Wonder Project

Power Challenge

Support notes

Term 3, 2023

engineering new zealand te ao rangahau

POWERED BY Callaghan Innovation New Zealand's Innovation Agency

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Contents

Using this document

This document provides additional support notes for student activities and key concepts, a vocab glossary and some tips to help you use the resources and run the challenge.

Use this document to complement the online modules in the Learning Hub designed for students. The activities are sectioned into their respective modules, in the order that students should complete them as they progress through the Learning Hub.

STEM skills

STEM education is a multi-disciplinary, holistic approach to learning where science, technology, engineering, and maths are taught as one. Some of the key STEM skills students will use throughout the challenge are:

STEM skill	Description
Teamwork	Teamwork is working together with others to achieve an end goal. To be effective team members, students need to recognise each other's expertise and strengths, be flexible, work together to complete tasks, and make sure each team member has a job. Engineers work in teams to develop solutions because they each bring a different set of skills and expertise to a project.
Communication	Communication is about passing on information effectively, listening when others are sharing ideas, understanding instructions, and asking questions. It's about bringing different knowledge and experience to the table to improve results.
Open mindedness	Open mindedness is about being willing to listen, considering and accepting different ideas. It's about being open to new experiences and learning about the world around you.
Creativity	Creativity is about taking risks, ignoring doubt and facing fears. It's about using inventiveness and outside the box thinking to bring new ideas to life.
Problem solving	Problem solving is about thinking innovatively, being resilient, never giving up and trying lots of ideas to find the best solution.
Analysis	Analysis is about being observant, collecting and interpreting data, detecting patterns, brainstorming ideas, and making decisions based on the results.

Curriculum links

Suggested assessment guide

Teachers can also make wider curriculum links to other achievement objectives depending on student level and individual learning programmes.

Achievement objectives	Students will	Curriculum level	Year level
Science: Nature of science	Ask questions, explore simple models, and carry out appropriate investigations to develop simple explanations around how energy is generated and used.	4	7–9
Science: Physical world	Explore different sources of energy, forms of energy and energy transformations including the transformation of different energy sources into electrical energy.	4	7–9
Technology: Technological knowledge	Use functional modelling to create a prototype that converts wind energy into electrical energy. Explore the relationship between aerodynamic features and energy efficiency through blade design.	4	7–9
Mathematics and Statistics: Geometry and measurement; statistics	Explore modelling with three dimensional geometric shapes. Gather, analyse and draw conclusions from wind turbine performance data.	4	7–9

Assessment rubric

The physical world strand of the science curriculum is the focus achievement objective of the Power Challenge.
You can assess students using the suggested rubric below or provide your own.

Achievement Objective – Science L4

Physical inquiry and physics concepts:

- Explore, describe and represent patterns and trends for everyday examples of electricity.
- Identify and describe everyday examples of sources of energy, forms of energy and energy transformations.

Assess through observation, conversation and by questioning students on how electricity is generated, moved, and used in Aotearoa. Question students on their wind turbine blade designs, prototype construction and improvement, and how much electricity their turbine generates when connected to the printed circuit board (PCB).

Alongside this, teachers can use **Activity 4.2: Wonder Cards**, and specifically their answers around everyday examples of energy, to assess student knowledge and understanding on sources of energy, forms of energy and energy transformations.

The student:

Attempts to explore/ describe/draw, to show a **limited understanding** of sources of energy, forms of energy and energy transformations using everyday examples.	**Is beginning** to explore/ describe/draw, to show a **basic understanding** of sources of energy, forms of energy and energy transformations using everyday examples.	Is able to and is **confident** about exploring/ describing and drawing, to show a **thorough understanding** of sources of energy, forms of energy and energy transformations using everyday examples.

Questioning and building understanding

By being familiar with the key concepts and vocabulary in the Power Challenge, you can ask the right questions and draw out student understanding and misconceptions through discussions. To support you to do this, you can find:

- Explanations of key concepts at the beginning of each module and within certain activities.
- Key vocabulary and definitions at the end of this document on pages 25–27.

Your resources

To complete the Power Challenge, you'll be using the items found in your Power Kit, alongside some items you'll need to source as a school.

We want the Power Challenge to be accessible to all schools across Aotearoa. So, if you need support sourcing the resources outlined in the 'schools to supply' table, we are happy to help. Please let us know what you need by reaching out to **wonder@engineeringnz.org**.

Unpack your Power Kit

Layer	Box	Items	When and how to use
Layer one (attic)	N/A	8 x Activity booklets	1 activity booklet is in the attic of the kit, the rest are underneath the first cardboard layer. In teams, students will work through the activities in these booklets as they progress through the Power Challenge.
		8 x Dowels (turbine tower)	Students will use these in Module 3 to form the tower of their turbine prototype.
Layer two	**Box 1:** Paper circuits	8 x Coin batteries	Students will use these in Module 1 to construct their paper circuits. You will also use these if you choose to complete the optional activity 'light up your kit' after the challenge.
		1 x Roll of copper tape	Students will use this in Module 1 to construct their paper circuits. You will also use this if you choose to complete the optional activity 'light up your kit' after the challenge.
		20 x LEDs	Students will use these in Module 1 to construct their paper circuits. You will also use these if you choose to complete the optional activity 'light up your kit' after the challenge.
	Box 2: Our town	2 x Printed circuit boards (PCB)	Students will test their turbine prototype's performance using the PCB in Module 3. It's used again in Module 4 in the final 'Light up our town' activity.
		2 x Solar panels	Students will use the solar panels in the final 'Light up our town' activity in Module 4.
Layer three	**Box 3:** Turbine	8 x Motors	Students will use these in Module 3 to form the 'generator' of their turbine prototype.
		10 x Hubs	Students will use these in Module 3 to form their turbine prototype hub.
		1 x Pack of popsicle sticks	Students will use these in Module 3 to form the 'spines' of their turbine blades.
		8 x Wingnut and screws	Students will use the wingnut and screw to secure the motor bracket to their turbine tower in Module 3.

Layer	Box	Items	When and how to use
Layer three	**Box 4:** Turbine and power cards	1 x Set of power cards	Students will use these in Module 3 for the 'Great grid race' activity.
		8 x Turbine bases	Students will use these in Module 3 to form the base of their turbine prototype.

School to supply

Module	Activity	Resources required
Module 1: Power up	Ambassador career story	Technology to display a PowerPoint presentation
	Activity 1.1: Transforming energy	• Balloons (1 per team) • Pencil (1 per team)
Module 2: Generate	**Activity 2.1:** Sources of energy	Computers/books to research renewable and non-renewable energy
Module 3: Move	**Activity 3.2:** Create	• Recyclable materials for turbine blades (we suggest cardboard or ice cream containers) • Decorations and colourful pens/pencils • Hot glue or other adhesives • Scissors
	Activity 3.3: Time to test	• Fans (a 40cm desk fan will work best) (2 per class) • 30cm ruler (2 per class)
Module 4: Illuminate	Engineering design process step 6: Improve	Recyclable materials and classroom resources to improve students' turbines
	Activity 4.1: Light up our town	• Fans (a 40cm desk fan will work best) (2 per class) • Light sources (we suggest a strong torch or desk lamp) (2 per class)
General	Power Challenge	Classroom resources including pens, scissors and rulers

Module 1:
Power up support notes

Use these notes about Power Challenge activities and key concepts as a reference as you go through Module 1 in the student Learning Hub with your class. Each activity is included in the order that they appear in the Learning Hub.

Before you get started, make sure you've completed the teacher pre-challenge survey, and shared the student pre-challenge survey.
These are an important tool for us to improve the programme each year and continue our funding to keep the Wonder Project free for schools.

- Teacher pre-challenge survey
- Student pre-challenge survey

Key concept: Let's talk energy

Support students to explore and discuss new ideas by becoming familiar with these key concepts.

Understanding energy

- **Energy** is the ability to do work.
- Energy comes in many different forms. These forms can be grouped into two main categories – **potential** energy and **kinetic** energy.
  - **Potential energy** is energy that is stored, waiting to make things happen.

    For example, an apple hanging off a tree has potential energy. This is because of its position above the ground, and the fact that it has potential to fall.
  - **Kinetic energy** is working energy that something has because of its motion.

    When the apple eventually falls, it has kinetic energy as it drops to the ground. This is because it's moving.
- Some forms of potential energy include gravitational, elastic, chemical, and nuclear.
- Some forms of kinetic energy include sound, light, thermal, and electrical.
- Refer to the 'Forms of energy' poster for more information.

Energy transformation and transfer

- Energy can't be created or destroyed, only transformed from one form into another, or transferred from one place to another.
  - **Energy transformation** – when energy changes form to do work.

    For example, a wind turbine works by transforming wind energy, into electrical energy.
  - **Energy transfer** – when energy moves from one place to another, or from one object to another.

    To get the electrical energy to our homes and communities, it is transferred, or moved, over long distances.

Understanding electricity

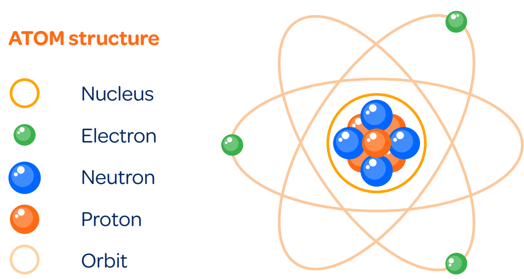
Electricity is a form of kinetic energy that helps us power our communities. It is defined as the 'flow of electrical power or charge'. Like everything, electricity is made up of atoms.

A more in-depth explanation is provided below for your reference. We do not expect electricity will be taught in this much detail as part of the Power Challenge.

Atoms

- The atom is the basic building block for all matter in the universe.
- Atoms are extremely small and are made up of a few even smaller particles.
- At the centre of an atom is the nucleus. The nucleus is comprised of tiny particles called protons and neutrons. Electrons revolve around the nucleus in shells.
- The protons and electrons of an atom carry an electrical charge and are attracted to one another. Protons have a positive charge and electrons have a negative charge.

ATOM structure



Electrons

- The electrons in the shell closest to the nucleus have a strong attraction to the protons.
- Sometimes, the electrons in an atom's outermost shells do not have a strong attraction to the protons and can be pushed out of their orbits causing them to move from one atom to another. These moving electrons are **electricity.**
- So, electricity is generated by the movement of electrons.

Electricity travels in closed circuits. A closed circuit is a circuit without interruption, providing a continuous path through which a current can flow. When you turn on a light by flipping a switch, you close a circuit.

Activity 1.1: Transforming energy

Purpose

Support students' understanding of the concept of energy transformation – when energy changes form to do work.

Resources

- Activity booklet (1 per team)
- Balloon (1 per team)
- Pencil (1 per team)

Overview

Begin the activity by getting students into a team of 3–6. There should be 8 teams or less per class. Keep in mind that the Power Challenge is team-based learning and students will remain in the same team for the rest of the challenge.

After getting into teams, students should review the definitions for potential energy and kinetic energy:

- **Potential energy:** Energy that is stored, waiting to make things happen.
- **Kinetic energy:** Working energy that something has because of its motion.

Frontload students' understanding of energy forms with a whole class discussion on the energy forms listed in the activity booklet. Forms of kinetic energy are listed in column 'A' and forms of potential energy are listed in column 'B'.

Encourage them to think of some examples of each energy form – using the forms of energy poster as a reference.

A) Kinetic energy		B) Potential energy	
Energy form	**Definition**	**Energy form**	**Definition**
Sound	Energy that we can hear. It's generated from vibrations moving through something, like air or water. Eg, people having a kōrero, a buzzing air conditioner, an airplane taking off.	**Gravitational potential**	Energy that is stored because of an object's height above the Earth. Eg, an apple hanging on a tree has gravitational potential energy because it could fall to the ground.
Light	Energy that helps us to see the things around us. Light energy travels in waves, called electromagnetic waves. Eg, the shining sun, light bulbs, a roaring fire.	**Elastic potential**	Energy that is stored in something elastic when it's stretched or compressed. Eg, a stretched rubber band has elastic potential energy because it would fly away if it's let go.
Thermal	Energy that's responsible for something's temperature. It's generated through tiny moving particles called molecules. The faster the molecules, the hotter the object! Eg, a steamy hot chocolate, a heater, a stove top.	**Chemical potential**	Energy that is stored in something because of its chemical makeup. Eg, a battery works by storing chemical potential energy and converting it into electrical energy through chemical reactions.
Electrical	Energy that helps us power our communities. It's generated by the movement of tiny particles called electrons. Eg, a bolt of lightning, wind turbines, electric eels.		

Kinetic energy → Kinetic energy

The first two tests are examples of kinetic energy transforming into other forms of kinetic energy.

All the blank boxes should be filled with a kinetic energy form from column 'A'.

Test 1: Rubbing hands together

B) Kinetic energy → **Thermal energy + Sound energy** (hands rubbing)

Test 2: Making a humming noise

B) Kinetic energy → **Sound energy** (throat humming)

Potential energy → Kinetic energy

The final three tests are examples of potential energy transforming into kinetic energy.

The blank boxes labelled with an 'A' in light orange should be filled with a kinetic energy form from column 'A'. The blank boxes labelled with a 'B' in dark orange should be filled with a potential energy form from column 'B'.

Answers

Test 3: Dropping a pencil

A) **Gravitational potential energy** (pencil held in the air) → B) Kinetic energy (pencil dropping) → **Sound energy** (pencil hitting the floor)

Test 4: Turning lights off and on

A) **Chemical potential energy** (lights off) → B) **Electrical energy** + **Light energy** + **Thermal energy** (lights on)

Test 5: Blowing up and releasing a balloon

A) **Elastic potential energy** (blown up balloon) → B) Kinetic energy + **Sound energy** (released balloon)

Additional examples of energy transformations

To end the activity, students are encouraged to think of additional examples of energy transformations. Some potential answers include:

- Our bodies transform the chemical potential energy in our food into kinetic energy for us to move
- Lightning transforms electrical energy into light, thermal, and sound energy
- A turbine transforms the kinetic energy of wind into electrical energy
- A battery transforms chemical potential energy into electrical energy to power your phone.

Activity 1.2: Paper circuits

Purpose

Learn the basics of electricity through this hands-on activity that demonstrates how we use electrical energy to do work.

Overview

In teams, students plan and construct a simple circuit following the instructions in the activity booklet.

Resources

- Activity booklet (1 per team)
- Copper tape (15 metre roll divided between teams. Allow each team 30cm so they have spares for mistakes and the light up your kit activity)
- LED (1 per team)
- Coin battery (1 per team)
- Scissors, tape, pens and pencils

Understanding circuits

Support students to explore and discuss new ideas by becoming familiar with these key concepts:

We build circuits to make electricity do useful things for us – like turn a light on.

A circuit is a path for electricity to move from one location to another. Every electrical circuit is made up of three basic things:

1. Energy source to provide electricity. Eg, a battery
2. A conductive path for the electricity to flow. Eg, copper tape
3. A load that uses the electrical energy. Eg, a LED.

- In a simple circuit, the battery pushes charged particles called **electrons** away from its negative terminal and pulls them towards the positive terminal. This movement of electrons is called electrical **current.**
- You might like to ask students what forms of energy and energy transformations are present in their electrical circuit:
  - Batteries store chemical potential energy. When batteries are connected to a complete circuit, energy is transferred from the battery to the components of the circuit. Most of this energy is transferred to the load (LED), where it is then transformed to thermal and light energy. A small amount of energy is transformed into thermal energy as it is transferred through the circuit.

Troubleshooting circuits

If students' LEDs don't light up after they've completed their circuits, start by checking the following:

Does the circuit flow from negative to positive?
To achieve an electrical current, a circuit needs to flow from negative to positive. The two things that impact this flow are the battery and the LED.

The battery has a positive side and a negative side. The positive side is labelled with a + symbol. Make sure the battery is placed on the circuit with the negative side facing down.

The LED also has a positive leg, and a negative leg. The positive leg is longer than the negative leg. Make sure students have connected the positive leg of their LED to the positive side of the circuit, and the negative leg of their LED to the negative side of the circuit.

Is the circuit broken?
We expect students to create some weird and wacky pathways from one end of the circuit to another – this is encouraged. However, make sure that when they create corners with their copper tape, they bend it, instead of cutting it. This is because the sticky part on the bottom of the tape is not conductive so it will break the circuit.

Other possible issues
Make sure that students have left a gap for their LED and that none of the components are damaged.

After the activity

Encourage students to explain how they created a functioning circuit and to identify everyday examples of circuits they can relate to. For example:

- Everyday appliances that rely on electric circuits such as mobile phones, TVs and laptops.
- A battery or power switch needs to be turned on to make energy work. When you turn on a switch, the electricity is free to flow around a circuit and produce light in the lightbulb or heat in your toaster. When a switch is turned off, this means no electricity can flow so the appliance or battery is turned 'off'.

Health & safety

Coin cell batteries are extremely dangerous if swallowed.

- Keep coin cell batteries in a secure container with a label, away from students.
- Before the activity, the ambassador/teacher should remind students of the dangers of ingesting the batteries, and then distribute the batteries to each team one by one.
- During the activity, monitor each team's use of the battery, then collect the batteries after the activity is complete and store them away securely.
- Batteries should be replaced after 3 months.

Module 2: Generate support notes

Use these notes about Power Challenge activities and key concepts as a reference as you go through Module 2 in the student Learning Hub with your class. Each activity is included in the order that they appear in the Learning Hub.

Key concept: The great journey of electricity – generate

Support students to explore and discuss new ideas by becoming familiar with these key concepts.

Understanding electricity's journey

Electricity goes on a long journey to reach our homes and communities. This journey can be broken down into three steps:

- Generate
- Move
- Use

In Module 2, students will focus on step 1, generate.

Generate

In the **generate** phase of electricity's journey, electricity is generated from an energy source.

Energy sources can be either renewable, or non-renewable:

- **Renewable energy** is made from resources that are naturally replenished. For example, we get solar power from the sun which is renewable because we can't use up all of the sun's sunlight.
- **Non-renewable energy** is made from resources that will run out, or won't be replenished for thousands, or even millions of years! Coal, oil and natural gas are all non-renewable.

Renewable energy

Currently, around 80% of our electricity already comes from renewable energy sources. Our goal as a country is to generate 100% of our electricity from renewable energy sources by 2035. This is because renewable energy is much better for the planet, and there's more of it to go around.

Our country's renewable energy goals play a big part in our mission to 'power a brighter future' with less carbon emissions, hence the focus on renewable energy in the Power Challenge.

For an in-depth summary of Aotearoa's renewable energy sources, watch the 'The future is bright' video in the Student Hub.

There are unfortunately still some challenges that come with renewable energy. These include:

- Renewable energy power stations often use a lot of land – this can disrupt existing communities and landscapes.
- The generation of renewable energy relies on weather conditions which are inevitably variable. There are methods of storing electricity generated through renewable energy – but there is still work to be done to ensure we have a steady and reliable supply of renewable energy, whatever the weather.
- It can cost a lot to install renewable energy power stations.
- Wind turbines can be dangerous to birds.
- The construction of hydro stations can affect land and freshwater species.

STEM professionals play a big part in addressing these challenges and increasing the amount of renewable energy we can generate in Aotearoa.

We encourage you to discuss both the benefits and challenges of renewable energy with your class as you work through the challenge.

Non-renewable energy

Non-renewable energy resources cannot be replaced at a pace quick enough to keep up with consumption.

In Aotearoa, natural gas and coal are our biggest non-renewable energy sources, accounting for around 20% of our electricity.

Many non-renewable energy sources come from fossil fuels (petroleum, natural gas, coal).

- Fossil fuels are made from decomposing plants and animals.
- They are found in the Earth's crust which means you need to drill or mine for these fuels to use them. This can upset and disrupt the land.
- Fossil fuels are burned for energy. This process releases greenhouse gases.
- Greenhouse gases are harmful gases such as carbon dioxide or methane that trap heat in the atmosphere and warm the planet, contributing to climate change.
- To slow down the process of climate change, we need to reduce the level of greenhouse gases that we release into the atmosphere.
- This is why our STEM superstars in the electricity system are working hard to increase the amount of renewable energy we generate in Aotearoa.

Activity 2.1: Sources of energy

Purpose

Support students' understanding of renewable and non-renewable energy sources and how these are used in Aotearoa.

Overview

In teams, students plan and construct a simple circuit following the instructions in the activity booklet.

Resources

- Activity booklet (1 per team)
- Activity 2.1: Sources of energy classroom display template (1 per class) – print using A3 paper
- Computers/books to research renewable and non-renewable energy
- Pens and scissors

Step 1: Discuss

Frontload the lesson by reflecting on previous learnings about what energy is. Discuss how energy can be sourced from our natural environment.

You might like to compile ideas into a table on the whiteboard, sorting them into renewable and non-renewable sources as the discussion progresses. Encourage ākonga to think critically about why they have been sorted this way and what the difference between the two categories might be.

Revisit the concepts of renewable and non-renewable energy. Use students' ideas to guide the discussion – they may have seen solar panels or wind turbines before, or news articles about oil spills in the ocean from deep sea drilling.

Step 2: Allocate an energy source

Allocate each team one renewable energy source to research from the table in the activity booklet:

Renewable energy	Non-renewable energy
Energy made from natural resources that won't run out.	*Energy made from resources that will run out or won't be replenished for a long time.*
• Hydropower • Solar power • Geothermal power • Wind power	• Coal • Oil • Natural gas

There are only seven options to choose from. So, some teams may need to research the same energy source.

Step 3: Research

Using computers or books, each team should research their allocated energy source to answer the following questions:

- He aha tēnei? What is this? Describe your energy source
- Where can you find your energy source in Aotearoa?
- What are the pros and cons of your energy source?
- What percentage of Aotearoa's energy comes from your energy source?

You might like to use Transpower's live data to start.

Example answers are as follows:

<u>Wind power</u>

He aha tēnei? What is this? Describe your energy source

Wind power is wind that's transformed into electricity thanks to wind turbines.

When wind energy moves over the turbine blades, it transforms into rotational energy – a type of kinetic energy. This makes the blades spin.

The blades are connected to a generator. So, when the blades spin, the generator spins – transforming the rotational energy into electrical energy.

Where can you find your energy source in Aotearoa?

Aotearoa has 17 wind farms all across the country!

They are in the Hawke's Bay, Gore, the Manawatu, South Taranaki, Wellington, Bluff, Marlborough, the Waikato, Clutha, the Chatham Islands, Central Otago, Southland, Canterbury, and the Wairarapa.

What are the pros and cons of your energy source?

Pros: Wind energy is a renewable and clean source of energy, it uses land space efficiently and has low operating costs.

Cons: If it's not windy, no power can be generated. Plus, wind turbines can be dangerous for birds.

What percentage of Aotearoa's energy comes from your energy source?

Around 5-6% of Aotearoa's energy comes from wind power.

<u>Extra:</u>

Students who finish quickly might like to research statistics on their power source. For example – how many homes are powered through wind? How much power is generated by the Tararua wind farm?

They could also turn these statistics into a graph. For example – a pie chart on all of Aotearoa's wind farms, and how much energy each one generates.

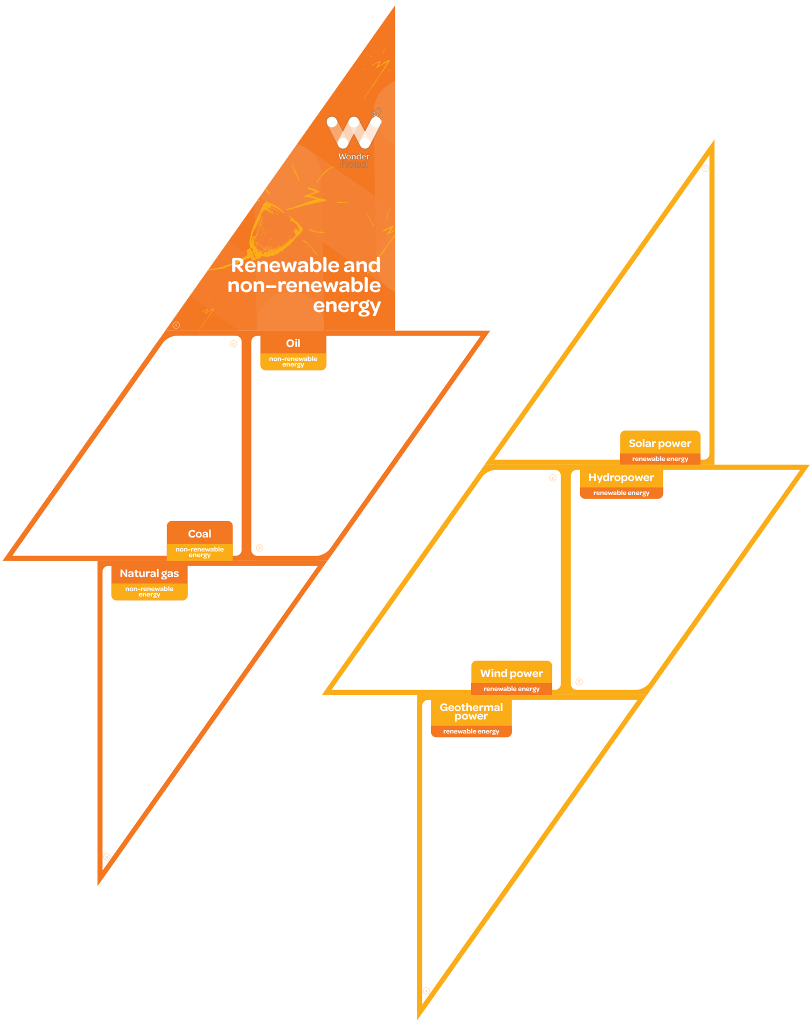
Step 4: Create an energy classroom display

Print the energy classroom display template on A3 paper – you'll find this in the teaching hub.

Each team should cut out the section of the template that corresponds with their energy source. Then, they'll write the information they've gathered from the research phase in their template section.

Now, the pages are ready to go up on the wall! This will consolidate the learning and serve as a reference point for students in future mahi. Teams might like to do a short presentation on their mahi before their section is added to the display.

Refer to the image on the right to see how the artwork might be displayed. Feel free to create your own template if you'd prefer.



Key concept: Wind turbines

Support students to explore and discuss new ideas by becoming familiar with these key concepts.

Understanding wind turbines

- Wind turbines generate electricity by transforming the kinetic energy of wind into electrical energy. They are made up of:
  - a sturdy base
  - a tower
  - a generator
  - a nacelle (generator housing)
  - a hub
  - and blades.
- When wind energy moves over the turbine blades, it transforms into rotational energy – a type of kinetic energy. This makes the blades spin.
- The blades are connected to a generator that lives inside the turbine nacelle. So, when the blades spin, they turn a magnetic rotor inside the generator. The spinning of the magnets inside the coils of the generator creates electricity. So, the rotational energy is transformed into electrical energy.
- The electricity travels down a cable, down the turbine tower, into the ground, and to the nearest substation.

For more information, refer to the student video 'ask'.

Aerodynamics

- Engineers use the principles of aerodynamics to design effective turbine blades.
- Aerodynamics is the study of how air moves around an object. The better the aerodynamic design of a turbine, the more electrical energy will be generated.
- There are two important aerodynamic forces at play when it comes to turbines:
  - Drag is the friction of the blades against the air as they rotate. Drag works against the rotation of the blades, causing them to slow down. Aerodynamic blades are designed to reduce the amount of drag acting on a turbine, so it can spin quickly.
  - Lift helps maximise the rotational force of the blades.
- Turbine blades have "winglets" on their tips, similar to those used on aeroplane wings, to support aerodynamic efficiency.

Blade pitch

- Turbine blades are all attached to the hub at a slight angle. This is called the blade pitch and has a significant part to play in increasing the aerodynamic efficiency of a wind turbine.
- This is because there is a specific pitch angle for any given wind speed to optimize the output of the turbine.
- So, turbines have a smart system that adjusts the blade pitch depending on the wind speed. This ensures that the turbine is getting the most out of the wind.

Students should consider the principles of aerodynamics when designing and creating their turbine blades in Modules 2 and 3.

Key concept: Engineering design process – ask, imagine and plan

Support students to explore and discuss new ideas by becoming familiar with these key concepts.

Understanding the engineering design process

The engineering design process is a series of simple steps that engineers use to solve problems and make ideas work.

Stuents will follow the engineering design process to create their wind turbines. In Module 2, you'll focus on the first three steps – Ask, Imagine and Plan.

Ask

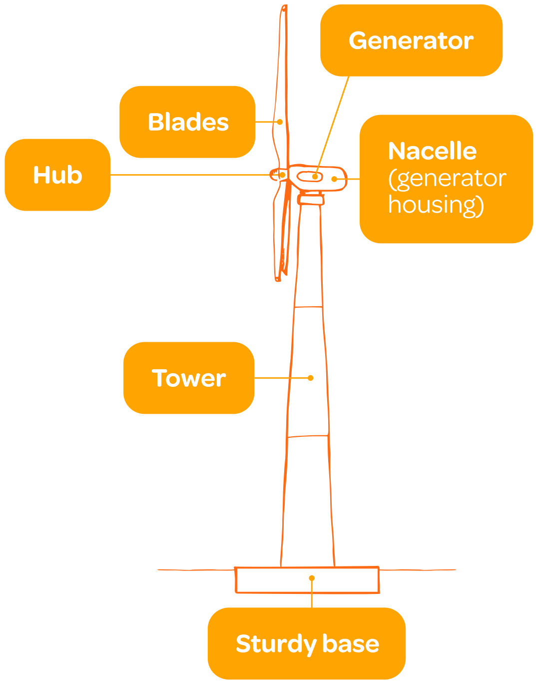
The 'ask' phase of the engineering design process is all about discovery and asking lots of questions to help you understand the problem better.

Students will watch a video that covers some solutions to the challenge question, the positives and challenges of renewable energy and how a turbine works.

As they watch the video, students should take notes in their activity booklets. They should also use the video content to help them label the turbine in their activity booklet. See answers to the right:

Following this, teams will be asked to decide on a goal for the challenge. They will work towards this goal as they progress through each module.

A challenge goal could be something like: 'We want to create a turbine with 100% recycled blades that lights up the entire town'.



Imagine and plan

For these stages, students will imagine and plan some wind turbine blade designs.

The 'imagine' stage of the engineering design process is where engineers imagine some possible solutions to the problem they defined in the first stage of the engineering design process, 'ask'.

The 'plan' stage is where engineers plan which solution to progress, and how to progress it.

Activity 2.2: Blade design

Purpose

Support students' understanding of the second and third stages of the engineering design process – imagine and plan.

Resources

- Activity booklet (1 per team)
- Decorations and colourful pens/pencils

Overview

In teams, students will apply the 'imagine and plan' stages of the engineering design process to the challenge question (I wonder how to power a brighter future?) by imagining and planning some wind turbine blade designs.

Start this activity by reflecting on the features of a real-life turbine and how these could be incorporated into students' designs. Refer to 'understanding wind turbines' on page 12 for a summary on how a wind turbine works.

Students should then imagine their own turbine blade designs – sketching as many as they can think of and experimenting with different shapes and sizes. Students should also take into account their knowledge of how a turbine works, design variables and aerodynamics.

Turbine design variables

The main goal of this activity is to get students to problem solve, think critically about how to design an efficient turbine, and most importantly, be creative. Students will get an opportunity to improve their designs later on.

However, for reference, please refer to 'understanding wind turbines' on page 12 and the table below for a summary of the features of an efficient turbine design.

Design variable	Effect on turbine efficiency
Blade materials	Blade materials need to be sturdy so they're not compromised by the wind, but light enough so that they don't affect spinning speed. We encourage students to play around with different materials. The most efficient materials to use include cardboard, corflute, or plastic ice cream containers.
Blade size	Blades need to cover enough surface area to catch the wind, but shouldn't be so large that the turbine is weighed down. Each blade on the turbine should also be the same size to ensure it's balanced. We encourage students to experiment with different blade sizes. A medium-sized blade (around 15cm) is generally most efficient.

Design variable	Effect on turbine efficiency
Blade shape	Blade shapes should be optimised to make the turbines aerodynamic. Each blade on the turbine should be the same shape to ensure it's balanced. We encourage students to experiment with different blade shapes. Generally, a rectangular shape with a curved tip, or a tall, thin triangle should be efficient. Students could also experiment with curving their blades to replicate a real turbine.
Blade number	The hubs in the power kit are designed to take anywhere from 1 to 12 blades. Turbines should have enough blades to catch the wind, but not so many that it affects spinning speed. We recommend students start with less blades, then scale up – it's much easier to add more blades than to remove blades. Generally, a turbine with 3 to 4 blades should work efficiently. Blades should also be placed evenly across the hub for balance.

After designing their turbines blades, students will move on to the 'plan' stage of the engineering design process.

For this stage, students should pick their final blade design, and draw it to scale in their activity booklet. They might like to use a ruler to check measurements.

From there, they'll explain why their design will be efficient and plan the recyclable materials they'll need to bring to construct their turbine. Encourage each team to decide which team member is responsible for bringing what.

Module 3: Wind power support notes

Use these notes about Power Challenge activities and key concepts as a reference as you go through Module 3 in the student Learning Hub with your class. Each activity is included in the order that they appear in the Learning Hub.

Key concept: The great journey of electricity – move

Support students to explore and discuss new ideas by becoming familiar with these key concepts.

Understanding the National Grid

In Module 3, students will focus on step 2 of energy's journey – move.

In Aotearoa, we rely on a special power system to move electricity that's generated, to the communities that use it. It's called the National Grid.

The National Grid is responsible for moving electrical energy all over the country. It's made up of over 12,000km of transmission lines and more than 170 substations. For more information on the components of the National Grid, watch the 'Move' video in the Student Hub, refer to the notes on Activity 3.1 below, the Journey of electricity poster, and/or the list of key vocabulary and concepts on pages 25–27.

Check out Transpower's live data for current statistics on our Power System.

Activity 3.1: Great grid race

Purpose

Support students' understanding of the second step in electricity's journey, move, where electricity is moved across the country through our National Grid.

Overview

In teams, students will recreate the journey that electricity travels to get to their home by putting the power cards in the right order, as fast as they can.

Resources

- Activity booklet (1 per team)
- Poster: Journey of electricity (1 per class)
- Power cards (1 per student)

1. To start, review the journey of electricity poster and great grid race instructions as a class.
2. When you're ready to start the activity, distribute one power card to each student.
   - Each card represents a step in electricity's journey – from generation, through to use.
   - There are 3 sets of 11 cards, enough for 3 teams of 11 students. Each card set is identical aside from its colour (orange, blue and pink).
     - Too many students? You could assign more than one student to one card. Or, you could appoint team leaders to help coordinate their team.
     - Not enough students? Give some students more than one card. Or, get students to work in their teams to order all of the cards.
3. When you say 'go', students should find the classmates that have the same colour card as them to form their team.
4. Each team will need to communicate with each other to put their power cards into the correct order, starting with the 'toaster' card, and ending with the 'wind' card.
   - For an extra challenge, encourage students to put the cards in order without looking at the information on the back.
5. When teams think they have the right order, they will raise their hands. Either the teacher, or the ambassador should then check that the order is correct.
6. The first team to get their cards into the correct order wins the race.

Answer

1. Toaster
2. Power outlet
3. Fuse board
4. Meter box
5. Distribution network
6. Substation
7. Step-down transformer
8. Pylons and transmission lines
9. Step-up transformer
10. Power station
11. Wind

Key concept: Engineering design process – create and test

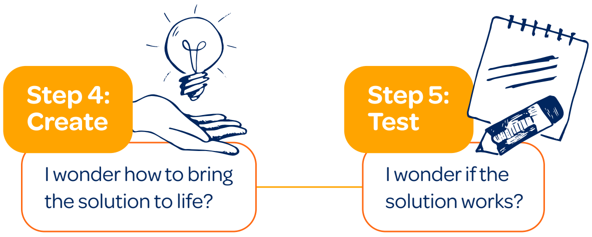
Support students to explore and discuss new ideas by becoming familiar with these key concepts.

Understanding the engineering design process

In Module 3, students will focus on the fourth and fifth steps of the engineering design process, create and test.

The 'create' stage is where engineers bring their solutions to life. Students will carry out this stage of the process by creating a wind turbine prototype.

The 'test' stage is where engineers perform a series of tests to determine whether their solution works, and if there are any ways it could be improved. Students will carry out this stage of the process by testing their prototypes and collecting data on the results.



Activity 3.2: Create

Purpose

Support students' understanding of the fourth stage of the engineering design process – create.

It's important that students understand they will be testing and improving these turbine designs as they progress through the challenge, as per the engineering design process.

Overview

Start by watching the 'Create' video and reading through the instructions in the activity booklet. Then, in their teams, students will create their own turbine prototype using their creativity, and knowledge from the challenge to date.

Blades

Students should start by creating their blades. Remind them to consider their design from Activity 2.2, and their knowledge on aerodynamics and design variables.

Please refer to the turbine design variables table on pages 13–14 for a reminder on the most efficient blade designs.

After creating their blades, students should glue a popsicle stick to the back of each blade so they can be easily inserted into the hub.

Resources

- Activity booklet (1 per team)
- Base (1 per team)
- Wooden dowel (1 per team)
- 3D printed bracket (1 per team)
- Motor (1 per team)
- Hub (1 per team)
- Popsicle sticks (up to 12 per team)
- Wingnut and screw (1 each per team)
- Recyclable materials for turbine blades (refer to page 13 for a list of suggested materials)
- Decorations and colourful pens/pencils
- Hot glue or other adhesives
- Scissors

Base and tower

The dowel (turbine tower) should fit securely into the turbine base. If it's wobbly, students should secure it in place with a bit of hot glue. You might find it's a bit of a tight squeeze to put them together. We suggest that students twist the dowel into the base with a bit of force.

Nacelle (3D printed bracket)

The turbine nacelle slides onto the turbine tower and is secured using the wingnut and screw.

Students can choose the height of their turbine by sliding the nacelle up or down the tower before locking it in place.

Motor

The back of the motor slides into the nacelle. It does not need to be secured with glue.

The motor wires are long and should be kept out of the way of spinning blades. To manage wires:

- There's a white connector near the top of the motor wires. This white connector plugs into a slot at the back of the nacelle. The wires should feed through the bottom of the nacelle. You can see this demonstrated in the 'Create' video.

Hub

Students should slot their blades into the hub. The hub has 12 slots to allow for many different blade configurations. Please remind students to start with less blades, then scale up – it's much easier to add more blades than to remove blades.

Each slot is slightly angled – this is to replicate turbine blade pitch. Turbine pitch has a big effect on the performance and energy output of wind turbines. Refer to page 12 for more information on turbine pitch.

Students should balance their blades evenly across the hub to ensure their turbine is stable. Once each turbine blade is inside the slot, secure it in place with some blu-tack or tape. This will give students the freedom to swap out their blades later in the challenge.

Connecting the hub to the motor

The hole in the middle of the hub fits onto the motor pin. You might find that it's a bit of a tight squeeze to put them together. We suggest that students twist the hub onto the pin with a bit of force. Once you've put the hub and the motor together once, it should get easier and easier each time.

Other ways to attach the hub and the motor include:

- Pressing it hard and securing it with a bit of hot glue.
- Tap it (not hit it!) with a hammer-type object.

Activity 3.3: Time to test

Purpose

Support students' understanding of the fifth stage of the engineering design process – test.

Overview

Students will test their turbine prototypes to collect data on their performance and determine whether they need improvement. By doing this, they will learn the value of iteration and that engineers test and improve multiple times before settling on their final design.

Resources

- Activity booklet (1 per team)
- Students' prototype wind turbines
- Printed circuit board (PCB) (2 per class)
- Fan (a 40cm desk fan will work best) (2 per class)
- Ruler (2 per class)

Test 1: Prototype functionality

Teams will test whether their prototypes are working as they should by spinning the blades with their hands. They should think about the following:

Test	Improvement
Do the blades spin?	Check whether the hub is attached correctly to the motor pin. Check that the motor isn't tangled in its wires. Check that there's no glue where it shouldn't be.

Test	Improvement
Are the blades balanced or wobbly when spinning?	Check that blades are evenly balanced across the hub. Check that all blades are the same size and shape. Check that blades have been inserted into the hub properly.
Are the blades secure?	Check that blades have been inserted into the hub properly. If not, secure with some extra hot glue.
Are the blades connected to the motor properly?	The motors in your kit come with an LED attached. Spin the blades to test whether they're connected to the motor properly – the LED should light up. If it doesn't light up, check the hub is securely attached to the motor pin.

Teams should write their results in the activity booklet before moving on to the next test.

Test 2: Power up your prototype

Teams will test the energy output of their turbines by connecting it to a printed circuit board (PCB) and setting it up against a desk fan.

How to get started

To set up the second test, we suggest splitting the class into two, keeping team members together. This will allow you to set up two activity stations, each with a PCB and a fan, so that teams don't have to wait too long for their turn.

Connect your turbine to the PCB by removing the LED from the turbine motor's connector cable, then, plugging the connector cable into the wind input on your PCB. This is labelled with a wind symbol.

Then, set the turbine up face on in front of the fan and observe the effect of two variables:

- Fan distance
- Blade design variables

It's important for students to understand that **you can't get out more energy than you are putting in.** This means the more efficiently a turbine works, the more LEDs on the PCB will light up.

What to expect

The turbine on its own should light up to 4–5 LEDs when working efficiently. Teams will not be able to light further LEDs until a second generator (solar) is introduced in Module 4.

The LEDs on the PCB are designed to light up sequentially. This could take a few moments as the current needs to travel through the board.

If teams cannot light up 4–5 lights, they should consider ways to improve their turbine's design so it works more efficiently. Refer to the turbine design variables table on pages 13–14 for a reminder on the most efficient blade designs.

Your fan

The fan speed, size and distance will have a big impact on the results of the second test. We recommend a 40cm desk fan for the best results. We also recommend running the fan on high each time it's used in the challenge.

Turbine blades need to spin quickly to generate enough electricity to power the PCB. So, it's unlikely that students will see a good result if they're using a small desk fan, or a fan that's not very powerful.

Make sure the centre of the fan matches up with the centre of the wind turbine. You may need to raise your fan with some books, or a container.

Recording results

Teams should record all results from their testing in the test tracker.

- Observation – watching what is happening during testing will help students figure out how to make their prototype spin faster and generate more electricity.
- Analysis – recording test results will help students see patterns and understand the effects of changing design variables. Use this data to improve the design of your turbine.

By changing variables, teams can improve the performance of their turbine. After their testing, encourage teams to record what design changes they will make. Teams should also record the optimal fan distance to achieve the maximum energy output. They will use this set up in the final 'Light up our town' activity.

Module 4: Illuminate support notes

Use these notes about Power Challenge activities and key concepts as a reference as you go through Module 4 in the student Learning Hub with your class. Each activity is included in the order that they appear in the Learning Hub.

Key concept: Engineering design process – improve

Support students to explore and discuss new ideas by becoming familiar with these key concepts.

Understanding the engineering design process

Step 6: Improve

I wonder how to make the solution even better?

In Module 4, students will focus on the final stage of the engineering design process – improve.

The 'improve' stage is where students analyse their performance data from Activity 3.3 and use it to make final improvements to their turbines. This ensures turbines are the best they can be before the final challenge.

Students should consider the following questions, and write the answers down in their activity booklets:

- What did you learn from your tests? Eg a stronger fan was required.
- Which variables worked well? What didn't work well? Eg fan distance and design variables.
- What changes could be made to improve blade design? Eg consider changing the materials or curving the blade.

For ideas on how to improve the turbines, refer to the turbine design variables table on pages 13–14.

At this stage, students should use some hot glue to secure their blades as they should have settled on their final design.

Key concept: The great journey of electricity – use

Support students to explore and discuss new ideas by becoming familiar with these key concepts.

Understanding being energy smart

In Module 4, students will focus on step 3 of energy's journey – use.

Our community relies on electricity to keep vital services running – like our schools and hospitals.

To ensure we have enough electricity in the future to accommodate for our growing population, and increasing reliance on electricity, we'll need to make more of it, and try to reduce the amount we use. Reducing the amount of electricity we use can also be beneficial to the environment.

Encourage students to reflect on ways to become energy smart – this could include turning off unnecessary lights, taking shorter showers, turning off the water when brushing teeth, using energy saving light bulbs.

Activity 4.1: Light up our town

Purpose

Students will connect their final improved turbines, and a solar panel, to the printed circuit board (PCB) and compete with other teams to see who designed the most efficient wind turbine.

Overview

Students will test their turbine prototypes to collect data on their performance and determine whether they need improvement. By doing this, they will learn the value of iteration and that engineers test and improve multiple times before settling on their final design.

Resources

- Activity booklets (1 per team)
- Students' final wind turbines
- Printed circuit board (PCB) (2 per class)
- Solar panel (2 per class)
- Fan (a 40cm desk fan will work best) (2 per class)
- Light source (we suggest a strong torch or desk lamp) (2 per class)

Understanding your printed circuit board

The printed circuit board (PCB) was designed to replicate the steps in electricity's journey – generate, move and use.

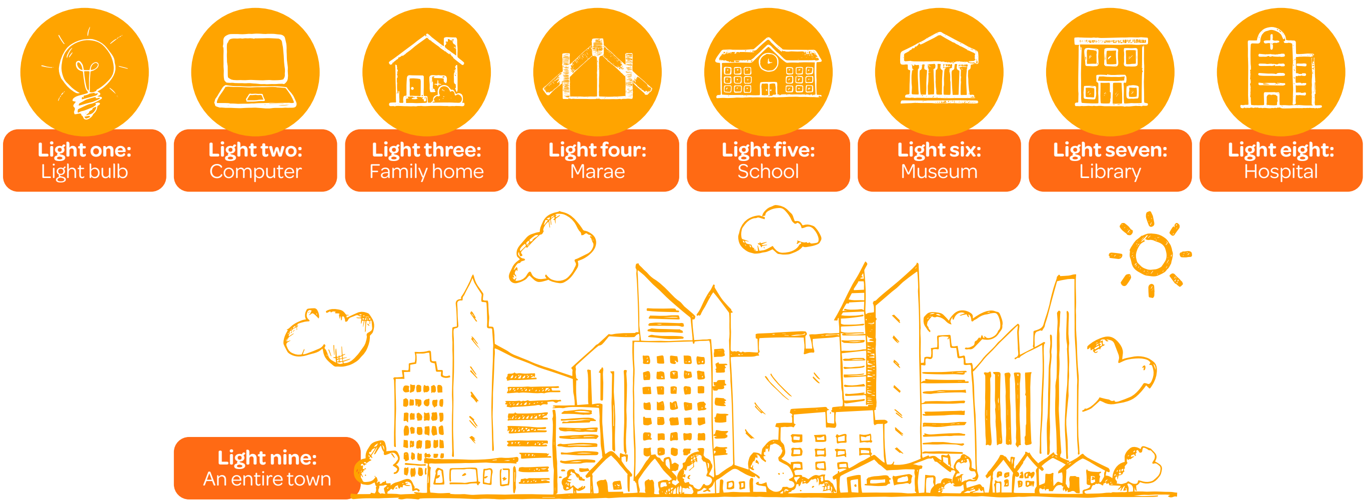
The generate section of the PCB is where students will connect their generators – their wind turbine, and a solar panel. The wind turbine wire should be plugged into the connector with the wind symbol, and the solar panel wire should be plugged into the connector with the sun symbol.

When the turbine and solar panel are plugged in and working, the electricity will move through the PCB, and reach the LEDs, where it will be used to light them up.

The LEDs on the PCB are designed to light up sequentially. As the current needs to travel through the board, this could take a few moments. Also, the further up the board, the harder it will be to light up the LEDs.

Our town

Each LED is attached to an object or building that makes up a mini town, as follows:



Start the activity by having a class discussion on each element of the mini town and why it's important for our community that each element has access to a reliable source of electricity.

Setting up the activity

To set up the activity, we suggest splitting the class into two, keeping team members together. This will allow you to set up two activity stations, each with a PCB, fan and a light source, so that teams don't have to wait too long for their turn.

Part one – the great turbine test

Taking turns in their teams, students should connect their final, improved turbine prototypes to the PCB, and set them up in front of a fan, using the optimal conditions they identified from their testing.

They should then collect data in their activity booklets on how many LEDs their final turbine can light up on its own. This data should be compared to their data from Activity 3.3 to see if there is a difference between the output of the improved turbine, and their initial prototype.

Part two – solar panel solutions

Remind students that we rely on multiple energy sources to power our communities. This means we have a safe, steady and reliable power supply regardless of weather conditions and how much electricity is being used day by day.

Students should then connect their solar panel to the PCB, by plugging it into the solar panel connector – it's labelled with a sun symbol. Their challenge is to see how many LEDs they can light up with the combined power of two generators.

Please ensure that all teams use the same light source (we suggest a desk lamp or strong torch), to ensure that results are fair. Try to also ensure that the distance between the light source and the solar panel is consistent across each team.

Record each team's results in the table in the activity booklet.

Deciding on the winning turbine

Use the data from the tables that students filled out to determine the best performing turbine – you should consider the amount of LEDs the turbine lit up on its own, and whether any teams reached all nine LEDs.

If there was more than one team that lit up all nine LEDs, you could appoint multiple winners, or bring turbine design, creativity, and teamwork/collaboration skills into the criteria.

You could also ask each team to give a presentation on their Power Challenge experience and explain their turbine creation process.

Activity extension

If you have extra time, you might like to adapt the PCB set up and test students' turbines against a set of scenarios, to see if it changes their power output.

Teams should compare their results against the below scenarios. You are welcome to create your own set of scenarios too!

Scenario one – Slip slop slap and wrap
It's a blistering hot day and the winds have almost slowed to a stop! Place the fan 1 metre away from the turbine and maintain the distance between the solar panel and light source. Record how many LEDs light up.

Scenario two – Winds galore
Hold onto your hats – it sure is windy! Remove the solar panel, and set up the fan as close to the turbine as possible. Record how many LEDs light up.

If you're in a windy area, you could even try setting up your turbine outside.

Scenario three – A calm, cold day
The sun's tucked behind the clouds and the winds are mellow. Use natural light from the windows on your solar panel and set the fan up 1 metre away from the turbine. Record how many LEDs light up.

Activity 4.2: Wonder cards

Purpose

Cement challenge learning by creating some wonder cards that students can use to test each other's knowledge on Power Challenge material, and in the bright sparks quiz.

Resources

- Activity booklets (1 per team)
- Scissors and pens

Overview

Using their knowledge of Power Challenge learning material, teams will create a set of wonder cards that cover key challenge concepts they've learned.

Step one: Cut out the wonder cards.

Step two: In their teams, students should brainstorm some 'I wonder' questions to include on their cards, that relate to Power Challenge material. Then, write them down on the front of the card. Examples include:

- I wonder where renewable energy comes from?
- I wonder what energy transformation and transfer are?
- I wonder what the National Grid is?
- I wonder what kinetic energy is?

Step three: Cut out the wonder cards.

Step four: Flip the cards over and write the answer to the 'I wonder' question on the back of the card.

Step five: Use these cards to compete in the bright sparks quiz.

Bright sparks quiz

- Collect the wonder cards from each team and choose around 10 – 15 (depending on how much time you have) to use in the bright sparks quiz.
- Ensure you have a good spread of key Power Challenge concepts in the cards. Make sure you check that the cards are correct before using them. Add in any extra questions as needed.
- Read out the 'I wonder' question on each card. Teams will buzz in when they know the answer.
- Record each team's tally on the whiteboard.

End of challenge reflection

How did our tīma do?

Teams are encouraged to reflect on their successes, failures and whether they acheived the goal they set at the beginning of the challenge. They do this by answering three questions at the back of the activity booklet:

- Did you solve the problem? How?
- Did you meet your goal? How?
- Is there anything you'd do differently next time?

This is also the perfect time to complete the post-challenge surveys and the optional activity extension – light up your kit on page 22.

Post challenge surveys

- Student post-challenge survey
- Ambassador post-challenge survey
- Teacher post-challenge survey

Optional extra activity: Light up your kit!

Purpose

Extend students' understanding of circuits and electricity by exploring parallel circuits and using this knowledge to light up their power kit.

Overview

As a class, work out a way to light up the kit by creating parallel circuits.

Resources

- Power kit
- Leftover copper tape
- LEDs (4 per class)
- Coin batteries (2 per class)
- Scissors, tape, pens and pencils

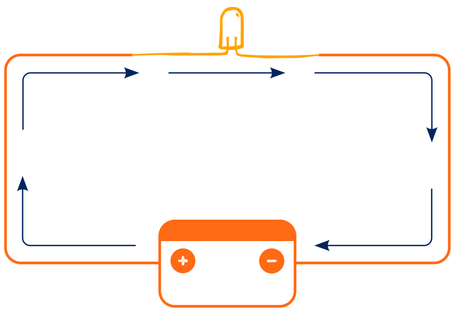
Understanding series vs parallel circuits

In Activity 1.2, the circuits teams created to light up their LEDs were series circuits. The differences between series circuits and parallel circuits are outlined in the comparison chart below:

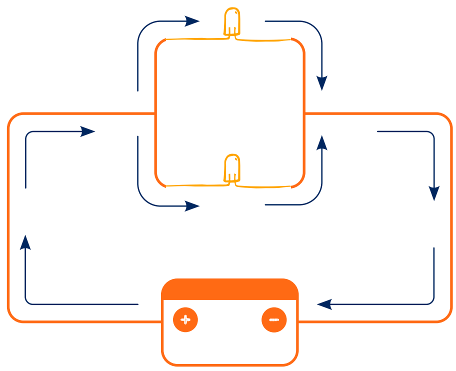
	Series circuit	Parallel circuit
Introduction	A circuit made up of components (eg LEDs, batteries) connected in a single path.	A circuit made up of components (eg LEDs, batteries) connected in parallel along multiple paths.
Current	The same amount of current flows through all components within the circuit. And, there's only one pathway for electricity to flow.	The current flowing through each component combines to form the current flow through the energy source (the battery).

	Series circuit	Parallel circuit
Voltage	The voltage of the battery is the sum of all voltage of the components in a circuit.	The voltage of every component of the circuit is the same.
Functionality	Components are not functional if any of the components are damaged because it disrupts the flow of current.	Components are functional even if any of the other components are damaged.
Examples	• Freezers • Refrigerators • Lamps • Bulbs	• Outlets in our home • Wiring in toys • Washing machine • Microwave

Difference between series and parallel circuits



Series circuit



Parallel circuit

So, how do these things relate to one another?

In a series circuit, the same amount of current flows through all components within the circuit which are all connected in a single path. And, there's only one pathway for electricity to flow. If one component fails, the circuit is broken and will no longer work.

In parallel circuits, components are placed in parallel with each other. Because of this, the circuit splits the flow of current. This ensures all components in the circuit have the same voltage as the source, allowing electricity to flow through more than one path. So, if one component fails, the others won't be affected.

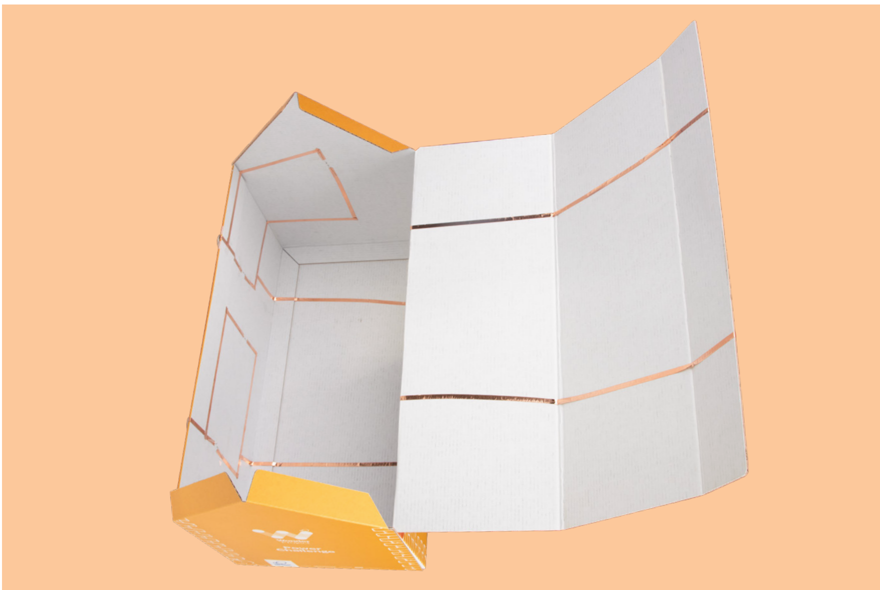
Parallel circuits also allow more components to be added into the circuit without changing the source (battery).

Try it yourself!

Referencing the principles and troubleshooting options in Activity 1.2, attempt to light up all lights on the outside of the power kit through a parallel circuit.

- There are four lights on the outside of the kit – we recommend placing your LEDs on top of these lights
- You should use one battery per two LEDs
- Ensure that the copper tape is placed carefully so you don't break your circuit

The image on the right is an example of how to create a successful parallel circuit. Encourage students to find a solution themselves without referencing this image.



Activity 4.3: Power Challenge competition

Purpose

An opportunity for students to reflect on their learnings to date, go in the draw to win some goodies for their class and be named as the Power Challenge champions.

Overview

Using the instructions in Activity 4.3, create a video or a poster to bring your Power Challenge journey to life.

Each school can submit one entry which can be either a video or a poster. You could choose to:

- Create your entry together as a school, OR
- Create an entry with your crew and get your ambassador/ teacher to select the best one

Schools who want to participate in the final blast off must have completed:

- All activities
- Pre-challenge and post-challenge student surveys.

Send in your entry

- Upload your video or a picture of your poster to the Wonder Project community Facebook group, OR
- Send your entry to wonder@engineeringnz.org

Resources

- Activity 4.3: Power Challenge competition (1 per class)
- **If making the video:**
  - Footage and pictures from the challenge
  - Video editing software – iMovie or Vimeo works
- **If making the poster:**
  - Pictures from the challenge
  - Poster paper
  - Decorations

How we choose the winner

At the end of the challenge, our wonder team will review all of the entries against these guidelines to choose a winner:

- Be clear rather than clever to help your audience understand your story
- **Video-specific guidelines:**
  - Plan the beginning, middle and end of your video
  - Think about sound, visuals and script
  - Make sure it's no more than 3 minutes long.
- **Poster-specific guidelines:**
  - Plan the poster layout so it's organised and easy to follow
  - Think about how to use graphics and visuals to enhance presentation.

The winner will be sent medals for each student, and a prize.

The prizes:

- **First place prize: LEGO set**
  - Space mission set (1700 pieces)
  - Lots of bricks set (1000 pieces)
  - Bricks and wheels set (653 pieces)
  - Build together set (1601 pieces)
  - 2x baseplates
- **Runner up prize: LEGO set**
  - Space mission set (1700 pieces)
  - Lots of bricks set (1000 pieces)
  - 2x baseplates

Examples of winning school videos:

Rocket Challenge winners playlist.

You may also use the completed competition entries as an assessment tool against the achievement objectives on page 2, but this is optional.

Key vocabulary and concepts

Aerodynamics	The study of how air moves around an object. The better the aerodynamic design of a turbine, the more effective it will be at generating electricity.
Climate change	Long term changes in average climate conditions and weather patterns, such as temperature, rainfall or wind.
Conductor	A substance or material that allows electricity to flow through it.
Current	Current is the flow of an electric charge. When electrons move, they carry electrical energy from one place to another.
Distribution network	Local distribution networks deliver power to homes and businesses through overhead power lines or underground cables.
Electrical circuit	A path for electricity to move from one location to another. Every electrical circuit is made up of three basic things: • Energy source to provide electricity • A conductive path for the electricity to flow • A load that uses the electrical energy. Eg a LED
Electricity	Energy that helps us power our communities. It's generated by the movement of tiny particles called electrons. Eg a bolt of lightning, wind turbines, electric eels.
Energy	The ability to do work. Energy makes things happen. It makes machines work and living things grow. People use energy to talk, run and think. Every time we do anything, we use energy!
Energy transfer	When energy moves from one place to another, or from one object to another. Eg heat energy moving from a light bulb onto your skin when you touch it.
Energy transformation	When energy changes form to do work. Eg chemical potential energy transforms into electrical, light and thermal energy when you turn the lights on.
Engineering design process	Six simple steps that engineers use to solve problems and make ideas work: **1. Ask** questions to help define the problem. **2. Imagine** solutions to the problem. **3. Plan** which solution to progress. **4. Create** the solution. **5. Test** whether the solution works. **6. Improve** the solution to make it the best it can be.

Fuse board	The fuse board distributes electricity through your home and protects your electrical system from overloading.
Geothermal energy	Geothermal energy is harnessed from the heat deep down inside the earth.
Greenhouse gas	Harmful gases such as carbon dioxide or methane that trap heat in the atmosphere and warm the planet, contributing to climate change.
Hydropower	Electricity generated from hydropower uses the kinetic energy of flowing water.
Insulator	A substance or material that does not let electricity flow through it.
Kinetic energy	Working energy that something has because of its motion. Eg sound, light, thermal, and electrical energy.
Meter box	The meter box measures how much electricity you use at home.
Non-renewable energy	Non-renewable energy is made from resources that will run out, or won't be replenished for thousands, or even millions of years. Coal, oil and natural gas are all non-renewable.
Potential energy	Energy that is stored, waiting to make things happen. Eg gravitational potential energy is energy that is stored because of an object's height above the Earth. Other examples include chemical potential, elastic potential, and magnetic potential energy.
Power station	A place where electricity is generated.
Prototype	A simple model that lets you test out an idea.
Pylon	Pylons are steel towers that hold transmission lines high above the ground.
Renewable energy	Renewable energy is made from resources that are naturally replenished. For example, we get solar power from the sun which is renewable because we can't use up all of the sun's sunlight.
Solar energy	Energy generated through the sun using solar panels. A solar panel uses photovoltaic cells to absorb light energy from the sun and transform it into electricity.
STEM	Science, Technology, Engineering and Maths.
Step-down transformer	Step-down transformers reduce the voltage of electricity so it's safe to use in the substation.
Step-up transformer	Step-up transformers are used at power stations to increase the voltage of electricity. This helps it move further through transmission lines.
Substation	The substation is a location where electricity's voltage is stepped down for safe distribution to the community.

Sustainability	The ability of individuals, groups, and communities to meet their needs without compromising the ability of future generations to meet theirs. It's important to understand that our present actions will impact the welfare of the environment and future generations.
The National Grid	A special power system that connects generated electricity, to the communities that need it.
Transmission lines	Conductors designed to carry electricity over long distances.
Variables	Things that change or can be changed. People with STEM jobs use variables to experiment and test the best way to achieve their goals.
Wind energy	Wind is a renewable energy source. It's transformed into electricity thanks to wind turbines.
Wind turbine	Wind turbines generate electricity by transforming the kinetic energy of wind into electrical energy. Turbines are made up of: • a sturdy base • a tower • a generator • a nacelle (generator housing) • a hub • and blades.