Electrifying Vehicles

YEAR 6
PHYSICAL SCIENCES
DESIGN AND TECHNOLOGIES

QGC | FUTUREMAKERS | QUEENSLAND MUSEUM NETWORK | Queensland Government

Future Makers

Future Makers is an innovative partnership between Queensland Museum Network and Shell's QGC business aiming to increase awareness and understanding of the value of science, technology, engineering and maths (STEM) education and skills in Queensland.

This partnership aims to engage and inspire people with the wonder of science, and increase the participation and performance of students in STEM-related subjects and careers – creating a highly capable workforce for the future.

Cover image: One of the Lucas Bedford electric vehicles used in the 1982 Commonwealth Games. This van is stored at The Workshops Rail Museum. Queensland Museum.

QUEENSLAND MUSEUM NETWORK

Queensland Government

EXPLORE – EXPLAIN – ELABORATE – EVALUATE

Electrifying Vehicles

Teacher Resource

We use electrical energy to power many things. In this activity, students explore vehicles powered by electricity. They explore the story of the Lucas Bedford electric van, make a battery-powered car in a hands-on design challenge, and then use the specifications of different electric vehicles to plan a road trip in Queensland. You can find additional information about these activities on the following pages.

The Lucas Bedford Electric Van

The Lucas Bedford electric van is part of Queensland Museum's Cultures and Histories collection. It was one of two vans used during the 1982 Commonwealth Games in Brisbane.

One of the Lucas Bedford electric vans used in the 1982 Commonwealth Games. It is now part of Queensland Museum's collection and is stored at The Workshops Rail Museum, Ipswich Queensland Museum.

Although the Lucas Bedford electric van was not the first electric vehicle on Australian roads, it is significant because it is an example of how the automotive and electrical manufacturing industries responded to the oil crisis of the mid-1970s. The goal of these industries was to mass-produce electric commercial vehicles as an alternative to oil-powered vehicles. The use of the van at major gatherings and events, such as the Commonwealth Games, was intended to promote the benefits of owning and using electric vehicles to the general public. However, as the oil crisis resolved, the high purchase cost of electric vehicles became a significant barrier to their widespread use and adoption.

Electric Vehicle Design Challenge

In this challenge, students design, create and test a battery-powered toy car that should be able to travel a distance of at least five metres. Students use recyclable materials and electrical components to create and test their designs. While the students may source some of these materials themselves, other materials will need to be provided by the teacher. Suggested materials for this design challenge are provided on the following pages.

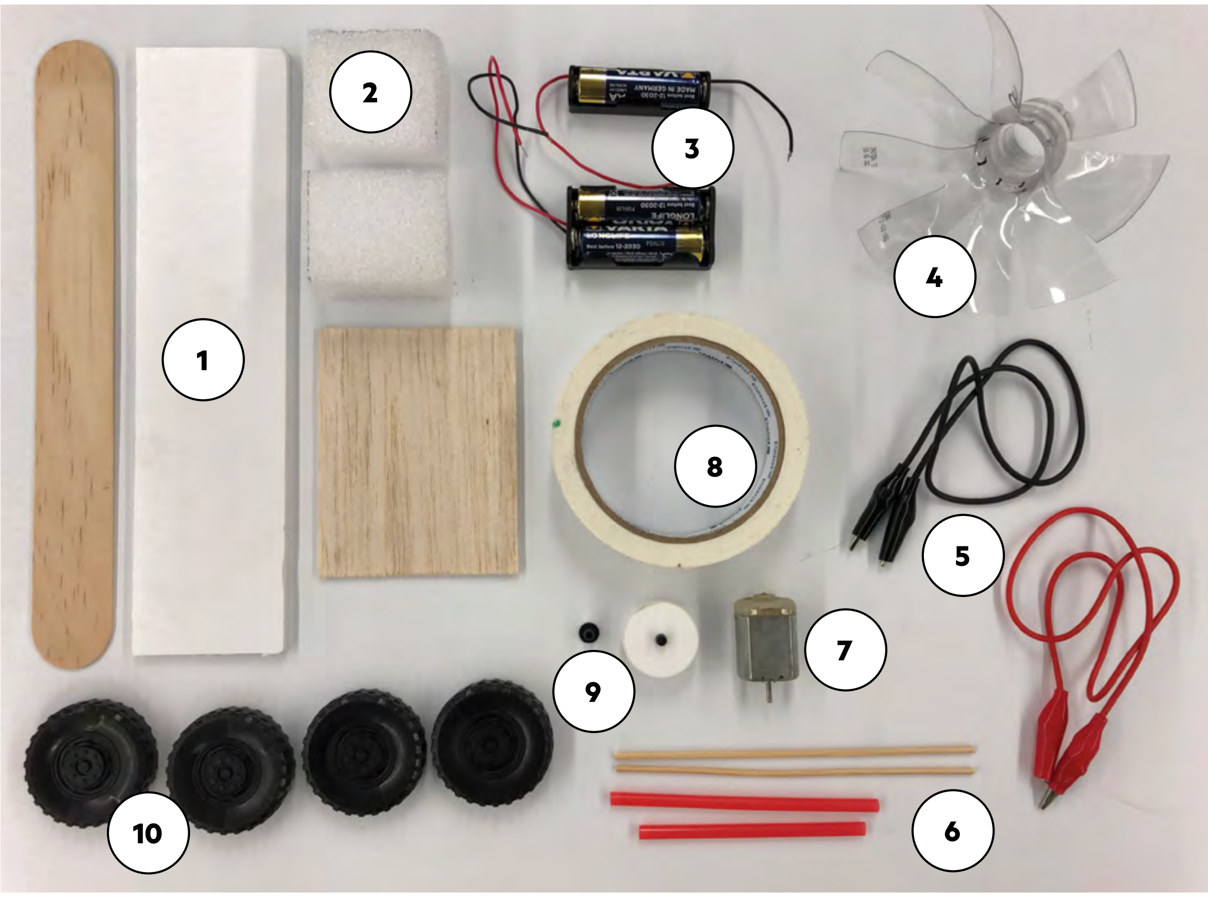
Electrifying Vehicles

Teacher Resource

Material Suggestions

We recommend the following materials for the *Electrifying Vehicles Design Challenge*. You can substitute some materials for others or provide additional materials that are not listed below. Ensure students know how to work safely with electrical components before they create their designed solutions.

Materials to Construct a Battery Powered Car



1 Chassis materials, such as large tongue depressors, corflute and balsawood.

2 Booster materials, such as foam blocks. The foam blocks raise the motor and fan, so that there is more space between the fan and the ground. Lighter materials will allow the fan to propel the vehicle further.

3 Batteries and battery holders. We recommend providing single and double AA battery holders for students to choose from, as well as the corresponding number of AA batteries. Students could also experiment with different battery sizes, including AAA, C, D or 9V batteries.

4 A fan, made from the top of a plastic bottle. The fan is attached to the motor. When the fan is connected to the circuit, it provides the force needed to move the car along the ground. Note: Teacher assistance will be required to construct the fan.

Curriculum Links

Science

YEAR 6

Science Understanding

Electrical energy can be transferred and transformed in electrical circuits and can be generated from a range of sources (ACSSU097)

Science as a Human Endeavour

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

Science Inquiry Skills

With guidance, pose clarifying questions and make predictions about scientific investigations (ACSIS232)

Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (ACSIS103)

Decide variables to be changed and measured in fair tests, and observe, measure and record data with accuracy using digital technologies as appropriate (ACSIS104)

Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate (ACSIS107)

Compare data with predictions and use as evidence in developing explanations (ACSIS221)

Reflect on and suggest improvements to scientific investigations (ACSIS108)

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

Design and Technologies

YEAR 5 AND 6

Design and Technologies Knowledge and Understanding

Investigate how electrical energy can control movement, sound or light in a designed product or system (ACTDEK020)

Investigate characteristics and properties of a range of materials, systems, components, tools and equipment and evaluate the impact of their use (ACTDEK023)

Design and Technologies Knowledge and Understanding

Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions (ACTDEP024)

Generate, develop and communicate design ideas and processes for audiences using appropriate technical terms and graphical representation techniques (ACTDEP025)

Select appropriate materials, components, tools, equipment and techniques and apply safe procedures to make designed solutions (ACTDEP026)

Mathematics

YEAR 6

Number and Algebra

Select and apply efficient mental and written strategies and appropriate digital technologies to solve problems involving all four operations with whole numbers (ACMNA123)

Find a simple fraction of a quantity where the result is a whole number, with and without digital technologies (ACMNA127)

Add and subtract decimals, with and without digital technologies, and use estimation and rounding to check the reasonableness of answers (ACMNA128)

Measurement and Geometry

Convert between common metric units of length, mass and capacity (ACMMG136)

Solve problems involving the comparison of lengths and areas using appropriate units (ACMMG137)

HASS: Economics and Business

YEAR 6

Knowledge and Understanding

How the concept of opportunity cost involves choices about the alternative use of resources and the need to consider trade-offs (ACHASSK149)

The effect that consumer and financial decisions can have on the individual, the broader community and the environment (ACHASSK150)

The reasons businesses exist and the different ways they provide goods and services (ACHASSK151)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Numeracy

Estimating and calculating with whole numbers

Using fractions, decimals, percentages, ratios and rates

Using spatial reasoning

Using measurement

Information and Communication Technology

Investigating with ICT

Creating with ICT

Critical and Creative Thinking

Inquiring – identifying, exploring and organising information and ideas

Generating ideas, possibilities and actions

Reflecting on thinking and processes

Analysing, synthesising and evaluating reasoning and procedures

Personal and Social Capability

Social management

5 Alligator clips.

6 Straws and skewers, used to make the front and rear axles.

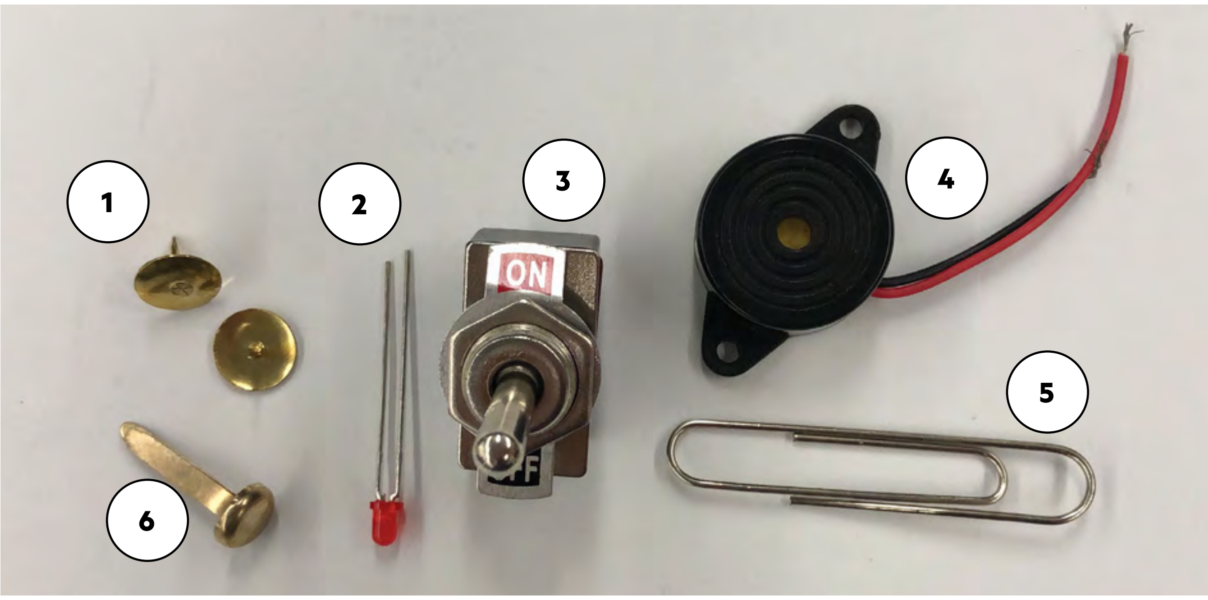
7 9V motor.

8 Masking tape.

9 A bottle lid and motor adaptor pin. A small hole is drilled into the centre of the lid. The motor adaptor pin is inserted into the lid and secured in place with hot glue. The motor adaptor pin is attached to the motor, and the lid is attached to the fan. Note: Teacher assistance will be required to make a hole in the lid of the bottle top and to secure the motor adaptor pin with hot glue.

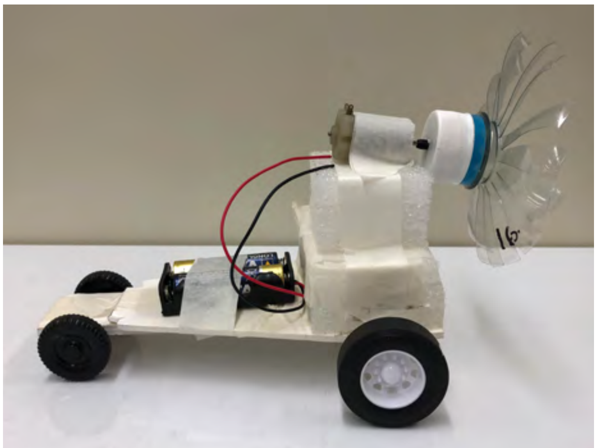
10 Plastic wheels.

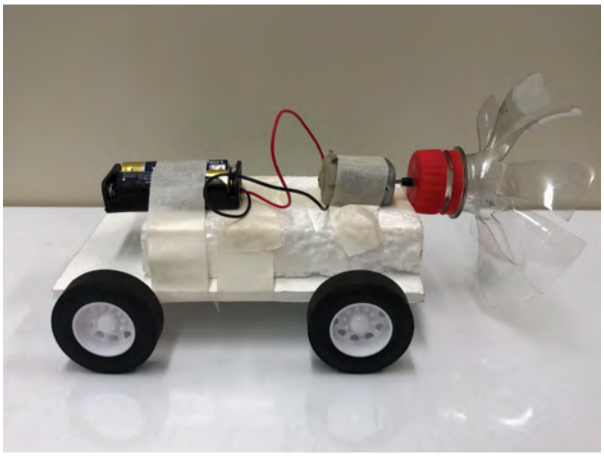
Optional Materials



1 Thumb tacks	**2** LED lights	**3** Switch
4 Buzzer	**5** Paperclip	**6** Split pins

Battery Powered Car Examples





Electrifying Vehicles

Student Activity

The Lucas Bedford Van

We use electrical energy to power many things, including vehicles. Electric vehicles have actually been around for a lot longer than you might think! The first electric car is believed to have been built by English inventor, Thomas Parker, in 1844. Around this time, the world was experiencing the rapid development of electricity, and many other inventors, engineers and scientists were also exploring how electrical energy could be used to power different vehicles and machines.

An electric vehicle that has an important place in Queensland's history is the Lucas Bedford electric van. Two Lucas Bedford electric vans were used during the 1982 Brisbane Commonwealth Games, and one of these vans is now part of Queensland Museum's collection.

Image, top: One of Thomas Parker's electric cars, circa 1895. Parker sits in the middle of the photograph.
Image, bottom: One of the Lucas Bedford electric vans used in the 1982 Commonwealth Games. Queensland Museum.

The vans were used during the road walk event and the men's marathon. One van led the competitors and carried a digital clock, which showed the race time and distance covered. The other van drove behind the competitors; this van transported crew and equipment and picked up exhausted or injured runners and walkers.

Image, right: Runners competing in the 1982 Commonwealth Games marathon. The Lucas Bedford electric vans, used as lead and field vehicles, are seen in the bottom right corner and the middle of the image. Image courtesy of Mimag, retrieved from http://nla.gov.au/nla.obj-306125746.

The vans travelled almost silently, could cover a distance of 100 kilometres and had a top speed of 80 kilometres/hour. A lightweight rechargeable battery was used to power the vehicles.

When a battery is connected to a circuit, a chemical reaction occurs within the battery. This reaction transforms chemical energy to electrical energy. The electrical energy then flows through the wires of the circuit, where it can be transformed into other types of energy, from light to sound to movement (kinetic energy), similar to the electrical energy travelling through your home or school. Over time, the materials in the battery no longer react and eventually the battery 'goes flat'.

For some batteries (like the ones you might find in a television remote), this chemical change is irreversible and a brand new battery is needed as a power source when the old battery goes flat. For other batteries (like the ones you might find in a mobile phone, laptop, or the Lucas Bedford van), this change is reversible and the battery can be recharged. This is because rechargeable batteries can be connected to an external source of electricity – say through a charger that is connected to mains power – and the flow of electricity into the battery can reverse the chemical reaction, restoring the battery's charge. The battery can then be reused as a power source.

Despite the benefits of the Lucas Bedford electric van, its high purchase and servicing costs, heavy mass and limited driving range meant that it was not widely used by people after the Commonwealth Games. Today, electric vehicles are comparable in cost, mass and driving range to most fuel-powered cars, and we are now seeing greater numbers of electric vehicles on the roads.

Electrifying Vehicles

Student Activity

Electric Vehicle Design Challenge

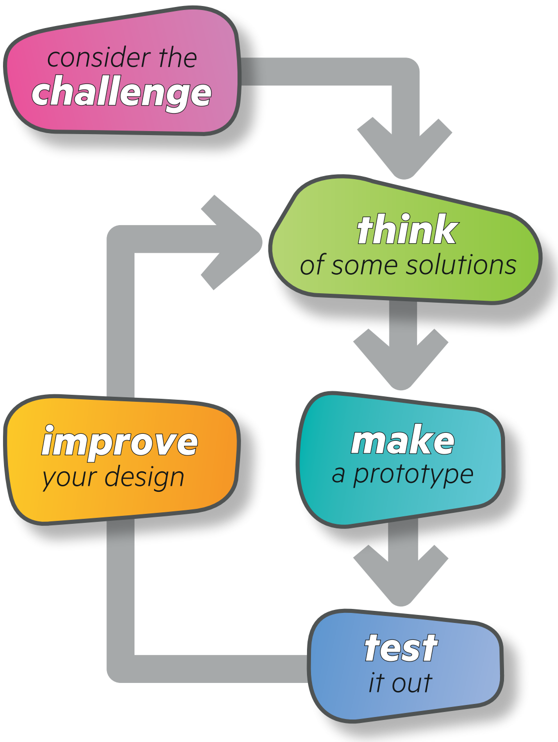
Task:

Design, create and test a battery-powered toy car. The car should be able to travel a distance of at least five metres.

You must:

- **Consider the challenge.** What are the requirements of the design challenge?

  Think of some solutions. Investigate the components that a car needs to move. What materials and electrical components could you use to replicate these parts? What other ideas do you have for a design?
- **Make a prototype.** What materials and components will you use? How will you work safely? Create a labelled diagram of your design, and then construct your prototype.
- **Test it out.** Test the prototype. What did you notice? Did the prototype operate as you intended? You may also like to explore the effect of different variables, such as the number of batteries used in your design.
- **Improve your design.** You may like to introduce new features to the car, such as light or sound. Keep testing and refining until you are satisfied with your design.
- **Evaluate your design.** What aspects of your design are you very satisfied with, and why? What challenges did you experience during the design process, and how did you overcome them?



Consider the Challenge

What are the requirements of the design challenge? Identify and record these requirements, and any criteria for success, below.

Think of Some Solutions

A car uses the following parts to move:

Wheels	Axle	Battery	Engine

Research what these parts do and where they are found in a car. Draw a labelled diagram of a car, showing the location of these important parts on your diagram.

Consider the materials and electrical components you could use to replicate these parts of the car, as well as other major car parts like the car body. Mark these ideas on your diagram above.

Make a Prototype

Design your battery-powered car. Consider the characteristics and properties of materials and how you will use electrical energy to control movement.

Draw a labelled diagram of your battery-powered toy car. Make sure you identify and justify the materials and electrical components you will use in your design.

Draw a circuit diagram of your battery-powered toy car.

Construct your prototype.

Explain any changes that were made to the design as you created the prototype.

Test It Out

Test your design and record your observations below.

Explain your observations. Consider what you already know about electrical energy and the properties of different materials. Make sure you include scientific language in your explanation.

If you are completing the Electric Vehicle Investigation, please do so now. Move ahead two pages to find the investigation.

Improve Your Design

Explain how you will improve your design. You may also like to introduce new features to the car, such as light or sound.

Draw a revised circuit diagram to show these modifications.

Re-test your design. Explain and evaluate the effect of these modifications.

Continue testing and refining until you are satisfied with your design.

Evaluate Your Design

Reflect on your actions with your team or class after you have completed the design challenge. You might like to think about the following questions to assist with your reflection:

- Explain how your knowledge of science helped you to make decisions about your design.
- Evaluate your final design. Which aspects are you most satisfied with? Which aspects would you further improve on? How would you make these improvements?
- Describe the main challenges you experienced during the design process. Explain how you overcame these challenges.
- Explain what you have learnt about electrical energy and/or the design process from this activity.

Electrifying Vehicles

Student Activity

Electric Vehicle Investigation

Explore the effect of changing one variable (the independent variable) on the design of your electric vehicle. You could investigate the effect of the number of batteries, voltage of batteries, mass of the car or another variable of your choice. Remember, for a fair experiment you should change only one variable.

Aim

State the purpose of your investigation.

Hypothesis

Make a prediction about the outcome of the investigation, giving reasons for your response.

Variables

Identify the variables you are going to change, measure or observe and keep the same.

Change? (Independent Variable)	Measure/Observe? (Dependent Variable)	Keep the same? (Control Variables)

Materials

List all of the equipment you will use in the investigation. Remember to include numbers and amounts.

Method

List all of the steps you will take to conduct the investigation.

Risk Assessment

What safety considerations must be made before, during and after the investigation? Identify at least five risks and how to minimise them.

Risk	How to manage the risk

Recording Results

Draw a table and record your results.

Represent this data as a graph. You could use Excel to create the graph.

Discussing Results

Summarise the results.

Explain the results.

Explain if your original prediction was supported by the data collected.

Discuss how you could use these results to improve your battery-powered toy car.

Describe any challenges you experienced during the investigation.

Explain how you could improve the investigation.

Conclusion

Summarise the experiment and the results. Was your prediction supported or refuted?

Electrifying Vehicles

Student Activity

Planning a Road Trip - EV Style

In this activity, you will plan a Queensland road trip in an electric vehicle. You must choose your vehicle, and then identify the approximate road trip route you would like to take. Identify where you would like to go, and then identify where you will need to stop to recharge.

You may use Queensland's Super Electric Highway and PlugShare charging points (focussed on Queensland) to plan your journey. You may also plan to charge using normal household 240 V power points, for example, while staying in overnight accommodation, however recharging using household power is significantly slower than most public charging points.

Electric Vehicle Specifications

Research an electric vehicle. Identify how far the vehicle can travel in a single charge (its range) and its top speed. Record this information in the table below.

	Electric Vehicle:
Range (km)	
Top speed (km/h)	

Plan Your Journey

Think about where you would like to travel on a road trip. Use Queensland's Super Electric Highway and PlugShare charging points in Queensland to plan your journey. If there are any parts of the journey where you will not have public charging stations, you may need to charge overnight at your accommodation.

Create a Map of Your Journey

Draw your trip on a map of Queensland, and record the distances between your major stops/points of interest.

Add the public charging stations along your route. Are there any long stretches of driving where you do not have a public charging station? Can you modify your journey slightly to travel via public charging stations, or will you need to charge at private accommodation?

Identify where you will need to charge along your journey. How many stops will you need to make? How many times will you need to stop to specifically charge your vehicle (rather than stopping at a destination or point of interest)?

Calculate how long it will take you to complete your journey. How much time do you spend at each destination? How long does it take to charge the vehicle along the way?

You may need to investigate charge time specific to your vehicle, because charging an electric vehicle can take anywhere from 20 minutes using a fast charger to over 24 hours using a regular household plug, depending on battery size and type of charger. The chargers along Queensland's Electric Super Highway generally have 22 kW AC charging points and 50 kW DC fast charging points. You can identify approximately how long it will take to charge your vehicle by searching the specifications of your vehicle. The Fleets Charge Together Vehicle Guide also has charging information for electric vehicles in Australia and the Electric Vehicle Database contains information on electric vehicles in the USA, UK and Germany.

Record your answers in the table below.

	Electric Vehicle:	
Explain why you chose your route. Were you required to make any trade-offs?		
How many stops will you need to make to complete your road trip?		
Which locations will you stop at to recharge? How did you choose these locations?		
How long will your road trip take? You may like to use the space here to record working out.		

Evaluate the strengths and limitations of long distance travel in these vehicles. What trade-offs do you need to consider?

Imagine the Queensland Government is selecting the location of 10 new fast-speed charging sites. Write a letter of recommendation to the government, detailing where you believe these sites should be located and why.

Examine how your road trip may change if the government accepts your proposal and builds your recommended charging stations.

Some private businesses have their own charging stations, such as the Birdsville Roadhouse and Cunnamulla Tourist Park. How did/could the decision of these businesses to provide charging stations affect your travel? Additionally, how could the decision affect the business, broader community and the environment?

If you were to complete your road trip in the Lucas Bedford van, discuss how your journey would change. Include data in your answer.