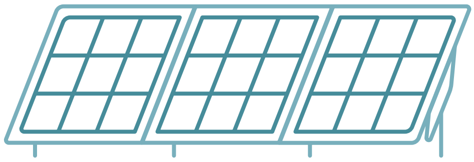
Diagrams can be used to show how energy is transformed from one form to another. An energy flow diagram uses arrows to show the energy changes. Arrows starts at one energy form and points to the new energy form showing the energy transfer and how it has been transformed. The diagrams below are examples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



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



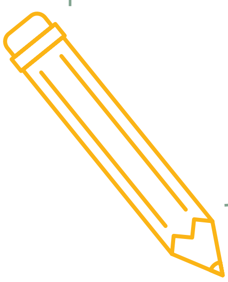
Activity 1



3. Solar Energy

The original source of **energy** on earth is the **sun**. The sun's energy is transferred as light energy from the sun to the earth. 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.



4. Energy, Work and Power

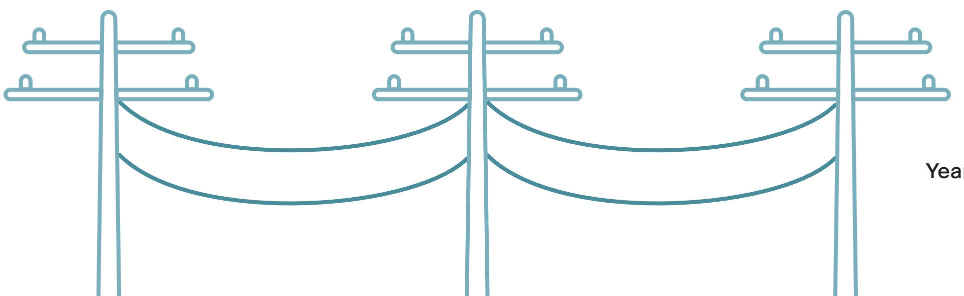
Energy is the ability to do work.

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.

Electrical power lines and household wiring and leads are made from a material that can conduct electricity. Copper is an **electrical conductor**. For safety reason, electrical leads and cables have plastic insulating material covering the conducting wire. **Insulators** don't allow electricity to flow through it.

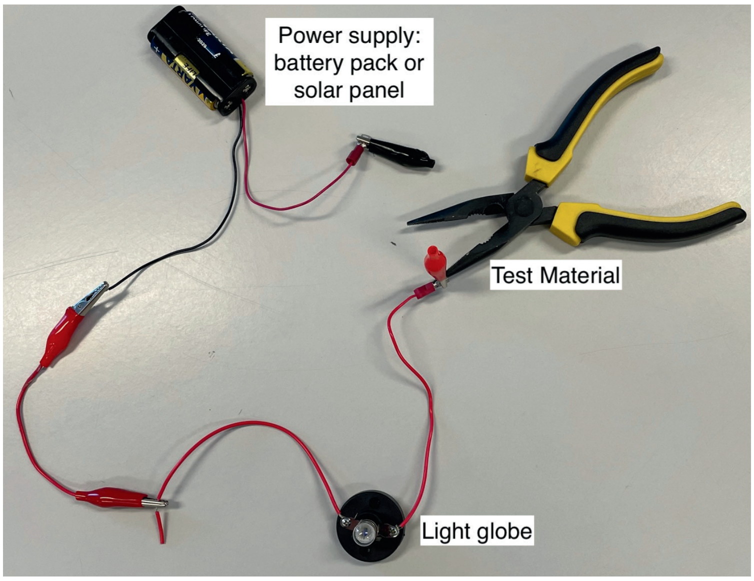


Experiment: Conductors and Insulators

Collect and set up the equipment as shown in the diagram. Test some materials such as wood, a plastic ruler, the different parts of a pen and pencil, plastic chair, metal table or chair leg, cotton cloth, the floor tiles, tin can, different parts of a stapler, brick wall, white board to see which materials are conductors and insulators. Record your results as a list or table using the headings Conductors, Insulators.

Use a battery pack or solar panel for power. Use a globe, motor or multimeter to test for conductivity.

Caution: If using a battery pack and globe. Do not leave these connected. To avoid blowing the globe, connect the test material, record your observation - globe glowed or did not glow - then disconnect.



Conductors	Insulators

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://www.youtube.com/watch?v=1_KjuGNzxc*

Electrical energy is needed to do the work of running an air-conditioner or a TV.

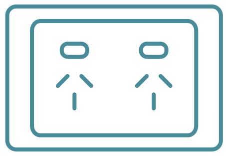
The basic unit of energy is the Joule, abbreviated to J.

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.

Activity 1

Exercises



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

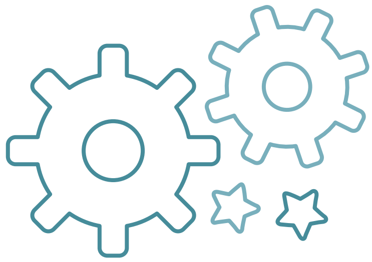
2. Electrical power can be calculated using the equation:

$$P = V \times I$$

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

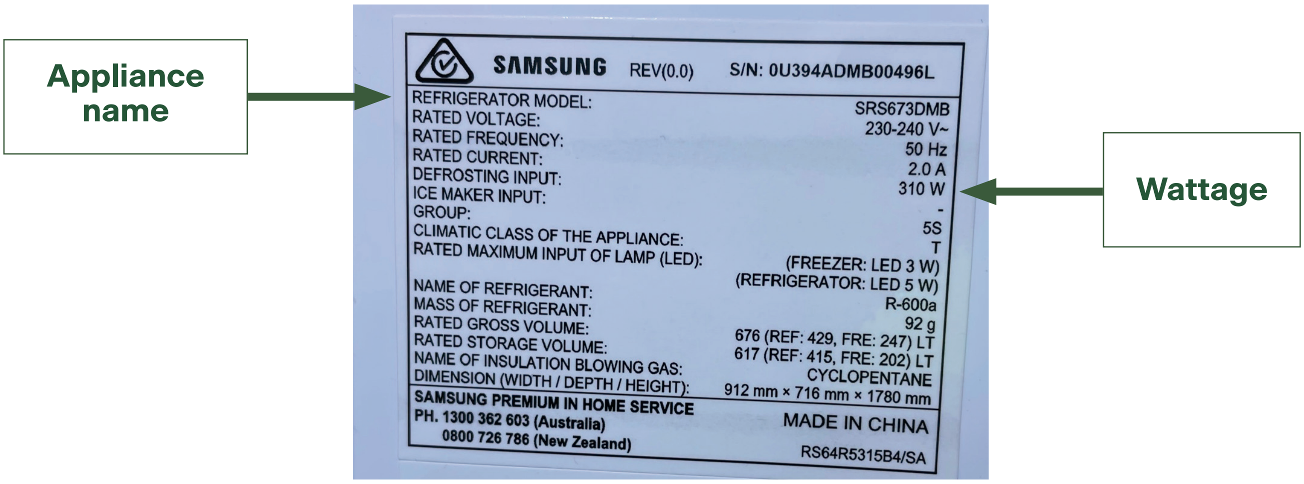
c) fold up solar panel producing 12 V and 11 A

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.

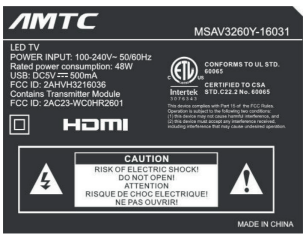


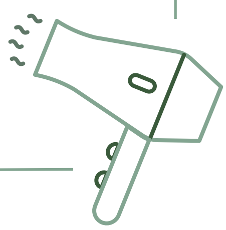
The higher the wattage reading the more power an appliance uses when working.

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

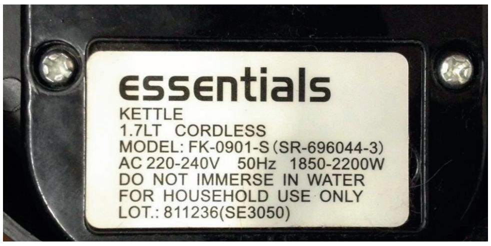
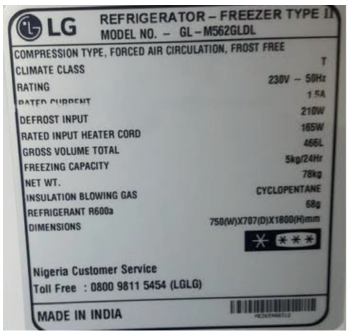
In a table below, photos of the electrical labels of different household appliances are shown.

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

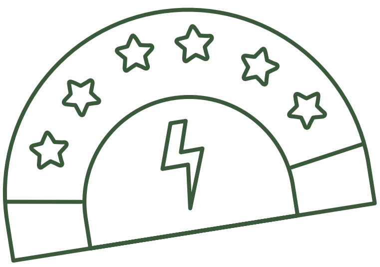
Appliance	Appliance Name	Wattage
	**Television**	
		



Activity 1

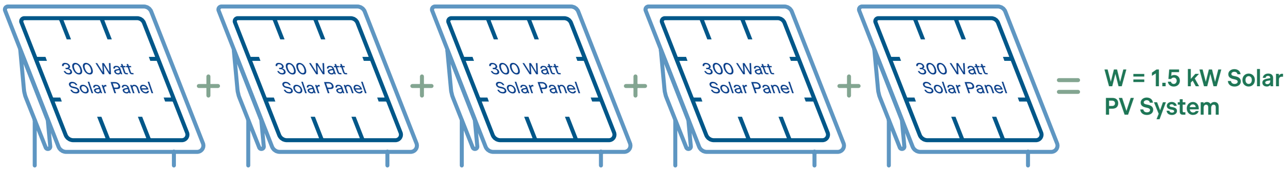
Appliance	Appliance Name	Wattage
		
	**Kettle**	
		

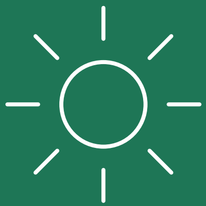
2. Remember the higher the wattage reading the more power an appliance uses when it is working.
   a) Which appliance in your table uses the most power? ______________________
   b) Which appliance in your table uses the least power? ______________________

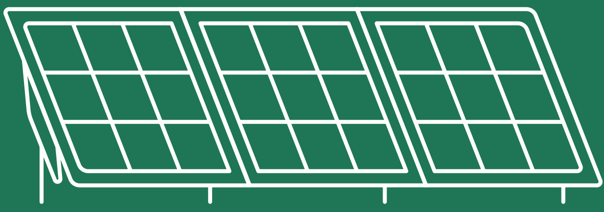


3. Can a 6.0 kW rooftop solar PV system run all of the appliances listed in the table at the same time? Show your working out.

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?







Activity 2

Investigate

Investigating factors affecting the power output of solar panels

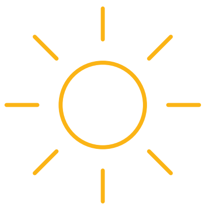
Conduct investigations into conditions that affect the electrical power output of solar panels.

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, like 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 (dependent variable)?

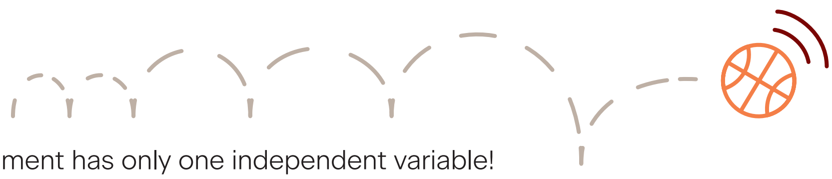
Identifying the variables in the example:

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 variables is how far I can throw it.

Fair Test



A good experiment has only one independent variable!

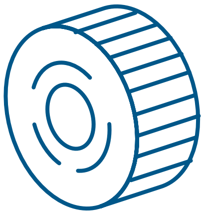
When investigating the answer to a scientific question, a fair test is used. A fair test is a test that controls all variables except the one independent variable. Only changing one variable allows you to know that no other variable has affected the results of the test (investigation).

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

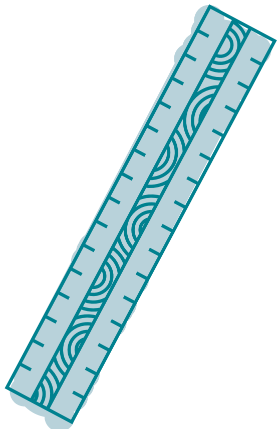


Controlled variables, the things to keep the same.

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

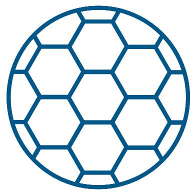
The size of the ball, the person throwing the ball, the person measuring (how far the ball is thrown and the weight of the ball) and the instrument used to do the measuring.

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?

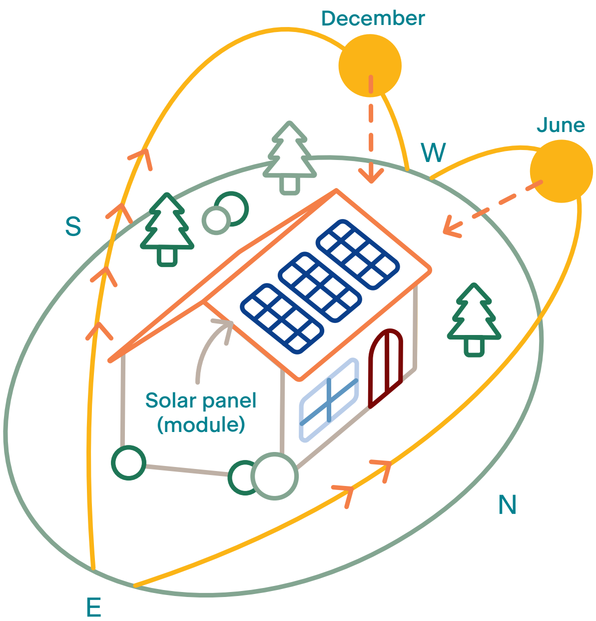
When conducting an investigation, you should make and record observations of what is happening. You need to record all measurements and changes to the independent and dependent variables. In most investigations results can be recorded in a table. Don't forget to include units for measurements made. Tables 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 from Step 2, 3, 4 and 5.

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

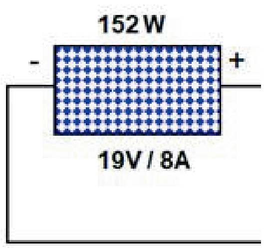
Photovoltaic cells make up solar panels and transform light energy into electrical energy. The electrical output of solar panels can be determined by measuring their voltage (V) output and current (I) output. When multiplied together these measurements give electrical power output in watts.

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.

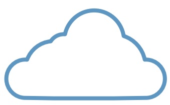
	Voltage (V)	19 V
	Current (A)	8 A
	Power (W) P = V x I	P = 19 V x 8 A = 152 W

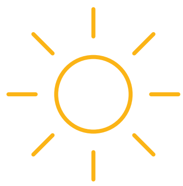
Electrical appliances require a certain amount of power to operate, for example, some LED light globes require 7 watts, while a hair dryer might need 1,000 watts.

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. You will investigate one or more of your questions, which might include:

- Panel tilt angle
- Direction the panel faces
- Shade





Question and prediction

For each investigation write a testable question and predict the outcome.

Factor that affect the electrical power output of solar panels	Testable investigation question	Prediction
Panel tilt angle		
Direction the panel faces		
Shade		

Planning

Refer to your table in Part 1 of Activity 2 and the introduction notes to help with identifying the variable.

Factors that affect the electrical power output of solar panels	Independent Variable (Change)	Dependent Variable (Measure)	Controlled Variables (Keep the same)
Panel tilt angle			
Direction the panel faces			
Shade			

Variables in detail

What is the independent variable for your first investigation?

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

What is the dependent variable for your first investigation?

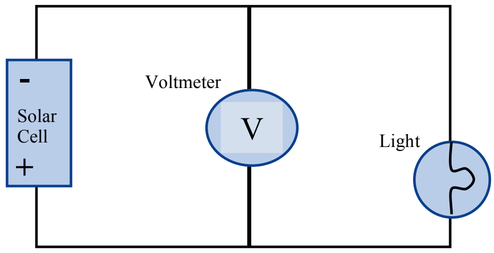
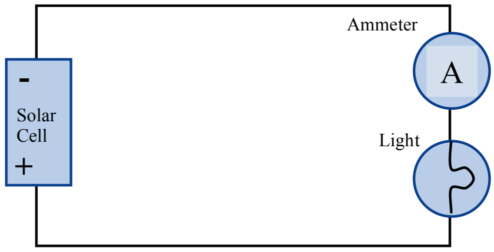
What measurements will you take of your dependent variable?

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

Activity 2

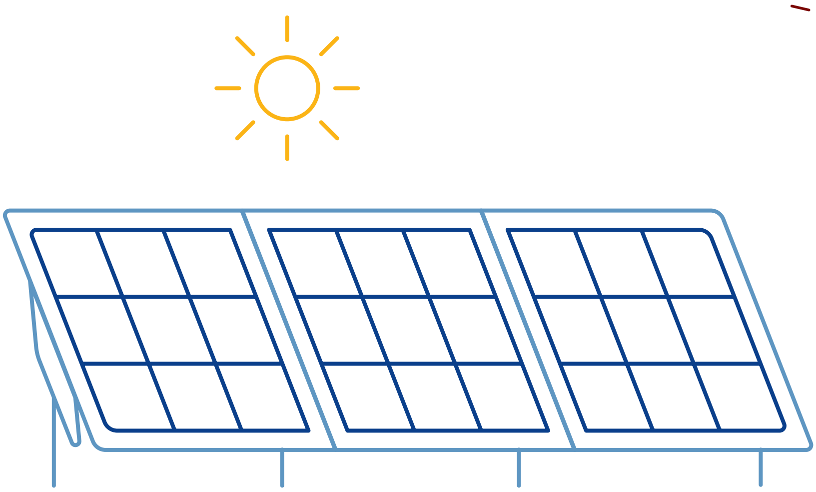
Set up

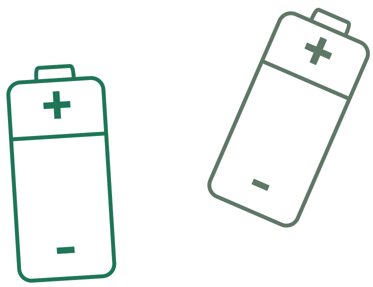
Set up your electrical circuit as shown in the circuit diagrams below. When measuring voltage and current you change the position of the multimeter.

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?

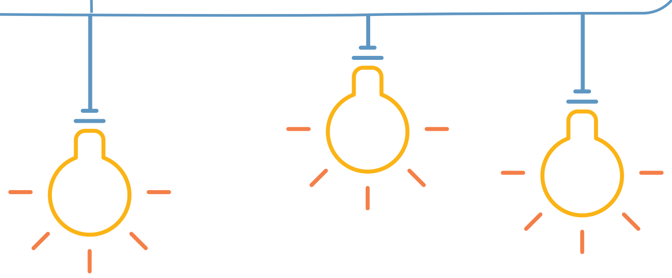
3. Was your prediction correct?

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?

Activity 3

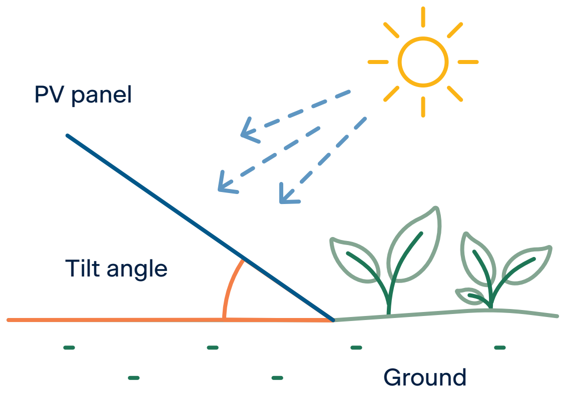
Imagine & Create

Project 1: What's the Angle?

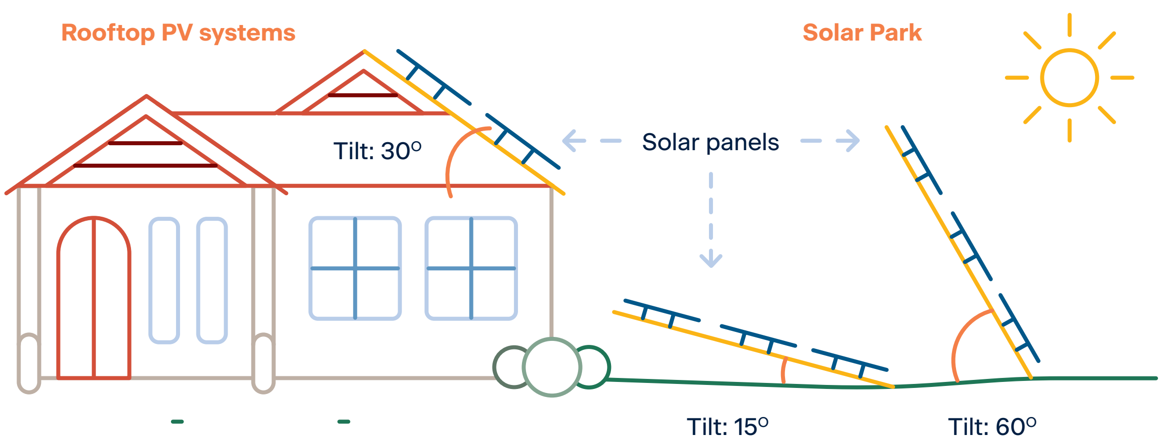
Explore the design process and apply it to designing and building a device that adjusts the angle of a mini solar panel to maximise its power output.

Background Information

Rooftop solar panels transform light energy from the sun into electrical energy. Solar panels are placed on rooftops to give the greatest possible power output at the best possible price. In Australia solar panels are usually installed facing towards the North. They are also at an angle that wherever possible matches the latitude of the building they are being installed. For reasons of costs, the panel angle is usually restricted to the pitch of the roof.



In Part 2: Investigating the electrical power output of solar panels, the power output of the solar panel was tested at different angles. This was difficult to do accurately. In many scientific investigations scientists often need to design and construct apparatus to enable them to carry out their investigation.



BRIGHT HORIZONS

HORIZON POWER

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.**

Materials – select those materials that you will use for your model

- Mini solar PV panel
- Scissors
- Compass
- Card or cardboard
- Pop stick or balsa wood
- Foam

Design ideas for the solar panel tilting device

In the space below or on a separate sheet of paper, sketch some design ideas for a panel tilting device.

Activity 3

Development of a design idea

Choose one of your design ideas. Draw a labelled diagram of your chosen tilting device.

Your labels should include dimensions and material type. The materials list gives ideas, but you might be able to source and built with other materials.

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

What observations of the tilting devices will you make?

How will you make judgements and measure about the robustness and accuracy of the device?

List the materials and equipment you need to build a model of your tilting device.

Build and test your tilting device prototype

- Build a model of your tilting device.
- Test the effectiveness of your model.
- Take a photograph of your finished model.

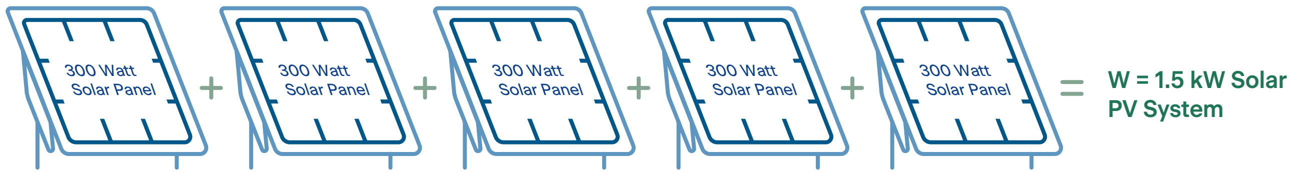
Project 2: What's the System?

Explore the design process and apply it to designing and building a model house with a 2.8 W solar PV system. Use the mini solar panel provided in your Horizon Power school pack.

Background Information

Rooftop solar panels transform light energy from the sun into electrical energy.
Solar panels can also be placed on the ground.

The figure below shows that when solar panels are connected in series their voltages add. The system of 5 panels each of 300 W add to give an output of (300 + 300 + 300 + 300 + 300) 1,500 W. This is called a 1.5 kW solar PV system.

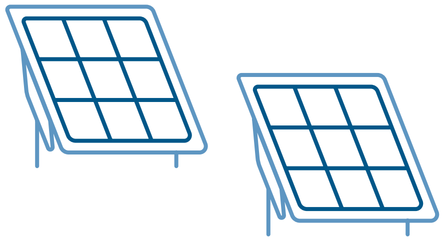


Safety notes

- 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.
- Follow all safety instructions when using cutting tools such as scissors.

Materials – list those materials that you will use for your model

Activity 3



Planning

How many mini-solar panels do you need to create a 2.8 W solar system?

Using the Pm value on each of the solar panel labels, determine the number of mini-solar panels you need to create a 2.8 W system.

Working out:

I will need ______________ solar panels to build my 2.8 W system.

Construction plan

Sketch of my house showing

- the location of the panels
- labels and dimensions
- a circuit diagram for my solar PV system and house

Design and build a model solar powered house

Design and build an approximately 2.8 W rooftop or free-standing solar PV system using the mini solar PV panels. You can use the house cut-outs sheets provided or supply your own materials to build your model house.

Your model needs to be wired to your solar system and be able to light up a globe and any other devices that you care to fit into the house.

Checklist of model house inclusions:

Must have Item	**Check**
Size: no greater than 1 m^3	
2.8 W rooftop or free-standing solar PV system	
Electrical Circuit connecting the solar system to a switch and globe	

Optional Items that I have included	**Check**

Activity 4

Evaluate & Communicate

Project 1: What's the Verdict?

Demonstrate, test and evaluate the model solar panel tilting device.

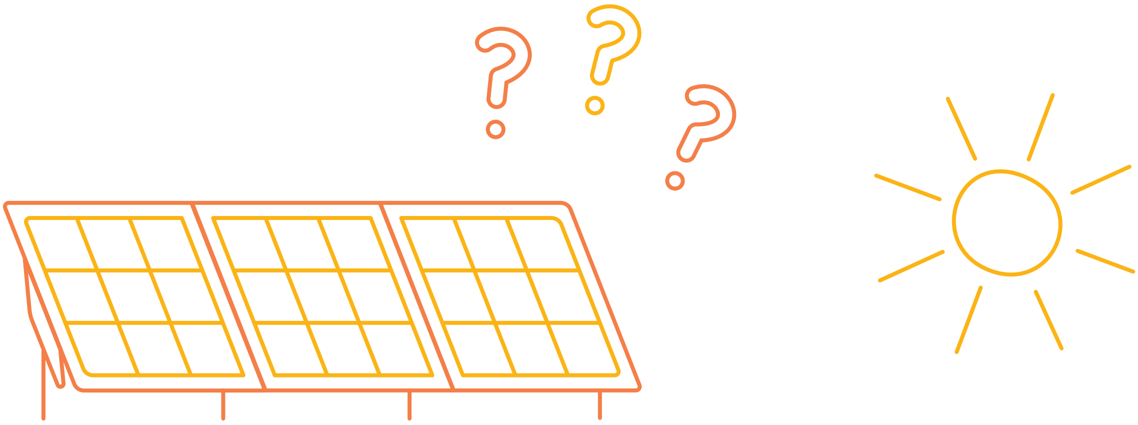
Evaluate your results and present your model and conclusions to an audience using multimedia.

Complete the

- Prototype troubleshooting table and
- Evaluation worksheet.

Prototype troubleshooting

Problem	Reason for the problem



	Possible changes to your design to solve the problem

Activity 4

Evaluation

Reflect on the process taken and the success of your design.

Write the steps you took to make your solar panel tilting device.

What is it?

What is it made from?

How does it work?

Activity 4

Draw a picture or glue a photograph of your solar PV panel tilting device.

Project 2: My Model Solar House

Demonstrate, test and evaluate the model 2.8 W solar PV system and house.

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

Create a video, power point, wall chart, story book or other multimedia presentation to:

- demonstrate how the mini solar panels were connected to create a 2.8 W solar PV system,
- explain how the system provides electrical energy to the electrical circuit built into the model house,
- describe any challenges and successes you had in designing and building your model, and
- provide advice that would help other students wanting to create a similar model.

Notes

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Client	HORIZONS
Job Number	HOPOPW0043
Date	10/08/21
Version	FA

Please check and initial your internal approval:

Engagement Team	Copy	Design/ Art Direction	Producer	Studio
any changes	any changes	any changes	any changes	

WUNDERMAN THOMPSON